Author manuscript, published in "5th Going Green – CARE INNOVATION 2010, Vienne : Austria (2010)"

hal-00544885, version 1 - 9 Dec 2010

METHOD AND TOOLS TO MEET ENERGY EFFICIENCY TARGETS AT PRODUCT DESIGN STAGE

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Abstract:
This paper introduces a new method to reduce in-use energy consumption of electr(on)ic equipment from the earliest design stage to the beginning of manufacturing stage. This method is based on 3 main tools which are energy indicator, guidelines and an environmental checking loop. The following paper is focused on a presentation of each tool and how it is used by two industrial partners, NEOPOST and SAGEMCOM.

1. INTRODUCTION

Energy consumption is a key topic for electr(on)ic products, due to growing regulations & sensibility of final consumers. Developments are possible to reduce energy consumption of products during use phase, but most of the time these development are specific to projects; there is a lack of method and capitalisation, which lead to parallel designs within the same company generating additional costs and delays. Moreover, not having a single approach can lead to non-compliance of products regarding EU directives, and difficulty in communication on Ecodesign. Last, having a mono criteria approach could lead to transfer pollution within the life cycle. For these reasons, it is relevant to design methods and tools to systematize developments on Energy efficiency of electr(on)ic products.

2. SYNERGICO PROJECT

Figure 1 - Synergy-Energy-Design: Synergico

Synergico project aims at creating and spreading a method that can be recognized by the electronic sector. This project is funded by the ADEME (French EPA) and has been set up by a research laboratory and two key information and communication technology equipment manufacturers.

The consortium which has been set up to lead this 2 years project started on 2008:

- Leader and academic partner: G-SCOP Laboratory at University of Grenoble
- SAGEMCOM, Telecommunication equipment leader
- NEOPOST Technologies, Mailing solutions leader.

The aim of this project is to develop a comprehensive method to integrate energy consumption concerns in Electric and Electronic Equipment design. Based on literature analysis and reviews of industrial practices and needs, the SYNERGICO project develops 3 complementary tools:

- Energy indicators: allows assessing and tracking the energy consumption of the product during its design.
- Guidelines tool: provides guidelines to fill the gap between energy consumption assessed by the indicator and the energy consumption objectives.
- Environmental checking loop tool: verify if an increase in energy efficiency in-use does not generate any environmental impact transfer.

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3. ENERGY CONSUMPTION IN-USE INDICATOR (IUE): THE CORNERSTONE OF SYNERGICO METHOD [1]

3.1. Defining the indicator structure

All efforts to use energy-related indicators in design are based on two dimensions considered alongside: power and time [2-4]. Focusing only on power issues leads to bury the problem of long lasting low power modes (such has stand by mode [5]).

Commonly, the notion of energy is amalgamated to power, for two reasons. The first one deals with the uncertainty of defining time: power is an instantaneous value, easy to measure with simple protocols. Taking into account the time dimension needs more formal protocol based on a scenario to propose a standardized framework for measurements. The second one deals with the fact that the only information given to consumers about energy is the maximum nameplate power consumption, so designers are used to reduce the scope of energy to power.

In order to "trace" energy in product development, the indicator must be based both from the functional and the physical point of view. Each product view represents a dimension of the indicator. Those dimensions are combined together, in a matrix, in order to give the "in-use total energy consumption" (IUE), over the product lifetime:

$$IUE = \sum_{(i,j)} \bar{t}_{Fi} * \bar{W}_i(P_j)$$

- IUE: In-Use total Energy consumption (in watthour – W.h)
- t_{Fi}: time duration vector of the function i (in hours - h)
- $W_i(P_j)$: power consumption vector of part j for realising the function i (in watt - W).

The indicator matrix is addressed to the different departments that have an influence on energy performance in use phase. Synergico Method aims at implicating all the protagonists of the energy performance: hardware, software and mechanical engineers as well as the design project management.

3.2. Allocating time to functions: Use phase scenario

3.2.1- Functional splitting

In most of energy related legislation [2] and energy label [6], time is usually managed by means of k mode splitting:

$$t_{life} = \sum_k t_k$$

Typically, there are 4 operating modes determined for a product:

- "On mode" where the product realizes the tasks it was bought for;
- "Idle mode" where the product actively waits for the next task;
- "Stand by mode" where the product only feature is to wake up to "On mode" at any time;
- "Off mode" where the product does not perform any task.

The new IUE indicator is based on the hypothesis that the power is stable during each time period t_k . But the standard definition of mode can cover a wide range of power consumption. For example, the on mode for a set top box covers two main power behaviours: decoding and recording the decoded information on hard drive. That means that we needed to go below mode splitting of time.

In order to have a stable power consumption W_i, the lifetime of the product should be defined as a chain of stable power time periods- $t_{k(Wi)}$, all along its lifetime.

$$t_{life} = \sum_i t_{k(Wi)} = \sum_i t_{Fi}$$

Power remains stable as long as a specific user action or software task is in progress. By defining more precisely the k modes into i sub-modes, stable power time periods can be obtained.

In the indicator, a mode is the combination of functions that can be realized one after another, or simultaneously. A function is a specific action of the product. The only restriction in function definition is that one function can be included only by a single mode. If an action takes place in two modes, it needs to be detailed for the two modes.

3.2.2. Defining product use scenarios

The next step is to allocate to each function the amount of hours that the product will spend realizing this function during its life.

For this purpose we need to separate the function in two categories: "independent function" and "user dependent function".

Independent function is defined by a software routine and its span is free of user influence. For example, whatever user does, the time to switch channels to another depends on processor speed.

User dependent function can vary depending on who is going to use the product. For example, a family with 3 children might watch the TV (e.g. decoding function) more than a couple with no child.

In order to consider the variety of users' attitude for the same product, different scenarios are built. Each scenario defines a specific time vector, on which the indicator can be calculated.

A scenario includes the span of a function and the lifetime of the product. The indicator is evaluated over the entire use phase, i.e. over one or more years.
Scenarios data are issued from two sources: "primary data" from marketing based questionnaire, interview with consumers, "secondary data" from customer specifications, standards (like eco-labels), regulations… In order to have a complete vision of product life, it is necessary to combine primary and secondary data to run the IUE evaluation on, at least, 2 scenarios.

3.3. Allocating power to the product subcomponents

3.3.1- Architecture splitting

Splitting product in small parts aims at identifying the physical parameters that influence the power behaviour of the product realizing a certain function. Same as for the EuP directive switching from Energy Using Product [2] to Energy Related Product [7], the aim of this splitting is to cover all the product design parameters that influence the power consumption patterns, and not only the electr(on)ic components that consume energy. The extension to the "Related" part helps emphasising the energy impact of, for example, the casing design: this part does not need to be "plugged to the grid" but depending on its material and form, the product will need or not a fan.
This tool is developed to be used by product design teams, and this is why it is suggested to split the product into j subcomponents that are relevant for the various teams, their vocabularies and work sharing. The indicator is based on the knowledge of 3 main departments:

- For electronic parts: the hardware and software departments are usually associated. They must work in close collaboration in order to tailor the energy consumption by adapting the software needs to the hardware design and the other way round.
- For mechanical parts: the members of the mechanical engineering department are asked to document the information related to their design decisions.

The degree of precision of the splitting depends on the scope and the aims of the design project. The criterion for part definition is that it is considered by designers has a scalable unit.

3.3.2- Power consumption

Designers do not often use power as raw data for there daily work. Nevertheless, power estimation is already needed to evaluate data like the power supply sizing. In order to fit department habits, each department can use rough power data or plough back their power dimensioning techniques. Hardware designers usually define power P(W) by means of tension U(V), current I(A) and efficiency Eff (depending on the quality of current). All this information is defined on components datasheets. For the definition of hardware subassemblies' power, they can decompose it like:

$$P_{hardware}(W) = I(A) * U(V) * Eff$$

Software designers never manipulate raw data on power. The only parameters that have a significant influence on power are: opening or closing of logic gate and intensity of the component solicitation. Their influence is on the percentage of occupation %soft of a subpart for realising a specific function:

$$P_{Software}(W) = I(A) * U(V) * Eff * \%soft$$

3.4. Application to Sagemcom development

<u>Nota</u>: data have been modified for confidentiality reasons and are not representative of Sagemcom products.

Figure 2 - Set top box by SAGEMCOM

3.4.1. Functional splitting

The product we used for the simulation is a complex set top box for digital terrestrial television.
We define, according to the customer specifications, 8 functions. A set top box mainly provides the following functions: decoding signal, recording signal, and viewing recorded information. It proposes 3 ways to wake up the product from the stand-by mode. Figure 3 summarises the functional splitting of a set top box with two alternative scenarios.

		Scenario 1			Scenario 2		
Mode	Function	Time	During Lifespan		Time	During Lifespan	
On	Decoding	29%	7665	h	13%	3285	h
On	Watching record data	8%	2190	h	0%	0	h
On	Setting	0.35%	91.25	h	0.35%	91.25	h
Idle	Recording	8%	2190	h	0%	0	h
Stand by	Wake up on Infrared	29%	7621.2	h	99%	26143.13	h
Stand by	Wake up on Scart	29%	7621.2	h	71%	18615	h
Stand by	Wake up on timer	29%	7621.2	h	71%	18615	h
Off	Wake up on Switch	33%	8760	h	0%	0	h

Figure 3 - Functional splitting for a Set Top Box

3.4.2. Architectural splitting

A set top box has very few mechanical parts. So, we focus the architectural division on electronic parts. The energy consumption can be traced to 10 physical subassemblies: remote control, tuners, CPU (central processing unit), sensors, scart connector, clocks, hard drive, on switch, power supply and display. Each subassembly is here named following the main component of the sub-assembly, ie. "on switch" does

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not only include the switch but also the components that are specific to relay the signal from the switch.

3.2.3. Filling the matrix with data

The first version of the matrix is filled with data coming from the previous design information with few adjustments:

- Implementation of a new generation of hard drive (less noisy, cheaper and less energy consuming)
- Implementation of a CPU with less heat dissipation (allowing the suppression of fans).

The information used for hard drive power was available on product datasheet. Since its power value is very dependent on the function performed, the CPU consumption is based on the experience of designs teams: hardware designers, according to software developers' functional specification.

Information on all other parts, like power supply, is taken from the previous study without any modification. Figure 4 summarises this information:

		CPU					Hardrive					Power supply			
		I(A)	U(V)	Eff	Soft(%)	W	I(A)	U(V)	Eff	Soft(%)	W	I(A)	U(V)	Eff	Soft(%
	Nom														
On	Decoding	0.8	3.6	0.8	100%	2.3	0	0	0	0%	0	0.1	12	0.8	10
On	Watching record data	0.8	3.6	0.8	100%	2.3	0.9	5	0.8	100%	3.6	0.1	12	0.8	1
On	Setting	0.8	3.6	0.8	100%	2.3	1	5	0.8	100%	4	0.1	12	0.8	
Idle	Recording	0.8	3.6	0.8	100%	2.3	1	5	0.8	100%	4	0.1	12	0.8	
Stand by	Wake up on Infrared	0.8	3.6	0.8	25%	0.6	0	0	0	0%	0	0.1	3	0.8	
Stand by	Wake up on Scart	0.8	3.6	0.8	25%	0.6	0	0	0	0%	0	0.1	3	0.8	
Stand by	Wake up on timer	0.8	3.6	0.8	25%	0.6	0	0	0	0%	0	0.1	3	0.8	
Off	Wake up on Switch	###	3.6	0.8	5%	0.1	0	0	0	100%	0	0.1	0.2	0.8	

Figure 4 - Example of Matrix

3.5. Results and potential improvements

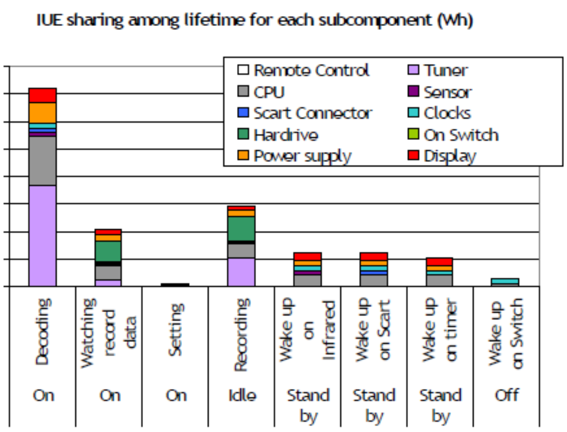

Figure 5 - Contribution of functions into the IUE

By correlating power consumption with scenarios, major contributors to energy consumption in the various life stage are identified ; in some cases some functions are not needed, but consume energy ; this identification has led to the development of new low power solutions, adjust active functions to real need of the users, and reach minimal power consumption. It also led to identification of new hardware solutions for next generation or for future redesigns of the product.

3.6. Conclusion on Energy Indicator

This simulation illustrates the interest of energy against power: the most powerful elements are not the ones that have the higher energy consumption.

Integration of time with different scenario helps discriminate what is due to specific use and what is common to every user's behaviours. This multi-scenario approach is useful when balancing tradeoffs between energy and functional performance.

In this specific case study, the fact that the project starts on an already designed platform made it easier for finding "mismatches" between product requirements and subcomponents in order to obtain simple improvement solutions.

The next step will be to check on a completely new plateform.

4. A GUIDELINE-BASED TOOL FOR ENERGY EFFICIENCY [8]

To answer the challenge addressed by the energy indicators tool, a guideline-tool for product and solution improvement has been built.

4.1. Definitions of guidelines

Guidelines can be defined in general as "principles put forward to set standards or determine a course of action" [9] . According to Bischoff, their use during design makes "the result of the activities of the designers more predictable and […] presumptively improve the results" [10]. Vezzoli combines these two concepts, defining guidelines as "procedures to orient a decision process towards given objectives" [11].

Generic guidelines are relevant for a wide range of situations [12] as they are transposable. However it may be more efficient for day-to-day design work to use more specific ones: the more a guideline is specific, the more it can be handled efficiently by designers [11],[13]. Thus, it may be useful to obtain specific guidelines from generic ones through the:

- selection of the guidelines applicable to a specific industrial context;
- reification of abstract concepts into practical ones.

Then, generic and specific guidelines can be both useful and relevant in different situations.

4.2. Structure

The core of our tool is a list of 59 guidelines gathered from the literature and classified into 8 criteria.

The tool is a spreadsheet (see Figure 6) where guidelines are in rows and criteria are in columns. Guidelines are kept as short and as simple as possible and usually contain one verb and one complement.

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However, for a better comprehension, hyperlinks pointing at more detailed descriptions allow the users to learn more about the guidelines.

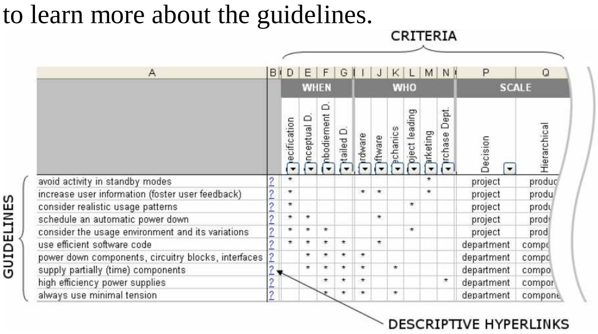

Figure 6 - Screenshot of the tool

4.3. The guidelines list

We have collected and organized all of the guidelines within the available channels, including standards (e.g. Energy Star), regulation related publications (i.e. EuP European directive preparatory studies), conferences proceedings, journals and Synergico guidelines, based on project expertize.

Guidelines found in literature are scattered amongst several documents. Once gathered in a unique list (step 1 in Figure 7), they are obviously heterogeneous as they are originally written for different purposes. We have processed the guidelines (step 2 in Figure 7) with respect to the following principles:

- non-redundancy: some ideas were covered by several sources; in order to keep the number of guidelines as small as possible, guidelines with similar content were grouped into a unique one.
- concept non-overlaps: some guidelines combined several different concepts, For readability concerns, we decided to formulate one idea per guideline.
- general applicability: some guidelines were too specific to be applicable at the EEE sector level. Therefore, we generalized guidelines when necessary. As an example, "set the standby power to 1W" became "set minimal performance consumption for standby (to be expressed in [W])".

For traceability purposes, we also documented our modifications to allow users to refer to the original sources of guidelines.

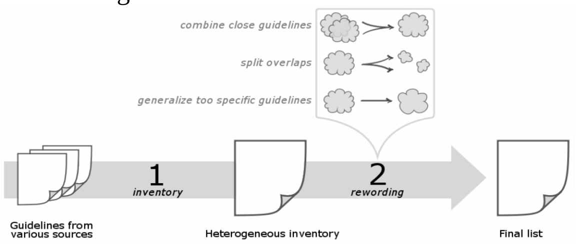

Figure 7 - Steps in the guideline list generation

4.4. Criteria used to classify the guidelines

Guidelines are listed and referred to new technical solutions, new strategies, new product architectures or new organizations.

In order to allow users to filter the most relevant guidelines according to the design context, we have selected 8 criteria. These criteria are divided into 3 categories:

- Design related criteria, that are related to organizational concerns, and help users to select the guidelines that are more likely to be used in the current design situation;
- Guideline related criteria, that give information about the type of the guideline;
- Power management related criteria, which are specifically related to energy and emphasize on important concepts related to energy management.

4.4.1. Design related criteria

The usability of a guideline is conditioned by three factors:

- Stage in design process: We included a criterion called "when" that indicates the stage where the decision to implement a guideline can be made. We based our choice list on the standard Pahl & Beitz [14] design process, quite similar to industrial practices.
- Department targeted by the guideline: each guideline does not concern every department in the company. Thus, we added a criterion called "who" that indicates the particular department(s) that has(have) to be involved in the implementation of a guideline. We based our choice list on the typical distribution of department we have found within the industrial partners' organizations namely "mechanics", "electronics", "software", "marketing", "purchase", and "management".
- Decision scale: some guidelines can generate major changes in the overall design; meanwhile others ones have fewer "side effects". Thus, some guidelines can be tackled by individuals through their own initiative; some others need a consensus in the team. To consider this, we added a criterion "decision level" that refers to the hierarchic level where the decision is taken. We have identified three different scales: "department", "project", and "company".

4.4.2. Guideline related criteria

Further classification can be made depending on the user needs:

- Hierarchical scale: guidelines may affect different physical scales on the product. Some may involve

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the modification of a "component", the entire "product", or the overall "system".
- Type: some guidelines deal with modifications of product/component functions within the system while others deal with changes in the technologies used
- Application: some guidelines may concern the product being designed, others may concern the design process itself. The first ones offer merely "solutions" to implement on the product, while others give advices about the organization (i.e. a "method"), and focus on the creation of a favorable environment for designers to find new solutions.

4.4.3. Power management related criteria

We added two criteria to our list to emphasize on strategies that are of major importance for EEE design:

- Power management scale: power management is generally considered at product level. However, we found several guidelines that go beyond that level and attempt to manage energy more subtly at the component scale. As this issue has not yet been well explored by electronic manufacturers but seems to have potential in energy efficiency improvements, we decided to put an emphasis on this criterion. It has three levels: "classic", "advanced" or "NR" (non relevant).
- Mode: definition of modes is a central issue in EEE energy efficiency improvement and has so far been limited to the distinction between operational and non operational ones. In order to highlight the potential of "mode" oriented design, we decide to introduce it as a criterion. It has four levels : "mono" (meaning that the guideline applies to a single mode), "multi" (meaning that the guideline deals with more than one mode), "trans" (meaning that the guideline deals with transitions between modes), and "NR" (non relevant)

4.5. An adaptable tool

A particular interest is that it exists generic guidelines and specific ones, in order to develop an industrial dedicated strategy.

The different guidelines can be considered as generic; they are not all relevant for all companies and products and they may need to be translated into a more technical language or reified into technical solutions. However, the tool is designed to allow companies to reach a desired level of specificity and set up its own strategy, linked to its company constraints. This can be done by updating either the criteria or the guidelines list (see Figure 8):

- Criteria update: companies can link the guidelines to their contexts by adding criteria columns.
- Guidelines update: companies can derive practical solutions adapted to their products from generic guidelines by rewording or adding lines in the list. Lastly, companies can generate guidelines by analyzing what has been done to improve energy efficiency within their previous product development projects.

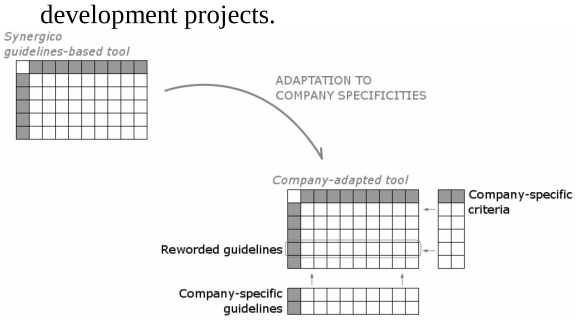

Figure 8 - Adaptation of the tool by a specific company

4.6. Integration into Neopost strategy

Figure 9 - Mailing machine IS-420 by NEOPOST

Based on the following 59 guidelines, a dedicated designer team from mechanical, software, hardware, functional and technical architect departments set up the company policy on product energy efficiency. This stage is a key step to success on implementation of these guidelines. In order to integrate it, the team reworded the different guidelines into its own internal language. After this first step of appropriation, the second step was to define the internal strategy. We define different class of guidelines, such as "Mandatory", "Recommended" or "Optional" for any new projects. For internal reasons, the choice is mainly based on Energy Star requirement and anticipation of future regulation such as ErP directive [7]. The objective is to systematize as a process the integration of these guidelines in various projects of the company.

Some guidelines are already known and used based on expertise of some department; some others guidelines are less known.

The strength of this tool is to formalize and share guidelines within a project and propose a good overview on what is available and well recognized.

Today, we did neither add new criteria nor new specific guideline, but we define our own company strategy based on this new tool, part of the Synergico method. Once those guidelines will be systematically implemented, we will add new ones as mandatory

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level and we will generate new guidelines, based on our own experience.

5. ENVIRONMENTAL CHECKING LOOP

Focusing on a single environmental issue, as energy consumption, can result, in major pollution transfer. To avoid such possible transfers generated by optimizing the product's energy efficiency, Synergico developed a tool to check possible trade off between energy efficiency in use phase and environmental efficiency in all phases.
The purpose of this tool is to define the most appropriate framework adapted from the lifecycle assessment methodology: find the significant environmental impact indicators and the most relevant modelling rules.
Like all Synergico tools, it is addressed to designers. This constraint has several repercussions on the construction of the tool.
A limited number of environmental impacts are used in this tool in order to be able to balance tradeoffs and a limited number of environmental impacts are used in order to clearly balance tradeoffs. Nevertheless, this selection of indicators and modules is adequate but specific to electric and electronic product and especially to design solutions for energy efficiency in use.

In order to find the most appropriate indicators, we focused our research on literature review on environmental impact assessment of electric and electronic products. The choice was made based on several criteria: be used by a majority of practitioners, be used as support for communication on environmental performance for this product category, be important after normalization of lifecycle assessment results for an electr(on)ic equipments.
Two main initiatives influence the choice of the indicators: a study for the Danish EPA on simplified assessment for electronic product, [15], and the project of the environmental information platform driven by ADEME (French EPA) and AFNOR (French standardisation organisation). The literature review highlights three topics: depletion of abiotic resources (especially precious metals), energy consumption and use of toxic substances.
In order to confirm the result from literature overview, we performed a comparative LCA in order to compare the energy savings generate by the addition of a microcontroller and the environmental impact of this component for a mailing machine. Two main impact categories were always point out: abiotic resources, and energy consumption. Toxicity was of minor importance and not always presents in the LCA assessment methods.

The conclusion of this study was to choose two impact indicators: Raw Material Depletion (US Geological Survey, 1998 model), in Y^{-1} and Energy Consumption (Ecobilan), in MJ.
In order to provide a basic database for modelling, we analysed all EuP preparatory studies, available in December 2009 [2]. This analysis aimed at describing what is and what can be implemented on product for energy efficiency. Classification of Best Available Technologies and Best Non Available Technologies into “no potential environmental tradeoffs” and “potential environmental tradeoffs” was done. In the first categories, we classified improvements such as software optimization, or user training. In the second one, we classified improvements such as modification or addition of materials, surface treatments or electronic components.
Our database was built crossing the list “potential environmental tradeoffs” with the solution that are potentially useful for product of our industrial partners. For example modification of refrigerant composition was not considered as relevant for our database.
Since solutions for energy efficiency are evolving fast, the database was built in order to be expanded as soon as new environmental data for a solution are available.
Once the theoretical basis of the tool was defined, we focused on the shape.
Given that it must be easy to identify tradeoffs, impacts transfers are measured based on the result of a base case impact assessment. Results are given in term of impact variation not in term of Y^{-1} or MJ.
For that purpose, each industrial partner documented the database with the impact of products that can be used as reference for comparison.
All modules of the database are documented with a dimension parameter used at design stage. For example, the weight of a chipset is not known at the design stage, nevertheless designers dimension chipsets in term of pins. Chipsets environmental impact is allocated according to pin number.
At the design stage, few or no information is available about distribution and end-of-life of component. This is why each component is associated to “typical” scenario for distribution, end-of-life or recycling. End-of-life and recycling scenario are based on the EcoDEEE [16] methodology.
At the beginning of a project, the reference product with the closest design must be chosen as the base case for environmental assessment of improvements for energy efficiency.
Every time a solution is implemented on the product for increasing energy efficiency, modelling and

evaluation of this solution must be done in the checking loop tool.
When modelling, designers must define:

- Quantity and type of added or substituted modules
- Energy savings obtained with this addition or substitution.

Then, they obtain the potential impact transfers, in percentage, on raw material depletion and energy consumption.
If the results show massive transfers on another phase (mainly manufacturing phase) or between impacts in the same phase, a decision must be taken during project review considering the opportunity to implement such a solution.
The implementation of microcontroller was used by our two industrial partners to decrease energy consumption during stand by mode.
In the case of a mailing machine, savings were up to 242 kWh over use phase with the addition of 6.65 grams of electronics components. Figure 10 is the result of the modelling of the microcontroller versus energy savings generated, with the reference (0%) being the previous version of the product.

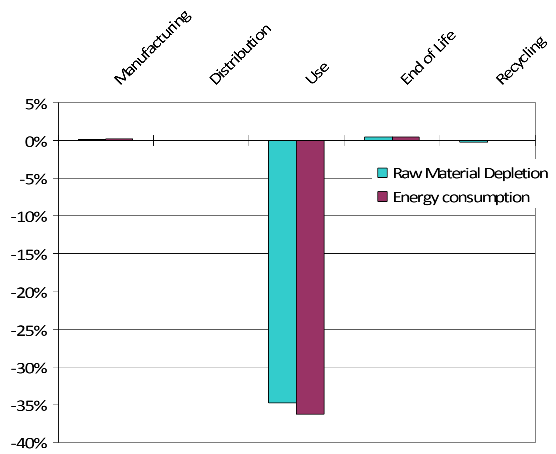

Figure 10 - Impact transfer control of a microcontroller on a mailing machine

For this product, microcontroller enhances energy efficiency without damaging anyothers area of protection.

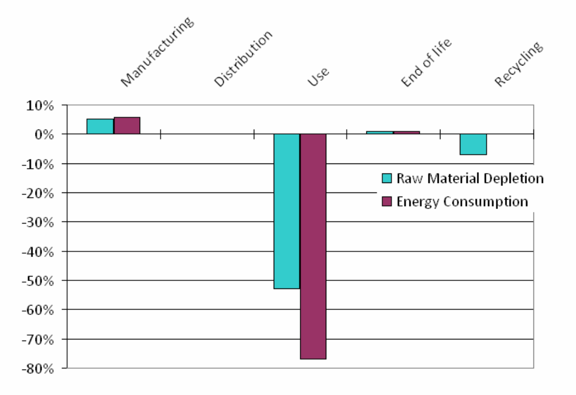

Figure 11 - Impact transfer control of a microcontroller on a set top box

For a smaller product, a set top box, results are illustrated in figure 11. The checking loop tool confirms a reduction of environmental impacts on the whole lifecyle. The implementation of the microcontroller function generates 5% impacts more on raw material depletion and Energy consumption during manufacturing phase. This solution allows a significant gain during use phase, upper than 50%. Distribution and End-of-life phase can be considered as unmodified.
In both industrial applications, design for energy efficiency in use phase means design for environment in all phases.

6. CONCLUSION

Synergico project is almost complete. Remaining tasks deal with the articulation of the three tools in the design of electr(on)ic products. It will be complete when the implementation of the method as a whole at industrial partners will be done.
Industrial partners, SAGEMCOM and NEOPOST already benefit from Synergico dynamics. In fact, the project supports formalization of best practices and knowledge on energy efficiency. It helps to centralize and share a standard approach, hopefully, useable for all electr(on)ic equipments.
Apart from the compliance with actual energy regulation, this project enables to anticipate the futures evolution of regulations and customers requirements.
Another side effect of Synergico was the questioning of actual design practices, starting discussion among design teams on potential innovation on product.

The added value of design tools for energy efficiency will be probe soon on the development of new products at our two industrials partners.

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7. ACKNOWLEDGEMENT

We would like to thank Daniel BRISSAUD and Fabrice MATHIEUX, for their strong support on Synergico project, ADEME, French EPA for the co-fundation, and all the designers from SAGEMCOM and NEOPOST for the time they spent.

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