European Energy Efficiency Improvement by means of Visualisation and Benchmarking tailored to the Print and Media Industry

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The objective of the European Energy Efficiency Improvement (EEEI) Project is to raise awareness on energy topics within the print and media industry on the European scale. As a start, an EU-wide inventory has been conducted, where directives on energy efficiency and a review of main literature has been included. This is completed by gathering best practice on energy efficiency in the sector. The whole survey is the base for the development of a set of tools which can help to remove observed barriers that inhibit efficiency improvement in small and media sized enterprises. The main tool is named E-BAG (Energy Benchmark Analyzer for Graphic Media) which elaborates benchmark results from a database.

To get beyond the level of awareness improvement, current approaches concerning benchmarking are extended by a system of more detailed sector specific key figures and visualisation methods.

1 Introduction

Energy is fundamental for our lives and substantiates all the functioning of society. Over the last few decades, the energy sector has changed drastically. The ever-increasing demand for energy, soaring oil prices, uncertain energy supplies from some areas of the world and fears of global warming are all challenges that are currently subjects of intense debate [Eurobarometer, 2006].

Topics concerning environmental protection like water and air pollution are also at the centre of international interest. In this regard is the printing industry is already leading. This is demonstrated in numerous innovations, which have led to considerable changes in the different printing techniques over the last few decades. Today, many processes are much more environmentally friendly than even 30 years ago. For the production of the same printing product fewer chemicals are needed. In addition environmentally friendly inks, additives as well as cleaning agents are available. Actual, printing plants were among the first that introduced ecological management systems.

Thus, it seems an obvious step to make the lowering of energy consumption, due to rising energy costs and global warming, a priority.

The EEEI-study bases on an extended survey among the graphic arts industry in the following five European countries: The Czech Republic, Germany, Greece, Hungary and the Netherlands. In this survey, the issues of environmental protection, energy consumption and its reduction as well as the management procedures on energy efficiency are investigated.

All collected data has been used for the development of tailored tools, which exactly fit to the graphic arts sector, to reach the objectives of the EEEI-study: A potential direct annual emission reduction of CO2 and an annual saving of energy and energy costs. Saving overall 500.000 € has been the concrete aim, within the scope of the project which started on January 2007 and ended March 2009.

Specific information to achieve the energy efficiency objectives are provided in form of benchmark tools that include operational and ecological key data. It is advantageous to compare the key data of different companies within such a benchmarking system, because each print facility has different job specifications and individual local circumstances. But benchmarking provides great advantages, especially if transparent key data and indicators can be obtained. These need to be detailed enough to describe comparable components in apparently different circumstances.

A list of measures outlines all best practices that have been found during the research. This list includes detailed information about measures to help SMEs in the European Graphic Media Industry to rid themselves of still existing barriers concerning energy efficiency improvement.

2 Literature

The review of the relevant main literature shows a wide spread spectrum on benchmarking approaches. Energy benchmarking has an exceptional position in this context. Therefore, benchmarking in general, benchmarking on environmental aspects and benchmarking on energy aspects are differentiated to each other in the following. Finally, approaches concerning benchmarking on energy aspects tailored to the print and media industry are introduced.

2.1 Benchmarking in general

David T. Kearns, CEO of Xerox Corporation announced that Benchmarking is the continuous process of measuring products, services and practices against the toughest competitors or those companies recognized as industry leaders.

Additionally to this continuousness in the process, G. Siebert and S. Kempf consider the "Goal setting" and the "Implementation" of measures within their benchmarking approach [Siebert&Kempf, 2000] (figure 7).

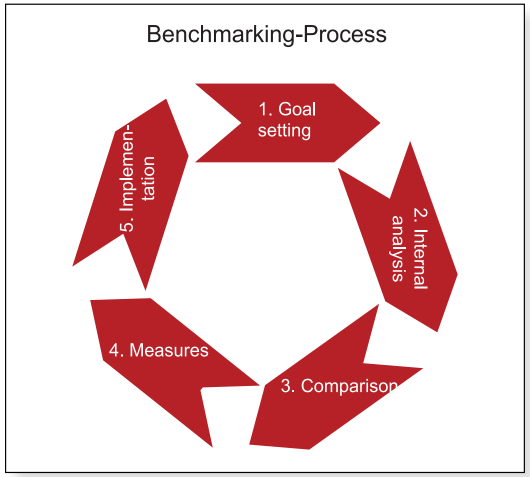


Figure1: Continuousness in the Benchmarking-Process, based on [Siebert &Kempf, 2000]

This general approach of G. Siebert and S. Kempf describes Benchmarking very well, but an international background is not included.

2.2 Benchmarking on Environmental Aspects

The German Öko-Institut e.V. developed an application-oriented approach, which mainly focuses on environmental key figures. Energy is also named as an important aspect, but it is discussed only on the basis of one single key figure (Total energy consumption per product) [Tebert, 2003]. Furthermore, Tebert's approach does also not consider international aspects.

2.3 Benchmarking concerning Energy

The research of C. Schmid points out that energy benchmarking bases on a comparative analysis of energy use per unit of physical production or specific energy consumption. Furthermore, cross sectional technologies are differentiated against sector-specific technologies [Schmid, 2004]. Cross sectional technologies, like space heating or compressed air, are in this context technologies that are not solely related to a single sector.

Energy benchmarking comprises the collection, analysis and reporting of data to provide companies with a context for assessing its energy efficiency in comparison to others of the same sector. In addition to technical factors, this benchmarking can be applied to energy management systems to evaluate how far a company has progressed in its efforts compared to other companies.

In the BESS-research (Benchmarking and Energy management Schemes in SMEs) a web-based tool for international benchmarking for selected sectors within the European industry was developed. This application offers options for different key figure adjustments: boiler efficiency, climate, production utilization and production mix [BESS, 2004].

The approach of Schmid is not sector specific. The approach of BESS is sector specific and international construed, but the print and media industry is not sufficiently included: All products have to be defined by using an international standard like the PRODCOM list. This list has been developed for the collection and dissemination of statistics on the production of manufactured goods [eurostat, 2009]. But it is concerning printing products too roughly.

2.4 Energy-Benchmarking for to the Print and Media Industry

The Deutsche Energie Agentur (DENA) in cooperation with the Bremer Energie-Konsens GmbH has developed the only web based benchmarking tool, which seems to consider the print and media industry. But this tool operates only on national level and does not differentiate the print and media industry against the paper industry [DENA, 2009], where totally different amounts of energy are needed determined by the production. Furthermore, no sector specific key figures are included.

3 EU-wide Inventory
To improve and modify these Benchmarking approaches to the print and media sector and the extension to the European level, an EU-wide inventory has been conducted. Points of this basis inventory are an overview about current directives concerning energy and greenhouse gas emission, different starting positions of the companies within the European countries and current approaches on benchmarking.

3.1 Directives
Nearly all governments in the world decreed regulations or participate in international agreements to promote a sustainable energy management and an eco-friendly economy.

The Kyoto Protocol is an agreement resolved by the United Nations Framework Convention on Climate Change (UNFCCC). Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain. The Kyoto Protocol covers more than 160 countries globally and more than 60% of countries in terms of global greenhouse gas emissions. Kyoto is a 'cap and trade' system that imposes national caps on the emissions of countries. On average, this cap requires countries to reduce their emissions by 5.2% compared to their baseline set in 1990 over the time period 2008

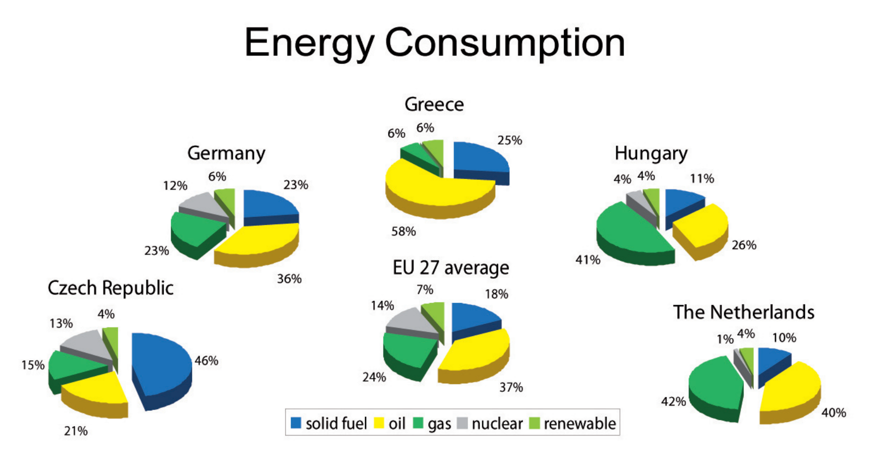


Figure 2:
Exemplified country specific Primary Energy supply 2006 in relation to each other, based on [eurostat, 2009]

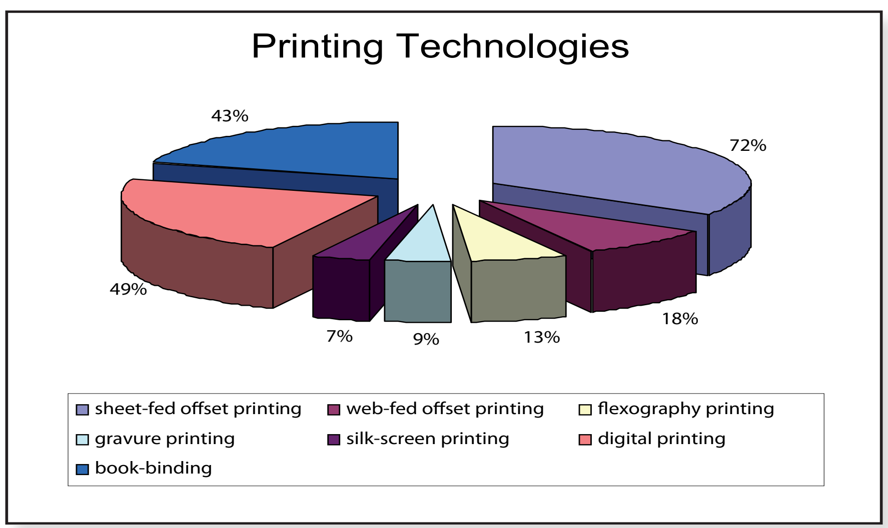


Figure 3:
Typical distribution of enterprise sizes in European countries in %, based on [Dattner&Silber, 2007]

to 2012. Although these caps are national-level commitments, in practice most countries have developed their emissions targets for individual industries, such as power plants or paper factories to reach this objective.

The Eco-Management and Audit Scheme (EMAS II) is the EU voluntary instrument which acknowledges organisations that continuously improve their environmental performance. EMAS registered organisations run an environmental management system and report on their environmental performance through the publication of an independently verified environmental statement.

The ISO/EN ISO 14001 is a European wide accepted standard that describes how to implement an effective Environmental Management System (EMS). This standard is designed to address the delicate balance between maintaining profitability and reducing environmental impact. A comprehensive package of policy measures to reduce greenhouse gas emissions has been initiated through the European Climate Change Program. The immediate objective of the ECCP is to ensure that the EU meets its objectives concerning the reduction of emissions constituted by the Kyoto Protocol.

Figure 4:
Typical distributions of enterprise sizes in European countries, exemplified by Greece and Germany, based on [Dattner&Silber, 2007]

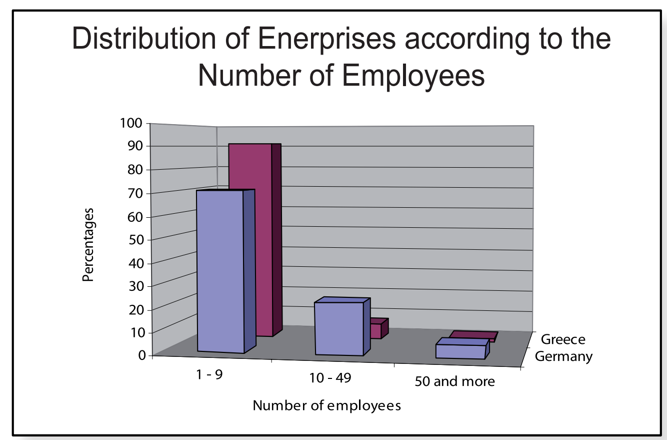


Figure 4 shows the country specific percentage values of the given answers to the questions:
- "Are you interested in ecological products?" (red bars: Answer "Yes")
- "Is your yearly energy consumption in MWh available?" (white bars: Answer "No")
- "Are your customers interested in ecological products?" (blue bars: Answer "Yes")

3.2 Starting Positions
To get a resilient benchmark, all the mentioned directives on EU- and country-level have to be regarded. Furthermore, the very unbalanced starting situation of companies in different countries has to be considered: Variances in the country specific Primary Energy Supply, in the distribution of printing technologies and company sizes, in the awareness on energy and in the climate situation are shown below.

3.2.1 Primary Energy Supply / Distribution of printing technologies
The EEEI-study shows an individual Primary Energy Supply for each regarded country (figure 1). These variances also exist in the distribution of printing technologies.

Sheet-fed offset printing is the dominant printing technology, followed by digital printing and book-binding installations (figure 2). The overall sum of 211% is caused by the multiple technologies that are used in 70% of all asked companies in the EEEI-Questionnaire (introduced in 3.2.3).

3.2.2 Company Sizes
Micro and small sized enterprises are EU-wide the dominant company sizes.

Figure 3 shows the two typical distributions of companies in the print and media sector. With Greece and Germany it is possible to show exemplary the differences in the participating countries: In the Netherlands and in Germany enterprises with 1 to 9 employees are dominant but there are some more enterprises with 10 to 49 employees compared to Greece, Hungary and the Czech Republic [Dattner&Silber, 2007].

3.2.3 Awareness on Energy on Company Level
Also the following cut-out of the questionnaire analysis, points out the very unbalanced starting situations in different countries. In total 77 graphic media companies in the five participating countries took part in the EEEI-Questionnaire study [EEEI, 2009]. In order to generate comparable answers, only questions that can be answered with "yes", "no" or "intended" were used. The twenty-two questions concerning energy efficiency and environmental matters are divided into three topics: General and technical questions and questions about the management structure and objectives [Dattner&Politis, 2007].

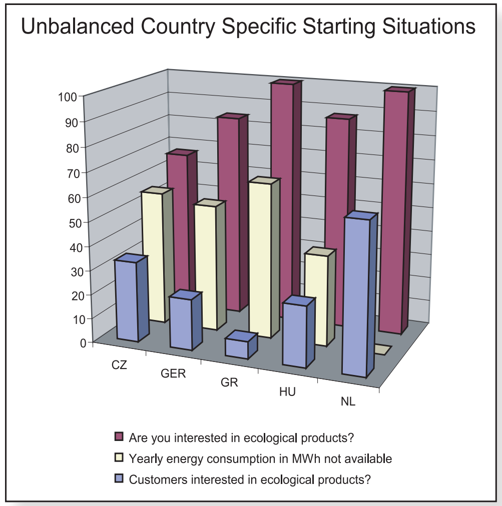


Figure 5: Exemplified percentage values of the given answers to the EEEI-Questionnaire, based on [Dattner&Silber, 2007]

Figure 6:
Answers given to the EEEI-Questionnaire concerning Energy Efficiency Possibilities, based on [Dattner&Silber, 2007]

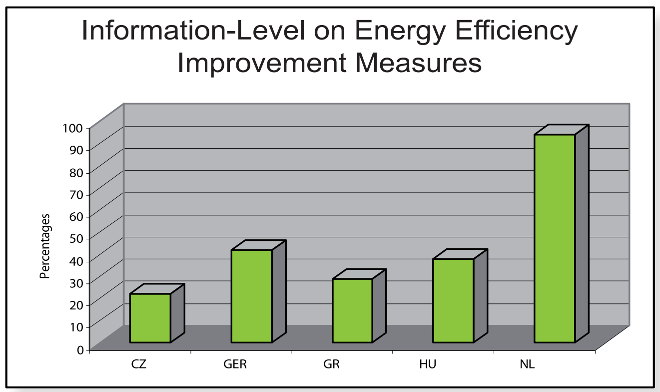
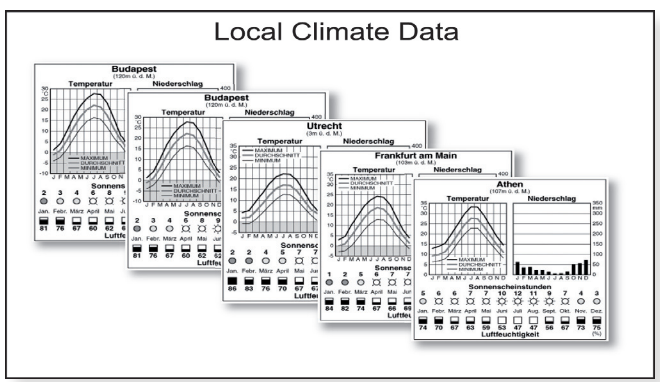


Figure 7:
Exemplified climate data, based on http://www.axodia.info



Even the answers given to these three questions show the very unequal starting situations. But most important are the answers given to the question concerning energy efficiency improvement possibilities (figure 5). Obviously, the Dutch "Millieu- en energiebesparingsplan voor Grafimedia" is well established in this country [Dattner&Silber, 2007]. This paragraph was added 1996 to the Environmental Policy Agreement (MBO) in the Netherlands and progresses the interest in and the possibilities to improve energy efficiency in this country.

3.2.4 Local Climate Data

The differences in the local climate in Europe, within the itemised countries and even from town to town are apparently (figure 6). To compare the energy consumption of companies for e.g. air conditioning, it is essential to consider regionally relevant meteorological factors for calculating heating degree-days (HDD) or cooling degree-days (CDD). These values are available at weather-stations or at governmental associations and can be used in adjustment parameters for benchmarking, that will be introduced in chapter 4.2.

4 EEEI-Benchmarking

The overview about existing literature concerning benchmarking and the consideration of the EU-inventory shows that additional approaches are required to realise a sufficient EU-wide energy benchmarking to improve the awareness on energy topics.

The main basis for this article is the web-based "Energy Benchmark Analyzer for Graphic Media" (E-BAG) tool of the EEEI-project. This tool enables an international benchmarking of European print and media companies. The E-BAG was tested by more than 100 pilot companies [EEEI, 2009].

Particularly, the product range and the corresponding, individual energy demand for the production vary very much in the print and media industry. Therefore, the matching with international standards like the PRODCOM or NACE (Nomenclature statistique des activités économiques dans la Communauté Européenne) lists are not sufficient, but print-technology-specific key figures enable this EEEI-benchmark. Additional adjustment parameters like the climate parameter or the productivity parameter are included and will be discussed in chapter 4.2.

4.1 EEEI Key Figures

All in all 18 energy key figures have been developed. Eleven of them belong to cross sectional technologies and seven are entirely sector-specific. But even the cross sectional key figures are only used print technology specific. This is due to the varying conditions in companies caused by the different types of installed print technologies. Exemplified values of a test company are shown in figure 8. Average value, best value and the individual value are presented concerning every key figure next to the ranking position in the colour bar. Adjustment factors like the climate parameter or the productivity parameter are included in the calculations.

Figure 8: Cut-out of the EEEI-Benchmarking key-figures, based on [EEEI, 2009]

It follows the full list of developed key figures with explanations for selected key figures.

4.1.1 Cross Sectional Key Figures

To the cross sectional key figures belong "Lightning", "Space heating", "Space cooling", "Ventilation", "Office equipment", "Internal transport", "Air pressure", "Shredder", "Fuel use per building volume", "Costs per floor area" and "CO2-emission per MegaJoul (MJ) total energy".

"Lightning" has still a very high saving potential. This key figure is easy to evaluate and measures are simple to implement [EEEI-conference, 2009]. For the calculation, the installed power for lightning, the company operating hours and the total floor area are required.

"Space heating" is a very tailored key figure because the individual influences of the different printing technologies on the heating situation are considered. Because of the climate parameter (cf. 4.2.2) the international approach is preserved. Data about the fuel use, the building volume and the HDDs is required for the calculation.

"CO2-emission per MJ total energy" is an important key figure because it is the link to environmental aspects in general. The calculation requires the total energy use and the individual conversation factor, which considers all primary energy sources separately.

4.1.2 Sector-Specific Key Figures

To the sector specific key figures belong "Total energy consumption per working hour and square meter produced product", "Total energy consumption per kilogram (kg) product", "Water use per kg product", "Space humidification", "Production", "Drying in production" and "Cooling in production".

"Total energy consumption per working hour and square meter produced product" is a very transparent key figure because it creates a direct connection between the production output and the energy consumption. Data about the total energy consumption, the amount of produced product in m² and the total working hours of the employees is required for the calculation.

"Drying in production" bases on the installed electrical power of the drying system and the system operating hours. If a gas drying system is installed, the gas consumption is converted into electrical consumption values. If no drying system is installed, a standard value is set.

The consideration of companies with more than one installed printing technology is (only) included by choosing the main technology with the corresponding adapted productivity parameter.

4.2 EEEI Adjustment Parameters

All introduced sector-specific key figures are calculated by considering a productivity parameter, while cross sectional key figures like heating and cooling base on a climate parameter, which are explained in the following.

4.2.1 Productivity Parameter

This parameter allows the consideration of the actual power consumption of the machinery without conspicuous measurements. This parameter only bases on the maximum installed power and the experience of an energy expert. Parameter values can be between 0 and 100%. With 65% for e.g. sheet fed offset [EEEI, 2009].

4.2.2 Climate Parameter

This climate parameter corresponds directly to the local HDDs and CDDs (cf. 2.2.4). These values are included as weighting factors for the key figures "Space heating" and "Space cooling". Therefore, the fuel use for heating in any company can be compared to all other companies independent of the company's site. This issue is very important for this international approach.

4.3 EEEI-Measure List

A list of measures outlines all best practices that have been found during the EEEI-research. In contrast to the DENA-approach (cf. 2.4), which only considers cross-sectional key figures and therefore only cross-sectional measures; this list includes also sector-specific measures. It includes detailed information to help SMEs in the European Graphic Media Industry to rid themselves of still existing barriers concerning energy efficiency improvement [EEEI-conference, 2009].

5 Results

To get beyond the level of awareness improvement, which has already been realised by the EEEI-Benchmarking, the system of sector specific key figures has to be extended. This Extended EEEI-Benchmarking is realised by expanding the EEEI key figures in terms of additional levels and more detailed data requirements. Additional adjustment factors will be introduced and more visualisation methods will be included. Furthermore, the consideration of companies with more than one installed printing technology (about 70% cf. 3.2.1) is included without the need for choosing the main technology. This is done by the differentiation of all technology specific energy data with no need for a corresponding productivity parameter.

To consolidate this extension, the different levels of available information need to be considered.

5.1 Consideration of the Level of Information

The level of detail of available information concerning energy data varies very strongly between companies. Some companies are not able to distinguish between the energy consumption of the administration division and of the production division [Dattner&Silber, 2007]; these companies belong to level one in figure 9.

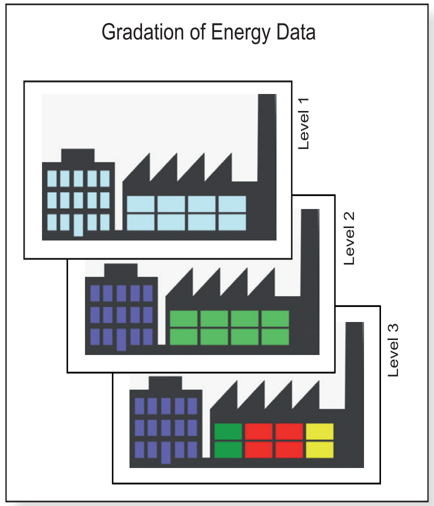


Figure 9: Gradation of the detail level of energy data available in companies, based on [Dattner&Silber, 2007]

Companies of level two and three have accordingly a better data overview [Dattner&Silber, 2007]. They should be able to compare themselves with companies on the corresponding level. To keep the comparability of the benchmarking, it has also to be built up as a multi-level system.

The multi-level problem definition is exemplified concerning "Drying-Technology" in figure 10. Additionally to "Drying installed" or "no drying" it is differentiated between "UV-drying" and "IR-drying". This multi-level approach makes it possible for the companies to benchmark themselves only against full comparable competitors.

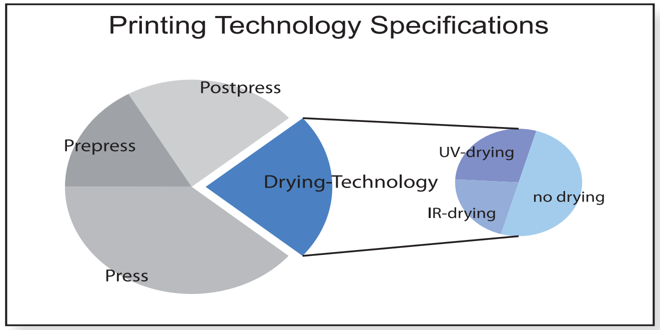


Figure 10: Multi-level differentiation shown at Drying-Technology

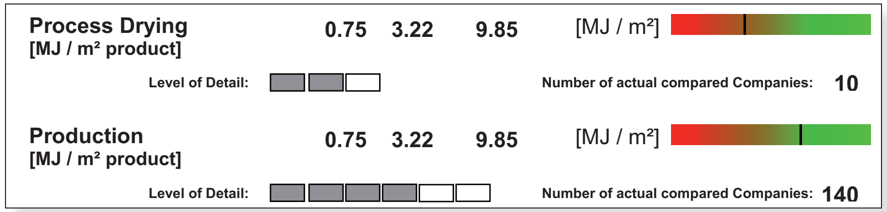


Figure 11: Extended Benchmarking

5.2 Extended Key Figures

According to the introduced multi-level-of-information approach the key figures have to be adapted. Notice that with more detailed key figures the corresponding data base becomes less extensive. Therefore, the number of actual compared companies has to be presented concerning every key figure next to the level of detail (figure 11). This is important to document the sustainability of the evaluation.

With the level of detail the level of interpretation complexity increases. These extensions and possibilities are exemplified in the following by several key figures belonging to cross sectional and sector-specific technologies.

5.2.1 Extended Cross-Sectional Key Figure

Considering cross sectional key figures "Space heating" and "Compressed air" will be exemplified.

Table 1: Key figure "Space heating" with its stages of extension

Space heating [MJ / m²]		
Available data	Estimated effort	Suitability
heat energy, room volume, print technology	low	suitable to only a limited extent
heat energy, room volume, print technology, installed drying technology	low	suitable
heat energy, room volume, print technology, installed drying technology, heat recovery	high	very suitable

The suitability of the key figure "Space heating" depends directly on the level of information (table 1): Close mesh HDD data is essential for a European comparison, because of varying climate conditions even on very local level. This data should be automatically generated in the system, only by considering the company's site. Furthermore, the company operation hours need to be considered, because key figure values of single shift companies would be otherwise compared to values of multi shift companies without any adjustment.

If information about fuel use, building volume and the main printing technology are available in addition to the HDD data and the company's shift form, the key figure is still only suitable to a limited extent. This is due to missing information concerning installed drying systems and heat recovery systems, respectively. Therefore, this extra information is considered in the superior levels which leads to a higher effort in the data generation.

If a heat recovery system is installed, the amount of recovered energy has to be taken into account e.g. at the key figure "Space heating". Notice that the amount of recovered energy must not be considered at the key figure, where the heat appears (e.g. "Drying in process"), it has to be evaluated where this energy is reused and needs to be considered at this point.

Compressed air [MJ / m²]		
Available data	Estimated effort	Suitability
installed electrical power, print technology, company working hours	low	suitable to only a limited extent
installed electrical power, print technology, company working hours, amount of printed product	low	suitable to only a limited extent
Actual electrical consumption, amount of printed product, print technology, compressor load	average (special measure equipment needed)	very suitable
Available data of companies with more than one print technology		
Actual electrical consumption, print technology specific printed area product, print technology, compressor load,	high (special measure equipment needed)	suitable to only a limited extent
Actual electrical consumption, , print technology specific printed area product,, print technology, compressor load, Actual print technology specific usage of compressed air	very high (special measure equipment needed)	very suitable

Table 2:
Key figure "Compressed air" with its stages of extension

The key figure "Compressed air" has five layers of extension (table 2). Is the installed power for compressed air, the printing technology and the operating time known, this key figure is suitable to only a limited extent. Is additionally the amount of produced product known, the suitability of this key figure is improved. With more detailed information concerning the compressor load (cf. 5.3.3) and the actual needed electrical power, this key figure becomes even more suitable. But specific measurement equipment is needed. Therefore, the effort for generating required data rises.

If more than one printing technology is installed, this can be considered by generating technology specific data. This suitability can only be improved by data concerning the actual and technology specific energy usage. This key figure shows the individual values with a high suitability for each printing technology, if the workload parameter (cf. 5.3.1) is considered. Thus, the comparability of this key figure is preserved also to single technology companies with the corresponding technology.

5.2.2 Extended Sector-Specific Key Figures

Table 3:
Key figure "Production" with its stages of extension

Production [MJ / m²]		
Available data	Estimated effort	Suitability
installed electrical power, amount of printed product, productivity parameter	high	suitable to only a limited extent
amount of printed product, actual electrical consumption	average (special measure equipment needed)	suitable
amount of printed product, actual electrical consumption, separated post press division	high	suitable
amount of printed product, actual electrical consumption, separated post press division, workload parameter	high	very suitable
Available data of companies with more than one print technology		
print technology specific data about the printed area as well as the actual electrical consumption	average (special measure equipment needed)	suitable
print technology specific data about the printed area as well as the actual electrical consumption, without post press division, print technology specific data about the workload parameter	high (special measure equipment needed)	Very suitable

The key figure "Production" has six layers of detail (table 3). On the lowest layer, only the installed power and the productivity parameter (cf. 4.2.1) are needed as input. The suitability is depending directly on the qualification of an energy expert. To avoid this element of uncertainty, all needed data has to be evaluated by measurements of the actual energy usage: The 2nd layer of detail. The internal effort for generating required data rises, but no external consultant is needed anymore.

By detaching the printing process from the post press division, the suitability of this key figure increases further. The energy use of the post press division in companies is very individual. But if mapped, an additional separated key figure can be introduced concerning exactly this topic and therefore, the key figure "Production" is improved.

The best results can be reached, if an additional adjustment parameter, concerning the energy usage between the production periods, is considered. This parameter, named "workload parameter" is introduced in chapter 4.3.1.

As mentioned above (cf. 3.2.1) about 70% of all print companies use more than one printing technology. This can be considered on layer 5 by differentiation of the energy consumption and the printed product concerning the installed printing technologies.

On the highest level of detail, the "workload parameter" has to be considered for each print technology to achieve the highest level of suitability also in comparison with corresponding single technology companies.

Notice: If a system concerning measurements of the actual energy usage is installed, the benchmarking and in particular, the internal benchmarking could be performed without high effort at any point in time.

Humidification [MJ / m³]		
Available data	Estimated effort	Suitability
installed electrical power, room volume	low	suitable to only a limited extent
installed electrical power, room volume, grammage parameter	low	suitable

Table 4:
Key figure "Humidification" with its stages of extension

The key figure "Humidification" is in a way a cross-sectional key figure but essential for the permanent high quality of the printing production (table 4). Therefore, an additional adjustment parameter is introduced, which considers the individual amount of paper that is printed in the corresponding company. This sector specific adjustment factor, named "Grammage parameter" is introduced in chapter 5.3.2.

5.3 Extended Adjustment Parameter

5.3.1 Workload Parameter

Specific energy consumption often increases when the production capacity isn't fully used because the basic energy consumption is being spread over less units of production than at full production rate. The objective to adjust for reduced production capacity utilization is to separate the effect of a production rate change from other variables and energy efficiency changes [BESS, 2004].

5.3.2 Grammage Parameter

The building volume and the installed electrical power are not the only regarded information for calculating the extended key figure "Humidification". The demand of humidification depends in fact also on the individual paper flow rate in a company. Therefore, the "Grammage Parameter" includes the individual percentage value concerning the highest paper flow rate found within the direct competitors.

The outdoor humidity is not that much relevant for air-conditioned areas.

5.3.3 Compressor Load Parameter

This parameter is necessary to identify improvement potentials, which are not directly belonging to the compressor. We distinguish between compressor systems with an average load under 30% and systems with a higher load. Compressor systems with an average load higher than 30% are suboptimal dimensioned [RMC, 2009].

5.4 Extended Visualisation

The benchmarking visualisation of the EEEI-study (figure 8) offers a quick overview over the current company's situation compared to other European companies. The first introduced extension is the presentation of the number of actual compared companies next to the level of detail (figure 11). This is as mentioned important to document the sustainability of the evaluation. A further step to get beyond the level of awareness improvement is to improve the visualisation framework. This is realised by integrating the energy flow chart and the Sankey chart into the benchmarking process.

5.4.1 Energy Flow Chart

With an energy flow chart it is possible to expose often hidden relations in the energy system. Therewith, it can be assured that all components of the energy system are regarded with their precise interrelations. In figure 12 the complexity of energy flows, in a company with two installed print technologies, is simplified exemplified. All adjustment parameters can be illustrated and documented with such a chart in a very transparent and comprehensible way.

If a heat recovery system is installed at the trying system, the amount of recovered energy has to be considered pro-rata to the corresponding key figures. Not the whole amount of recovered energy obligatory is reused in the heating system; some amounts could also be used in the drying process itself, or elsewhere (figure 12).

5.4.2 Sankey Chart

Different to the introduced qualitative presentation of the energy flows, it is possible to visualise the quantitative relations between the itemised power loads (figure 13).

A Sankey chart combined with benchmarking shows, where possible improvement measures are most urgent to be implemented or where the advantage of improvement is the largest. A very

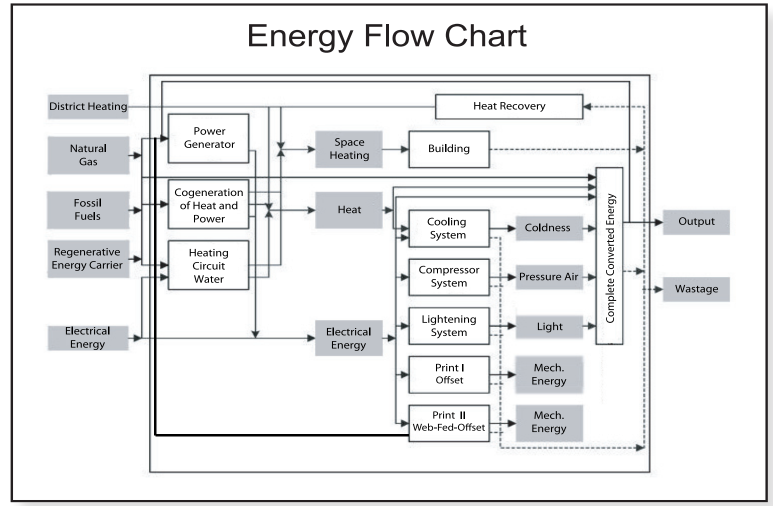


Figure 12:
Energy Flow Chart, based on [Schmid, 2004]

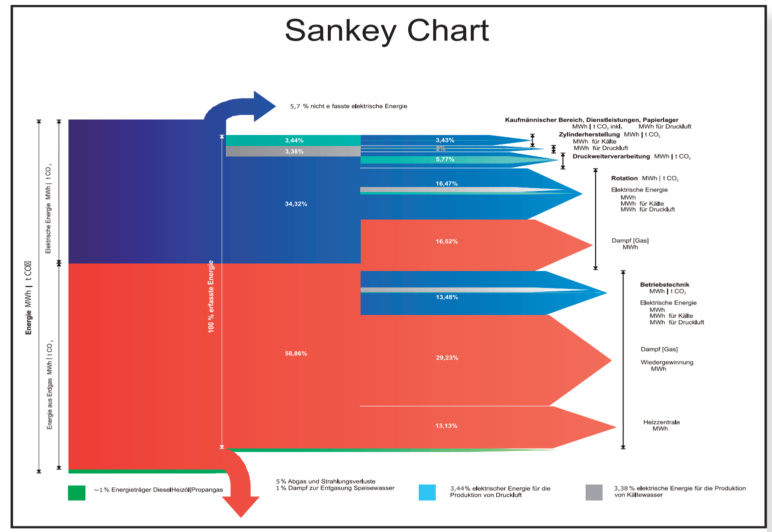


Figure 13:
Quantitative energy flows, structured on energy sources, based on [Breuer, 2008]

bad scoring itself, in divisions which require very less energy, justifies no implementation of improvement measures. In contrast, a good scoring in combination with high individual energy consumption could offer a high attraction to consider all improvement measures for the corresponding division.

5.5 Extended Conversion Factors

The final extension to the EEEI-approach is the adjustment of the conversion factors, due to only the conversion factor for "coal to electricity" was used to calculate the theoretical CO2 emission reduction potentials in the EEEI tool.

For the extended calculation of the theoretical CO2 emission reduction potentials, it is essential to consider the following points:

- CO2 emissions (and prices) vary depending on the energy source. Individual energy mix conditions (e.g. green electricity) have to be considered also.
- If no information concerning the energy mix available, the country typical energy mix conditions have to be taken as a basis.
- Installed heating recovery systems or district heating have to be individually considered.

6 Conclusions

The completed EEEI-Project has shown how considerable using an energy benchmark could be. With only less than 110 companies in the itemised countries, it was possible to reach the final objectives of the EEEI-study. Saving overall 500.000 € has been the concrete aim and has been excelled by more than 100%, if all proposed improvement measures would be optimal implemented (figure 14). According to this, the intended potential CO2 emission reduction about 2.500 t was also excelled by the achieved 5.000 t per year.

Even if these results are only of theoretical quality the EEEI-Project has shown that the identification of improvement potentials is possible with relative low effort. The missing of information concerning energy topics was identified as the main problem to overcome barriers concerning energy efficiency improvement within SMEs.

Even so, the EEEI E-BAG has achieved its objective of awareness improvement the system of sector specific key figures has to be extended to get beyond this level of awareness improvement. This extension was realised by including additional levels of detail concerning the key figures with more detailed data requirements. Additional adjustment factors were introduced and more visualisation methods are included.

Furthermore, the consideration of companies with more than one installed printing technology is included by the differentiation of all technology specific energy data.

Finally and as mentioned at the very beginning of the literature review: Benchmarking is the continuous process of measuring products, services and practices against comparable competitors, while considering internal goals and the implementation of measures within the process.

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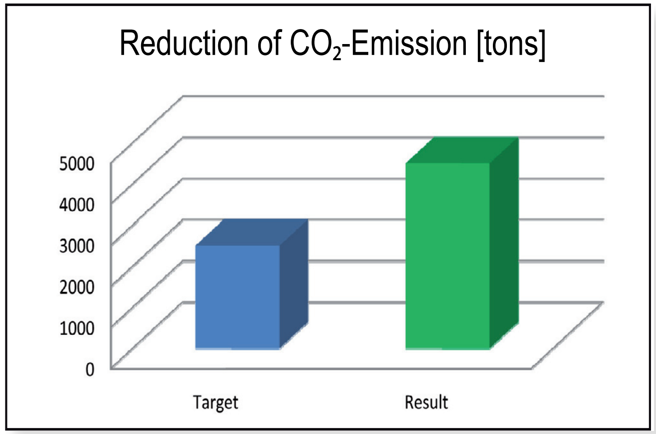

Figure 14:
Aimed and actual realised energy savings with 108 companies, based on [EEEI-conference, 2009].

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