EuP Preparatory Studies
"Imaging Equipment" (Lot 4)

Final Report on Task 3
"Consumer Behavior and Local Infrastructure"

Compiled by Öko-Institut and Fraunhofer IZM

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Content

Introduction

This is the **final report** on Task 3 “Consumer Behavior and Local Infrastructure” 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. The statements and recommendations presented in the final report however are not to be perceived as the opinion of the European Commission.

We like to acknowledge the fruitful collaboration and trustful working relationship with various industry partners, non-industry stakeholders and the European Commission throughout the study. We like to thank all stakeholders for their contribution and critical reviews of our reports.

12th November 2007

3. Consumer Behaviour & Local Infrastructure

Introduction

Task 3 has the general objective to identify use patterns and crucial user behavior that influence the environmental impact of imaging equipment during product life. The first aspect to be investigated is the characteristics and frequency of use (use patterns). The user's perception of the products functionality and the user's actual behavior has a considerable influence on the real life efficiency of a product. With respect to the variety of marking technologies, functionalities, performance characteristics, and application environments that the full range of office imaging equipment provide to the consumer, use patters are of course highly diverse and user behavior not stereotype. As the following examples will show there are no basic or comprehensively representative use patterns even for one and the same devices.

A copier or copier-based MFD for instance is designed to provide a more instant reactivation in order to reduce the waiting time of the user. The user is standing in front of the machine and is waiting (maybe under time pressure) for the copies. With the trend towards copier-based MFD, offices use the same machines for regular print jobs. Time delays for that application might be less important. The same concept applies to a workgroup laser printer in an office environment. The users may have to walk to the printer room in order to get the printouts. Somewhat longer reactivation times (delays) might be acceptable. But if the same laser printer is used in an up-front desk environment, e.g. at the service desk of a large store, an immediate reaction to a print job is required by the consumer because time is critical in this situation.

The applied technology and technical design of copiers or printers have to reflect usually multiple use patterns und consumer requirements. To give an example, a high speed EP-product could be applied as a workgroup printer in a large office environment or as digital press in a production environment. The use frequency and image volume are in both cases very different. The diversity of product segments which we have in the office imaging equipment market reflects this situation. The reports on Task 1 and 2 indicated the difficulty related to a common definition of market segments (and in consequence the exact scope of the Lot 4 study or later base cases in the study). Manufacturer, retailer, market survey institutions, and national statistics offices apply various schemes in order to structure the office imaging equipment market. Product characteristics such as functionality and performance parameter are overlapping even in common schemes. There is no clear borderline (technical specification by speed or technology) for instance between products that are applied in regular "office workgroup" or "production". This scope issue is progressed in the problem of allocating particular use patterns or user behavior to specific products. It is of course not possible to analyze the full spectrum of products and their applications. We therefore limit the analysis to the examples of main product segments for which basic economic data (installed base and image creation volume) could be obtained in Task 2.

Basic economic data are available for the following product segments:

- EP-Copier SFD/MFD monochrome
- EP-Copier SFD/MFD colour
- EP-Printer SFD/MFD monochrome
- EP-Printer SFD/MFD colour
- IJ-Printer SFD/MFD personal
- IJ-Printer SFD/MFD workgroup
- Facsimile Machine SFD/MFD

Table 1 provides a summary of economic data (stock and image creation volume) for the chosen product segments. The differentiations between personal and workgroup environment indicates a further dimension in the use patterns that is of concern for the accuracy of the study.

Table 1: Basic economic data for main product segments

Product Segment	EU-25 Stock in 2005 (in 1000 units)	Personal Images in 2005 (in 1000 impressions)	Workgroup Images 2005 (in 1000 impressions)	EU-25 Stock in 2010 (in 1000 units)	Personal Images in 2010 (in 1000 impressions)	Workgroup Images 2010 (in 1000 impressions)
EP-Copier mono	5.970			4.122		
EP-Copier color	381			691		
EP-Copier (total)	**6.351**	**13.000.000**	**116.000.000**	**4.813**	**5.000.000**	**125.000.000**
EP-Printer mono	14.735			14.306		
EP-Printer color	1.919			4.198		
EP-Printer (total)	**16.654**	**18.000.000**	**421.000.000**	**18.504**	**1.000.000**	**500.000.000**
IJ-Printer SFD	68.412			31.322		
IJ-Printer MFD	21.760			77.776		
IJ-Printer (total)	**90.172**	**71.000.000**	**8.000.000**	**109.098**	**82.000.000**	**5.000.000**
Facsimile SFD	13.241			4.382		
Facsimile MFD	6.890			8.874		
Facsimile (total)	**20.131**	**17.000.000**	**11.000.000**	**13.256**	**8.000.000**	**7.000.000**

Despite the question of product scope for which use patterns have to be analyzed, the Task 3 report contains an investigation on characteristics and frequency of use, user interaction regarding power management settings, supply and utilization of auxiliaries (consumables) such as toner, ink, and paper. Section 3.2 is dedicated to the end-of-life behavior and the questions of servicing, economical product lifetimes including second-hand markets and refurbishment. The final Section 3.3 will cover aspects of the local infrastructure and related barriers to possible eco-design measures.

3.1. Real Life Efficiency

3.1.1. Buying decision and use patterns

3.1.1.1. Buying decision

The environmental performance of office imaging equipment during use (e.g. energy efficiency) is primarily determined by the technology and design of the product. The user will determine the environmental impact of a product, firstly through their choice of product, secondly through their actual use of the product's functions and the characteristics of use over the whole product lifetime. The consumer may also influence real life efficiency of a product by changing mode settings or the choice of consumables. A questionnaire concerning consumer's buying decisions was compiled and sent to stakeholders[1]. According to the results of this questionnaire, the purchasing price, functionality, and related technology are as important to professional as to private users. Technology and functionality are similar important for professional users as the purchase price, whilst design plays a major role for private users, which is in turn one of the least important criteria for professional users. It is also noticeable that also the costs of consumables are very important for both business and private users.

For **business users**, power saving functions and energy consumption are most important within the environmental criteria. The aspects longer life cycle, re-use or recycling options as well as eco-labels are of equal relevance for business users and with an average of 2.9 points still weighted quite high. According to interviews with some manufacturers these aspects however are subordinated to the technical and functional needs and especially to the price. Less relevant aspects are emissions, ecological relevance of consumables, and the use of recycled materials.

The results of the questionnaire show that **private consumers** weighing environmental aspects quite low in their buying decision – with energy consumption, longer life cycle and emissions being little more relevant than power saving functions or re-use and recycling options. According to interviews with manufacturers particularly the awareness of private users seems to be quite low as there are only very few "convinced" purchasers who explicitly ask for environmental features or Eco-Labels. A socio-scientific market analysis conducted by the Institute for Socio-Ecologic Research (ISOE)[2] comes to similar conclusions, for example that the existence and use of duplex units as option for saving paper and environmental impacts is nearly unknown. According to ISOE the most important aspects of private users' buying decision are the costs per printed page and costs

[1] Questionnaire with results s. Annex 1
[2] ISOE GmbH (2006) „Eco Top Ten Computer", Presentation

for consumables whereas the latter is not associated with environmental aspects but only as a cost factor. One reason for a better awareness of business users in general regarding environmental aspects could be that purchasing of imaging devices in companies is often organized by central procurement with predefined tender requirements. "Green (public and private) procurement", which means integrating environmental criteria like eco-efficiency or eco-label requirements into the tender specifications for buying products, is an increasingly applied concept of business and public authorities. Initiated on European level and already being implemented in many Member States, this concept raises awareness for "green" products being efficient from an environmental and energy point of view. Figure 1 illustrates the percentage of public tenders including green specifications in different EU Member States[3].

Public tenders are split into four categories according to the number of green specifications:

- No criteria: no green specifications in the tenders
- Grey: attempts for green specifications, but not followed by a green purchase
- Light green: one to three clear green specifications
- Solid green: more than three green specifications

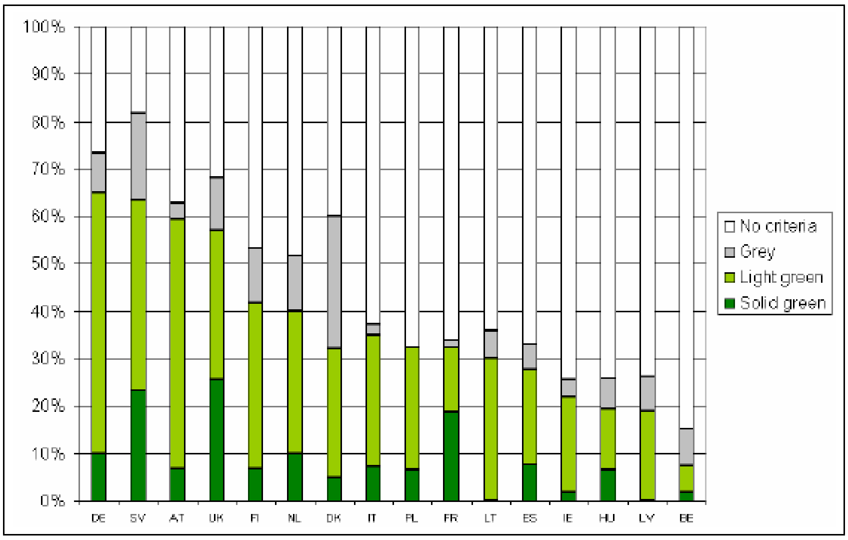

Figure 1: Green factor in public procurement tenders

The results show that in several EU member states like Germany, Sweden, Austria or UK more than 50 percent of public tenders include green criteria. On the other hand, there is still a very high improvement potential especially for countries like Estonia, Latvia, Hungary or Ireland. The diagram does not allow drawing explicit conclusions for imaging equipment but it may give a hint on possible differences in the buying decision between the different countries from EU-25. Answers to the questionnaire given from industry state that they expect people in EU-15 Member

[3] Bouwer M, Jonk M, Berman T, Bersani R, Lusser H, Nappa V, Nissinen A, Parikka K, Szuppinger P and Viganò C, 2006. Green Public Procurement in Europe 2006 – Conclusions and recommendations. Virage Milieu & Management bv, Korte Spaarne 31, 2011 AJ Haarlem, the Netherlands.

States being more environmental conscious than people in new Member States. They furthermore assume that priorities might be set different due to different income situations.

In 2004 and 2005, the market research institute InfoTrends[4] asked around 200-300 professional users concerning environmental issues and the impact to their printing behavior over the next 3 years (see Figure 2). Differing from the results of the questionnaire, this analysis shows that the respondents do not have strong opinions on environmental issues, e.g. buying environmentally labeled printers, at all as most statements are answered around the option "neither agree nor disagree".

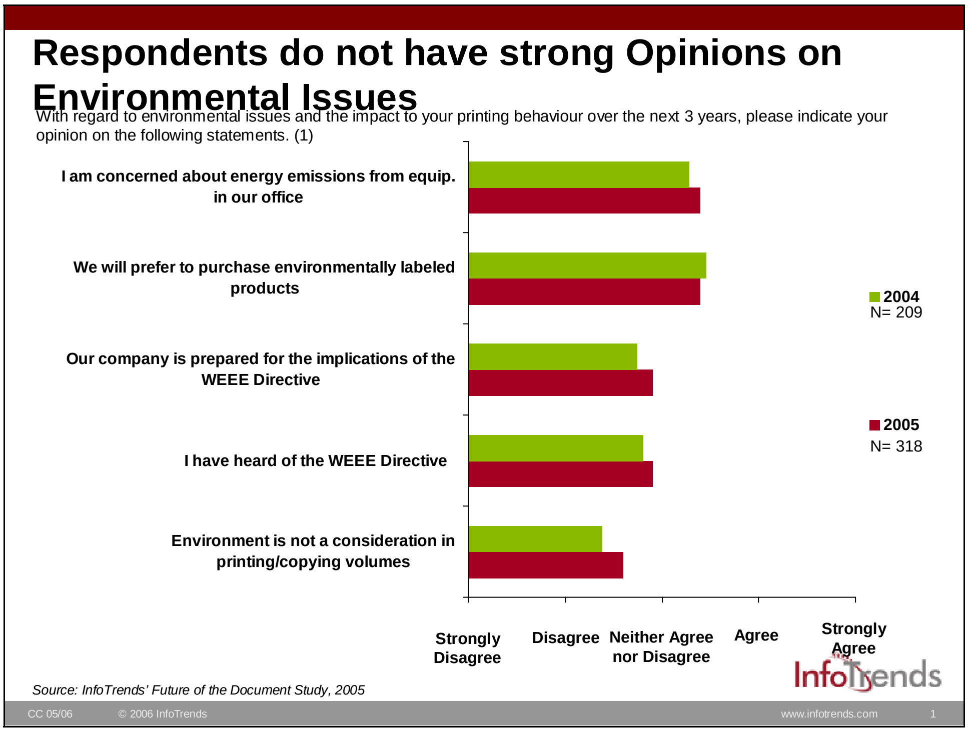

Figure 2: Importance of environmental issues

3.1.1.2. Frequency and characteristics of use

Use patterns – the frequency and characteristics of use – in the field of office imaging equipment are highly diverse. In the introduction of this task report we argued therefore to analyze use patterns for a representative number of product segments. The selection of these product segments is based on main economic data (Section 2.2) concerning the installed base of products in EU-25 as well as the annual image output volume (see Figure 1). Following product segments will be distinguished in the study:

[4] Info Trends (2005) „Future of the document study", Presentation

- EP-Copier SFD/MFD monochrome
- EP-Copier SFD/MFD colour
- EP-Printer SFD/MFD monochrome
- EP-Printer SFD/MFD colour
- IJ-Printer SFD/MFD personal
- IJ-Printer SFD/MFD workgroup
- Facsimile Machine SFD/MFD

With these product segments the diversity of use patterns is somewhat reduced by the functionality and performance features that are allocated to the category. Still, it is not possible to define a single use pattern per product segment. That leads to the question, which aspects define a use pattern. The product's functionality, power modes, and general performance characteristics offer answers to this question. Empirical observations as well as an investigation of existing test procedures also provide further clues.

The authors of the EuP Preparatory Studies on "standby and off-mode losses" (Lot 6) introduced the adequate terminology "job-based product" and applied this term to office imaging equipment. According to the Lot 6 Task 1 report job-based products are: "… devices, which run a defined function cycle or job in active mode. After finishing a job the device reduces the set of functions by changing into a transitional mode. The device may stay ready (high power level with quick reactivation) or starts a power save scheme typically leading to standby or sleep modes." Under the definition of Lot 6 these modes are summarized into the term transition into standby and off-mode[5].

In summary, office imaging equipment provides its main function (e.g. a fixed number of prints or copies) by means of a consumer defined "job". After fulfilling the "job" an automatic transition into a reduced power mode usually takes place. Following this understanding a use pattern for an office imaging equipment can be described based on standard modes:

- Wake-up from off-mode or sleep-mode (In the case of printer and MFD this activation could occur in conjunction with activating a PC environment or network. In the case of facsimile machines or fax capable MFD the device may always be online [ready mode]).
- Active mode in order to fulfill main functionality such as printing or copying (EP-products usually need certain warm-up/reactivation time periods).
- After fulfilling the main functionality the device may remain in a high readiness (ready mode) in order to proceed without much time delay it main function (active mode)

[5] Lot 6 EuP Preparatory Study, Interim Report on Task 1, cp. 1.1.5.4, (http://www.ecostandby.org)

- After a certain time delay with no job requirement the device usually reduces its functional spectrum automatically in order to save energy (sleep modes or standby modes).
- The device can be reactivated from such modes or turned off (off-mode with or without power draw).

These operation modes, which functionality and performance characteristics are fixed by the product's design, provide one structural aspect of a daily use pattern. The second aspect is variable. It is the frequency and time duration the product remains in these modes. The duration of the active mode is influenced primarily by the job requirement, meaning the quantity and quality of the produced images. This also determines the utilization of consumables such as paper and toner or ink. The default time setting of the machine (software) and the direct (manual) user interaction will also determine the duration of a mode (e.g. transition into standby or off-mode). With this set of factors a daily use pattern can be characterized. Figure 3 again illustrates these multiple factors of a daily use pattern.

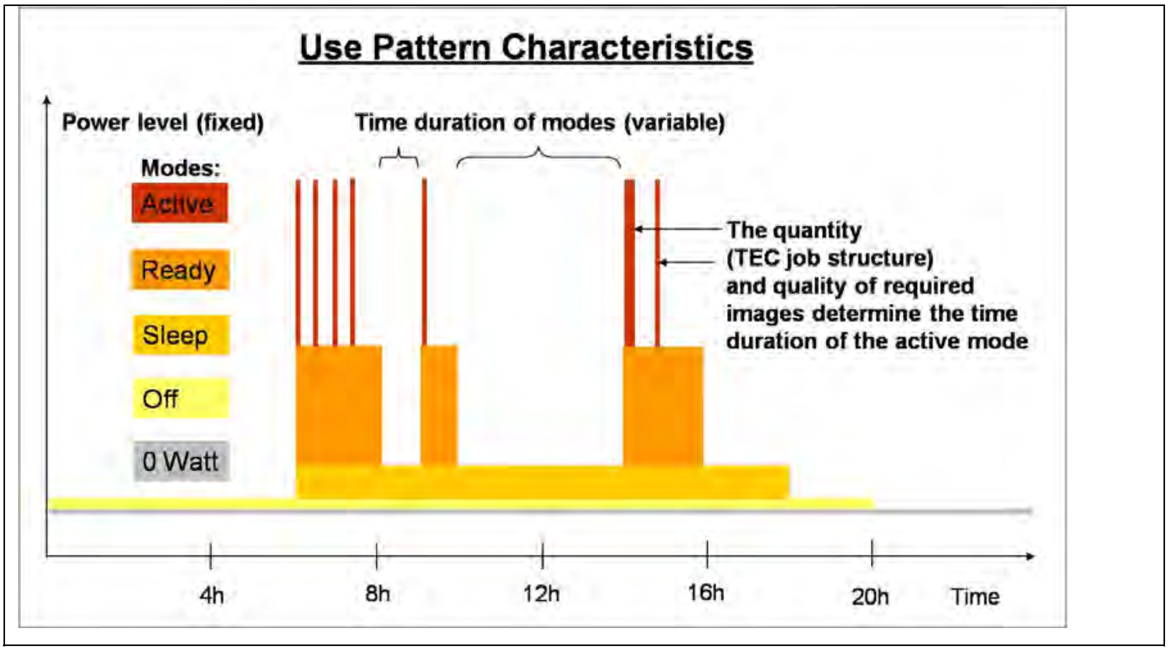

Figure 3: Schematic description of use pattern factors

The daily use pattern may change over a week or season. It is widely recognized that office printers and copiers are not frequently in use over the weekend. The same maybe applies during vacation times. It is therefore necessary to define an annual use pattern as well. We suggest calculating the annual use pattern based on 5 days a week for 52 weeks a year (260 days per year). This seems to be a reasonable average for professional and personal user environment.

As a comment from the "Market Transformation Programme" (MTP) an annual use pattern of 240 days per year was proposed, because 260 days per year would "only allow for weekend closure, and not vacations. A more realistic number of weeks, as used by MTP and others who have carried out such analysis is 240 days per year, but it is important to also include in calculations that the standby state will be potentially 365 days per year. For personal users, use is likely to be higher at the weekends, but lower during the week, and could be 7 days per week, so you cannot assume that the same profile applies to personal users as applies to professional." But within this study the above named annual use pattern of 5 days a week, 52 weeks a year and 260 days per year will be used.

3.1.1.3. Adoption of TEC method as use pattern for EP-Products

The characteristic aspects of use patterns, as we just described them, are already reflected for imaging equipment with high-temperature marking technology such as EP by the Energy Star Program's Typical Electricity Consumption (TEC) test method[6]. The Energy Star Program for imaging equipment is widely accepted within the industry as well as governmental and non-governmental institutions. The TEC value reflects assumptions about how many hours a day the product is in general use, the pattern of use during those hours (quantity of images), and the default-delay times that the product uses to transition to lower power modes. The test pattern is set based on a required number of imaging jobs being distributed in two clusters over a day with the unit going to its lowest power mode in between (as during a lunch break). The main principles are illustrated in the flowing Figure 4.

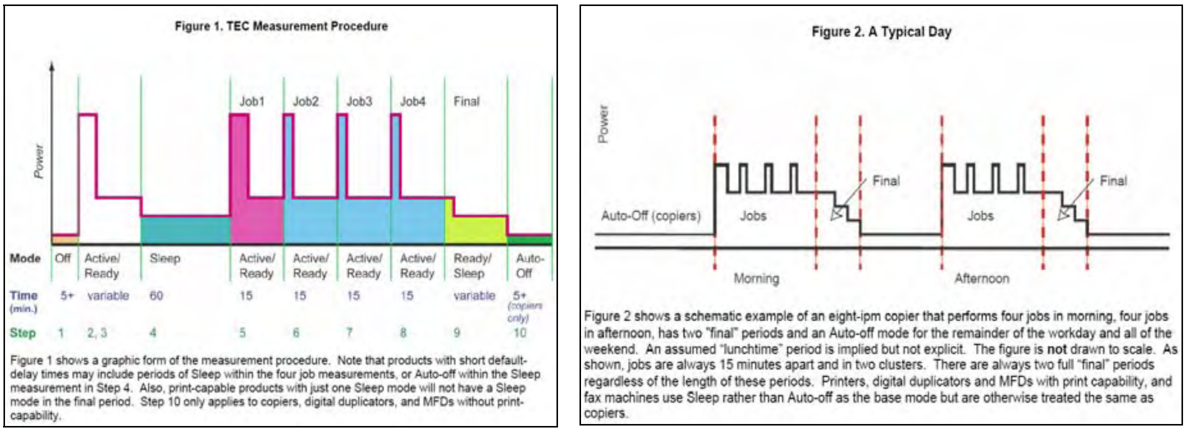

Figure 4: Energy Star TEC Measurement Procedure

A key element in the TEC test method is the prescription of a daily amount of jobs and images per job. The reference point for these values is the printing/copying speed of the machine. According to

[6] The TEC procedure is to be used to obtain and evaluate the TEC of Standard-size IE products such as copiers, digital duplicators, fax machines, multifunction devices (MFDs), and printers that use high-temperature technologies such as Electro Photography (EP) and Solid Ink (SI), and those that provide comparable functionality. It is not intended for low-temperature technologies such as conventional Ink Jet (IJ) or Impact, nor for large-format or small-format products.

TEC job table, the daily output of a 25ipm laser printer would be calculated on 25 jobs per day with 12 images per job, resulting in 300 images per day in total. Table 2 below shows the TEC reference values for daily jobs and images according to speed classes.

Table 2: TEC daily jobs and images reference table

Table 4. Job Table Calculated

Speed	Jobs/ Day	Interim Images/ Day	Interim Images/ Job	Images/ Job	Images/ Day	Speed	Jobs/ Day	Interim Images/ Day	Interim Images/ Job	Images/ Job	Images/ Day
1	8	1	0.06	**1**	8	51	32	1301	40.64	**40**	1280
2	8	2	0.25	**1**	8	52	32	1352	42.25	**42**	1344
3	8	5	0.56	**1**	8	53	32	1405	43.89	**43**	1376
4	8	8	1.00	**1**	8	54	32	1458	45.56	**45**	1440
5	8	13	1.56	**1**	8	55	32	1513	47.27	**47**	1504
6	8	18	2.25	**2**	16	56	32	1568	49.00	**49**	1568
7	8	25	3.06	**3**	24	57	32	1625	50.77	**50**	1600
8	8	32	4.00	**4**	32	58	32	1682	52.56	**52**	1664
9	9	41	4.50	**4**	36	59	32	1741	54.39	**54**	1728
10	10	50	5.00	**5**	50	60	32	1800	56.25	**56**	1792
11	11	61	5.50	**5**	55	61	32	1861	58.14	**58**	1856
12	12	72	6.00	**6**	72	62	32	1922	60.06	**60**	1920
13	13	85	6.50	**6**	78	63	32	1985	62.02	**62**	1984
14	14	98	7.00	**7**	98	64	32	2048	64.00	**64**	2048
15	15	113	7.50	**7**	105	65	32	2113	66.02	**66**	2112
16	16	128	8.00	**8**	128	66	32	2178	68.06	**68**	2176
17	17	145	8.50	**8**	136	67	32	2245	70.14	**70**	2240
18	18	162	9.00	**9**	162	68	32	2312	72.25	**72**	2304
19	19	181	9.50	**9**	171	69	32	2381	74.39	**74**	2368
20	20	200	10.00	**10**	200	70	32	2450	76.56	**76**	2432
21	21	221	10.50	**10**	210	71	32	2521	78.77	**78**	2496
22	22	242	11.00	**11**	242	72	32	2592	81.00	**81**	2592
23	23	265	11.50	**11**	253	73	32	2665	83.27	**83**	2656
24	24	288	12.00	**12**	288	74	32	2738	85.56	**85**	2720
25	25	313	12.50	**12**	300	75	32	2813	87.89	**87**	2784
26	26	338	13.00	**13**	338	76	32	2888	90.25	**90**	2880
27	27	365	13.50	**13**	351	77	32	2965	92.64	**92**	2944
28	28	392	14.00	**14**	392	78	32	3042	95.06	**95**	3040
29	29	421	14.50	**14**	406	79	32	3121	97.52	**97**	3104
30	30	450	15.00	**15**	450	80	32	3200	100.00	**100**	3200
31	31	481	15.50	**15**	465	81	32	3281	102.52	**102**	3264
32	32	512	16.00	**16**	512	82	32	3362	105.06	**105**	3360
33	32	545	17.02	**17**	544	83	32	3445	107.64	**107**	3424
34	32	578	18.06	**18**	576	84	32	3528	110.25	**110**	3520
35	32	613	19.14	**19**	608	85	32	3613	112.89	**112**	3584
36	32	648	20.25	**20**	640	86	32	3698	115.56	**115**	3680
37	32	685	21.39	**21**	672	87	32	3785	118.27	**118**	3776
38	32	722	22.56	**22**	704	88	32	3872	121.00	**121**	3872
39	32	761	23.77	**23**	736	89	32	3961	123.77	**123**	3936
40	32	800	25.00	**25**	800	90	32	4050	126.56	**126**	4032
41	32	841	26.27	**26**	832	91	32	4141	129.39	**129**	4128
42	32	882	27.56	**27**	864	92	32	4232	132.25	**132**	4224
43	32	925	28.89	**28**	896	93	32	4325	135.14	**135**	4320
44	32	968	30.25	**30**	960	94	32	4418	138.06	**138**	4416
45	32	1013	31.64	**31**	992	95	32	4513	141.02	**141**	4512
46	32	1058	33.06	**33**	1056	96	32	4608	144.00	**144**	4608
47	32	1105	34.52	**34**	1088	97	32	4705	147.02	**147**	4704
48	32	1152	36.00	**36**	1152	98	32	4802	150.06	**150**	4800
49	32	1201	37.52	**37**	1184	99	32	4901	153.14	**153**	4896
50	32	1250	39.06	**39**	1248	100	32	5000	156.25	**156**	4992

The number of daily jobs and images per job that are calculated by the Energy Star TEC derive from a correlation of speed to an assumed image output volume. In earlier reports we indicated the notion that these TEC reference values for the image volume per speed class are somewhat high especially for faster machines. Some industry sources indicated that according to their market surveillance data TEC values overestimate volume output by 2 to 4 times in product segments of over 30 ipm. This assessment was given for regular workgroup (office) environments. But further discussion with industry was leading to another consideration and that is the distinction between office and production environment. With regards to very fast products (>80ipm), which are used as digital press in semi-professional and professional printing environments (production), the average image output volume is in this case 2 to 4 times higher that the TEC values. Against that background the TEC values are averaging – at least in the fast speed segments – the image creation volume in office and production environments. TEC job table is a consecutive metrics of speed and image volume, which does not reflect specific application environments. In the Lot 4 Study however, we do make a differentiation between office and production imaging equipment. In order to show the possible extent of the TEC reference values we made the following calculation based on the available economic data and the respective image creation volume. In a first step we calculated an annual number of images resulting from 2005 stock data of EP-Copier and EP-Printer and their related image creation volume (see row 1 and 2 of Table 3). Than we calculate a daily amount of images assuming 5 days a week and 52 weeks a year use pattern. According to this calculation EP-Copiers would on average produce only 78 images per day and EP-printer 101 images per day respectively. These results would correspond to a speed class of 13 ipm for EP-Copiers and 15 ipm for EP-Printers according to TEC.

In a second step we calculate two scenarios taking the TEC as the initial point (see row 3 and 4 of Table 3). We assume for the scenarios that the imaging speed of an average EP-Copier is 26 ipm and of an EP-Printer 30 ipm. We applied a factor 2 to the preview calculated averages (13 ipm and 15 ipm) on purpose although 26 ipm for copiers and 30 ipm for printers seems to be a realistic average today. Based on the same use pattern and stock data, the total EU-25 output images were calculated. The results of the scenarios show that the image creation volume quadruples in comparison to the economic data from InfoTrends.

Table 3: TEC values correlated to EU-25 basic economic data

	Product Segment	EU-25 stock (in 1000 units)	EU-25 images (in 1000 images)	Images per unit (images)	Daily images per unit (260 days er year)	TEC speed class (images per minute)
1	EP-Copier (2005)	6.351	129.000.000	20.312	78	13 ipm
2	EP-Printer (2005)	16.654	439.000.000	26.360	101	15 ipm
3	*EP-Copier (scenario*)*	6.351	*558.125.880*	*87.880*	*338*	*26 ipm*
4	*EP-Printer (scenario**)*	16.654	*1.948.518.000*	*117.000*	*450*	*30 ipm*
	* This scenario assumes that an average EP-Copier features 26 ipm					
	** This scenario assumes that an average EP-Printer features 30 ipm					

An interpretation of the results is necessary. First of all, the example calculation indicates the tremendous magnitude of correlated images (output volume) according to TEC speed class values. If we take TEC values (images per day according to speed class) as reference for a daily use pattern the resulting overall environmental impact related to the created images (paper and toner consumption) might be unrealistically high. The results of Task 4 and 5 should provide a clearer picture regarding this assumption. On the other hand, the TEC method and related values provide a common basis – and therefore use pattern – for measurement of power consumption and consumables. These aspects, both power and auxiliary consumption, are defining the main environmental impact. We therefore conclude that the TEC method is a reasonable option to set a use pattern for EP-products. It is intended to apply TEC values for assessing power and auxiliary consumption in the environmental assessments (Task 4 and 5).

Please note: For the purpose of this study we will summarize EP-Copiers/MFD/Printers etc. under the term “TEC-Products”, drawing from the Energy Star Program TEC methodology. The resulting use patterns for individual TEC-Products are based on the speed correlated structure for daily jobs and images (TEC job structure). The annual use pattern is based on the (daily) TEC job structure with 5 days a week and 52 weeks a year. Power and auxiliary consumption will be calculated based on TEC measurements (daily or weekly values) and projected on the annual use pattern. We assume 6 years average lifetime for TEC-Products.

3.1.1.4. Adoption of use pattern for Inkjet printers, scanners and facsimile machines

The Energy Star TEC does only apply to high-temperature marking technologies. The testing of energy performance regarding non-thermal marking technologies such as inkjet is covered in the Operational Mode (OM) approach. Due to the fact that OM focuses on low power modes, such as standby and off-modes, it is not applicable for defining average use patterns of inkjet printers, facsimile machines, or scanners. It is therefore necessary to define a general use pattern for these products in order to calculate power and auxiliary consumption in the later tasks.

Please note: For the purpose of this study we will summarize IJ-printers, facsimile machines and flatbed scanners under the term “OM-Products”, drawing from the Energy Star Program methodology “Operational Mode” in comparison to “TEC-Products”.

Following the assumption that the use pattern of OM-Products is rather defined by the application environment (personal or workgroup) than by the speed class (TEC job structure), we propose to define two general use patterns for OM-Products:

- Personal environment (low utilization)
- Workgroup environment (more intensive utilization)

The use pattern for OM-Products has to be based on the following data-set:

- Job structure (jobs/images per day)
- Active-mode duration (in hours per day)
- Ready/Sleep-mode combined to standby duration (in hours per day)
- Off-mode duration (in hours per day)
- Zero Watts or Disconnected duration (in hours per day)
- Days per week
- Weeks per year

Literature does not provide a common job structure or use pattern for OM-Products. In order to determine a reasonable job structure we made the following calculation applying the basic economic data for IJ-Printers and Facsimile Machines (see Table 4). The use pattern reflects an averaging and rounding of both IJ-Printer and Facsimile daily image volume. In order to simplify further calculations we will take only one use pattern for "personal" and one for "workgroup" and apply them to both IJ-Printer and Facsimile machines.

Table 4: Calculation of job structure for OM-Products

	Product Segment (stock 2005)	EU-25 stock* (in 1000 units)	EU-25 images** (in 1000 images)	Images per unit (images)	Daily images per unit (260 days er year)	Use Pattern*** (images/hours per day)
	IJ-Printer (total)	*90.172*	*79.000.000*	*876*	*3,4*	
	IJ-Printer (Personal)	88.320	71.000.000	804	3,1	4 images / 0,07h
	IJ-Printer (Workgroup)	1.852	8.000.000	4.320	16,6	15 images / 0,25h
	Facsimile (total)	*20.131*	*28.000.000*	*1.391*	*5,3*	
	Facsimile (Personal)	16.920	17.000.000	1.005	3,9	4 images / 0,07h
	Facsimile (Workgroup)	3.211	11.000.000	3.426	13,2	15 images / 0,25h

* The data on total stock are from InfoTrends. The particular stock in the "personal" environment was calculated based on household penetartion rates. Assumed household penetration for IJ-Printer is 46% and for facsimile machines 9% in 2005 (see task 2.2).

** The data on the image creation volume are from InfoTrends. In the case of workgroup IJ-Printers the number seems somewhat low, whereas the data for fax are somewhat high. According to InfoTrends will the fax volume rapidly decline and IJ volume increase.

*** The use pattern reflects an averaging and rounding of both IJ-Printer and Fax daily image volume. In order to simplify further calculations we will take only one use pattern for "personal" and one for "workgroup" and apply them to both IJ-Printer and Facsimile machines.

As for the **"personal environment"** use pattern we assume that OM-Products are 4 hours in use (in active, ready or sleep mode) and 20 hours in off-mode. Products with fax capability are considered always on (in sleep mode). Due to the fact that OM-Products could consume power in off-mode and therefore some users disconnect the device, we subdivide the off time duration in 16 h off-mode with losses and 4 h zero watt[7]. The job structure equally distributes 2 jobs with 2 images each per day. Active-mode duration is 0.07 h per day which is one minute per image. The remaining time duration is 0.50 h ready and 3.43 h sleep mode per day. The personal use pattern for OM-Products is illustrated in Figure 5 below.

[7] This assumption reflects data from literature (see task 3.1.2.3).

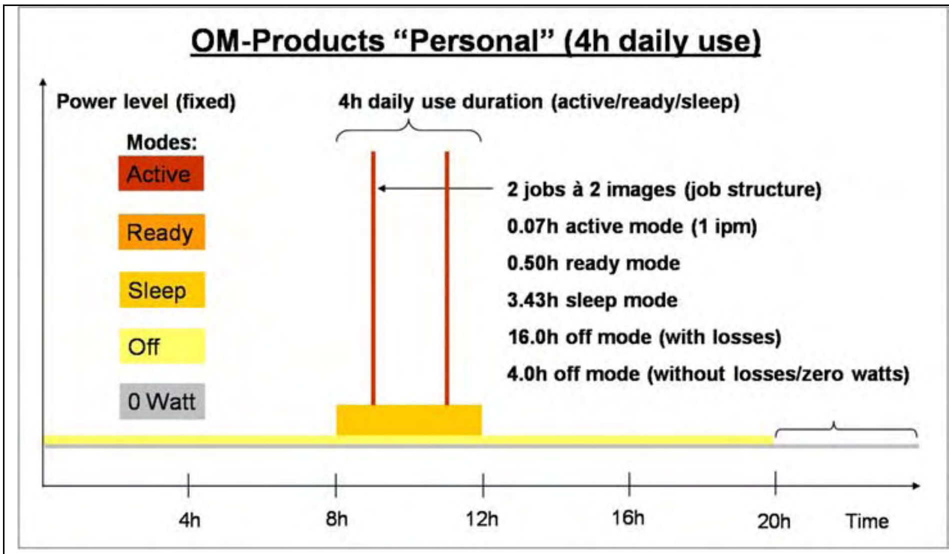

Figure 5: Personal use pattern for OM-Products

As for the **"workgroup environment"** use pattern we assume that OM-Products are 12 hours in use (in active, ready or sleep mode)[8] and 12 hours in off-mode. Due to the fact that OM-Products could consume power in off-mode and therefore some users disconnect the device, we subdivide the off time duration in 8 h off-mode with losses and 4 h zero watt. The job structure of 5 job á 3 images is equally distributed over the day. Active-mode duration is 0.25 h per day which is one minute per image. The remaining "on-time" we consider as standby. This time duration is 1.25 h ready and 10.50 h sleep mode per day. The workgroup use pattern for OM-Products is illustrated in Figure 6.

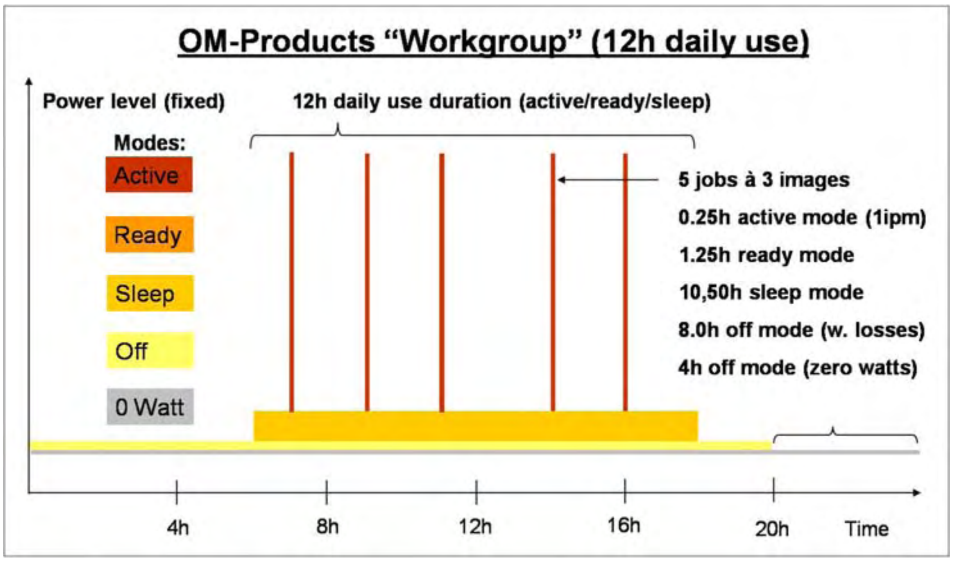

Figure 6: Workgroup use pattern for OM-Products

[8] The 12 hours has been chosen in order to indicate an extensive workgroup office use. In real life, workgroup IJ-printers might only be used during particular office hours (e.g. in a private medical practice) or even 24 h (e.g. in a hospital's emergency room). The 12 hours is an educated assumption.

Please note: The annual use pattern for OM-products is based on the daily job structure distinguishing a personal and workgroup user environment. The annual use is calculated based on 5 days a week and 52 weeks a year (260 days/a). Power consumption will be calculated based on single mode measurements and correlated with the annual use pattern. We assume an average lifetime of 4 years for OM-Products. Paper and ink consumption is calculated based on personal and workgroup scenario featuring:

- Personal: 4 images/day, 260 days/year, 4 years lifetime = 1,040 images
- Workgroup: 15 images/day, 260 days/year, 4 years lifetime = 21,600 images

3.1.2. Power management enabling-rate and other user settings

3.1.2.1. Operation modes and power management

Imaging equipment provides its main function after (re)activation and receiving of a user defined print, copy, scan or fax job. After completing the job the device remains in ready-mode for a certain period of time and then makes a transition into standby or sleep (intermediate modes) in order to save energy. Eventually the device will be manually or automatically switched off. As a matter of fact, the energy efficiency of imaging equipment is influenced by both, the power demand in each operation mode as well as the time duration in which the device remains in these modes. Before we analyze the user interaction with regards to power consumption it seems necessary to provide a short introduction into the topic of operation modes and power management. To begin with, there is neither a coherently defined structure of operational modes nor single terminology of the "intermediate" modes available as a global standard. Manufacturers, standardization bodies and labeling institutions (e.g. Energy Star) are using a wide range of sometimes overlapping mode structures and terminology. Figure 7 illustrates this difficult situation at the example of an EP-printer with multiple power modes.

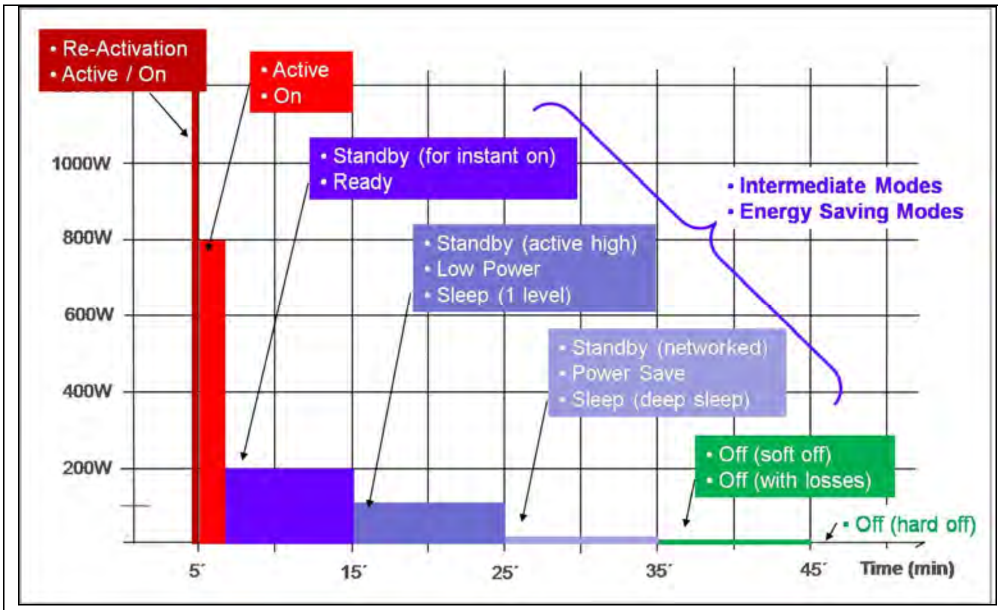

Figure 7: Common mode structure and mode terminology

Regarding power management, the ideal situation would be an instant on (active) and off without intermediate modes. But our currently available marking technologies – particularly high temperature marking technology such as electro photography – have considerable warm-up requirements which make intermediate modes necessary in order to guarantee a fast and reliable reactivation of the device[9]. The most power demanding component of an EP-product is the fuser, which has to realize an average 180°C working temperature of the fixing unit. According to industry sources the fuser demands 60 to 70 % of total power in active mode. In standby mode (ready as well as usually in the first energy saving mode) the fuser remains with 50 to 60 % the most dominant power drawing component. In the sleep mode (networked standby) the fuser is usually deactivated. In the case of EP-products, the energy requirements of the fuser/fixing unit is the most critical aspect to achieve fast recovery times. Despite the actual marking technology, all imaging equipment maintains certain subsystems operational in order to ensure fast reactivation. The print engine, network interfaces (for receiving a job), data processing, and memory capacities are usually operational in standby. Copier, MFD, and scanner which require higher voltage for charging the scanner lamp (e.g. CCFL) most likely keep the scanner lamp charged[10]. Power consumption varies of course from technology to technology and product to product making an

[9] In general, EP-products in comparison to inkjet consume considerably more power in active and standby mode, however in off-mode IJ-products mostly consume more energy because of the external power supplies. In the case of EP-products it is also noticeable, that faster machines also consume more power in the single modes.

[10] This could mean 15 to 20 W.

analysis of power management a highly diverse task[11]. In conclusion, even products with the same marking technology and functional spectrum can show large differences in power distribution due to the utilization of a special – most often patented – technology[12], the set-up and performance characteristics. However, reducing the functional spectrum and therefore power requirements of the imaging equipment through intermediate modes is an important measure for energy saving. In this regards, default delay time settings are providing the option to further improve the power management (energy efficiency).

3.1.2.2. Default delay time settings

Default delay time settings provide the option of balancing power consumption (improve energy efficiency) with user requirements such as fast reactivation (recovery). According to studies and interviews with industry, the users' tolerance for longer reactivation times is rather low and does not exceed a few seconds (see e.g. Bush 2006, Aebischer 1997). As a rule of thumb the user accepts between 10 and 15 seconds. According to some manufacturers a prolonged recovery period does lead to the consumer's notion that the device might not work properly. The manufacturers therefore apply cascading power saving modes in combination with default delay time settings in order to ensure maximum user comfort and improved energy efficiency. The presetting by the manufacturer should reflect an optimum balance between fast transition into lower power modes and power requirements for fast reactivation. This correlation depends on the actual power requirements in each mode as well as the respective recovery time. In the past, interval setting options have been up to 240 minutes. With the introduction of advanced "instant-on" technologies typical default delay times are ranging from one to sixty minutes. Older studies (e.g. Bruce Nordman et al. [1998]) had also shown that a significant percentage of users manually disabled preset power management functions. Disabling of power management was most likely occurring in devices with medium to high speed used in workgroup networks. These older results were confirmed by Bush (2006). He points in the same direction, showing that people using devices with low speed more likely feel responsible for the energy efficient usage (e.g. to switch it off when not in use) than people using devices with medium speed in an office network. In a comment to the draft report EICTA indicated that this situation has changed over the years by referring to a study (Judy Roberson et al, 2004) actually showing that especially for EP-products the power management enabling rates are increasing (up to 60 % for printers, incl. products that do not allow power management). Furthermore, only a limited number of laser printers had delay times of more than one hour (5 %) or disabled power management settings (5 %).

[11] A comprehensive study "Field Power Measurements of Imaging Equipment" clearly indicating this situation was published by Lawrence Berkeley National Laboratory (Marla McWhinney and Judy Roberson et al, 2004, LBNL-54202) as background research for the U.S EPA Energy Star Program.

[12] This could be for instance an instant fusing technology.

In conclusion, default delay time settings are useful measures to improve energy efficiency of imaging equipment. A correlation exists between the actual delay time and the power requirements for reactivation. Energy efficiency would benefit the most from an optimum default delay time setting. Further study is necessary describing this correlation with an algorithm. Regarding the actual user behavior, older studies indicated that delay time settings were manipulated by the user in order to ensure faster reactivation times. According to industry the average default delay time settings today are shorter with power management enabling rates increasing. Field studies in the EU would be necessary to confirm this improved situation. For the purpose of this study we conclude, that extended delay times settings as well as the manipulation of default delay times by the user may lead to extensive power consumption and reduced energy efficiency. These aspects are therefore of environmental concern. They will be further analyzed in the study.

3.1.2.3. Lowest power and off-mode

Imaging equipment with fax functionality is an always on product. Network printers and Copier/MFD in 24 h office environments may also be permanently used and never be switched off. But a majority of office imaging equipment is not permanently used (in standby). Most office equipment is switched on in the morning or in conjunction with a PC and switched off in the evening. We assume this as the general use pattern[13]. According to the assumptions in Section 3.1.1 is the average daily off-mode duration 20 hours for IJ-products and 12 hours for EP-products. This is considerable time in which no or the lowest power consumption should be targeted. The technical analysis in Task 4 has to determine average standby (network/passive) and off-mode (losses) power consumption for various product types. But the findings and comments deriving from the Lot 6 study regarding standby and off-mode losses (Lot 6, Section 4.3.15) indicate that IJ-Printers for instance consume 6 W (IJ-MFDs up to 20 W) in networked standby and that IJ-Products with EPS consume up to 4 W in off-mode. It is in the interest of the environment and the user’s life-cycle costs to improve this situation. If no functionality is provided to the consumer off-mode losses should be avoided. Most compact IJ-products have an EPS with only a soft switch. Disconnecting the device is the only way to avoid off-mode losses which are still in a range of 1 to 3.5 W. Pulling the plug is the only way to ensure zero Watt. Home and small office (SOHO) users are using master-slave power strip as an external solution for easy hard-off. EP-products on the other hand still feature a hard-off-switch. These features seem to be widely used according to other studies. With respect to Schlomann et al. 2005 the Lot 6 study provides following data on average daily use times per mode for IJ and Laser printer differentiating home and office use (see Table 5).

[13] MTP commented on that point that switch of rates of office equipment seem to be a lot lower (printers: 15-30%, copiers: 48%). (see also: http://www.osti.gov/bridge/servlets/purl/821675-waYRd0/native/821675.PDF)

Table 5: Average daily use times of printers in households and office environment

	Active mode Time [h/d]	Standby mode time [h/d]	Off-mode losses time [h/d]	0 W off-mode time [h/d]
Laser Printer (home)	0.1	1.9	13.1	8.9
IJ-Printer (home)	0.1	1.9	17.7	4.3
Laser Printer (office)	0.4	5.9	14.2	3.5
IJ-Printer (office)	0.3	6.0	14.2	3.5

It should be assumed for the study that some users are aware that products consume power when switched "soft" off (off-mode losses) and other users are not aware of this fact. It does not matter to what percentage this fact applies to users. It matters that imaging equipment potentially consumes power in off-mode (no functionality) and that these losses should be avoided by a technical solution because some users are not aware. Automatic off and hard-off switch are good technical solutions. But the user's awareness is the critical link. Improving user awareness is a political issue that has to be supported by technical solutions. The user needs easy-to-understand information not only from hard-copy manuals but through menu support (software solutions). The industry's concern about the user's comfort (fastest recovery) has to be balanced with power consumption in the non-active phase. The analysis of best available technology (BAT) in Task 6 should focus on lowest power in standby and off-mode.

3.1.3. Dosage, quality and consumption of auxiliary inputs (paper and toner use)

The use of imaging equipment mainly induces the consumption of the following auxiliary inputs:

- Paper
- Toner or inkjet cartridges

3.1.3.1. Paper Consumption

In order to determine the extent of paper consumption the specifics of the applied marking technology, the use pattern, and required image quality (including specifics of paper) have an important influence. Most important however are the questions: How many jobs are performed per day and how many images are printed/copied/faxed per job? It is impossible to precisely determine these figures. A rough estimate of the overall image creation volume in Western Europe and related paper consumption of EP printers, copiers, inkjet printers and facsimile machines (in total and per unit) is given in the subsequent Table 6. Scanners are not considered.

Table 6: Output volume and paper consumption of EP devices, IJ printer and facsimile machines (based on data provided by InfoTrends)

Product Case **Year 2005**	**Product Stock** (in 1000 units)	**Total Images** (in 1000 pages)	**Total Paper** (in tons)	**Unit Images** (pages per unit)	**Unit Paper** (in kg per unit)
EP Printer (total)	16,654				
# EP-P (mono)	*14,735*	439,000,000	2,195,000	26,360	132
# EP-P (colour)	*1,919*				
EP Copier (total)	6,351				
# EP-C (mono)	*5,970*	103,000,000	515,000	16,218	81
# EP-C (coluor)	*381*				
IJ Printer (total	90,172				
# IJ SFD	68,412	79,000,000	395,000	876	4
#IJ MFD	21,760				
Facsimile (total)	20,131				
# Fax SFD	13,241	29,000,000	145,000	1,440	7
#Fax MFD	6,890				

EP copiers and EP printers are mainly designed for intensive use meaning a medium to high hardcopy (paper) output volume per day[14]. The actual use intensity was determined by correlating the European product stock for EP copier (monochrome and colour) and EP printer (monochrome and colour) with the output volume for these products in 2005. The same was done for inkjet printers and facsimile machines, which obviously do not have such a high output. The data were provided by InfoTrends and cover the region "Western Europe". The quality of data cannot be assessed because other sources like GfK or IDC data are not available for the study. As for the output "black & white" images on regular A4 paper are still pervasive in documents. Colour images and photo prints may increase to 25 % of total in the long-term but most documents will be mainly monochrome[15]. Nevertheless, it is important to recognize that colour and photo printing usually require special paper and toner. Paper quality such as the use of recycled paper or the thickness of paper is an environmentally relevant aspect. However for the purpose of this study we calculated power consumption based on an average 80 gr/m² A4 document paper.

Paper consumption[16] through use of imaging equipment in home and offices has, with 3 to 4 million tons of paper annually, a considerable magnitude in the European Union. According to statistical data from the European Recovered Paper Council (ERPC 2005) the average utilization

[14] See Energy Star TEC assumption for daily images per speed class, which seems to be somewhat high for the faster machines.
[15] MTP states that for Western Europe printouts of printers which can print monochrome and colour, 60% are monochrome.
[16] The high energy consumption related to paper manufacturing and use was addressed as the biggest issue already by Nordman et al (1998). The task 4 and 5 report will indicate the energy intensity of paper again.

rate of **recovered paper** in the production of new paper is 46.9 percent. Paper used in imaging equipment – printer, copiers etc. – belongs to the paper category “other graphics”. The European average[17] of the utilization rate of recovered paper in the paper category “other graphic” is only 8.7 percent. This is very low.

3.1.3.2. Consumption of toner and inkjet cartridges

Toner and inkjet cartridges have a restricted mileage which is connected to the filling-quantity of the cartridges, toner size, and printer specifications (e.g. cleaning cycles for ink cartridges). There are various test standards for determining the efficiency of monochrome and (new) colour toner and ink consumption (see Section 1.2). There are technical differences related to toner and ink (and basic marking technology process) which influence the quality and efficiency of a resulting image. There is a difference for example if a one or two component toner is used. It is also important to understand the complete image creation process. There are for instance minus or plus charged toners which respective effects on the EP process. Task 4 will provide a detailed technical analysis regarding the EP and IJ process (technology), the composition and shape of toner and ink (substances), and other properties of toner particles and ink.

Following the draft report EICTA commented (27th April 2007): “The statement, ‘From an environmental and cost saving point of view it is advantageous to use recovered cartridges,’ is not supported, either within the text of the Task 3 report or by published studies. Published studies have indicated that neither original nor remanufactured cartridges have a distinct environmental advantage (First Environment, 2004), are a small fraction of environmental impact of the printing system (Berglind & Eriksson, 2002), and that remanufacture is only environmentally advantageous under certain circumstances (Huisman & Scheijgrond, 2004). Additionally, numerous reports and published articles have concluded that remanufactured cartridges do not provide an economic advantage, especially where printer output quality considerations are important.”

EICTA also recommend that the following text should be amended:

- “**Rebuild cartridges** are used cartridges where expendable parts have been exchanged, new toner material or ink is filled in and a new warranty is given. A toner cartridge can be remanufactured approximately seven times.”
- **Refilled cartridges** are used cartridges where new toner material or ink is filled in.

EICTA amended as follows:

[17] 19 countries of EU25 are covered, excluding Malta, Cyprus, Lithuania, Latvia, Estonia and Slovenia

- "**Remanufactured cartridges** are used cartridges where expendable parts have been exchanged, and new toner material or ink is filled in."

Warranties are not an inherent part of cartridge rebuilding, also known as remanufacturing. Indeed, to the best of our [EICTA] knowledge, not all remanufactured cartridges are covered by a manufacturer's warranty. Further, the statement that "a toner cartridge can be remanufactured approximately seven times," is not supported by industry practice. In fact, industry data strongly indicate that most cartridges that are remanufactured are only remanufactured a single time and then discarded. No statistical data were found on the share of remanufactured toner and inkjet cartridges used by consumers or professionals. There are only single estimates, stating that about 10 to 15 percent of cartridges are being remanufactured[18]. Estimations for the UK state higher amounts of remanufactured cartridges (24 % remanufactured, 5 % refilled[19]).

3.1.3.3. Ongoing research on toner particle emissions

In conjunction with toner-based office imaging equipment public attention is currently drawn to the topic of micro dust (particle) emission and related potential health risks. We are mentioning the particle emission issue at this point of the study because it is related to the user behavior topic. Although MEEuP methodology and EcoReport covers toxic emissions to air within the impact categories PAHs and Heavy Metals, the default values for toner do not measure particle emissions specifically. The pending scientific discussion regarding potential health risks related to particle emissions from toner-based office imaging equipment calls however for the precautionary principle. Acknowledging herewith the importance of the particle emission issue on the one hand, we have to acknowledge certain limits of the Lot 4 study on the other hand as well. In that respect the Lot 4 study cannot:

- Test or measure toner-related particle emissions
- Evaluate the results of ongoing research, and therefore
- Evaluate potential health risks

However, in order to be comprehensive we shortly outline legal requirements and the ongoing scientific discussion regarding micro dust (particle) emissions. Toners for laser printers, copiers and multifunctional devices undergo defined quality testing and are examined according to the assessment criteria for preparations of the European Union (Directive 1999/45/EC, as amended). This means that any toners classified as toxic, carcinogenic, mutagenic, toxic to reproduction or

[18] See e.g.: http://www.octopus-office.de/tinte/Barock_Pelikan_des_Ostens.178.98.html (retrieved in January 2007)
[19] See Market Transformation Programme; BNICT23: Waste considerations relating to printer cartridges (under review) (http://www.mtprog.com/ApprovedBriefingNotes/pdf.aspx?intBriefingNoteID=474)

sensitizing must by regulatory requirement be labeled as such. Toner-based electro-photographic printing and copying systems must comply with applicable and internationally recognized occupational safety standards. Accordingly, under intended conditions of use, potential device emissions such as ozone, styrene and particles are significantly below the German workplace limits (AGW, formerly MAK) and the emission limit values of the U.S. Occupational Safety and Health Administration (OSHA).

A recent study by the BGfA (German Research Institute for Occupational Medicine of the Institutions for Statutory Accident Insurance and Prevention), summarizes: "All studies show that copiers and printers mainly emit VOCs to the ambient air during operation. However, the measured indoor air concentrations are below the currently valid occupational limit values for the respective single substances approximately by the factor 100 to 1,000. Thus, almost all of the measured concentrations lie within the background exposure of the average population. People are inevitably exposed to these concentrations via the environment in form of dust exposure in apartments, or car traffic and industry emissions. According to current scientific knowledge, there are no additional occupational exposure to and hazard due to toner emissions, which exceed an already existent environmental exposure and hazard. In total, an additional health risk for occupationally exposed employees cannot be assumed on the basis of the existing measurements at the examined workplaces."

The VBG (German OSHA) concludes in their current brochure "Laser printers – recommendations for safer use": "All research results along with medical assessments lead to the following conclusion: a risk for health linked to the utilization of a laser printer at the working station is unlikely to occur when of course the specified normal operation and regular maintenance are fully respected". Early in 2007, the BfR (German Federal Institute for Risk Assessment), published preliminary results of their printing emissions pilot study, which was divided in two parts: measurement of indoor air quality during printing and a clinical examination. While the 1st part of the study concludes that it is "not possible to draw conclusions from first results about health problems due to toner emissions", the 2nd part summarizes its results under the headline "Clinical examination of test persons at office workplaces does not indicate special health problems due to toner emissions"[20].

[20] Both reports are available in full length at:
http://www.bfr.bund.de/cm/252/klinische_untersuchungen_von_probanden_an_bueroarbeitsplaetzen.pdf
http://www.bfr.bund.de/cm/252/pilotstudie_erste_ergebnisse_erlauben_keine_rueckschluesse_auf_gesundheitliche_probleme_durch_toner_emissionen.pdf

The latest input to the discussion was provided by a research from the Queensland University of Technology. According to the “Sidney Morning Harold” from 31st July 2007[21], the Queensland University’s International Laboratory for Air Quality and Health tested particle emission characteristics of office printers. The results are published in the American Chemical Society's Environmental Science and Technology Journal. Interesting is the statement of Professor Lidia Morawska that emission rates are printer-type specific and are affected by toner coverage and cartridge age. Printers emitted more particles when the toner cartridge was new and when greater quantities of toner were required. Again, Fraunhofer IZM cannot evaluate the results of the Australian study. But if such product and cartridge specific differences in particle emission would be confirmed in future research it would be adequate to analyze the technical design that leads to these emissions and therefore also design options (technologies) to minimize potential emissions in a separate study.

3.1.4. Best practice in sustainable product use

3.1.4.1. Automatic power management with short delay times

Whereas the enabling of power management functions seems to be self-explanatory it needs to be emphasized that it is important to balance the default delay times for ready and power saving modes in accordance to reactivation power requirements. There are many aspects that influence this balance. The general objective should be to reduce overall energy consumption. This means that the devices should automatically reduce the functional spectrum in order to save energy. The balance that has to be achieved between power consumption and functionality depends on the applied technology. The reduction of the intermediate mode’s time duration should be correlated according to the power consumption requirements per recovery time. Depending on the applied technology this aspect is variable. As indicated before, the thermal energy requirement of the fuser/fixing unit determines (50 to 70 %) the actual power consumption of EP-products. The recovery (reactivation) time depends on how the thermal energy is generated or maintained in the unit. The time delay from ready or sleep mode depends not only from the fuser technology (e.g. instant on fuser). Technical specifications of the fixing unit as well (e.g. drum material, thickness, insulation) determine for how long the thermal energy is kept in the fixing unit. If the thermal energy is maintained in the fixing unit for certain period of time, the reactivation is less energy intensive. These aspects have to be further investigated.

[21] http://www.smh.com.au/news/technology/printers-pose-serious-health-risks-study/2007/07/31/1185647873474.html

3.1.4.2. Usage of duplex functions in order to save paper

Especially in low speed classes the usage of duplex functions is still not wide spread. About half the used paper could be saved, a consequent usage of the duplex function presumed. As it is proven that the production of paper has a significant impact on the environment this measure seems to be very simple. EICTA commented on this part: It is correct to state that many consumers are not using duplex mode due to a lack of education. Indeed, it seems unrealistic to think that systematic use of duplex on low speed classes would save “half the used paper”. Consumers using low speed classes print often only texts, e-mails or web information being less than 2 pages long. Based on Lyra Research the first type document printed in the home (generally with low speed devices) are “short text documents”.

3.1.4.3. Usage of recycling and low weight paper

As the former point this practice aims at a reduction of the environmental impacts of paper consumption by reducing the amount used and reverting to recycling material: The production of recycled paper has a significant lower environmental impact than virgin paper.

3.2. End-of-Life Behaviour

3.2.1. Economical product life (= time to disposal)

In Section 2.2.2 the question of product life has already been discussed. Based on literature data, product life of imaging equipment was found to be between four and six years. Only little differentiation was found e.g. on speed classes and technologies. InfoTrends differentiates average life cycle and retirement period see Table 7 below.

Table 7: Average life cycle and retirement period of imaging equipment assumed by InfoTrends

	Life cycle	Retirement period	Matrix
EP Printer Mono	2-3 years	3-5 years	23 – 35
EP Printer Colour	2-3 years	4-5 years	24 – 35
Copier Mono	2-4 years	4-5 years	24 – 45
Copier Colour	2-3 years	4 years	24 – 34
IJ Printer	2-3 years	3-5 years	23 – 35
Facsimile Machine	2 years	4 years	24

For the purpose of this study we assume following product life times for imaging equipment.

3.2.1.1. EP Printers and EP Copiers (6 years)

Our perception is that monochrome EP printers in general are sold to businesses and stay in primary office use for 4 to 6 years. Due to the higher purchasing price of colour EP printers and EP

MFDs a longer lifetime seems feasible. On the other hand, the technical improvement in colour EP is still very dynamic, and a faster turnover could also be assumed. This concern was confirmed in interviews with manufacturers which indicated that colour machines have currently a shorter redesign cycle of two or three years in comparison to monochrome machines with a redesign of the main components between three and five years. In conclusion we will calculate a life time of 6 years on average for EP printers. The product life of EP copiers is somewhat more difficult to calculate. As a matter of fact, copiers are more often leased than sold. The conditions of the leasing scheme may vary largely between different manufacturers. Due to the closer contact of copier manufacturers to their products in the use phase a faster exchange of complete products or components from copiers has to be assumed. However, the redesign cycles for EP copiers have to be assumed similar to EP printers. Therefore we will calculate also a life time of 6 years on average for EP copiers.

3.2.1.2. Inkjet Printers, IJ MFDs and Flatbed Scanners (4 years)

Compared with the literature data and Table 7 above which indicate four to six years average life time of IJ products, statements from industry make believe that inkjet printers for private and business use have a considerably shorter time in primary service of only three years. Still it is expected that it takes another three years until the printer is disposed of, adding up to an overall time of ownership of about six years. Second hand markets are negligible. The redesign cycles of IJ printers, IJ based MFD, and flatbed scanners had been approximately two years in the past. Miniaturization of hardware (e.g. print heads, engines, scanners, and main electronics), new interfaces, and continuous improvements in software are the main driver of these shorter redesign cycles. This development will probably continue. We therefore assume a life time of 4 years on average for IJ products.

3.2.1.3. Facsimile Machines (8 years)

In the literature the lifetime of facsimile machines are estimated to be four to six years. These figures are quite low for our perspective. We discussed this issue with industry, which confirmed our observation. One argument was that MFDs with fax functionality might have been included in the calculation, or that the recent introduction of such devices altered the data towards a shorter use period. Against existing data from literature we will therefore assume a life time of 8 years on average for facsimile machines.

3.2.2. Repair and Maintenance

Concerning repair and maintenance two main aspects have to be differentiated:

- Price of new devices
- Business model

Furthermore a differentiation of EP and IJ devices is necessary. As a consequence of decreasing sales prices of new devices repair and maintenance appears to be of less importance in general. Statements from industry make believe that repair and maintenance is of no importance for inkjet printers and flatbed scanners due to low prices of new products. If this is really the case also regarding more expensive inkjet MFDs or facsimile machines has to be questioned. Repair and maintenance however is in contrast to inkjet more likely an issue for EP printers and particularly copiers although reliability improvements are a key issue in product design. Industry comments indicated that design for reliability has a very high priority in order to reduce service calls, spares and improve consumer satisfaction. EP products are of much higher value and sales prices are not decreasing as rapidly. EP products are also more frequently applied in business environments and less in private home environment. This situation allows two typical business models – leasing and selling. Devices that are leased tend to be maintained intensively by the provider. Leasing is a typical business model for more expensive copiers and printers. Copier-based machines with an open system need regular cleaning due to soiling tendencies. EP printers are on the other hand more frequently sold because maintenance is less laborious in comparison to copiers.

EICTA comment on this issue: “The level of contamination is mainly related to the number of copies or prints. This means that every product has to be regularly cleaned/maintained, but in terms of time this needs to be done sooner for high-end products (service, maintenance and cleaning mostly part of the contract) than for low-end products (often no maintenance contract available, especially in case of private consumers)”. EICTA also indicated that: “leasing is mostly applied for high-end products (not only copiers) and/or large customers (many placements and high volume).” The print volume is the critical point in maintenance.

3.2.3. Discarded Devices and Recycling Issues

Imaging equipment for private use are collected and recycled at the end of their life according to WEEE. Müller and Giegrich (2005) calculated that about 4,000 tons per year electronic waste are to be expected from printers alone in Germany (private and business environment). A rough extrapolation on the basis of the population size leads to an estimation of about 22,000 tons per year electronic waste from printers in EU-25.

3.2.3.1. Private (home) usage

Producers usually don't know what happens to the consumer products during use phase and at the end-of-life. Usually there is no connection between producer and product after the products leave the production site. That way there are almost no incentives for a good design for disassembly and recycling for producers. A different situation occurs in a B2B environment.

3.2.3.2. Business(office) usage

As indicated before, the leasing of devices, e.g. of copiers, is connected with a close relation of producers and their products over the whole life cycle. As the value of both – materials and components – is high and the producers manage their products themselves, they are highly stimulated to optimize their product design concerning the reusability of components and materials and to practice reuse and recycling. This optimization supports in most cases a cost efficient manufacturing process. For sold devices the connection between producers and products is less close over the product life cycle. Still it might be advantageous for producers to offer a take back system when selling new business products especially if larger amounts are purchased. A survey from 1999 for Germany showed that only 23 percent of vendors (Retailer and producers) offered to take back used devices (VZ NRW 1999). This should have been increased according to WEEE. Some companies have their own programs. Hewlett Packard (HP) e.g. stated in its 2006 Global Citizenship report that the combined recycling and reuse rate had been 10.3 percent of all sold products for fiscal year 2005.

EICTA added the statement: "For some products it is thinkable that they are replaced well before their technical life-time or that of some of the components is over. Replacement may occur for a number of reasons. In those cases where the replaced product still has significant value in terms of materials, components or even the entire product (except maybe for wear-sensitive parts), secured collection of the used products, reconditioning of the used products, remanufacturing, reusing the used components, and material recycling should be promoted. As an example you could think of the situation where a leased product is replaced after only 2 – 3 years, whereas the actual product life is 5 years. In this case the product may cause additional pollution beyond what was expected, unless there is secure collection of these used products, as well as subsequent reconditioning of the used products, or remanufacturing, or reuse of the used components, and/or material recycling."

3.2.4. Estimated second hand use

The relevance of the second hand market for imaging devices in EU-25 is difficult to judge as almost no data were available. Still two main aspects of the second hand use could be identified:

- Markets for refurbished products or devices containing second hand components
- Markets for second hand devices

3.2.4.1. Markets for refurbished products

Some manufacturers refurbish used imaging devices and sell them again with full guarantee or use single used components in new products (e.g. Canon (2006), HP (2006)): Canon e.g. states in its Sustainability Report 2006 “Remanufacturing allows up to 89 percent of parts and materials (by weight) to be reused in products that have the same performance and reliability as new products.” This strategy is followed for some business products like copiers or multifunctional devices. But even though a full guarantee is given, some customers still prefer completely virgin products.

3.2.4.2. Markets for second hand devices

Due to low prices of new consumer products industry does not see a significant second hand market within EU-25. Used devices are rather expected to get exported to non-EU second hand markets e.g. in Russia or Africa. No data were available on the amount of used products being exported. For business products some manufacturers offer donation programs (HP 2006) or support for selling used products (e.g. Rethink Initiative of HP and eBay).

3.3. Local infrastructure

3.3.1. Network Imaging Equipment

From an environmental point of view as well as from cost perspective it makes sense to integrate imaging equipment such as printer and copier MFDs in larger networks, giving a group of people access to one device. Small workgroups consist of up to 24 people whereas larger workgroups consist of up to 100 people. Network printing in offices is very efficient because of the potentially high utilization of single imaging equipment. But there are some issues which reduce this efficiency. There is empirical evidence (e.g. Busch 2006) that some types of imaging devices are not able to enter low power mode when integrated in a computer network. The reason is that responsible servers regularly check the network components that way awakening ineligible printers, copiers and scanners and preventing them from staying in low power modes. This aspect should be investigated more thoroughly throughout the study.

EICTA believes that: “most products currently in the market do not perform in this manner, nor are we aware of any competing products that come out of sleep mode due to basic server activity”.
After further discussion with industry it seems that such problems occurred with older product generations. An extensive field study would be necessary to confirm if such an issue is still relevant. We assume that it is not an issue of modern products.

The reliability of the electric grid seems of only limited relevance. The installation of uninterruptible power supplies (UPS) as a consequence of an unreliable electric grid at the most if at all would be relevant for large devices with high speed for special purposes (difference to computers/servers).

3.3.2. Commercial Copy and Print Services

The availability of copy shops, photo print out facilities in drugstores etc. might have a limited influence on the amount of imaging equipment of private households. Imaging equipment in copy shops are usually the same machines as in offices. They are of varying speed although professional equipment can be found. The intensive utilization of machines in copy shops results in fast “wear and tear” which is partially compensated through continuous maintenance of service personnel.

3.4. Literature

Aebischer 1997 Aebischer, Bernar. Co-operative Procurement of Innovative Copiers. Sustainable energy opportunities for a greater Europe (the energy efficiency challenge for Europe). 1997 ECEEE summer study, Spindlerův Mlýn , Tcheque Republic. 9-14 June 1997

Bush 2006 Bush, Eric. Marktcheck elektronische Geräte. Swiss Alpine Laboratories for Testing of Energy Efficiency (S.A.L.T.). Chur. 2006

Canon 2006 Sustainability Report 2006. Canon. 2006

Cremer et al. 2003 Cremer et al.; Der Einfluss moderner Gerätegenerationen der Informations- und Kommunikationstechnik auf den Energieverbrauch in Deutschland bis zum Jahr 2010 – Möglichkeiten zur Erhöhung der Energieeffizienz und zur Energieeinsparung in diesen Bereichen. Projektnummer 28/01. Abschlussbericht an das Bundesministerium für Wirtschaft und Arbeit. Karlsruhe, Zürich 2003.

EPRC 2005 European Recovered Paper Council. The European declaration on paper recycling – annual report 2004. 2005

EU 2005 The attitudes of European citizens towards environment. Fieldwork November 2004. Special Eurobarometer 217 / Wave 62.1 – TNS Opinion & Social. 2005

Graff and Fishbein 1991 Graff, R.; FishbeinGraff, B.. Reducing office paper waste. INFORM. New York

Graulich 2007 Graulich K.; Drucker als EcoTopTen-Produkte. Produkt-Nachhaltigkeitsanalyse (PROSA) von Druckern und Ableitung von Kriterien für die EcoTopTen-Verbraucherinformationskampagne. Freiburg. 2007

HP 2006 Global Citizenship Report 2006. Hewlett Packard. 2006

Müller and Giegrich 2005 Müller, B.; Giegrich, J.. Beitrag der Abfallwirtschaft zur nachhaltigen Entwicklung in Deutschland Fallbeispiel Elektro- und Elektronikaltgeräte. Institut für Energie- und Umweltforschung GmbH. Heidelberg. 2005

Kawamoto 2001 Kaoru Kawamoto, Jonathan G. Koomey, Bruce Nordman, Richard E. Brown, Mary Ann Piette, Michael Ting, and Alan K. Meier. Electricity Used by Office Equipment and Network Equipment in the U.S.: Detailed Report and Appendices Energy Analysis Department Environmental

Energy Technologies Division Ernest Orlando Lawrence Berkeley National Laboratory Universit y of California Berkeley. 2001

Meyer & Schaltegger 1999 Meyer and Schaltegger. Bestimmung des Energieverbrauchs von Unterhaltungselektronikgeraeten, Buerogeraeten und Automaten in der Schweitz", Report from Research Programme, Communication and Information Systems, Swiss Federal Office of Energy, Berne, Switzerland.. 1999

NAEEC 2003a The National Appliance and Equipment Energy Efficiency Committee (NAEEC). Product Profile – Computer Printers. Government of Australia. 2003

NAEEC 2003b The National Appliance and Equipment Energy Efficiency Committee (NAEEC). Product Profile - Scanner, MFDs. Government of Australia. 2003

NAEEC 2003c The National Appliance and Equipment Energy Efficiency Committee (NAEEC). Product Profile - Photocopiers. Government of Australia. 2003

Nordman et al. 1998 Nordman, Bruce; Piette, Mary Ann; Pon, Brian; Kinney, Kristopher. It's midnight … Is your copier on?: Energy star copier performance. LBNL-41332 UC-1600. Energy Technologies division. Lawrence Berkeley National Laboratory . University of California. Berkley 1998.

Puhe 2001 Puhe, Henry. Bevölkerungsrepräsentative Studie zum Urheberrechtsschutz bei PC-Druckern. Institut für Sozialforschung und Kommunikation. Bielefeld. 2001

Ritter et al. 2003 Ritter, Herbert; Schäppi, Bernd; Reichel, Franz. Marktanalyse zur Verbreitung und Nutzung der Energieeffizienz-Kennzeichnung Energy Star in Österreich. Im Auftrag des Bundesministeriums für Wirtschaft und Arbeit. .Wien 2003

Roth et al. 2002 Roth, Kurt W.; Larocque, Gerald R.; Kleinman, Jonathan. Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings. Vol. I: Energy Consumption Baseline. TIAX LLC, Cambrigde, MA. 2002

Roth et al. 2004 Roth, Kurt W.; Larocque, Gerald R.; Kleinman, Jonathan. Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings. Vol. II: Energy Saving Potentials. Arthur D. Little Inc. Cambridge, MA. 2004

Schlomann et al. 2005 Schlomann, B.; Cremer, C.; Friedewald, M.; Georgieff, P.; Gruber, E.; Corradini, R.; Kraus, D.; Arndt, U.; Mauch, W.; Schaefer, H.; Schulte, M.; Schröder, R..Technische und rechtliche Anwendungsmöglichkeiten einer verpflichtenden Kennzeichnung des Leerlaufverbrauchs strombetriebener Haushalts- und Bürogeräte. Karlsruhe, München, Dresden. April 2005

Seidel 2006 — Seidel, Michael. Presentation AG 3: Visionen. In Innovationsmotor Informations- und Kommunikationstechnologie – Dynamik auch für die Ressourcenschonung. Umweltbundesamt. 29.11. 2006

StiWa 2003 — Stiftung Warentest. „Starke Konkurrenz“. test 11/2003

VZ NRW 1999 — Verbraucherzentrale NRW. Entsorgungswegweiser Elektronikschrott. Umfrage der Verbraucherzentrale NRW bei Herstellern und großen Anbietern. 1999