

EuP Preparatory Studies “Imaging Equipment” (Lot 4)

Final Report on Task 7 “Improvement Potential”

Compiled by Fraunhofer IZM

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Introduction

This is the fully revised final report on Task 7 “Improvement Potential” for the EuP Preparatory Studies on Imaging Equipment (Lot 4). The findings presented in this report are reflecting the research conducted by the IZM consortium as well as important feedback by industry and other stakeholders. We would like to thank all participants who contributed to this study. Please use the opportunity to comment on this task report. We are looking forward to your feedback.

30th November 2007

7 Improvement Potential

According to the MEEuP methodology is the general objective of this task “the identification of design options for environmental improvement, their monetary consequences in terms of Life Cycle Costs (LCC) for the consumer, their environmental costs and benefits (impacts) and to pinpoint the solutions with the Least Life Cycle Costs (LLCC) and Best Available Technologies (BAT)”. The assessment of monetary LCC is relevant to indicate whether design solutions might negatively or positively impact the total EU consumer’s expenditure over the total product life (purchase, running costs, etc.). The distance between LLCC and the BAT indicates – in a case a LLCC solution is set as a minimum target – the remaining space for product-differentiation (competition). The BAT indicates a medium-target that would probably more subject to promotion measures than restrictive action. The Best Not yet Available Technologies (BNAT) indicate long-term possibilities and help to define the exact scope and definition of possible measures.”¹

This given scope of Task 7 has to be adapted to the specifics of the Lot 4 study on office imaging equipment. The authors see a conflict between the required “identification of individual eco-design options, including impact and life cycle costs assessment” and the wide product scope of Lot 4. This aspect was addressed throughout the study and particularly in the discussion of the base cases. Keeping in mind the limited number of base cases and the allocation of the base case results to the wide spectrum of office imaging equipment covered by Lot 4, it is necessary to accept that the individual eco-design options which are applicable to the base cases may not apply to other products even if they feature the same marking technology. In that respect we also face the issue of costs allocation to an individual eco-design option. The monetary quantification of the consumer’s expenditures and benefits needs careful consideration with respect to the allocation of single cost factors to the full scope of office imaging equipment. To give an example, the adoption of a fast fusing technology in an low-end EP-printer cannot be assessed due to missing cost transparency regarding such – likely to be proprietary – technology. On the other hand, high-speed EP-printer may have use patterns and technical requirements that do not favor such fast fusing technology. In conclusion, the Lot 4 study has considerable limits in terms of:

- allocation of individual eco-design options to the full scope of office imaging equipment
- quantitative assessment of the environmental improvement per eco-design option
- assessment of life cycle costs and the difference between LLCC and BAT

¹ MEEuP Methodology Report, 28.11.2005, VHK, p.152.

Revision of draft report

Stakeholder comments, following the publication of the draft report on 28th September 2007, and the discussions at the stakeholder meeting on 24th October 2007 indicated that there is a necessity for the complete revision of the improvement options outlined in the draft report. This revision is not addressing a change in the main improvement areas, which are:

- Energy efficiency (power consumption and power management in the use phase)
- Resource efficiency (particular electronics and bulk plastics in the manufacturing phase)
- Consumables efficiency (paper utilization, toner and ink yield)
- Specific emissions (ozone and micro dust as health risks)²

The revision is necessary in terms of the definition and determination of improvement potentials for the individual options. The following changes have been made regarding the order and content of the improvement options:

- Former option #1 “reduction of ready mode time” and option #2 “automatic shift into networked standby” are merging into the:
 - **new option #1 “shorter default time settings for transition into networked standby”**
- Former option #3 “good design practice for low standby and off-mode” becomes the:
 - **new option #2 “power budget for networked standby”** and
 - **new option #3 “power budget for off-mode”**
- Former option #4 “miniaturization” will merge with former miscellaneous options
- Former option #5 “lifecycle conscious selection and use of plastics” will become the:
 - **new option #4 “resource efficient material and component design”**
- Former option #7 “duplex unit” will be renamed and becomes the:
 - **new option #5 “duplex printing”**
- Former option #6 “replace corona wire charger” will be renamed and becomes the:
 - **new option #6 “ozone emission control”**

As a matter of fact, there are many other eco-design options which we have to summarize under “**miscellaneous options**” because their improvement potential is very individual and depends on the available technology, performance, and use of the actual product. Hence, it is not possible to quantify the improvement in terms of environmental impact reduction or lifecycle costs.

Each new option would be explained in detail in the following chapters. Before that we make a short discussion of the mode definitions.

² In the framework of the Lot 4 study is a scientific analysis of these particular aspects not possible.

Mode Definitions

Actually, there are no harmonized definitions of “power states” or “modes” currently available for imaging equipment. Industry standards (ISO/IEC) and labeling schemes (Energy Star) are using a wide range of terminology for the description of power management modes such as “on”, “active”, “ready”, “sleep”, “power save”, “low power”, “standby mode”, “off-mode” and so on. Office imaging equipment features a complex power management with a cascading pattern of reducing main functionality and thereby reducing power consumption. The basic idea is to overcome a considerable time period of up to a couple of hours while providing the user with the possible fastest recovery time. For the purpose of this study we define a “**transition phase**” as:

“The power states which enters a device following “active” and in which it remains until shifting automatically into “networked standby”.

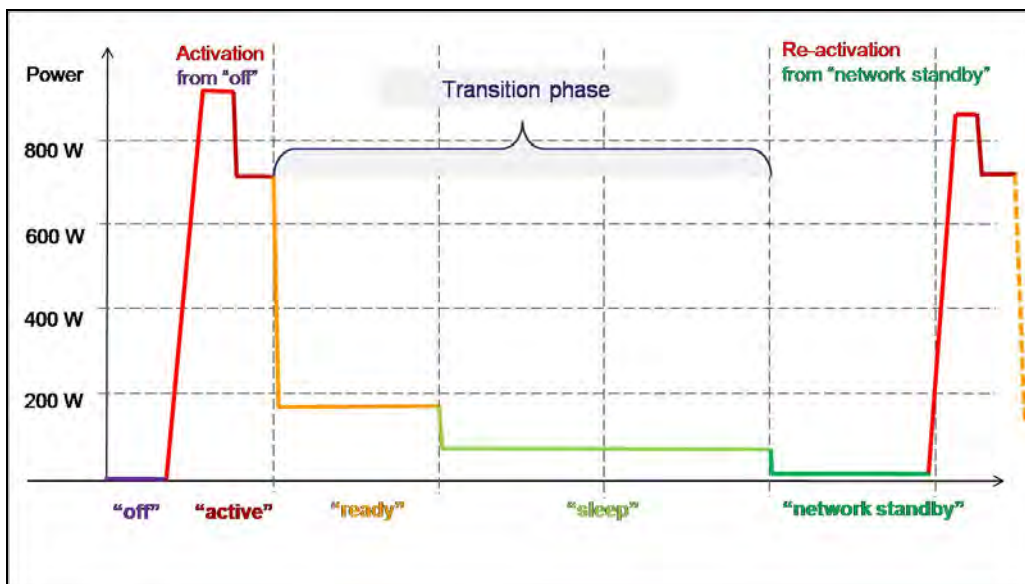


Figure 1: Transition phase and concept of an energy budget (not to scale)

The advantage of a “transition phase” scheme is that it is not necessary to define intermediate modes with a functional spectrum for the transition phase because of the defined boundaries, which are the “active mode” and “networked standby” (see Figure 1).

Regarding the definition of “**active**” we refer to the Energy Star Program Requirements for Imaging Equipment:

“The power state in which the product is connected to a power source and is actively producing output as well as performing any of its other primary function”.

Regarding “networked standby” we still consider the definition provided by the Lot 6 study as applicable to office imaging equipment (Lot 4). “**Networked standby**” has been defined by Lot 6:

“When the EuP is in Lot 6 standby according to (iii [see box below]) and offers either a remote network reactivation and/or network integrity communication, then the product is considered to be in networked standby mode”.³

Lot 6 Standby definition (iii)

An EuP is considered to be in Lot 6 standby mode, when it is connected to a power source and offers a reactivation function (remote reactivation, self reactivation or switch reactivation). Additional functions, which may be active and consuming energy, are the following continuously running functions

- information or status display, such as displaying the time,
- information storage needing continuous energy supply,
- sensor-based safety functions,
- network integrity communication.

In addition to the reactivation possibilities a deactivation function (from standby to a lower standby or from standby to off-mode) may be offered. The above function types shall be termed Lot 6 standby functions. The associated energy consumption is the Lot 6 standby energy consumption.

However, there are considerable overlaps with the “sleep mode” definition of the Energy Star Program and the functional spectrum allocated to them. The Energy Star Program Requirement for Imaging Equipment defines “**sleep mode**” as:

“Sleep – The reduced power state that the product enters: 1) automatically after a period of inactivity, 2) at a user set time-of-day, or 3) immediately in response to user manual action, without actually turning off. All product features can be enabled in this mode and the product must be able to enter Active mode by responding to any potential input options designed into the product; however, there may be a delay. Potential inputs include external electrical stimulus (e.g., network stimulus, fax call, remote control) and direct physical intervention (e.g., activating a physical switch or button). The product must maintain network connectivity while in Sleep, waking up only as necessary.”⁴

The particular issue that raises concern regarding the applicability of Lot 6 “networked standby” within the framework of existing “test procedures” is the on-board print controller (**Digital Front End or DFE**) which performs a number of functions like⁵:

- Network Connectivity in various environments

³ EuP Preparatory Study Lot 6 „standby and off-mode losses“; Task 1 final report (2nd October 2007), page 1-9, in the internet: http://www.ecostandby.org/docs/20071002_Lot6_Task1_final.pdf

⁴ Energy Star Program Requirements for Imaging Equipment

⁵ This useful comment was provided on 8th November 2007 by Mr. Jos Beekwilder of Océ Technologies B.V., Product Safety and Environment.

- Mailbox functionality
- Job Queue management
- Machine Management, for example waking the imaging equipment from a low-power state
- Advanced Graphic UI
- Able to initiate communication with other host servers and client computers, for example scanning to email or polling remote mailboxes for jobs
- Able to post-process pages, for example re-formatting pages before printing.

In conclusion, the industry needs clarification regarding the question if the Digital Front End falls under the scope of Lot 6 “networked standby”. Due to the fact that Digital Front End controllers are using standard available PC technology the power requirement in idle has to be considered when discussing minimum power requirements. The Digital Front End power requirement correlates with the supported network interfaces, the function management and particularly with the imaging speed, format and quality.

Furthermore, the EICTA stated general concern regarding the “un-harmonized definitions of standby”. They continued arguing that “it would be confusing for both product designers and end users” to apply the Lot 6 definitions. EICTA clearly indicated the differences in the definitions e.g. between IEC 62301 and Energy Star. However, it was not recognized by EICTA that with the “function/mode” definition of standby modes and off-modes taken by the Lot 6 study, a new widely accepted definition is at hand which has a good potential to “harmonize” the standby mode definitions.

EICTA also requested a clarification in respect to the functional spectrum of Lot 6 “networked standby”. EICTA wrote that they “need to understand if a printer connected to a PC via a serial/USB connection and a product containing a FAX-function are to be regarded as “networked””. To our knowledge both cases would fall under the scope of Lot 6 “networked standby”.

7.1. Options and Improvement Potential

7.1.1. Specific options for improving energy efficiency

The results of the base case assessment (Task 5.4) in conjunction with the analysis of best available technology (Task 6.2) indicate that the energy efficiency of office imaging equipment is in general on a good level. Nevertheless energy efficiency remains a task for continuous improvement. The reason for this statement is related to the justified assumption that under real life conditions the energy efficiency potential of imaging equipment is not necessarily explored due to a potentially suboptimal use by the consumer. This means for instance, that power management functions could be disabled by the user or that transition mode settings are prolonged to its maximum (e.g. 4 hours). Networked standby and off-mode power consumption requirements are also still of concern.

Energy efficiency of EP-products (base cases V1 to V4)

With respect to EP-products or products that would fall under the Energy Star TEC test method, the need to improve the energy efficiency is mainly driven by growing power demand in “active mode” which is the result of technical market trends towards:

- increasing imaging speed
- full colour capability
- larger formats and a wide spectrum of paper qualities
- multifunction and always on-line

The increase of “active mode” power consumption due to growing speed performance and colour capability has a direct influence on the transition phase’s power consumption and on the “ready mode” in particular. Furthermore, the increase of functionality (print, copy, scan, and fax) and particularly the network interface options influence “sleep mode” power consumption. Both trends are directly linked to the response performance (recovery time) of the imaging equipment. The “ready mode” power consumption is mainly related to the preheating of the fixing unit (fuser) and ensures the instant printing capability. It has the highest power level of the transition phase (approx. 70%) and depends on the actual marking/fuser technology.⁶ The power consumption in “ready mode” varies in a range of 50 W to 300 W. The “sleep mode” power consumption on the other hand is influenced by the Digital Front End (data processing and control), print engine, scanner lamp, displays or status interfaces, as well as network readiness functionality. The power consumption in “sleep mode” varies according to the products performance and functional

⁶ Although the Lot 4 Study focuses on EP technology it should be notice that other marking technologies such as solid ink is in need of constant preheating in order to maintain instant printing capability.

spectrum. This power consumption is in a range of 25 W to 70 W. This considerable range of power consumption related to the maintenance of functions (modes) within the potentially long transition phase is the reason for the necessity of continuous energy efficiency improvement.

In that respect, we notice that the Energy Star TEC – the methodology for measuring energy efficiency of EP-products – has shortcomings to address potentially long transition phases. This limitation is directly linked to the seemingly overestimated job structure (the assumed image output per day) and the 15 minutes time limit between jobs. If a smaller number of jobs would be assumed and the time duration between jobs extended by a couple of minutes, it seems that the resulting energy consumption would be more realistic. We will discuss this issue later in the report again. Another aspect that is limiting the possible energy efficiency is the quite long default delay time settings that are still allowed under the Energy Star Program eligibility requirements.

Energy efficiency of IJ-products (base case V5 and V6)

With respect to IJ-products or products that would fall under the Energy Star OM test method, the need to improve energy efficiency is driven by the:

- still large difference in standby and off-mode power consumption between the worst and the best performing products in the market
- shift to multifunction and always on-line products

The base case assessments indicated that the power consumption of IJ-products in the networked standby and off-modes are still considerably high. Off-mode is in a range of 0.2 W and 3.2 W. Particularly, low-end IJ-Printers feature still high off-mode power consumption which indicates that less efficient linear PSU are used instead of (more expensive) switched mode PSU. On the other hand there is the best available technology at a level of 0.2 W as shown in the following examples.

The German Magazine “Computer Bild” (15/2007) listed the following (BAT) off-mode power consumption for IJ-Printers:

- Epson Stylus D88 (0.2 W)
- Epson Stylus Photo R220 (0.3 W)
- Canon Pixma IP 1600 (0.3 W)

Concerning the IJ-MFDs⁷, these are the (BAT) off-mode power consumptions listed in the German Magazine Computer Bild (15/2007):

- Epson Stylus Photo RX640 (0.2 W)

⁷ Without fax function

- Canon Pixma PM 500 (0.4 W)

The following (BAT) off-mode power consumptions were listed “Computer Bild” (15/2007) for compact photo printers:

- Lexmark P350 (0.7 W)
- Canon Selphy CP720 (0.8 W)
- Sony DPP-FP55 (0.9 W)

In comparison to the still existing products with up to 3.5 W power consumption in off-mode, the improvement potential is considered to be good and it reflects the results of the Lot 6 study as well. The increasing market share of IJ-MFDs with integrated fax functionality and a wide spectrum of network interfaces will impact the overall energy consumption to increasing “networked standby” power requirements. Because “networked standby” can be maintained indefinitely it is essential to further reduce the power consumption or at least to limit the increase of power consumption in this mode. This basic consideration applies not only to IJ-products but to all office imaging equipment. Requirements concerning “networked standby” power consumption should however reflect the typical application environment, use pattern, and performance of a device in order to be realistic and applicable.

Options to improve energy efficiency

The following improvement option #1 “shorter default time settings for transition into networked standby” is focusing on an optimized power management to improve the overall energy efficiency or at least to prevent the suboptimal use. In conjunction with this option a discussion started during the stakeholder meeting held on 24th October 2007 regarding the introduction of an energy budget for the transition phase. Following the meeting we investigated this option and came to the conclusion that although an energy budget has certain advantages in comparison to a simple reduction of the default delay times, it was not possible to develop a feasible energy budget without statistical data and prove the positive impact of it.⁸ In the course of this research we also analyzed the Energy Star TEC methodology regarding the question of how realistically the energy efficiency is measured. We came to the conclusion that the TEC is a very feasible methodology to measure energy efficiency. TEC provides actually an energy budget due to the contribution of the “final energy”. However, we see the necessity to modify the TEC to some extent in order to improve the accuracy of the resulting energy values. This will be outlined in the later Task 8 report. The new

⁸ Please note that we exemplarily outline the idea and methodology of an energy budget in the following chapter.

options #2 and #3 are intended to limit power consumption of IJ-products in “networked standby” and “off-mode”.

7.1.1.1. Option #1: Shorter default time settings for transition into networked standby

Option #1 supports the intention to limit the total energy consumption related to the transition phase between “active mode” and “networked standby”⁹ and applies to EP-products or products that would fall under the Energy Star TEC methodology. The proposed reduction of the default time settings is a compromise. In order to improve the energy efficiency both the power consumption per mode and the time duration in which a device remains in the transition mode are important to consider. This approach again reflects the idea of an energy budget. The practical advantage of this approach is the incentive given to the manufacturer to reduce the power consumption level per mode because he simultaneously gains a longer transition phase. The consumer will benefit through a short recovery time over a longer period and the manufacturer by a greater design freedom. From our perspective the energy budget approach provides a greater incentive to continue the development and implementation of energy saving fast fusing technologies. It is a more fair approach taking into account also the preheating requirements of different marking technologies such as solid ink.

Although we are in favor of an energy budget approach for limiting the overall energy consumption in the transition phase, the practicality and feasibility of this approach is questionable. We therefore promote with the option #1 a simple time limit for modes that are typically called ready and sleep mode and which are applied to the transition phase. As we will outline in the Task 7.2 “Improvement Potential” the optimization of energy efficiency is clearly related to the time duration of the “ready mode”. For the purpose of this study we are defining “ready mode” as a power state which includes a preheating functionality. In the following argumentation we are using the EP-product base cases V1 to V4 as examples.

EP-products are preheating the fixing unit in the “ready mode” in order to achieve a very short recovery time. The power consumption in the “ready mode” varies according to the marking technology’s power requirements but also to the performance of the product namely speed, format and image quality. Depending on the fuser technology the power consumption in “ready mode” can be in a range of 50 W to 300 W. Fast fuser technologies such as multiple heater lamp systems, ceramic heaters, and induction heating system reduce power consumption because they enable a faster distribution of thermal energy to the fixing roller or belt. As a matter of fact, fast fuser

⁹ For products that are not network-capable such as a Copier/SFD or Flatbed Scanner/SFD the energy budget would be allocated to the transition from “active mode” to “off-mode”. Passive standby (lot 6 standby) is not applicable to office imaging equipment.

technologies are proprietary technologies and therefore, not commonly available to all manufacturers. This fact however does not mean that we have a limited use of these technologies. The majority of manufacturers feature these technologies in products up to speed segments of 50 ipm already for a couple of years (see Lot 4 Task 6 report). We can assume that fast fuser technologies become a “mainstream technology”, and that a reduction of the “ready mode” (preheating function) is an appropriate strategy to improve energy efficiency.

In the introduction to this chapter we have already discussed the fact that the power consumption related to the “ready mode” is increasing due to the continuous improvement of performance. The total energy consumption increases according to the time duration in which the device remains in “ready mode”. Even if this aspect is covered to some extent by the Energy Star TEC methodology (power consumption between jobs and during final time) it seems still necessary to propose a reduction of the allowed default time settings for “modes” (e.g. “ready modes” and “sleep modes”) that are provided by power management in the transition phase. The improvement option #1 consists of the general requirement to shorten the default time settings for “ready” and “sleep” modes. As an orientation, we suggest for products with a ready mode power consumption of >150 W that the “ready mode” default time setting should not extent 30 minutes and be at best at 15 minutes or less. Products with <150 W ready mode power the default time setting should not extent 60 minutes. In a similar way should the default time settings for the “sleep mode” not extent 180 minutes and should be at best at 60 minutes or less.

Option #1 needs to be viewed in conjunction with the adoption of fast fusing/fixing technologies and other technical power management measures such as improved power supply efficiency. Please note that option #1 might influence the reactivation time of the machine and could have a negative effect on the user convenience (longer waiting time).

7.1.1.2. Exemplary determination of an energy budget

The following example shows the basic approach to determine an energy budget in consideration of imaging speed and quality. The exemplary calculation describes the methodology. Unfortunately the Lot 4 study has only limited data available regarding the actual power consumption per mode and can not therefore provide statistical prove of their energy budget assumptions. Nevertheless, if industry partners provide a relevant set of data the fine tuning of the energy budget is easily possible. Following the stakeholder meeting we have asked manufacturers to provide respective product data:

- Typical ready mode(s) power consumption in Watt

- Typical ready mode(s) delay time settings in minutes
- Typical sleep mode(s) power consumption in Watt
- Typical sleep mode(s) delay time settings in minutes
- Networked standby power requirements based on functionality such as network interfaces

For statistical purposes a characterization of the product is also necessary:

- Product type (copier, printer)
- Marking technology (EP, SI, etc.)
- Functionality (SFD, MFD)
- Imaging speed (ipm)
- Image quality (monochrome, color)
- Image format (A4, A3, etc.)

Exemplary calculation of an energy budget

The energy budget (E_{Budget}) is the sum of a speed dependent variable and a constant energy budget reflecting for instance imaging quality and format:

$$E_{\text{Budget}} = E_{\text{base}} + \text{ipm} * E_{\text{ipm}}$$

In this example we assume as a constant energy base (E_{base}) a value of 100 Wh as realistic for a monochrome device for standard image format A4. In general, the energy base (E_{base}) should reflect the power requirement in “ready mode” according to the type and performance of the product. The image format (e.g. A4 or A3) is influencing the size of the fixing roller and therefore the fuser’s power requirement.

The adjustment of the energy base (E_{base}) according to the image format could be done by using a specific Form Factor:

- Image format A4: Factor 1
- Image format A3: Factor 1,4

(Please note: The factor 1.4 for the format A3 derives from a simple correlation of the image size and may not be realistic. Further data are required to confirm a justified factor.)

The energy base (E_{base}) should also reflect the aspect of image quality (monochrome or colour). The complexity of colour fixing units is one aspect that makes an adapted energy budget reasonable. More important is the consideration of speed because colour machines are usually slower than monochrome machines and need less thermal energy in the fixing process. Statistical

data are necessary to confirm our assumptions. Based on such data a realistic energy base could be defined.

In the exemplary calculation we furthermore define an energy constant in correlation to imaging speed. This constant (E_{ipm}) determines the influence of the imaging speed in relation to the reactivation time or the preheating requirements. We assume an E_{ipm} value of 0.5 Wh/ipm as justified. A higher value would overestimate the influence of the speed factor in terms of the power requirement in “ready mode”. In that respect we should also keep in mind that faster machines are more frequently used (that is what TEC suggests) and that the time between jobs are shorter. The power requirement and therefore the energy budget do not necessarily have to be much higher for faster machines.

Based on the above assumptions the specific energy budget for a 50 ipm device would be calculated in the following equation:

$$E_{\text{Budget}} = 1 \text{ (form factor } A_4) * 100 \text{ Wh (} E_{\text{base}}) + 50 \text{ipm} * 0.5 \text{ Wh/ipm (} E_{\text{ipm}})$$

$$E_{\text{Budget}} = 125 \text{ Wh}$$

Figure 2 provides the exemplary energy budgets in correlation to imaging speed according to the equations above. The Figure 3 provides a matrix for the speed specific energy budgets and their distribution to either “ready-mode” or “sleep-mode”.

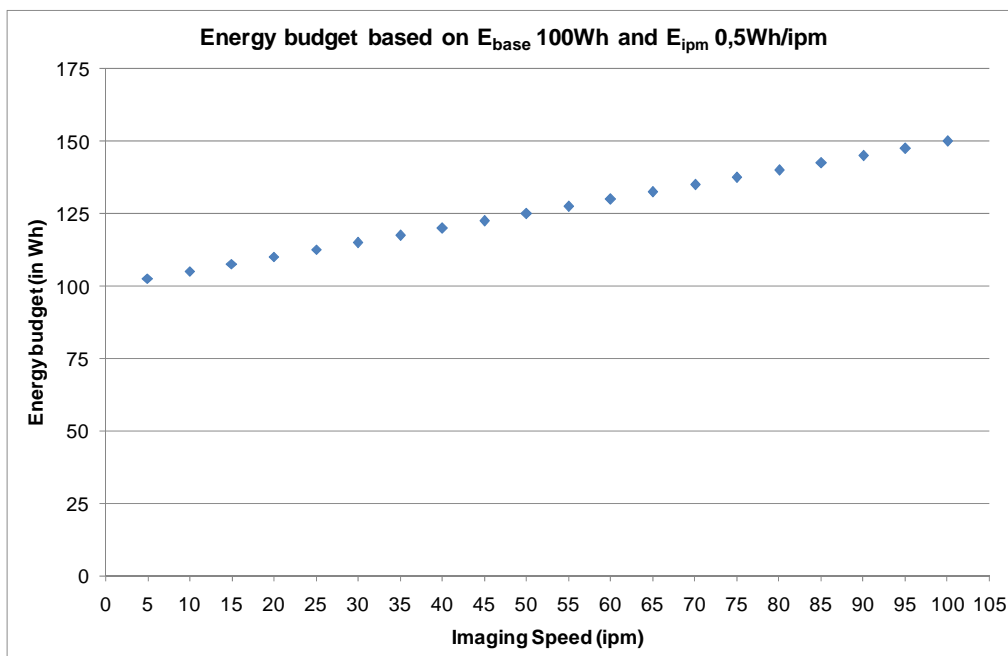


Figure 2: Exemplary energy budget for transition mode based on E_{base} 100 Wh and E_{ipm} 0,5 Wh/ipm

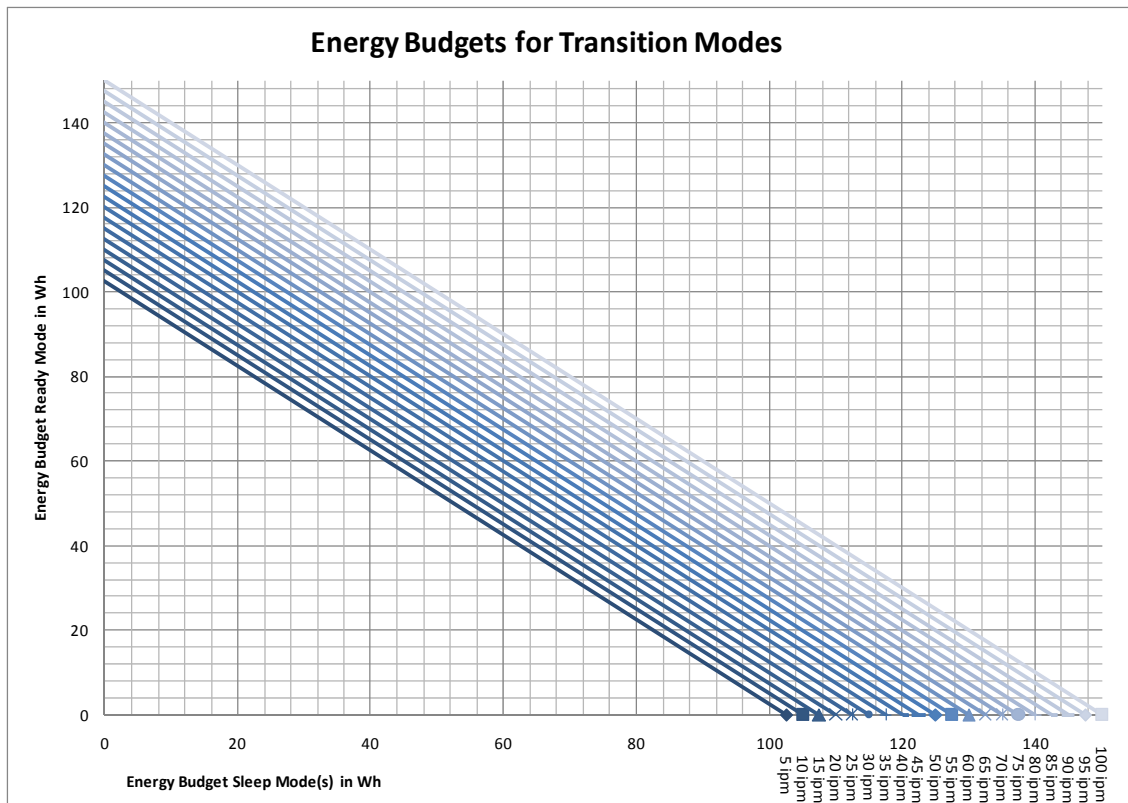


Figure 3: Matrix for the speed specific energy budgets in ready and sleep mode

The following examples are intended to show the feasibility of the energy budget.

50 ipm device (125 Wh)

The 125 Wh energy budget for the 50 ipm device would allow the following distribution and power levels for “ready mode” and “sleep mode”:

- 15 minutes ready mode at 250 W plus 120 minutes sleep mode at 31.25 W
- 30 minutes ready mode at 125 W plus 120 minutes sleep mode at 31.25 W
- 15 minutes ready mode at 125 W plus 240 minutes sleep mode at 31.25 W

25 ipm device (112.5 Wh)

The 112.5 Wh energy budget for the 25 ipm device would allow the following distribution and power levels for “ready mode” and “sleep mode”:

- 15 minutes ready mode at 250 W plus 120 minutes sleep mode at 25 W
- 30 minutes ready mode at 125 W plus 120 minutes sleep mode at 25 W
- 15 minutes ready mode at 125 W plus 180 minutes sleep mode at 27 W

Definition of rules for ensuring proper use of the energy budget

In order to ensure proper application of the energy budget the power management software needs to be modified. The default delay times for the “ready” and “sleep” modes have to be adjusted to the given energy budget. The manufacturers should consider a harmonization of the default time setting options as well as the menu navigation. The disabling of the power management (in order to realize an indefinite transition phase) should be prevented by software.

7.1.1.3. Option #2: Power budget for networked standby

Most office imaging equipment are network capable and maintain a wired or wireless connection to PCs or telephone in order to receive print or fax jobs. When a device offers either remote network reactivation and/or network integrity communication, then the product is considered to be in networked standby mode according to the Lot 6 definition of “networked standby”.¹⁰ Imaging equipment could stay indefinitely in “networked standby”. It is therefore plausible to apply a power budget to office imaging equipment in order to ensure certain level of energy efficiency.

Option #2 has the intention to limit the energy consumption in “networked standby”. For the EP-products (base cases V1 to V4) the Energy Star TEC method indirectly covers the “networked standby” energy consumption. For the IJ-products (base case V5 and V6) the Energy Star OM requirements for “sleep mode” basically cover “network standby” as well. A networked standby power consumption requirement should reflect some product specifications such as rated power supply output, characteristics/number of network interfaces, number of wall plugs, and product application environment (e.g. office or professional). The more professional the use of a product the more complex the power requirements in networked standby become.

In the draft report we proposed the option for setting minimum “networked standby” requirements according to the Lot 6 study results (see Table 1). Following the stakeholder meeting discussion and also EICTA comments, which rejected the Lot 6 “networked standby” values and stressed the necessity of studying their applicability to the product scope of Lot 4 in more detail, we investigated the Lot 6 requirements again and particular in conjunction with the Energy Star OM eligibility criteria.

¹⁰ EuP Preparatory Study Lot 6 „standby and off-mode losses“; Task 1 final report (2nd October 2007), page 1-9, in the internet: http://www.ecostandby.org/docs/20071002_Lot6_Task1_final.pdf

Table 1: Lot 6 two-tiered implementation proposal for networked standby

	Tier 1	Tier 2
Networked standby "Type I"¹¹	3 W	1 W
Networked standby "Type II"¹²	4 W	2 W
Networked standby "Type III"¹³	10 W	5 W

Comparing the Energy Star Program's "sleep mode" definition with the Lot 6 "networked standby" definition a similar scope is noticeable. The Energy Star Program Requirement for Imaging Equipment defines the sleep mode as:

"Sleep – The reduced power state that the product enters: 1) automatically after a period of inactivity, 2) at a user set time-of-day, or 3) immediately in response to user manual action, without actually turning off. All product features can be enabled in this mode and the product must be able to enter Active mode by responding to any potential input options designed into the product; however, there may be a delay. Potential inputs include external electrical stimulus (e.g., network stimulus, fax call, remote control) and direct physical intervention (e.g., activating a physical switch or button). The product must maintain network connectivity while in Sleep, waking up only as necessary."¹⁴

A complex differentiation of networks (similar to the Lot 6 approach) is part of the Energy Star "operational mode" (OM) scheme. The OM eligibility criteria (1st Tier) consist of a 3 W base (sleep mode for marking engine) and functional adders for various network interfaces and others (see Table 2). Of the first column numbers "primary" a maximum of 3 can be added, if they are active together. For further features, or if the features are not "active" in sleep the lower secondary values have to be added.

¹¹ Type I, "Simple networks": Analogue signaling and signal detection, and low speed connections (<0.5 Mbps or <5 MHz, such as IrDA or a phone line without DSL).

¹² Type II, "Standard range networks": Standard data networks, lower speed wireless and non-continuous broadcast reception.

¹³ Type III, "High speed networks": Data networks (Gbps range or >500 MHz), higher speed wireless (all WLAN types) and continuous broadcast reception.

¹⁴ Energy Star Program Requirements for Imaging Equipment

Table 2: Energy Star OM eligibility criteria (tier 1)

Type	Details	Functional Adder Allowances (W)	
		Primary	Secondary
Interfaces	A. Wired < 20 MHz	0.3	0.2
	B. Wired ≥ 20 MHz and < 500 MHz	0.6	0.2
	C. Wired ≥ 500 MHz	1.5	0.5
	D. Wireless	3.0	0.7
	E. Wired card/camera/storage	0.5	0.1
	G. Infrared	0.2	0.2
	Other	Storage	-
Scanners with CCFL lamps		-	2.0
Scanners with non-CCFL lamps		-	0.5
PC-based system (cannot print/copy/scan without use of significant PC resources)		-	-0.5
Cordless handset		-	0.8
Memory		-	1.0 W per 1 GB
Power-supply (PS) size, based on PS output rating (OR) [Note: this adder does not apply to scanners]		-	For PSOR > 10 W, 0.05 x (PSOR - 10 W)

Option #2 “power budget for networked standby” is an important measure to counterbalance the increasing energy consumption related to always-online networked office imaging equipment and the power demand for maintaining various network interfaces. The power demand in “sleep mode” and in “networked standby” respectively varies according to the individual marking technology, functionality, and performance of imaging equipment. In order to give some examples of best available technology we investigated products which achieved the Blue Angel Label. The following two examples describe the current situation:

- 30ipm color Copier/MFD features 7.6 W in the lowest sleep mode¹⁵
- 45ipm color Copier/MFD features 21.0 W in the lowest sleep mode¹⁶

Whereas the first example (Ricoh) indicates best available technology on the highest level is the second example (Konica Minolta) typical for products that achieve the Blue Angel Label. The average sleep mode power consumption is currently between 10 and 30 Watts for medium to high speed EP-products. In the case of Ricoh do we assume that no standard technology is used but specialized chips-sets, board and power supply design. Ricoh’s technological and financial assets allow this large company to develop specialized components for their mass products. On the other hand, we have to recognize that more specialized manufacturers such as Konica Minolta or Océ Technologies are usually apply standard “off-the-shelf” components and technologies with limited

¹⁵ Ricoh Aficio MP C3000, Color Copier/MFD 30ipm, Blue Angel Environmental Data Sheet: (http://www.ricoh.de/Binary/AficioMPC3000_Umweltdatenblatt_v3_070926_tcm89-57672.pdf)

¹⁶ Konica Minolta bizhub C451, Color Copier/MFD, 45ipm, Blue Angel Environmental Data Sheet: (http://www.konicaminolta.de/fileadmin/BusinessSolutions/Specials/Blauer_Engel_Produkt-_und_Nutzerinformationen_fuer_bizhub_C451_v1.pdf)

options for improvement. This means that for the data processing (CPU) or Digital Front End (DFE) standard PC/Laptop technology is most commonly used. According to the Lot 3 Study is the typical idle mode power consumption of PCs 74 Watt and of Laptops 32 Watt. The Lot 3 Study indicates an improvement potential of 40% which in the case of the Laptop technology means 20 Watts in sleep mode. This is the value we see already today for products such as the Konica Minolta example that qualify for the Blue Angel.

With respect to “networked standby” we have to consider that the CPU or DFE has to be deactivated and the network integrity is maintained through a separate microcontroller. In consequence we are considering in conjunction with option #2 a longer transition mode duration in which the product can remain in sleep mode.

7.1.1.4. Option #3: Power budget for off-mode

The option #3 has the intention to improve overall energy efficiency of office imaging equipment. Power consumption in “off-mode” should be as low as possible and ideally zero Watts (hard-off). However, there are technical features and practical considerations that influence the actual power consumption in “off-mode” and therefore the design for off. This includes for instance:

- The question of an internal or external power supply unit,
- the maximum load of the power supply unit,
- the number of power supply units in one system,
- power-down requirements

Particularly the last aspect may limit the feasibility of an instant hard-off switch due to the possibility of improper handling by the user and the resulting in a failure of electronic components. In order to ensure a safe powering-down of the Digital-Front-End the “soft-off” might be the more feasible option. A device must in any case be technically designed for being disconnected from mains (while in off-mode) without causing damage to the product.

Against that background, option #3 requires a power budget for off-mode without demanding a hard-off switch. The horizontal EuP Preparatory Studies on “standby and off-mode losses” (Lot 6) and on “battery charger and external power supplies” (Lot 7) proposed minimum off-mode and no-load requirements according to the rated output power. The proposed values reflect also the level of current technologies in comparison to the best available technology (BAT). In the Lot 4 assessment of the base cases V5 and V6 we also showed that the 0.2 W off-mode BAT for IJ-products is considerably good in comparison to still existing products in the market. Option #3 therefore

proposes an off-mode power budget for IJ-products according to the Lot 6 set requirements (see Table 3).

Table 3: Lot 6 two-tiered implementation proposal for standby

	Tier 1	Tier 2
Off-mode for rated output <10 W	1 W	0.5 W
Off-mode for rated output >10 W	1 W	0.75 W

7.1.2. Miscellaneous options for improving energy efficiency

The environmental impact assessment (Task 4 and 5) clearly indicated that the manufacturing phase contributes considerably to the overall eco-impact of imaging equipment. This is particularly apparent in the case of smaller IJ-products, where the input category “electronics” showed the highest impacts in terms of energy and emissions. Over the past years manufacturers have miniaturized their products intensively and have achieved a good weight and volume reduction for their products (see Task 6). The further miniaturization of electrical and electronic components is an eco-design strategy for all products that becomes important due to the fact that the functionality of products is improved through an intensified use of new hardware and software.

7.1.2.1. Miniaturization of electrical and electronic components

Optional improvement measures:

- **Miniaturization of main boards** through adoption of finer structured multilayer boards, high density electronics and chip packaging technology¹⁷
- **Smaller power supply units** (e.g. circuitry design and choice of electronic components)
- **Smaller motors** and paper transport mechanics
- **Smaller scanner unit** through miniaturized scanner head and lamp system (e.g. Reduction of weight and volume of the scanner head will also reduce the requirements for electro-mechanics such as motors. Some manufacturers have, in that respect, applied LEDs as a light source which might have an impact on the performance)
- **Smaller laser unit** through high density MOEMS¹⁸ packaging

¹⁷ Such measures are usually determined by costs and supply conditions. EICTA also commented with respect to the miniaturization of electronic boards that a complete miniaturization would limit the flexibility of manufacturers to re-design and up-grad boards. If the board design anticipates a later reuse we agree that this is a good measure.

¹⁸ MOEMS or Micro-Opto-Electro-Mechanical-System

The environmental improvement potential of these generic eco-design options cannot be quantified at this point. However, the conscious miniaturization of electrical and electronic components is generally considered an environmental improvement due to the reduction of material input and potential improvement of energy efficiency in use. Despite the increase in complexity, miniaturization on the component and board level of electronic assemblies reduces not only the weight, but also the energy and the contained toxicity.¹⁹ When assessing the improvement potential of miniaturized components in detail it is necessary to consider the chemical composition of the material (e.g. the use of precious metals) and the manufacturing processes (e.g. clean room requirements).

7.1.2.2. Thermal management and other options

There are a number of options that could further improve the energy efficiency of office imaging equipment.²⁰ Some of these options are related to proprietary technologies. Others might interfere with typical use patterns, performance and reliability requirements. The improvement potential of these options will depend on the technical specifications of individual products and cannot be quantified at this point.

The miscellaneous options include:

- **Thermal management** in order to avoid higher temperatures and/or temperature cycling on electronic components and boards level. High temperature and cycling reduce the lifetime of electronics. Design measures are physical distance from the fuser unit and shielding. Active cooling (e.g. by fans) increases power consumption, noise, and the dissipation of dust and it is a suboptimal solution.
- **Efficient data processing** enhanced through faster CPUs, advanced memory chip-sets, advanced data compression and interface technologies. This shortens data processing time and saves energy.
- **Sensors** for recognition of paper size and thickness, which in combination with particular software drive electromechanical actuators and fuser/fixing units more efficiently. We also assume that energy saving is related to the charger design, photoconductor drum, and particularly to the developer design of colour processing system (e.g. the number of developers and for instance the separation of black (K) and colours (YMC)).

¹⁹ See: Nissen, N. F., "Development of an environmental evaluation method for the assessment of electronic systems", Dissertation at the Technical University of Berlin, 2001, http://edocs.tu-berlin.de/diss/2001/nissen_nils.htm

²⁰ The list of options does not include measures related to paper use such as duplexing or utilization of thinner paper which is from our point of view a separate topic.

7.1.3. Options for improving resource efficiency

The improvement of power consumption in the use phase has to be considered also in conjunction with the overall product lifetime. As a general observation we can notice that the fast product turn-over in the market (3 to 4 years for IJ-Products and 4 to 6 years for EP-Products) supported the overall improvement of energy efficiency in the past years. With the improvement of the individual product's energy consumption closer to an optimum (for the current marking technologies) a prolonged lifetime of the product is a further improvement option. To put it differently, when energy efficiency in the use phase reaches a peak the manufacturing phase increases in importance and a longer product lifetime will reduce the overall environmental impact of the product. It is a positive trend that manufacturers of office equipment (EP-Copier/MFD and EP-Printer/MFD) use the B2B conditions for direct take-back, refurbishment and reuse of components as well as more advanced material recycling. This kind of best practice (close loop product life) should continue and be further elaborated.

7.1.3.1. Option #4: Resource efficient material and component design

Option #4 could consist of the following measures:

- Reduce the multitude of plastics
- Select plastics with respect to a recycling strategy and existing recycling technologies (e.g. ABS/PC for material recycling)
- Utilization of bio-plastic or hybrid bio-plastics if appropriate (this measure should consider however the conditions of manufacturing [agricultural condition] the eco-footprint of the supply infrastructure as well as qualitative characteristics of bio-plastics)
- Select recycle plastics if they meet technical requirements
- Ensure separation of plastics
- Reduce or avoid coatings of plastics
- Apply material requirements and the checklist "recyclable design" according to Blue Angel RAL-UZ 122 (e.g. use of flame retardants)
- Marking of plastics (e.g. according to ISO 11469 referring to ISO 1043)

The best eco-design solution is also determined by factors such as:

- the manufacturing conditions and supply infrastructure (e.g. In the case of bio-plastics please note that an assessment of the eco-feasibility of bio-plastics is always necessary due to varying supply chain conditions and possible regional difference in plant growing)

- the required technical properties for processing and application of the material (e.g. thermal properties, surface requirements, need for flame retardants)
- Take-back and recycling conditions in the region (e.g. there are known shortcomings of the WEEE)

Regarding the aspect of prolonged product lifetime following measures could be considered:

- **Design for easy toner/ink cartridge refurbishment** and parts that get exchanged frequently. The OEM's product design should not limit the refurbishment or the utilization of refurbished cartridges. Toner and ink cartridges should be provided with seals or lids in order to prevent spilling/dust emissions and support easy handling. User manuals and warning labels should inform the consumer about the options.
- **Print head cleaning and drainage design** in IJ-products. A problem that occurs is that the drainage and ink collecting tank gets full and stops the operation of the IJ-printer. Product design should address this issue in order to prolong the product use cycle. User information on cleaning and maintenance should be provided if necessary.
- **Reliable design of electronics.** Due to the increasing integration of electronic hardware it is necessary to ensure a design that prevents failure in operation. Thermo and mechanical stress, moist, and unstable power supply are typical failure sources in the field of electronics. The product design should ensure save power-up and power-down operation.

These eco-design options are product specific and provide only a general improvement strategy. Option #4 applies to all office imaging equipment.

7.1.4. Options for improving consumable efficiency

According to the base case assessments (Task 5) paper consumption has the most considerable environmental impact related to office imaging equipment. But paper is not regarded as an Energy-using Product (EuP) and should therefore be viewed independently from the eco-design measures for office imaging equipment. The only relevant design option is related to duplex printing which can improve the efficiency of paper consumption.

7.1.4.1. Option #5: Duplex printing unit

Option #5 could consist of the following measure:

- **Duplex printing units** should be designed into devices with considerable print volume

- **Common interface or menu for activating and canceling the duplex option.** The duplex option should be given to the user at the highest menu level. This measure could support the user's handling of a device and therefore help to facilitate duplex printing.

In the draft report we had proposed to adopt the Blue Angel basic award criteria according to RAL-UZ 122 that requires devices with maximum operating speed of ≥ 45 ipm A4 sized pages to be equipped with a unit for automatic double-sided printing/copying. All other devices with lower maximum operation speed must offer a manual option ... EP devices with a maximum speed of 21 to 44 ipm must additionally be capable of being equipped – at least optionally – with a duplex unit. On the other hand, the Energy Star Program sets automatic duplexing requirements for imaging equipment as well (see following Figure 4). During the stakeholder meeting the issue of harmonization of duplex requirements occurred. We are in support of a harmonization of this issue.

The environmental improvement potential of option #5 cannot be quantified. There is an undisputed understanding that duplex printing will increase resource efficiency by reducing potentially the amount of paper consumed.

Duplexing: Standard-size copiers, MFDs, and printers that use EP, SI, and heat-intensive IJ marking technologies addressed by the TEC approach in Section 3.A. must meet the following duplexing requirements, based on product speed:

Color Copiers, MFDs, and Printers	
Product Speed	Duplexing Requirement
≤ 19 ipm	N/A
20 – 39 ipm	Automatic duplexing must be offered as a standard feature or optional accessory at the time of purchase.
≥ 40 ipm	Automatic duplexing is required as a standard feature at the time of purchase.

Monochrome Copiers, MFDs, and Printers	
Product Speed	Duplexing Requirement
≤ 24 ipm	N/A
25 – 44 ipm	Automatic duplexing must be offered as a standard feature or optional accessory at the time of purchase.
≥ 45 ipm	Automatic duplexing is required as a standard feature at the time of purchase.

Note: EPA has retained the duplexing requirements proposed in Draft 3 for color and monochrome products. However, these requirements now apply to all Standard-size copiers, MFDs, and printers using heat-intensive IJ in addition to those using EP and SI.

Figure 4: Energy Star Program requirements on duplexing

7.1.4.2. Miscellaneous Options

The general environmental impact might be reduced by:

- **Use of recycled paper** should be promoted in personal, public and corporate procurement (e.g. products must be capable of processing recycled paper that meets Euro Norm requirements EN 12281:2002)
- **Use of thinner (light weight) paper** (e.g. paper thickness directly correlates with the thermal energy requirements of the EP-process. Japanese manufacturers have indicated that power consumption of EP-machines is considerably lower when using the typical 4 gram paper in Japan and not the typical 5 gram paper in Europe).
- **Advanced toner and ink with high cartridge yield** (e.g. in Task 6 advanced toner and ink technology have been introduced, most of these are proprietary technologies and currently not available to all manufacturers)

The environmental improvement potential of these measures cannot be quantified.

7.1.5. Options for reducing substance emissions

Office imaging equipment is interacting with their environment by producing noise, emitting dust, generating ozone (see Task 3 report) as well as to some extent volatile organic substances. Over the past years measures have been taken by industry to reduce substance emissions. The further reduction of potentially hazardous substance emissions should be addressed in the design of ever product.

7.1.5.1. Option #6: Ozone emission control

Option #6 consists of the following measure:

- Adoption of the Blue Angel RAL-UZ 122 permissible maximum emission rates for TVOC, Benzene, Styrene, Ozone and Dust.
- If possible replace corona wire charger
- Control of air flow in thermal design (e.g. most EP-products create considerable thermal energy that has to be transported out of the devices, thus potentially emitting dust)
- Control of noise

The environmental improvement potential of these measures will depend on the technical specifications of individual products. In the case of emissions, reference values and respective measurement procedures (test standards) are necessary in order to quantify an impact or improvement. The Blue Angel RAL-UZ 122 for example, provides permissible maximum emission

rates for TVOC, Benzene, Styrene, Ozone and Dust. Regarding the aspect of micro dust the scientific discussion is ongoing (see Task 3 report). Against that background it is not possible to define particular eco-design options and assess their improvement potential in the framework of the Lot 4 Study.

7.2. Improvement Potential and Impact Assessment

7.2.1. Improvement potential of option #1

The option #1 addresses the default delay time settings of “ready mode” and “sleep mode” as part of the power management in EP-products. This option applies mainly to the Base Cases V1 to V4 because these EP-products are featuring a considerable energy consuming “ready mode” due to the heating of the fuser unit²¹. The relevance of this measure derives from the fact that the Energy Star TEC methodology (the test procedure with which the energy efficiency of EP-products is measured) prescribes the time between jobs with 15 minutes, so that the possible environmental impact of a prolonged “ready mode” (e.g. 30 or 60 minutes) is not adequately reflected in the TEC value. We have to assume that under real life conditions prolonged “ready mode” and “sleep mode” phases occur and that energy consumption could increase significantly under such conditions. The following scenarios have been created in order to show the magnitude of this energy consumption and the possible improvement potential when limiting or reducing the time duration of the “ready mode”. The scenarios are product specific. We have selected the base cases V1 and V3 for this exercise. Generalizations of the results regarding the improvement potential of the full product scope of EP-products or other products that would fall under TEC methodology should be made very consciously. Nevertheless, the scenarios indicate the correlation between the total energy consumption and the duration of the transition phase. They therefore describe the improvement potential of the option #1 as it is required by the MEEuP methodology for the EuP studies.

7.2.1.1. Improvement potential scenario for Base Case V1

The following three scenarios have been created in order to indicate the improvement potential of option #1 exemplarily for the base case V1. The base case V1 is an EP-Copier/MFD monochrome with an imaging speed of 26 ipm. The reference energy consumption value is based on the TEC value for the base case V1 which is 4.81 kWh per week or 250 kWh per year respectively. According to the TEC methodology the time duration between jobs is of 15 minutes. For the first set of scenarios we assume that the device remains in “ready mode” for these 15 minutes (scenario #1, see Table 4). In the scenarios we have modeled the given TEC value (4.81 kWh/week) based on a plausible “power consumption per mode approach” in conjunction with the job structure of the TEC methodology. The improvement potential was then calculated for a shorter 5 minutes “ready mode” scenario (scenario #2, see Table 5) and for a longer one of 25 minutes ready mode scenario (scenario #3, see Table 6).

²¹ The power consumption in ready or multiple ready-modes are in a range of 100 W to 500 W depending on the performance (imaging speed and colour) of the EP-product.

Table 4: Ready mode scenario #1

Scenario #1 (15 Minutes Ready-Mode)										
Base Case V1	EPCMM-26			Job	Job	Job	Job	Job		Total (TEC)
	<i>Condition</i>	Activation	Sleep	Reactivation from Sleep*	Reactivation from Ready**	Active	Ready	Sleep	Final	
Power (W)		1.000,0	20,0	1.000,0	1.000,0	600,0	110,0	20,0		20,0
Min./job		1,5	60,0	0,7	0,2	0,5	14,3	0,0		5,0
Min./day [jobs]	26,0	1,5	60,0	1,3	4,8	13,0	371,8	0,0		10,0
h/day	60,0	0,025	1,000	0,022	0,080	0,217	6,197	0,000		0,167
Wh/day		25,0	20,0	22,0	80,0	130,0	681,6	0,0		3,3
TEC (kWh/week)	5,0	0,125	0,100	0,110	0,400	0,650	3,408	0,000		0,017
Comments: 4,81 kWh/week correlates exactly with the 4,81 kWh/week which is the average TEC value used in the Base Case V1 assessment. This result indicates, that the assumed power consumption values and the daily use pattern is realistic for a scenario.										
* Reactivation from Sleep is estimated with 40 Seconds (2 times per day)										
** Reactivation from Ready is estimated with 10 Seconds (24 times per day)										

Table 5: Ready mode scenario #2

Scenario #2 (5 Minutes Ready-Mode)										
Base Case V1	EPCMM-26			Job	Job	Job	Job	Job		Total (TEC)
	<i>Condition</i>	Activation	Sleep	Reactivation from Sleep*	Reactivation from Ready**	Active	Ready	Sleep	Final	
Power (W)		1.000,0	20,0	1.000,0	1.000,0	600,0	110,0	20,0		20,0
Min./job		1,5	60,0	0,7	0,0	0,5	5,0	9,5		5,0
Min./day [jobs]	26,0	1,5	60,0	17,2	0,0	13,0	130,0	14,3		10,0
h/day	60,0	0,025	1,000	0,286	0,000	0,217	2,167	0,238		0,167
Wh/day		25,0	20,0	286,0	0,0	130,0	238,3	4,8		3,3
TEC (kWh/week)	5,0	0,125	0,100	1,430	0,000	0,650	1,192	0,024		0,017
Comments: The reduction of the ready mode default time from 15 minutes to 5 minutes results in an overall power reduction of 26,5%.										
* Reactivation from Sleep is estimated with 40 Seconds (26 times per day)										
** Reactivation from Ready is estimated with 10 Seconds (zero times per day)										

Table 6: Ready mode scenario #3

Scenario #3 (25 Minutes Ready-Mode)										
Base Case V1	EPCMM-26			Job	Job	Job	Job	Job		Total (TEC)
	<i>Condition</i>	Activation	Sleep	Reactivation from Sleep*	Reactivation from Ready**	Active	Ready	Sleep	Final	
Power (W)		1.000,0	20,0	1.000,0	1.000,0	600,0	110,0	20,0		20,0
Min./job		1,5	60,0	0,7	0,2	0,5	24,3	0,0		5,0
Min./day [jobs]	26,0	1,5	60,0	1,3	4,8	13,0	631,8	0,0		10,0
h/day	60,0	0,025	1,000	0,022	0,080	0,217	10,530	0,000		0,167
Wh/day		25,0	20,0	22,0	80,0	130,0	1.158,3	0,0		3,3
TEC (kWh/week)	5,0	0,125	0,100	0,110	0,400	0,650	5,792	0,000		0,017
Comments: The setting of the ready mode to 25 minutes results in an overall power consumption increase by 50% in comparison to the scenario #1.										
* Reactivation from Sleep is estimated with 40 Seconds (2 times per day)										
** Reactivation from Ready is estimated with 10 Seconds (24 times per day)										

Discussion of the scenarios #1, #2, and #3

The reduction of the “ready mode” duration from 15 minutes (scenario #1) to 5 minutes (scenario #2) shows for the base case V1 a considerable decrease of the overall energy consumption by 26.5%. In terms of annual energy consumption a reduction from 250 kWh/a (base case V1) to 184 kWh/a (scenario #1) would be achieved. The scenario #2 would equal a reduction of 9.25 € in electricity costs²² per year. Over an assumed product life of 6 years the life cycle costs would be reduced by 55.50 € through the application of this option.

²² 1 kWh = 0.14 €

The scenario #3 is featuring an increase of the “ready mode” duration from 15 minutes to 25 minutes. In scenario #3 the overall energy consumption increases by 50% which equals 374 kWh/a in comparison to 250 kWh/a of the base case V1. This scenario indicates the potential increase in energy consumption when the “ready mode” phase is extended to a degree that is not typically considered by the TEC methodology. Under real life conditions of extended default time setting the improvement option #1 shows a good improvement potential for reducing total energy consumption in a range of 25% and up to 50%.

Due to the fact that the base case V1 is already conform to the Energy Star TEC requirements – and therefore it is on a good environmental performance level – the option #1 is designed to prevent extended energy consumption rather than to improve energy consumption. The improvement potential however is real and should be explored to a reduction of the power consumption in the transition phase. Please note again, that energy efficiency is a correlation of power consumption per mode in conjunction with the time duration a product remains in the specific mode. The EP base cases feature a relatively high ready mode power consumption of over 100 W or even 200 W whereas certain marking technologies such as solid ink require less than 100 W in “ready mode” which would allow a prolonged “ready mode” phase (see discussion on energy budget).

7.2.1.2. Improvement potential scenario for Base Case V3

The following three scenarios have been created in order to indicate the improvement potential of option #1 exemplarily for the base case V3. The base case V3 is an EP-Printer/SFD monochrome with an imaging speed of 32 ipm. The reference energy consumption value is based on the TEC value for the base case V3 which is 5.19 kWh per week or 270 kWh per year respectively. According to the TEC methodology is the time duration between jobs 15 minutes. For the first set of scenarios we assume that the device remains in “ready mode” for these 15 minutes (scenario #4, see Table 7). In the scenarios we have modeled the given TEC value (5.19 kWh/week) based on a plausible “power consumption per mode approach” in conjunction with the job structure of the TEC methodology. The improvement potential was then calculated for a shorter 5 minutes “ready mode” scenario (scenario #5, see Table 8) and longer 25 minutes ready mode scenario (scenario #6, see Table 9).

Table 7: Ready mode scenario #4

Scenario #4 (15 Minutes Ready-Mode)										
Base Case V3	EPCMM-32			Job	Job	Job	Job	Job		Total (TEC)
	Condition	Activation	Sleep	Reactivation from Sleep*	Reactivation from Ready**	Active	Ready	Sleep	Final	
Power (W)		700,0	15,0	700,0	700,0	550,0	100,0	15,0		15,0
Min./job		1,5	60,0	0,7	0,2	0,5	14,3	0,0		5,0
Min./day [jobs]	32,0	1,5	60,0	1,3	6,0	16,0	457,6	0,0		10,0
h/day	60,0	0,025	1,000	0,022	0,100	0,267	7,627	0,000		0,167
Wh/day		17,5	15,0	15,4	70,0	146,7	762,7	0,0		2,5
TEC (kWh/week)	5,0	0,088	0,075	0,077	0,350	0,733	3,813	0,000	0,013	5,149
Comments: 5,15 kWh/week correlates with the 5,19 kWh/week which is the average TEC value used in the Base Case V3 assessment. This result indicates, that the assumed power consumption values and the daily use pattern is realistic for a scenario. * Reactivation from Sleep is estimated with 40 Seconds (2 times per day) ** Reactivation from Ready is estimated with 10 Seconds (24 times per day)										

Table 8: Ready mode scenario #5

Scenario #5 (5 Minutes Ready-Mode)										
Base Case V3	EPCMM-32			Job	Job	Job	Job	Job		Total (TEC)
	Condition	Activation	Sleep	Reactivation from Sleep*	Reactivation from Ready**	Active	Ready	Sleep	Final	
Power (W)		700,0	15,0	700,0	700,0	550,0	100,0	15,0		15,0
Min./job		1,5	60,0	0,7	0,2	0,5	5,0	9,5		5,0
Min./day [jobs]	32,0	1,5	60,0	1,3	6,0	16,0	160,0	14,3		10,0
h/day	60,0	0,025	1,000	0,022	0,100	0,267	2,667	0,238		0,167
Wh/day		17,5	15,0	15,4	70,0	146,7	266,7	3,6		2,5
TEC (kWh/week)	5,0	0,088	0,075	0,077	0,350	0,733	1,333	0,018	0,013	2,686
Comments: The reduction of the ready mode default time from 15 minutes to 5 minutes results in an overall power reduction of 48%. * Reactivation from Sleep is estimated with 40 Seconds (2 times per day) ** Reactivation from Ready is estimated with 10 Seconds (24 times per day)										

Table 9: Ready mode scenario #6

Scenario #6 (25 Minutes Ready-Mode)										
Base Case V3	EPCMM-32			Job	Job	Job	Job	Job		Total (TEC)
	Condition	Activation	Sleep	Reactivation from Sleep*	Reactivation from Ready**	Active	Ready	Sleep	Final	
Power (W)		700,0	15,0	700,0	700,0	550,0	100,0	15,0		15,0
Min./job		1,5	60,0	0,7	0,2	0,5	24,3	0,0		5,0
Min./day [jobs]	32,0	1,5	60,0	1,3	6,0	16,0	777,6	0,0		10,0
h/day	60,0	0,025	1,000	0,022	0,100	0,267	12,960	0,000		0,167
Wh/day		17,5	15,0	15,4	70,0	146,7	1.296,0	0,0		2,5
TEC (kWh/week)	5,0	0,088	0,075	0,077	0,350	0,733	6,480	0,000	0,013	7,815
Comments: The setting of the ready mode to 25 minutes results in an overall power consumption increase by 52% in comparison to the scenario #4. * Reactivation from Sleep is estimated with 40 Seconds (2 times per day) ** Reactivation from Ready is estimated with 10 Seconds (24 times per day)										

Discussion of the scenarios #4, #5, and #6

The reduction of the “ready mode” duration from 15 minutes (scenario #4) to 5 minutes (scenario #5) shows for the base case V3 a considerable decrease of overall energy consumption by 48%. In terms of annual energy consumption a reduction from 270 kWh/a (base case V3) to 140 kWh/a (scenario #5) would be achieved. The scenario #5 would equal a reduction of 18.20 € in electricity costs per year. Over an assumed product life of 6 years the life cycle costs would be reduced by 109.20 € through the application of this option.

The scenario #6 is featuring an increase of the “ready mode” duration from 15 minutes to 25 minutes. In scenario #6 the overall energy consumption increases by 52% which equals 406 kWh/a in comparison to 270 kWh/a of the base case V3. This scenario indicates the potential

increase in energy consumption when the “ready mode” phase is extended to a degree that is not typically considered by the TEC methodology. Under real life conditions of extended default time setting the improvement option #1 shows a good improvement potential for reducing total energy consumption by 50% and more.

General remarks on the improvement potential of option #1 for EP-products

The two sets of scenarios indicate following aspects:

- The improvement of energy efficiency is supported by shorter “ready mode” phases or at least by the avoidance of prolonged “ready mode” phases²³.
- Depending on the actual power consumption in the individual modes the improvement potential increases for faster products due to the higher ready mode power requirements.
- The scenarios also indicated that the improvement potential varies according to the individual power consumption in each mode. This particular observation makes it very difficult to quantify an improvement potential for all products or marking technologies that would fall under the Energy Star TEC methodology.
- When adopting the TEC values as benchmark for energy efficiency, a standard (regulation) for maximum default delay times (e.g. 15 min or 5 min) appears to be necessary in order to avoid low energy efficiency under real life use conditions.
- User convenience (quick reactivation) might be reduced when no fast fusing/fixing technology is adopted.

In conclusion, eco-design option #1 has a very good potential for improving overall energy efficiency in a range of 25% and up to 50% depending on the real life use pattern. However this option comes with the condition that a fast fixing/fusing technology is necessary in order to maintain user convenience (quick reactivation). It also has to be said that products which feature lower “ready mode” power consumption such as solid ink are in need of a prolonged “ready mode” phase in order to provide short recovery times. A correlation of the actual power consumption in “ready mode” and the default delay time settings should be considered.

7.2.2. Improvement potential of option #2 and option #3

The improvement potential of the option #2 (power budget for networked standby) and option #3 (power budget for off-mode) will be quantified according to the use pattern that were assumed for the assessment of the inkjet base cases V5 (personal) and V6 (workgroup). The allocation of “networked standby” to the inkjet use patterns (personal and workgroup) created a problem and

²³ The Energy Star TEC method of setting time between jobs to 15 minutes has shortcomings in that respect.

showed a possible allocation mistake in the base case assessment. As a result of this allocation problem we have to assume that the overall energy consumption of the inkjet base cases is actually somewhat higher than the results of the assessment in the Task 5.

The following scenarios have been created in order to show the possible improvement potential when limiting the power consumption of the “networked standby” and “off-mode”. The scenarios are IJ-product specific. We have selected the base cases V5 and V6 for this exercise. Generalizations of the results regarding the improvement potential of the full product scope of IJ-products or other products that would fall under OM methodology should be made very consciously. Nevertheless, the scenarios indicate the correlation between the total energy consumption and the power consumption of the two low power modes. They therefore describe the improvement potential of the option #2 and option #3 as it is required by the MEEuP methodology for the EuP studies.

7.2.2.1. Improvement potential for base case V5

The following scenarios have been created in order to indicate the improvement potential of option #2 and option #3 exemplarily for the base case V5. The base case V5 is an IJ-MFD in a “personal” use application. The reference power consumption value for the “networked standby” is based on the average “ready mode” and “sleep mode” values for the base case V5. The distinction of these two modes for IJ-products is untypical. Usually an IJ-product requires no “ready mode”. The “sleep mode” value is a better indicator for the “networked standby” power consumption. The particular product cases from which the base case was aggregated showed for two products similar values of about 7 W for ready and sleep mode which seems plausible for “networked standby”. However, the other two product cases showed a surprisingly low “sleep mode” power consumption of 1.7 W and 1.2 W. The respective “ready mode” values for these two products were with 5.2 W and 10.3 W on a more realistic level for “networked standby”. Based on the individual power consumption values an average 6 W “networked standby” would result. For the following “networked standby” scenario we only modified the “ready mode” power consumption. Instead of the “ready mode” power of 7.68 W (base case V5) we assumed for the option #2 scenario a “ready mode” power consumption of 5.0 W. The “sleep mode” power consumption was kept the same at value 4.35 W. Regarding the option #3 we modified the “off-mode” power consumption value. The “off-mode” power consumption of 3.15 W (base case V5) was changed to 1.0 W for the option #3 scenario. The results of the scenario are shown in the Table 10 below.

Table 10: Option #2 and #3 scenario for base case V5

Modes:	Active	Ready	Sleep	Off-mode	0 (zero) W	Day (total)	
	in hours	in hours	in hours	in hours	in hours	in hours	
Base Case (V5)	0,07	0,50	3,43	16,00	4,00	24,00	

Mode	Active	Ready	Sleep	Off	Power/week	Power/year	Potential
	in Watt	in Watt	in Watt	in Watt	in kWh/w	in kWh/a	
Base Case (V5)	16,45	7,68	4,35	3,15	0,35	18,28	100%
Option #2	16,45	5,00	4,35	3,15	0,34	17,93	98%
Option #3	16,45	7,68	4,35	1,00	0,18	9,34	51%
Option #2+3	16,45	5,00	4,35	1,00	0,17	8,99	49%

Discussion of the scenario results

The reduction of the “ready mode” power consumption value simulating a reduced “networked standby” results in a 2% improvement. The low improvement potential can be explained by the allocation of power consumption to the ready and sleep mode. The option #2 scenario only changes the short “ready mode” phase. If we assume that “networked standby” is the sum of the “ready” and “sleep” mode and that we have an effective 1 or 2 Watts reduction related to both modes, then the resulting effect would be about 2 kWh/a or roughly 10% improvement.

Regarding option #3 the improvement potential is more obvious. The reduction of “off-mode” power consumption to 1.0 W results in a total improvement of about 50%. The annual power consumption of the base case V5 would decline from 18.28 kWh/a to 9.34 kWh/a. In terms of electricity costs this improvement would result over average 4 year product life cycle in 5 € reduction.

7.2.2.2. Improvement potential for base case V6

The following scenarios have been created in order to indicate the improvement potential of option #2 and option #3 exemplarily for the base case V6. The base case V6 is the same IJ-MFD in a “workgroup” use application. The allocated values for “networked standby” (ready and sleep mode) as well as “off-mode” are exactly the same as in the base case V5. The results of the scenario are shown in the Table 11 below.

Table 11: Option #2 and #3 scenario for base case V6

Modes:	Active	Ready	Sleep	Off-mode	0 (zero) W	Day (total)	
	in hours	in hours	in hours	in hours	in hours	in hours	
Base Case (V6)	0,25	1,25	10,50	8,00	4,00	24,00	

Mode	Active	Ready	Sleep	Off	Power/week	Power/year	Potential
	in Watt	in Watt	in Watt	in Watt	in kWh/w	in kWh/a	
Base Case (V6)	16,45	7,68	4,35	3,15	0,42	21,99	100%
Option #2	16,45	5,00	4,35	3,15	0,41	21,12	96%
Option #3	16,45	7,68	4,35	1,00	0,34	17,52	80%
Option #2+3	16,45	5,00	4,35	1,00	0,32	16,65	76%

Discussion of the scenario results

The reduction of the “ready mode” power consumption value simulating a reduced “networked standby” results in a 4% improvement. Similar to the scenario for the base case V5, the low improvement potential can be explained by the allocation of power consumption to the ready and sleep mode. The option #2 scenario only changes the short “ready mode” phase. If we assume that “networked standby” is the sum of the “ready” and “sleep” mode and that we have an effective 1 or 2 Watts reduction related to both modes, then the resulting effect would be about 6 kWh/a or roughly 20% improvement.

Regarding option #3 the improvement potential is more obvious. The reduction of “off-mode” power consumption to 1.0 W results in a total improvement of about 20%. The annual power consumption of the base case V6 would decline from 21.99 kWh/a to 17.52 kWh/a. In terms of electricity costs this improvement would result over average 4 year product life cycle in 2.5 € reduction.

Impact assessment of option #2 and #3

The improvement potential of the combined option #2 and #3 is considerable for the base cases V5 (personal) and base case V6 (workgroup). Based on the use pattern assumption of the inkjet base cases we conclude that the use phase’s energy consumption could be reduced by 25% to 50%.

7.2.3. Improvement potential of option #4

The environmental improvement potential of option #4 “resource efficient material and component design” is difficult to assess. The objective of the option #4 is to select and use materials such as metals and plastics as well as electronic components effectively under consideration of the whole product life cycle. Resource efficiency is defined not only by the amount of materials that is used in a product. Resource efficiency addresses also the energy and resource consumption of production processes, waste generation, and the possibilities for reuse of components, recycling and recovery of materials and/or energy at the product’s end-of-life. Furthermore, it is necessary to consider that each material and component has a functional benefit. This functional benefit is not fixed and can be increased or decreased by a particular design. The same consideration applies to the environmental burden including the toxicity of a material.

To give an example: If a material provides a high technical reliability or it is easy to recover in recycling processes the ecological footprint might be reduced over a longer time period. At the same time the material could be very toxic and cause concern in certain process steps. The

resource efficiency might be compromised by the toxicity of a material or substance. In this case the environmental impact has to be weighted consciously between a potential environmental hazard and the aspect of resource efficiency. The second example addresses resource efficiency by component reuse. Copier manufacturers have developed a successful business model in which components of products or the whole product platform are designed for reuse. The reuse of components and the platform concept is a good method to save resources. These manufacturers have an interest to assess the resource efficiency of their reuse strategies. Third, there are manufacturers of imaging equipment providing a voluntary manufacturer warranty on their products (typically between 1 and 3 years) as they consider their products being of high reliability and to make this visible to the consumer as a marketing argument. This can be taken as an indirect indication, that some products might have a longer technical lifetime than others – high reliability and long technical lifetime being aspects, which significantly can lower the total environmental impacts regarding raw materials / manufacturing.

All these general product improvement options are assumed to have a significant potential, but this is not quantifiable on the general level of the base cases. A product individual comparison of design improvements and resulting environmental improvement effects would be required. However, there are statements by industry, such as “Design for Recycling guidance and requirements stated in the Blue Angel criteria helped us to re-think product design and to realize significant improvements.”

7.2.4. Improvement potential of option #5 and option #6

The improvement potential of option #5 and option #6 cannot be quantified.