GLOBAL IMPACT ASSESSMENT OF AN OPTIMISED ENVIRONMENTALLY FRIENDLY LIGHTNING ARRESTER

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ABSTRACT

The present paper describes the methodology applied to assess AREVA lightning arrester VARISIL™ environmental performance as evaluated by a Life Cycle Assessment (LCA) carried out according to ISO 14040 standard.
This paper illustrates the environmental advantages as well as the technological improvements accomplished for the newly designed arrester.
Besides, the design of the surge arrester has been carefully studied, both in terms of optimisation of the necessary quantity and selection of the type of materials to be used, and in terms of constraints and opportunities for dismantling and possible recycling of the device.

INTRODUCTION

At present the end-of-life product management is a worldwide environmental concern. Integrated Product Policy, RoHS, WEEE and EuP Europeans directives seek to minimise environmental degradation caused by products throughout their whole life-cycle. Others countries such as Canada, China, Japan, Korea, Norway, Switzerland, Taiwan and United States are proposing/enacting similar legislation. Thorough and proper understanding of a product main technical and environmental performance during its total life cycle is essential. This has direct consequences on the product design (eco-design) to be optimised.
AREVA policy falls [1] under this logic to anticipate the legislation and AREVA T&D, being an international leader in energy transmission and distribution, is also a pioneer in the adoption of eco-design concepts [2]
Thanks to the excellent co-operation with both the ENSAM Chambéry Institute and the AREVA T&D production plant, AREVA T&D / DRC has been able to implement a product global impact assessment to identify and optimize the product environmental performance.

PRESENTATION OF THE LIGHTNING ARRESTER

VARISIL™ HE 24 S3D2 surge arrester manufactured by AREVA Parafoudres SA is a heavy duty type surge arrester intended for overvoltage protection of distribution networks and was specially designed for areas where strong lightning exposure and high pollution levels are observed. *Table 1* gives the main technical data of the VARISIL™ HE 24 surge arrester. An available option is an insulating bracket with a built-in disconnector (S3D2 option). This option improves service continuity by disconnecting the surge arrester from earth in case of failure.

Characteristics	Values
Rated voltage Ur	24 kV rms
Continuous operating voltage Uc	20 kV rms
Class	10 kA / Line Discharge Class 1
Lightning impulse protective level at 10 kA	65.1 kV peak
Lightning impulse withstand level of the housing	125 kV
Creepage distance	800 mm
Weight	2.6 kg

***Table 1**: Main features of VARISIL™ HE 24 surge arrester*

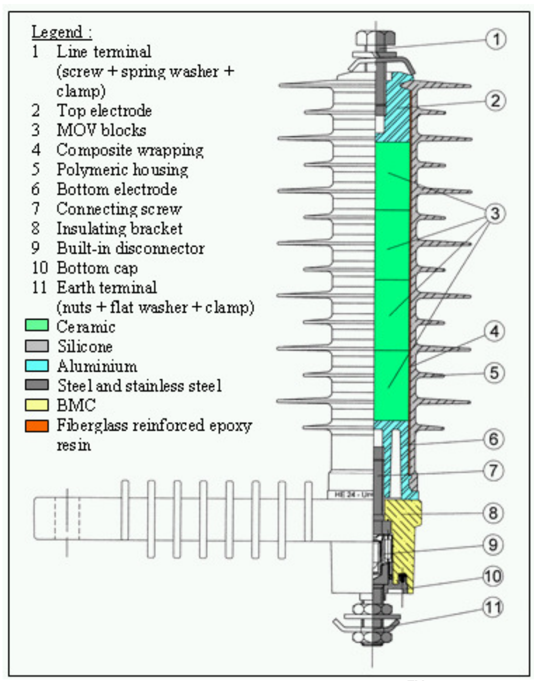

***Figure 1** : Longitudinal half section of the VARISIL™ HE 24 S3D2*

PRESENTATION OF THE IMPACT ASSESSMENT

The global impact assessment of the surge arrester is evaluated by a Life Cycle Assessment (LCA) procedure carried out according to ISO 14040 standard [3]. A LCA is the assessment of the environmental impact of a given product throughout its life span.
The goal of a LCA is to compare the environmental performance of somehow similar products to be able to choose the one having a less intensive impact. The term « life cycle » refers to the notion that for a fair and holistic assessment, the raw material production, manufacture, distribution, use and disposal (including all intervening transportation steps) need to be assessed. The concept can also be used to optimize the environmental performance of a single product (eco-design) or a whole company.
The aim of the present work is to assess the VARISIL™ HE 24 S3D2 environmental performance from cradle to grave.

METHODOLOGY

Nowadays there is no common agreement in the international environmental community as to how the end-of- life of a product can be managed. Nonetheless, some common features as applicable for every methodology of end -of -life assessment such as:

- cost evaluation and
- satisfy relevant legislation

can be conveniently chosen.

The LCA is the most complete analysis. The general principles and its methodology are described in ISO 14040 standard.
Environment and health impacts were calculated using the E.I.M.E software version 1.6 and the ECOBILAN 5.4 data base complemented by internal data modules.
The E.I.M.E Software[3] (Environmental Information and Management Explorer) is a software design tool, database, and environmental management system. This tool, based on product LCA, permits a quantitative environmental evaluation. It allows the comparison of the environmental performances of different design alternatives and gives contextual "warnings" during the product description process. The E.I.M.E software allows modelling of product pollution impacts and calculates the environmental performance of the product for 11 indicators as follows:

RMD	= Raw Material Depletion	POC	= Photochemical Ozone Creation
ED	= Energy Depletion	AA	= Air Acidification
WD	= Water Depletion	WT	= Water Toxicity
GW	= Global Warming	WE	= Water Eutrophication
OD	= Ozone Depletion	HWP	= Hazardous Waste production
AT	= Air Toxicity		

As the E.I.M.E software is brief about the end-of-life phase data, they were integrated in the manufacturing phase. The recycling data were carried out from a careful additional study.

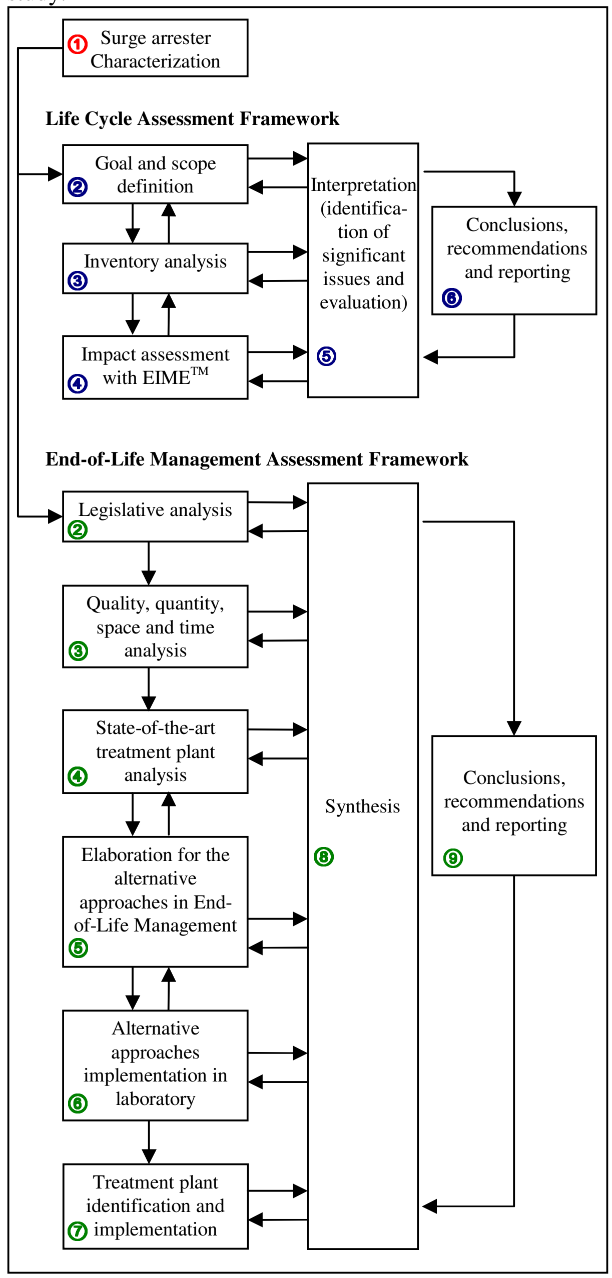

***Figure 2**: Schematic diagram of the Life Cycle Assessment and End-of-life Management Assessment Framework.*

ENVIRONMENTAL PERFORMANCE

Global impact performance [4].

Figure 3 shows the results of the comparative analysis conducted with the E.I.M.E software for the manufacturing, distribution and use phase.
Right away it can be seen on *figure3* that the distribution phase does not have any significant impact on both the environment and health hazard as compared to the other life cycle phases. In fact the distribution phase contributes to 1% of the global impact performance including both arrester

transportation and packaging.
The manufacturing phase includes both the material and the technology data. *Figure 3* shows that manufacturing is mainly responsible for the raw material depletion (RMD) with 95% of the total impact remaining to the materials used for the product manufacture. The 5% left is for power generation necessary to energise the product over 20 years and, in a slightest way, to transport it. *Figure 4* shows that process choice is also very important in terms of environment and health impacts for both raw material and product manufacturing. In fact, the gap between the top of the columns and 100% is much larger than the light bleu stripes on *figure 4,* which means that the raw material production process has more impacts than the product manufacture.

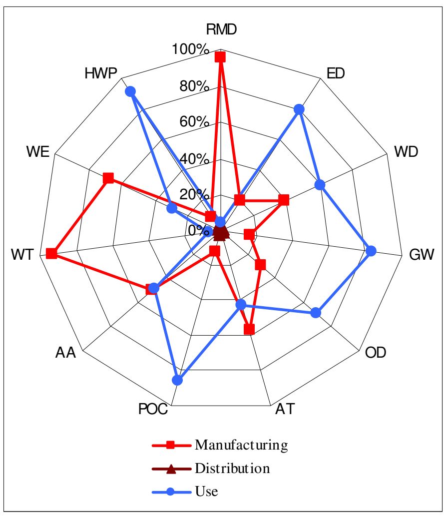

Figure 3*: Contribution of each life cycle for the manufacturing, distribution and use phases.*

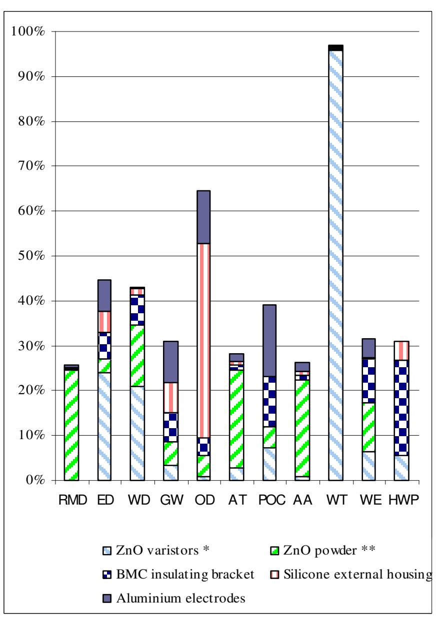

Figure 4*: Main materials contributions to the environmental impacts of the VARISIL*^{TM} *HE 24 S3D2 surge arrester. * Data supplied by the arrester production plant whose activities are assimilated to the ZnO varistors production** Data supplied by the ZnO powder manufacturer*

As for the end-of-life, two « extreme » alternatives are presented for illustration purpose. The first one corresponds to a situation whereby total dismantling of the device is carried out and the second one corresponds to total crushing of the product.
The objective is to obtain the maximum material revalorization as possible. The result is at least a 89% recyclability rate when brought to suitable treatment plants.

Tables 2a and 2b show the remarkable capability of this type of arrester for recycling achieving 98.1 % in the case for total dismantling and 89.4 % for the case of total grinding. These outstanding results have been achieved as a consequence of adopting a development policy that contemplates from the beginning all the environmental constraints as well as following all the practical rules for eco-design .

Waste destinations

ABS
Can go to an incinerator. For economical reasons they actually do not have a specific treatment plant and are not collected.

Aluminum
Goes to a refinery.

BMC
Is recoverable as filler by co-incineration in cement kilns, the glass and fillers becoming part of the cement and the resin being burnt off. The usual particle size needed is 5 cm by 5 cm. Some cement works as those located in Czech Republic are able to valorise BMC insulating brackets without any grinding.

Brass
Goes to a foundry.

Carbon film resistor
Goes to an incinerator.

EPDM
Can go to an incinerator. For economical reasons they actually do not have a specific treatment plant and are not collected.

Fiberglass reinforced epoxy resin
Goes to cement works to be incinerated. It has to be noticed that fibreglass reinforced epoxy resin must be separated from metal oxide varistor to make the varistors recyclable. Only a low quantity of composite per ton of varistors is allowed not to affect results and let metal oxide varistors recyclable. Fiberglass reinforced epoxy resin does not melt at temperatures observed during this processing path making electrolysis dissolution and distillation impossible.

Metal Oxide Varistors
Go to zinc oxide production plants where they are ground and used as a compounding ingredient or as a replacement of raw zinc oxide. Zinc can be recovered by chemical solubilization, settling and electrolysis with ultrasonic stirring.

PE
Goes to a specific treatment plant.

Silicone rubber
Can be recycled trough chemical process to obtain silicone oils.

Steel and stainless steel
Go to a steel mill

Materials		% mass /Total mass	Recycling		Incineration		Landfilling%
			%	Recycled mass/ total mass	%	Incinerated %	
Metals	steel and stainless steel	7,8	100	7,8	0	0,0	0,0
	Aluminium	8,78	100	8,8	0	0,0	0,0
	Brass	0,14	100	0,1	0	0,0	0,0
Plastics	ThermoPlastic	0,28	34	0,1	66	0,2	0,0
	Elastomer	17	100	17,0	0	0,0	0,0
ZnO ceramic		43	100	43,0	0	0,0	0,0
Thermoset matrix composites		22,6	94	21,3	6	1,3	0,0
Others		0,4	0	0,0	100	0,4	0,0
Total (%)		100		**98,1**		**1,9**	**0,0**

***Table 2a**: Material balance and recycling assessment at end-of-life of VARISIL™ HE 24 S3D2 for total dismantling of product.*

Materials		Initial Mass (g)	Recycling		Incineration		Landfilling %
			%	Recycled total mass %	%	Incinerated %	
Metals	steel and stainless steel	7,8	90	7,0	9	0,7	0,1
	Aluminium	8,78	90	7,9	9	0,8	0,1
	Brass	0,14	90	0,1	9	0,0	0,0
Plastics	ThermoPlastic	0,28	0	0,0	90	0,3	0,0
	Elastomer	17	90	15,3	0	0,0	1,7
ZnO ceramic		43	90	38,7	9	3,9	0,4
Thermoset matrix composites		22,6	90	20,3	9	2,0	0,2
Others		0,4	0	0,0	90	0,4	0,0
Total (%)		100		**89,4**		**8,0**	**2,6**

***Table 2b**: Material balance and recycling assessment at end-of-life of VARISIL™ HE 24 S3D2 for total grinding alternative.*

CONCLUSIONS

The VARISIL™ HE 24 S3D2 surge arrester is designed for a lifetime of at least 20 years with no maintenance and low power losses.
The VARISIL™ HE 24 surge arrester is an environment friendly product. It is hazardous material free and almost 98 % recyclable.
However, total dismantling is the best end-of-life alternative for VARISIL™ HE 24 arrester when there is low cost manpower and short distance transportation to the treatment plant.
On the contrary, the total crushing alternative is the best end-of-life alternative for VARISIL™ HE 24 arrester when manpower is expensive and the treatment plant is located abroad with harder waste legislation or too far from the place it was used.
In fact, the best solution is a compromise between the two alternatives presented.

PERSPECTIVES

Thanks to the excellent co-operation between AREVA and ENSAM, a product environmental profile and an end-of-life management manual were issued in July 2006. The manual summarizes [4] all main environmental and health impacts and main valorisation alternatives and treatment techniques associated with subcontractors selected for industrial implementation, recyclability rates obtained and cost evaluation. This type of initiatives is widely deployed throughout AREVA.

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