Eco-sheet

1.6 MVA industrial transformer designs with increasing efficiency

July 2006

by Hans De Keulenaer[1]
email hdk@eurocopper.org

This eco-sheet has been produced by Leonardo ENERGY[2] in the context of its ecodesign project, which aims to demonstrate and quantify the environmental benefits of high efficiency electrical systems.

1 Product description and typical application

This is an environmental declaration for increasing the efficiency in a 1.6 MVA oil-cooled industrial transformer (20kV/690V). Such transformer is typically used in industry for buying electricity at high or medium voltage, to transform and distribute on-site. Industrial transformers are typically loaded more heavily than their counterparts in the utility network. This declaration is for an average 50% loading. Three design alternatives are compared:

- Transformer with AA' class of losses according to CENELEC HD428
- Transformer with CC' class of losses according to CENELEC HD428
- Transformer with amorphous iron core and C-class load losses according to CENELEC HD428

[1]European Copper Institute
[2]LE is the outreach programme on Electricity & Energy managed by European Copper Institute

2 Scope of the LCA

The declared unit for the LCA is the production, utilisation and end-of-life phase of 3 different designs for a 1.6 MVA industrial transformer. All LCA data was taken from the GaBi4 database [GABI]. The modelling and the inventory data specifically regarding data quality were performed in accordance with ISO 14040 series as far as applicable.

2.1 Manufacturing

The manufacturing phase uses the following amounts of materials for the 3 alternative designs, cf table 1 [THERMIE, 1999]:

Material (kg)	AA'	CC'	C-Amorphous
Copper	505	725	1 225
Electrical steel	1 100	1 200	1 550
Mechanical steel	850	725	887
Oil	850	725	887

Table 1: Bill of materials for 3 transformer designs

2.2 Utilisation phase

For the utilisation phase, the European electricity grid mix (EU-15) was used. Only the losses in the induction transformer are calculated as the environmental impact in this phase, using the following parameters[3]:

Parameter	AA'	CC'	C-Amorphous
Rating (MVA)	1.6	1.6	1.6
Lifetime (years)	30	30	30
Load (%)	50	50	50
Load loss (kW)	17	14	14
No-load loss (kW)	2.6	1.7	0.42
Operating hours	8 760	8 760	8 760

Table 2: Utilization profile for 3 transformer types

[3] The electrical energy delivered at the low voltage side is considered as useful energy, and needs to be taken into account for an environmental declaration of the final electricity application. It is not included in the environmental declaration of the transformer component in the electricity distribution system.

2.3 End of life

The end of life is defined by the amount of dismantled material for recycling [kg]/ amount of shred material for recycling [kg].

The masses of recyclable materials are calculated as environmental credits.

3 Results

3.1 Inventory

The table below shows the result at inventory level, i.e. resource utilisation, emissions and waste.

Parameter	Unit	AA'	CC'	C-Amorphous
Primary energy consumption	GJ	19 750	15 061	11 439
Crude oil (resource)	tonne	31	24	19
Hard coal (resource)	tonne	153	117	89
Lignite (resource)	tonne	217	165	125
Natural gas (resource)	tonne	76	57	44
Waste	kg	295	255	261
Carbon dioxide	tonne	897	683	522
Nitrogen oxides	kg	1 796	1 368	1 042
Sulphur dioxide	kg	3 173	2 416	1 838

Table 3: Inventory results for 3 transformer types

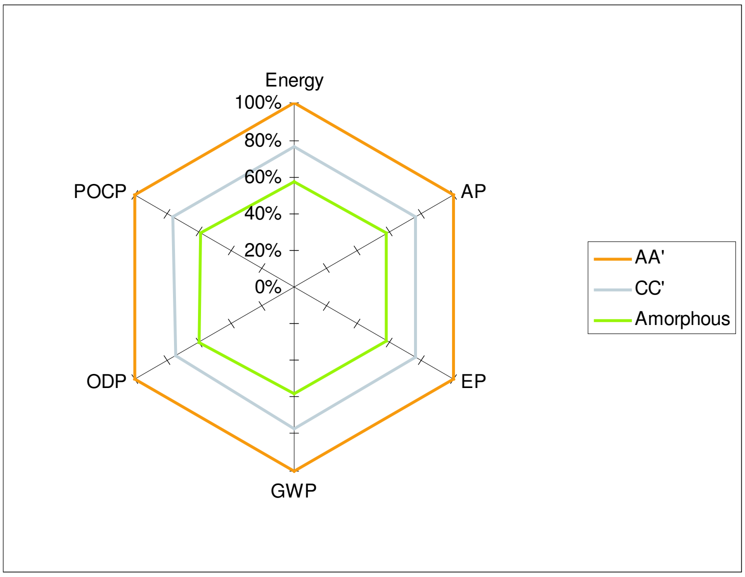
3.2 Impact results

The following table lists the environmental impact for the life cycle of the 3 designs, according to 5 major environmental impact categories:

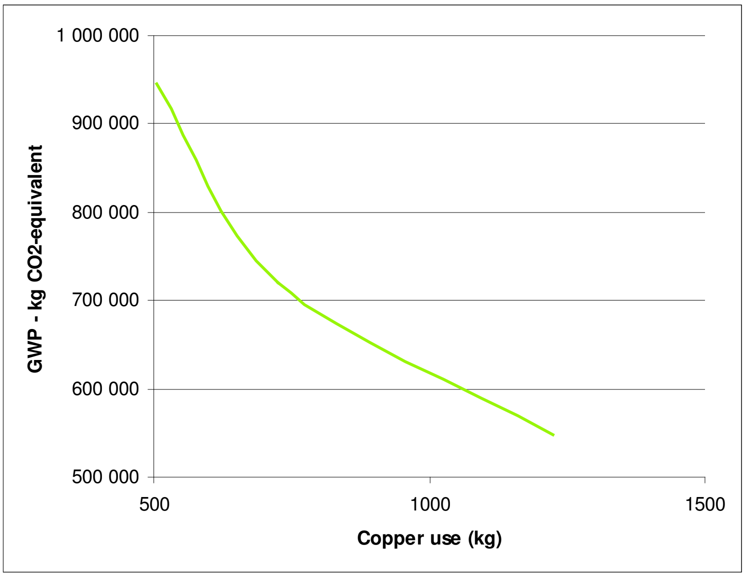
Impact category	Unit	AA'	CC'	C-Amorphous
Acidification Potential	kg SO_2-eq	4 616	3 517	2 677
Eutrophication Potential	kg Phosphate-eq	336	256	195
Global Warming Pot. (100 yrs)	tonne CO_2 eq	947	722	551
Ozone Layer Depletion Pot.	kg R11-eq	0.27	0.20	0.15
Photochemical Ozone Creation Potential	kg Ethene-eq	353	270	207

Table 4: Impact categories (CML 2001) per life cycle

The table shows more than 40% improvement in environmental impact between the designs, largely caused by a reduction in losses. The following radar plots presents the impact data in a graphical way.



The most efficient design uses almost 40% more material than its lowest efficiency alternative, but this is more than offset in the use phase. Using the method '1' described in [PE Europe, 2005], we can calculate the environmental performance of using additional copper to increase efficiency. Each additional kg of copper use saves over 500 kg of CO_{2e} emissions in this particular application. Given that one kg of copper takes 3 kg of CO_{2e} emissions in production (for electrical applications, [Copper, 2006]), the environmental payback is more than a factor 100, while at the end of life, the kg copper can be fully recycled for the next application.



4 Conclusion

Increasing efficiency of industrial transformers can produce significant environmental benefits. A 50% loaded 1.6 MVA high efficiency transformer saves almost 400 tonnes of CO_{2eq} emissions over its 30 year lifetime. The environmental payback on the additional material used for improving efficiency is more than a factor 100.

References

[Copper, 2006] ECI, information site providing up to date life cycle data on its key products, www.copper-life-cycle.org

[GABI] The respective tools and models have been provided by PE Europe, Hauptstrasse 111-113, D-70771 Leinfelden-Echterdingen (Stuttgart), Germany, www.gabi-software.com

[THERMIE, 1999] THERMIE STR-1678-98-UK, The Scope for Energy Saving in the EU through the Use of Energy-Efficient Distribution Transformers, December 1999, available from www.leonardo-energy.org

[PE Europe, 2005] PE Europe, Recommendation Paper, Options for Calculating the Long-Term Sustainability of Copper Use, November 2005, available from www.leonardo-energy.org

[Toolbox, 2005] The original information of this environmental declaration sheet is taken from the results of the GABI4 i-report referring to the ecodesign toolbox 2005 (for information, contact Hans De Keulenaer, email hdk@eurocopper.org)