



manroland

HOCHSCHULE DER MEDIEN

expressis business

CMYK goes GREEN

Environmental compatibility in the printing process

Energy and environment in the printing process

The manroland HdM »Energy and Environment in the Printing Process« study examines a subject of the utmost topicality and urgency: how important are energy and environmental issues in the printing industry? How are printing companies meeting the challenge of producing in the most environmentally compatible manner possible? What are their priorities and focuses? How do they succeed in producing economically and in an environmentally compatible manner at the same time? What are their working methods and what measures do they implement? Are there regional differences?

manroland accepts its responsibility

manroland AG, as one of the world's leading manufacturers of printing systems, accepts this responsibility both in the production of its presses and in the partnership with its customers, the printing companies around the world. By means of its PRINT-VALUE program with its areas printservices, printcom, printnet and printadvice, manroland provides numerous options for economic, productive and at the same time environmentally compatible printing.

In order to find out more about the energy and environmental consciousness of the printing industry and to derive practical recommendations from this knowledge, manroland has carried out a study entitled »Energy and Environment in the Printing Process« in collaboration with the Stuttgart Hochschule der Medien (Stuttgart Media University) (HdM). We have presented the results for you to see in this issue of expressis business. Here is just a taster: all the printing houses surveyed take the subject of energy and environment seriously and do not see it as a temporary fashion. Large companies in particular also use their facilities for activities and investment in the energy and environment field. All participating companies showed great interest in the project. Many companies are already committing themselves heavily to environmentally compatible production. Differences in the results of the survey for sheetfed and web offset printing houses can be attributed to the different processes and business situations. There remains much to be done, though, and there is also an obligation on the suppliers. For, with the right partner and the right equipment, ecologically sound printing also means economically successful printing every time.

We wish you beneficial, informative reading and hope that you enjoy expressis business in its new design. ■



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manroland has a fifth color CMYK+GREEN

■ One of manroland's priority objectives is to provide its customers with printing systems and process system components for the most environmentally compatible and at the same time most economic production possible.

Continuous dialogue with customers

Intensive research and development activities are necessary in order to realize this goal. However, at least as important is the continuous dialogue with the customers. This is because the requirements of printing companies throughout the world are the most important thing for manroland. They are continuously confronted with market demands and must daily meet the high expectations of their customers. Their experience and knowledge from this demanding daily business form the focal point for manroland and provide manroland with the basis and crucial motivation for its work.

manroland staff are continuously talking to the customer at every opportunity: at exhibitions, in consultations, on customer visits, during sales negotiations, in every phase of the partnership. This ensures that manroland knows what motivates its customers. However, surveys constitute a successful method of obtaining material with statistically relevant significance and also serve to expand the horizon of understanding on a scientific basis. manroland and students of the Print-Media-Management course run by the Stuttgart Hochschule der Medien (HdM) have therefore carried out a study entitled »Energy and Environment in the Printing Process«.

Sheetfed offset and commercial web offset printing houses surveyed

Based on a questionnaire, sheetfed offset and commercial web offset printing houses in Germany, Austria and Switzerland as well as Slovakian printing companies were interviewed in person, by telephone or via e-mail with regard to their interest in the subject of energy and environment. They were also asked about their investment projects and their readiness to take measures for environmental protection.

bvdm and consultants surveyed

The Bundesverband Druck und Medien (The German Printing and Media Industries Federation), bvdm) and three companies that provide advice on climate-neutral printing production were also surveyed. They offer consultation programs for determining carbon dioxide emissions (CO₂). Subsequently, the CO₂ emissions during printing are balanced in environmental protection projects at other locations on the basis of emission reduction certificates.



An eye on the competition

The study is rounded off with a consideration of the activities and offerings of manroland's competitors Heidelberger Druckmaschinen, Koenig & Bauer, and Komori with regard to energy and environment, and shows the different approaches in dealing with the subject. This is not question of a valuation but a mention and appreciation of all activities targeted towards making industrial printing production more environmentally compatible without adversely affecting its high quality and performance level.

First let us look at manroland's activities for achieving printing production which is as environmentally compatible as possible.

Climate protection activities, combined in the product divisions under manroland EcoLogic (economy through ecology), have already considerably reduced emissions and increased energy efficiency in the printing house.

To produce in an environmentally compatible manner is a strategic factor, a prerequisite for economic success in the printing industry. This applies to our customers as well as to ourselves in our own production. The objective is to offer the printing company every conceivable advantage over and above the pure usage of the printing press in order to enable sustainable production to be economically and ecologically achieved and expanded within the organization.

- Energy efficiency: by need-driven control of appropriate components
- Reduction of emissions: no VOC emissions by dispensing with IPA in the moistening agent (VOC stands for Volatile Organic Compound. This means substances such as hydrocarbons, alcohol, aldehydes and organic acids. VOC emissions can cause complaints such as irritation of the mucus membranes, headaches and concentration difficulties.)
- Conservation of resources: low waste means conservation of natural resources and reduction of costs.

manroland has a fifth color: CMYK+GREEN

A modern printing result is always green. For as well as CMYK, ecological responsibility also belongs on every printed sheet. We call this CMYK+GREEN.

One thing is very important to us: CMYK+GREEN does not mean greater production costs for customers. On the contrary. Ecology and sustainability mean greater efficiency for the customer. manroland provides comprehensive technologies, processes and innovations. With CMYK+GREEN, customers find an answer to two central requirements: printed products at favorable prices and printed products with a good eco-balance. ■

Environmental management, preferably certified



It is all about machine concepts which optimize processes and the use of resources. As well as resource conservation, the main themes are the reduction of emissions and, in particular, energy efficiency.

Companies that conserve resources save real money. More efficient energy management reduces operating costs and protects the environment. Ecology and economy are not a contradiction in terms.

manroland exemplifies what it researches. It has received acknowledgements from a series of renowned sources for its environmental protection measures. One example is the Glanzlicht-Auszeichnung 2007 (Highlight Award) from the Ministry for the Environment in the German state of Hesse. This award recognizes the reduced energy consumption at the Offenbach/Mainhausen site which manroland achieves with increased sales and higher productivity. Consumption has been falling since 2001: electricity by 30 percent, natural gas by 38 percent and water by 32 percent.

Environmental certification for manroland's webfed sites

manroland has implemented and successfully certified an integrated management system at the Augsburg and Plauen sites in accordance with the quality management norm DIN EN ISO 9001:2000 and the environmental management norm DIN EN ISO 14001:2005.

With this certification, manroland fulfils the requirements of the customer, the legislator and its own expectations. manroland wishes to promote the knowledge, consciousness and attention of the staff for appropriate environmental behavior.

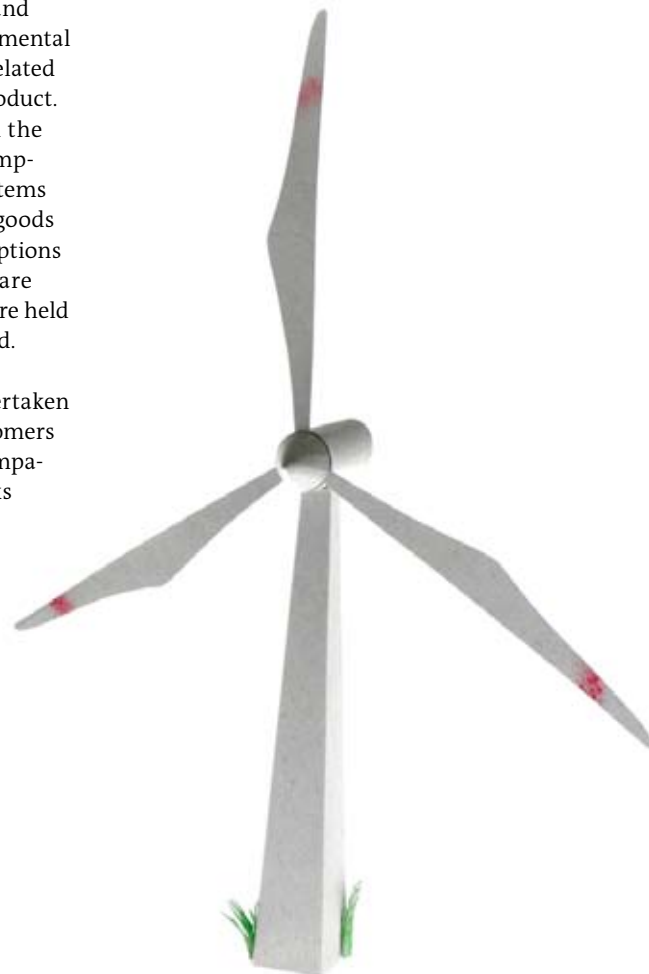
At the same time, the certified environmental management system according to DIN EN ISO 14001:2005 is an instrument for providing evidence of processes, systems and compliance with legislation. A team comprising environmental, quality and safety-at-work specialists has therefore carefully examined all environmentally related company processes against this background.

Why a certified environmental management system?

manroland would like to significantly reduce environmental pollution and environmental risks. The environmental performance is being improved related both to the location and to the product. manroland focuses attention on the reduction of waste, energy consumption and emissions. Extensive systems record the data for all disposable goods and the associated costs. Consumptions and environmental parameters are monitored and training courses are held relating to the environmental field.

These are the specific efforts undertaken by manroland to support its customers in achieving environmentally compatible production. manroland works continuously in expanding and optimizing these activities.

We would now like to present the results of the manroland - HdM »Energy and Environment in the Printing Process« study. ■



bvdm sketches the background to the industry

Information on the background to the industry was provided by the discussion with the bvdm which formed the start of the interviews. The bvdm and its eleven regional associations advise and inform printing companies, work out strategies and represent the interests of the sector within the industry and with regard to environmental legislation. The bvdm has no direct contact with individual printing companies; it develops services for the eleven regional state associations. The bvdm therefore performs basic work which is implemented by the state associations. 4,500 companies are members of the bvdm; this is about half of all German printing houses.

Walter Fleck, Department Manager Engineering and Research/Environmental Protection, gave students of the HdM information on the environmental behavior of the printing industry at the bvdm Wiesbaden site on 30th April 2008. Fleck was of the opinion that environmental protection is a subject with which the printing organizations are seriously involved. However, according to Fleck, it is often difficult for the numerous small companies with less than 20 employees, which make up 85 percent of all German printing houses, to address the subject appropriately. On the other hand, the environmental aspect is omnipresent, as it is included in every technical innovation, for example with equipment for shortening the makeready time or reducing waste.

For Fleck, environmental protection is no temporary fashion, but a corporate task. It should be intensively used not only as a marketing argument but also as a competitive instrument, which however requires continuous updating and activation.

According to Walter Fleck, commitment to the environment is strongly dependent on the economic development. In economically difficult times, printing organizations concentrate on keeping the business running. However, as a general principle, no company takes energy and resource-saving measures which are not profitable.

The principle of sustainability which should be the basis of any type of commitment to the environment is determined by three aspects: ecology, economy and company policy. They must be in harmony and in proportion so that both environmental protection and the economic development of the company or industry can benefit.

According to Fleck, the bvdm believes that it has an obligation to the extremely complex subject of energy saving and resource conservation. A pool of experts is planned which will produce efficiency analyses for printing companies and, if necessary, propose optimization measures.

As an answer to the emission reduction certificates available on the market which, according to Walter Fleck, are of very differing quality the bvdm offers an emissions calculation tool as a free service for its members and accordingly also provides certificates, which, says Fleck, are »high-quality certificates ... from serious providers«.



Companies offering consultancy services for climate-neutral printing

The survey of three German consultancy firms in Munich, Bad Vilbel, and Augsburg, and one Swiss company, mainly targeted information relating to the number of interested printing companies, and thereafter what type of advice these expect and what proposals they implement, why the subject of energy and environment is important for the printing industry, whether climate-neutral printing will be a legal requirement in the future, whether the demand for certificates has recently increased, what calculation tools cost, and which and how many definite projects are already in hand.

The German consultancy firms initially came across as being receptive to the interviews, but soon backed down, pointing to the change in which the printing industry currently finds itself with regard to the subject of energy and environment. It must also be assumed that they did not want to divulge detailed information relating to their business idea, the sale of certificates. The Swiss company answered the questionnaire.

Reduction of emissions and CO₂ footprint

Companies that give advice on climate neutrality and offer climate protection concepts determine the emissions balance (CO₂ footprint) for each printing order in the company and the balance of these emissions by the purchase of emission reduction certificates.

Companies can purchase these certificates in order to have CO₂ which is emitted by their organization saved at some other place in the world. In this way, they support worldwide projects which take measures for reducing CO₂ emissions. The money which has been paid for the emission reduction certificates is used for these projects. Nothing is done to reduce the CO₂ emissions in the company that has purchased the certificate. The value is determined by software and the company and the respective client decide whether a certificate is to be purchased or not. If yes, the CO₂ is saved somewhere else and the printing of the order is therefore climate-neutral. An example of a climate-neutral project is the b2fair cooperation forum which was held in 2007 as part of the Hanover Fair. Here it was calculated how many tonnes of CO₂ the visitors had to compensate for (caused by the production of their information and advertising material, their travel etc.). This came to about 600 tonnes which was balanced by the purchase of emission reduction certificates by 250 small and medium-sized companies from 33 countries which benefited a wind power project in Chitradurga District in Karnataka/India.





Switzerland and Germany with different concepts

Research in Switzerland has clearly shown basic differences with respect to Germany. The Verband der Schweizer Druckindustrie (Swiss Printing Industry Association, vsd) offers an eco rating service which is carried out by authorized consultancy firms with a so-called WINERGIE check directly in the printing company. This determines where companies can save CO₂. When they implement the savings, they are listed and identified in the eco rating on the vsd website. Environmentally conscious printing house customers can select a printing house which meets their requirements based on this rating, which also records various other significant certifications such as FSC and DIN ISO 14001.

Since drupa 2008: climate initiative bvdm, Heidelberg, manroland

The bvdm climate initiative together with Heidelberger Druckmaschinen and manroland has been in existence since drupa 2008. The climate initiative works in three stages with the determination of CO₂, the prevention of CO₂, and the compensation of CO₂. It follows strict guidelines and expressly points out that climate protection must be incorporated in the company philosophy in the long term. All parameters are carefully agreed in close contact with science and policy.

The partners of the climate initiative distanced themselves from the emission reduction certificates and concepts of the climate neutrality consultancies. This may be one reason that, of the four companies surveyed, only the Swiss company answered the questionnaire. Even so, valuable knowledge was obtained from this. In recent times, companies have been increasingly making contact with climate protection consultants. As for all projects of this kind, more or less serious organizations are also to be found in this field, so the choice should be made carefully and critically. ■



A sample: Environmental protection optimization in sheetfed printing

At the center of the project was the survey of the printing houses. The sheetfed offset questionnaire with general and energy-related questions on offset printing and on the sheetfed offset printing process was sent to sixteen companies who mostly work with two to four machines in 3B format or larger. Eight printing houses answered the questions either in a face-to-face meeting or by e-mail.

Statistical matters

Of these, half employed more than fifty staff, the smallest company ten, the largest 380. Seven of the eight companies are bvdM members.

The subject of the environment was considered to be important in almost all printing houses. No printing house attributed absolutely no significance to the subject.

62.5 percent gather production data relating to alcohol and waste paper consumption, which they then analyse. Smaller companies do this rather less often.

About 75 percent think that environmental protection should have an even higher priority in the future. The remainder either refuse this or only see a possible need in equal part.

What do printing houses think of when it comes to environmental protection?

- Use only biological detergents
- Pay attention to power consumption when procuring machinery
- Purchase packaging material regionally
- Use consumed energy (waste heat for climate control and secondary combustion)
- Use as little alcohol, paper, and ink as possible
- Work with a central air supply
- Reduce energy consumption
- Use solar energy for new buildings
- Measure gas, water and electricity consumption with separate meters at the appropriate point of consumption

Only two printing houses said that they were under pressure from the market. Customers had requested printing on FSC paper and sent an energy questionnaire. Apart from the usual requirements and directives of the legislator or the Employer's Liability Insurance Association, no company had to comply with special legal requirements relating to environmentally friendly production. ■



How can process savings be made?

Paper

Detailed requirements are placed on suppliers and machine manufacturers. This also applies to the paper costs. When it comes to the printing material, printing companies attach importance to certification for sustainable forestry, resource conservation and wherever possible regional paper factories.

Alcohol

Equipment for alcohol-reduced and alcohol-free production is expected from the machine manufacturer. Half the companies already print without the use of isopropanol.

Emissions

Air cleaning processes, energy reduction, reduced emissions, and energy costs, alcohol elimination, afterburners, and a simpler packaging system for consumables were named as possible joint projects. Only three of the eight companies were aware of emission reduction certificates. Comments on these varied from restrained to negative. Only one company had already worked with a climate-neutrality consultant, and even this company had had only one consultation.

Energy

Companies also aim for the lowest possible energy consumption. A software solution for determining the energy consumption, for peripherals for example, was also discussed. Apart from one very small printing house all companies in the survey were prepared to become even more involved with energy and environment in the future. 62.5 percent can envisage doing this together with suppliers, customers and machine manufacturers, 25 percent think that this may be a possibility, and 12.5 percent cannot envisage this at all.

Inks

The companies in the survey rely on inks made from renewable raw materials and inks that are free from mineral oil or that are food-safe. They prefer regional manufacturers with modern production plants. Of course, this is also followed on the wish list by a favorable price.

Readiness to invest

Over 60 percent of those surveyed would agree to additional investment when making a new purchase if an acceptable ceiling for the company were not exceeded. However, this investment should be worthwhile, technically sound, and promote productivity and economy. 75 percent of those surveyed were of the opinion that there should be support from banks, associations, or the state for an additional investment in the interests of environmental compatibility. Again 75 percent knew that manroland had a comprehensive range for making printing production more economic, more productive and at the same time more environmentally compatible, for example equipment for reducing waste, alcohol and set-up time.



Recycling

When making ready, there are major differences. Four companies make ready exclusively with original paper, two with waste and original paper, one company decides depending on the size of the print run, and one sets up only with waste paper. The latter is usually the case when there is no proof run with the customer and the quality of the product allows waste paper to be used.

No company recovers remaining ink by mixing with black, as this negatively affects the printing process and is also not acceptable to the customer. Some companies spoke from experience, as they had already tested this method. The printing houses and the customers were not satisfied with the quality of the result. As many companies already print with ink tanks, for the most part no ink remains in the scale area. One printing house was of the opinion that this was only possible when printing advertising material.

The companies surveyed avoid the use of solvents with aromatic hydrocarbons in order to protect the health of their employees. Half the printing houses measure performance figures, for example by means of separate water meters on the machines. All companies said that they disposed of their raw materials, auxiliary materials and operating materials via the supplier or recycling firms. These are mostly qualified and certified disposal companies.

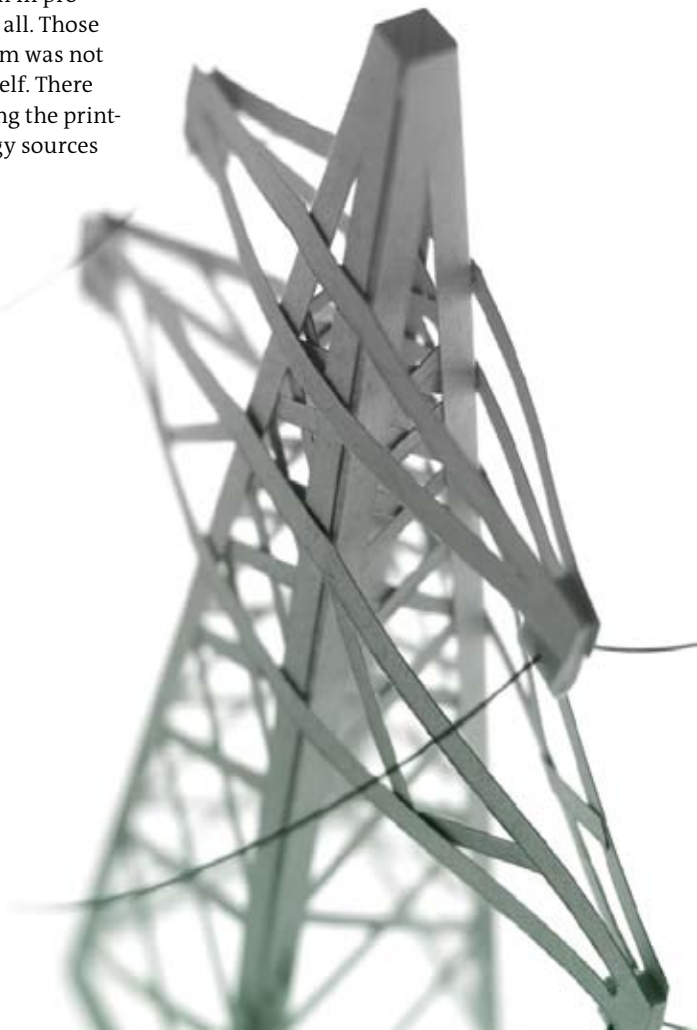


Need for advice where alternative energy is concerned

Only three printing houses use energy management to reduce peak electricity consumption. These are the larger companies with 40 to 380 employees. In doing so, they make use of building automation software which measures all states in real time and thus prevents load peaks occurring simultaneously. All consumers are connected to a network and the computer switches off all machines that are currently not needed before a particular peak electricity consumption is reached. Five companies increase their efficiency by heat recovery, using the waste heat from the machines for heating the building. One company intends to use this efficiency-increasing method in its planned new building.

Three companies were still unclear as to whether they wanted to purchase machines with low power consumption. On the other hand, five printing houses want to invest in machines, equipment, and lighting with low power consumption when this becomes necessary. Some already work with LED or energy-saving lamps. Seven of those surveyed said that they pay attention to energy-saving possibilities when arranging and switching their lighting components. Six companies avoid standby power consumption in production and administration, one company only in production and one not at all. Those surveyed were of the opinion that investment in a solar or photovoltaic system was not worthwhile, as the system would have to be replaced before it had paid for itself. There seems to be a considerable need for information and advice in this area to bring the printing houses up to date. Two companies would like to install regenerative energy sources in their new buildings.

Only two companies have already had an energy audit carried out; four more plan to do this. For one company, the energy audit is a project for the town, which is having the whole industrial area checked. Five companies are striving both for energy recovery and an increase in energy efficiency. Two printing houses are concentrating exclusively on energy efficiency, one only on energy recovery. ■



Energy as an environmental factor in the web offset printing company

The web offset questionnaire was similar to that for sheetfed offset and therefore contained both general and energy-related questions on offset printing and questions on the web offset printing process. It was sent to ten companies in the whole German speaking area with 80 to 380 employees. Six printing houses finally took part in the survey by telephone or by e-mail.

Requirements and conditions

On average, those surveyed employed 187 staff. Five of the six printing companies are members of the bvdm. Energy and environmental subjects are of great importance for more than 80 percent and of medium importance for the rest. All companies gather and analyse data relating to alcohol consumption and waste.

Over 80 percent are conscious that more must be done for environmental protection. However, the remainder do not see this as a priority. Notwithstanding this, half of the companies surveyed are under pressure from customer requirements. These demand reduced CO₂ emissions, less waste paper, the use of FSC paper and climate-neutral printing.

The statutory environmental conditions that have to be fulfilled include waste gas scrubbing, monitoring by the industrial inspectorate, the measurement of emissions on the dryer, compliance with exhaust air limits, and compliance with the guideline values for noise.

The web offset printing houses also expect something from their suppliers. Inks must have high yield, contain no substances that are hazardous to health, comply with the ISO standards, provide information on the solvents used and have good drying characteristics.

The paper must likewise comply with ISO standards, be of high quality and, if possible, not be transported by road but by rail.

Those surveyed expect the machine manufacturers to develop technologies for reducing energy and waste and for increasing energy efficiency, and that the systems comply with ISO standards. All companies agreed in their readiness to do even more in the future to save energy and conserve resources. Two-thirds can envisage approaching this subject together with suppliers, customers, and machine manufacturers.

The remainder think that this may be a possibility; however some cannot envisage how this collaboration would work.

Those in favor of collaboration would like a group project on the subject of heat recovery and exhaust air cleaning. Two-thirds of the printing houses are aware of emission reduction certificates. One company was of the opinion that this concept was a modern selling of indulgences, which however at least drew attention to the subject. One company had already taken advantage of a climate neutrality consultation and had also used the emission reduction certificates. All those surveyed were prepared to invest more in a new procurement as long as the amount for the company remained below an acceptable ceiling. Two-thirds are of the opinion that there should be financial support for this from banks, associations, or the state. Likewise, two-thirds are aware of the manroland range for economic, productive and environmentally compatible printing.



Energy management in web offset printing

Two-thirds of the printing companies surveyed already use energy management to reduce peak electricity consumption, many with time-delayed start-up of production machines. This is almost twice as many as in sheetfed offset, which may also be due to the fact that the energy consumption in web offset is much higher.

All those surveyed increase the efficiency of their building climate control, for example by heat recovery, by cooling machines with ground water and by dissipation of secondary heat to the outside.

Two-thirds are already considering purchasing equipment and lighting with low power consumption, the remaining third are still planning this step. Likewise, two-thirds have energy-related reasons for the positioning of their lighting, one-third arrange the lighting purely according to functionality. Five of the six companies surveyed try to avoid using standby power in production. Up to now, regenerative energy sources and energy audits have not become established as hoped. All companies strive towards energy recovery and energy efficiency.

Key figures in web offset

Half of the companies surveyed inform their customers of the economic/ecological advantages of the use of standard inks as a matter of principle. One-third do this depending on the order, the rest not at all.

Isopropanol-free printing has become well-established. Apart from one company, all already print without the use of alcohol. Solvents with aromatic hydrocarbons have had their day. With an eye on the health of their employees, these are no longer used by any of the printing houses surveyed.

When using volatile solvents, half the companies use systems which are as closed as possible in combination with efficient exhaust gas scrubbing.

Two-thirds measure performance figures for water consumption, the remaining third do not yet do this or plan to do it in equal part. A basic change can be seen in the approach to water consumption. More and more companies are trying to monitor and reduce their water consumption in order to save costs and the valuable resource water.



Something new in the East, Slovakia sets an example

■ The students of the HdM also asked one web offset printing company and two sheetfed printing houses in Slovakia about their environmental behavior in order to establish whether there were differences compared with companies in the German speaking area.

The web offset printing house works with around 900 employees, the sheetfed printing houses with about 400 and 145 respectively. Service providers such as climate protection consultants were unknown to any of those surveyed. All companies are interested in energy and environmental topics and have already done something for environmental protection themselves. One of the printing houses is able to claim to be the first in Slovakia with FSC certification. Two companies are striving for alcohol-free production. All want to become more involved with the subject of energy and environment in the

future. They are also prepared to invest more money in new machines if this is more environmentally compatible and the procurement remains within reasonable bounds.

What does the customer want?

To the question »How would you describe the ecological consciousness of your customers in one sentence?«, all those surveyed replied that it is steadily increasing. There is great interest in certified materials such as paper, for example.

The printing process is similar to that in German companies. Web offset printing presses are set up with waste paper when the order allows. Machines are sometimes run without isopropanol. An attempt is also made to use solvents without aromatic hydrocarbons. Left-over ink, moistening agents and detergents are disposed of using a special disposal company.

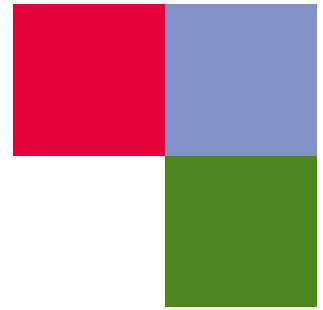
Solar scores

All three companies use energy management to reduce peak electricity consumption and sometimes use special software. In addition, all those surveyed use waste machine heat for heating and have arranged and switch their lighting according to energy-saving criteria. One of the sheetfed offset printing houses has reduced the lighting energy consumption by 40 percent by changing the lighting components. Both sheetfed printing companies are prepared to reduce their present electricity consumption by means of similar actions. However, there is currently no avoidance of standby power in production and administration.

One sheetfed printing house has installed 40 solar panels. The costs have been amortized after five years. This shows the difference in how well informed the printing houses are. One sheetfed printing house has also had an energy audit carried out.

All those surveyed strive towards energy recovery; the web offset printing house and one of the sheetfed companies would like to become more energy efficient. ■





Glossary

- **BFE Institute:** Institut für Energie und Umwelt GmbH (Mühlhausen and Hamburg), carries out checks relating to energy-saving measures.
- **Climate protection consultants:** companies that give advice on climate-neutral production and develop climate protection concepts and strategies.
- **CO₂ footprint (= emissions balance):** calculation of the carbon dioxide output of a company or individual. Produced with the help of a CO₂ computer.
- **Emission reduction certificates:** can be purchased by printing companies; this supports worldwide projects that take measures to reduce CO₂ emissions. Emission reduction certificates provide a method of offsetting CO₂ emissions on a concessionary basis.
- **Energy audit:** building analysis which enables the auditor to identify heat and power losses and to recommend improvement measures for the building shell, heating system, hot water production, ventilation and possibly overheating.
- **FSC/PEFC papers:** FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification Schemes, international umbrella organization for the mutual recognition of national certification processes). The deforestation processes and, above all, the reforestation processes are certified for the production of these papers.
- **Eco balance:** estimate of the environmental effects of a product over its whole life span referred to production, use and disposal as well as to previous and subsequent processes.

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