Eco-sheet

22 kW induction motors with increasing efficiency

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This eco-sheet has been produced by Leonardo ENERGY[4] in the context of its project 'Efficiency and ecodesign'. This project aims to demonstrate and quantify the environmental benefits of high efficiency electrical equipment.

1 Product description and typical application

This is an environmental declaration for 22 kW low-voltage induction motors, operating a motor driven system, with typical applications such as water pumping, compressed air, or ventilation. Three different designs for a 22 kW motor have been performed [Save, 1999], with increasing efficiency.

2 Scope of the LCA

The declared unit for the LCA is the production phase, utilization phase and recycling phase of 3 different types of a 22 kW electric motor.

All LCA data was taken from the GaBi4 database [GABI]. The modelling and the inventory data specifically regarding data quality aspects were performed in accordance with ISO 14040 series as far as applicable.

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

2.1 Manufacturing

The manufacturing phase covers the most significant materials, cf table 1:

Material	Type 1	Type 2	Type 3
Aluminium	3.46	3.5	4
Copper	8.8	12.9	13.9
Electrical steel	108	108	108
Mechanical steel	n.a.	n.a.	n.a.

Table 1: Bill of materials for 3 motor types [Save, 1999]

2.2 Utilisation

For the utilisation phase, the European electricity grid mix (EU-15) was used. The losses in the induction motor are calculated as the environmental impact, using the following parameters:

Parameter	Type 1	Type 2	Type 3
Rating	22	22	22
η (%)	89.5	91.8	92.6
Lifetime	20	20	20
Load (%)	50	50	50
Operating hours	4380	4380	4380

Table 2: Utilization profile for 3 motor types

The mechanical power output of the motor at the axis is considered useful work, delivering input to the driven system (compressor, fan, pump, . . .).

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	Type 1	Type 2	Type 3
Primary energy consumption	GJ	1 233	940	841
Crude oil (resource)	kg	1897	1446	1294
Hard coal (resource)	kg	9516	7254	6493
Lignite (resource)	kg	13635	10390	9300
Natural gas (resource)	kg	4723	3600	3222
Waste	kg	14	11	11
Carbon dioxide	kg	56080	42767	38287
Nitrogen oxides	kg	112	85	77
Sulphur dioxide	kg	198	151	135

Table 3: Inventory results for 3 motor types, as produced by the toolbox

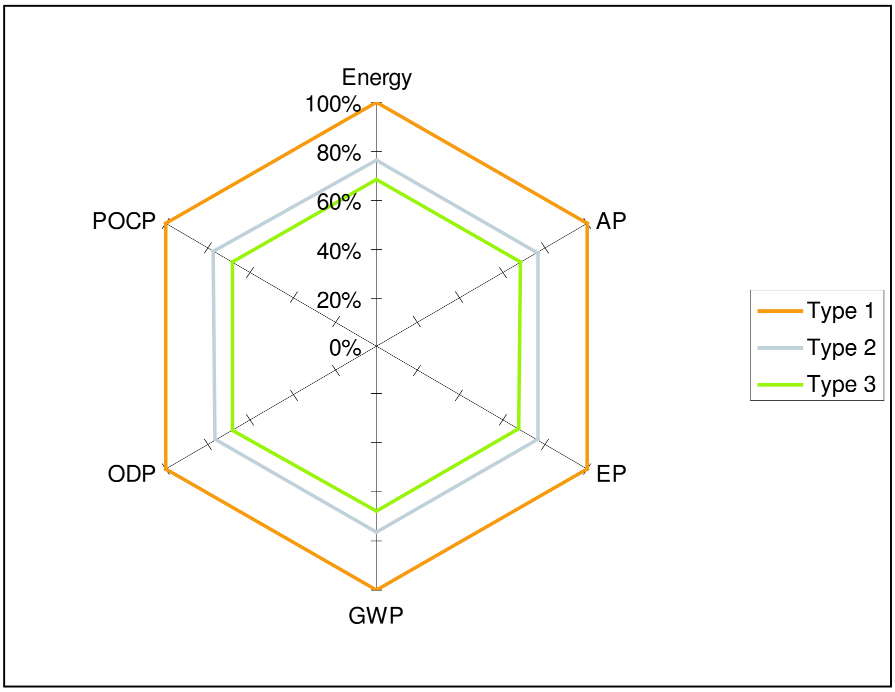
3.2 Impact results

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

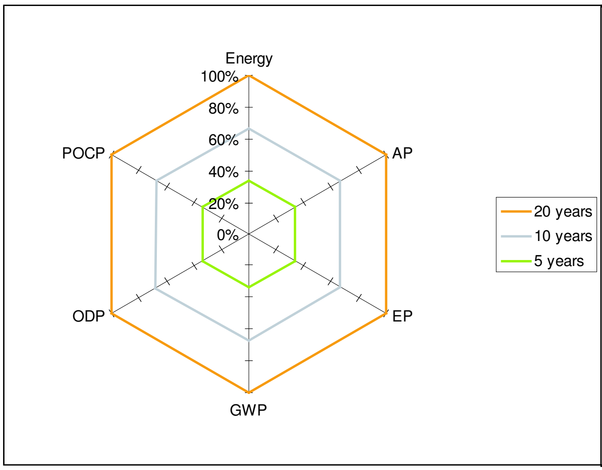
Impact category	Unit	Type 1	Type 2	Type 3
Acidification Potential	kg SO_2-eq	288	220	197
Eutrophication Potential	kg Phosphate-eq	21	16	14
Global Warming Pot. (100 yrs)	kg CO_2 eq	59092	45060	40337
Ozone Layer Depletion Pot.	kg R11-eq	0.017	0.013	0.012
Photochemical Ozone Creation Potential	kg Ethene-eq	22	17	15

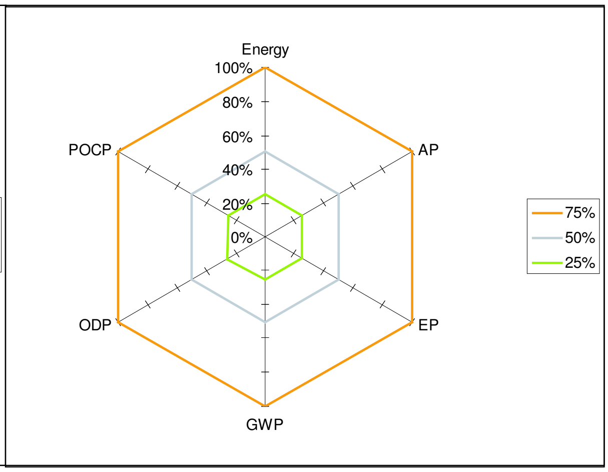
Table 4: Impact categories (CML 2001) per life cycle

The toolbox subdivides impact per lifecycle phase, showing over 99% of life cycle environmental impact for the type 1 motor in the utilisation phase. As a result, the use phase dominates life-cycle impact, and all impact categories reduce with increasing efficiency in an almost linear way. The following radar plots presents the impact data in a graphical way.

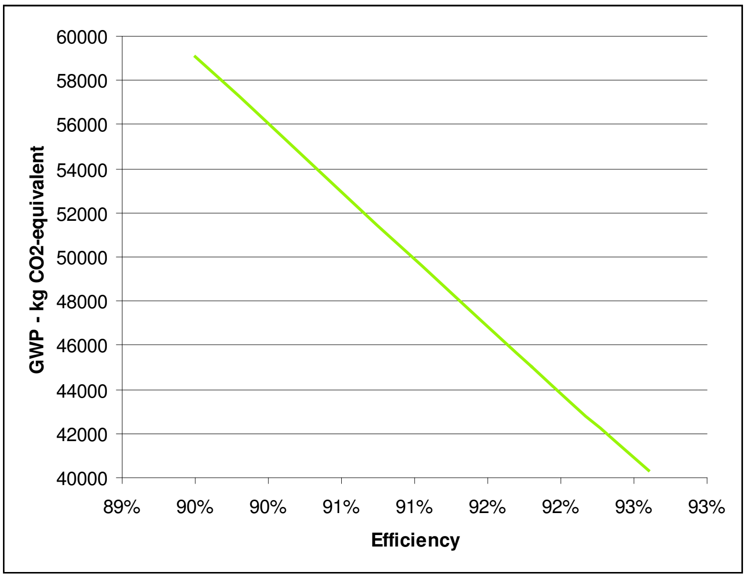


Taking the high efficiency motor (type 3), but varying the lifetime (between 5 and 20 years) and load (between 25 and 75%) demonstrates how the lifetime electricity use totally dominates the lifecycle environmental impact. Hence the importance of an accurate estimate of lifetime, load and efficiency.





Plotting CO_2-eq emissions against efficiency shows the linear relation – emissions reduce more than 6 tonnes per percentage point increase in efficiency[5].



Using the method '1' described in [PE Europe, 2005], we can calculate the environmental performance of using additional copper to increase motor efficiency. Each additional kg of copper use saves well over 3 tonnes 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 1000, while at the end of life, the kg copper can be recycled for the next application.

The additional use of copper causes, in this case, an additional use of aluminium. The environmental impact of additional use of other materials has been included as negative reduced emissions in the table below (rucksack principle).

Case	Additional copper (Al) use (kg)	Reduced emissions (kg CO_2-equivalent)	Ratio
From type 1 to type 2	4.1 (0.04)	14019	3419
From type 1 to type 3	5.1 (0.34)	18737	3674

[5] This linear curve cannot be extrapollated indefinitely, but for the type 3 motor, the utilization phase is still 99.3% of the life cycle impact, and the simplifying assumptions of this LCA remain valid.

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

[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

[PSR, 2000] EPD, Product Specific Requirements for Rotating Electrical Machines, May 2000, available from www.environdec.com

[Save, 1999] European Commission - DG TREN, Study on technical - economic and cost - benefit analyses of energy efficiency improvements in industrial three-phase induction motors, 1999, 50 pp

[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)