Strategic energy management in energy-intensive enterprises – an integrated SWOT-AHP analysis of the Austrian paper and pulp industry

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Important Note

This is a preprint version of the following paper:

Posch A, Brudermann T, Braschel N & Gabriel M. (2014). Strategic energy management in energy-intensive enterprises – a quantitative analysis of relevant factors in the Austrian paper and pulp industry. *Journal of Cleaner Production*. doi:10.1016/j.jclepro.2014.11.044.

Original version: <http://www.sciencedirect.com/science/article/pii/S0959652614012244>

Abstract

Increasing energy prices and market volatilities force energy intensive industries to implement energy management systems in order to ensure competitiveness. In this paper, we focus on the strategic level of energy management, specifically, on the analysis of the internal and external conditions that form the basis for strategic development. For this, we selected the case of the Austrian paper and pulp industry. We applied a hybrid method by combining a SWOT (strengths, weaknesses, opportunities, and threats) analysis with an analytic hierarchy process (AHP) which was based on a survey of expert opinion. The results show that cost-related factors predominate. According to our analysis, the four most important factors are all directly linked to energy costs, energy efficiency, and the energy market. Experts pay little attention to environmental issues or to energy market volatilities. Apart from that, we recommend SWOT-AHP as a standard instrument in strategic energy management, especially for energy intensive companies and/or sectors, since it enables decision makers to take strategic decisions based on a systematic understanding of the main issues.

Keywords

Analytic hierarchy process, energy costs, energy market volatilities, paper and pulp industry, strategic energy management, SWOT analysis

Highlights

- The integrated SWOT-AHP analysis is a novel approach to strategic energy management in industry.
- Expert judgements indicate high awareness of energy costs, but low awareness of energy market volatilities.
- Environmental issues are considered to be of only relatively minor importance.
- The method applied is recommended for use as a standard instrument in strategic energy management.

1 Introduction

The paper and pulp industry is characterized by both highly energy-intensive production processes as well as by the generation of large amounts of energy outputs as a side-product (Laurijssen, Faabij, & Worrell, 2012). For example, in 2006, 6 % of total global industrial energy use was consumed by the pulp and paper industry. In 2007, the corresponding figure was 5 %. i.e., 6.87 exajoules¹ (EJ) (Abdelaziz, Saidur, & Mekhilef, 2011; Kong, Price, Hasanbeigi, Liu, & Li, 2013; Trudeau, Tam, Graczyk, & Taylor, 2011).

Thus, it is not surprising that the paper and pulp industry has been highly motivated when attempting to deploy sophisticated energy management techniques in order to optimize energy supply, improve energy efficiency, or identify possibilities for cascading energy within production processes. Over 20 years ago, Collins (1992) pointed out that up to 60% of the production energy needed could be saved by recycling wastepaper, thus generating a clear cost advantage. A number of different approaches, guidelines and strategies for increasing energy efficiency, or for saving energy have since been developed. For example, Abdelaziz et al. (2011) and Kong et al. (2013) define three approaches for improving energy efficiency: (i) energy saving via management, (ii) energy saving via technology, and (iii) energy saving via policies / regulations. A strategic approach to energy management can magnify potential efficiencies. For example, Stawicki, Lozo, & Lajić (2010, 524) present energy management guidelines consisting of seven steps, based on the US Environmental Protection Agency's (EPA) Energy Star partnerships. These outline the key activities needed for successful energy management. The starting point is given by the initial commitment to continuous improvement, which then forms the basis for the subsequent strategic steps, entailing assessing performance and establishing objectives. Once objectives are defined, an action plan can then be derived and implemented, progress evaluated, and achievements recognized.

When it comes to technical energy optimization in the pulp and paper industry, frequent areas of research are cogeneration or combined heat and power systems (CHP) (Marshman, Chmelyk, Sidhu, Copaluni, & Dumont, 2010), wastewater treatment (Sandberg, 2010), assessing the potential of new energy conversion technologies (Laurijssen et al., 2012), and (somewhat less frequently) bio-refinery units (Moshkelani, Marinova, Perrier, & Paris, 2013). In order to study the potential available for improving energy efficiency, Fleiter et al. (Fleiter et al. 2012) developed scenario analyses and assessed 17 different technologies in the pulp and paper sector. They found that the technologies with the highest energy saving potential are heat recovery in paper mills, and the use of innovative paper drying technologies. They conclude that significant savings potential is still available, especially where system boundaries are extended beyond company level so as to allow for the inclusion of cross-cutting technologies. A related scenario analysis by Szabó et al., (2009) also reveals that as far as carbon is concerned, significant reduction potential remains within the paper and pulp industry.

¹ Note: The largest industrial energy user is the chemical industry with a total global industrial energy use of about 29.2 exajoules in 2007. (Trudeau et al., 2011)

What the majority of these studies and approaches on optimizing energy utilization have in common is their strong focus on technological improvements in efficiency at the operational level (Cagno et al., 2013; Dobes, 2013; Fleiter et al., 2012; Laurijssen et al., 2012; Marshman et al., 2010; Moshkelani et al., 2013; Sandberg, 2010). There seems to be a clear lack of studies concerning the strategic dimension of energy management, particularly with respect to energy intensive areas such as the paper and pulp industry. This corresponds to the findings of Backlund et al. (2012) who identified energy management as a crucial component of the 'extended energy efficiency gap'. Thollander & Ottosson (2010) also found that a considerable share of Swedish mills in the pulp and paper industry, and in the foundry industry, have no long-term energy strategy. Hence, they concluded that there is still a large untapped potential with respect to the creation of a cleaner, more environmentally sound form of production in the sector.

Thus, our intention in this study is to concentrate on strategic energy management in an energy intensive industry, and in particular, on the analysis of the internal and external conditions that form the basis for strategy development in energy management. For this, we selected the case of the Austrian paper and pulp industry. It is the objective of this paper to identify the most important factors that determine the strategic planning options for energy management in the Austrian paper and pulp industry. Here, we move well beyond a traditional analysis of industry strengths, weaknesses, opportunities, and threats (i.e. a SWOT analysis) and apply a hybrid method which entails integrating SWOT analysis into an analytic hierarchy process (AHP). The purpose, of course, is to gain a better understanding of the relative importance of the respective factors. To the best of our knowledge, such an approach has not been taken before with respect to strategic energy management in energy intensive industries. We thus expect this approach to become a suitable tool for strategic energy management, not only for companies within the paper and pulp industry, but also for other energy intensive enterprises.

On the basis of secondary data and literature, and in order to provide a better general understanding of the industry, we summarize the current situation of the paper and pulp industry in Austria in the following section. In section 3, we then present our methodological approach, i.e. an integrated SWOT/AHP analysis based on expert judgement. Section 4 presents the results of the analysis. First the strengths, weaknesses, opportunities and threats for the Austrian case are discussed in terms of a standard SWOT analysis. The factors identified are then quantified via AHP. Section 5 rounds up the paper and offers some conclusions.

2 The paper and pulp industry in Austria

The paper industry has a long history in Austria, and dates back to the first paper mill in the 15th century (Austropapier, 2009). In 2012, Austria produced about 5 million tonnes of paper and 2 million tonnes of pulp (Austropapier, 2012). The pulp and paper industry is an important element in the Austrian economy. In 2012, about 8000 people, or 0.2% of Austrian employees, were directly employed in this sector. Furthermore, a number of people are

working in related sectors which are dependent on or connected to the paper and pulp industry. These include the wood or transport industry, waste paper procurement, printing and advertising, and the packaging industry. Taking all these sectors into account, the paper industry is considered to be a significant factor in the job market, and subsequently in the entire economy. Apart from that, paper mills also tend to be located in peripheral regions. Thus, they are often among the most important regional employers (Austropapier, 2012).

The Austrian paper and pulp industry comprises 21 companies with 24 mills (Austropapier, 2011). The Association of the Austrian Paper Industry, ‘Austropapier’, represents the interests of all 21 producers of paper, carton, or pulp. Austropapier is also a member of the Confederation of the European Paper Industries (CEPI)².

The capacity structure of the companies is not particularly uniform: According to official statistics³, the four largest companies in terms of production capacity account for nearly half (45% or 2,491 kt) of the annual Austrian production. Nine medium-sized firms, with an annual production capacity of 100 to 490 kt, account for another 49% (2,675 kt/year) of the total production, while together, the remaining eight smaller firms have a comparatively low production output of less than 6%, or 300 kt/year.

According to Austropapier (2012), the product range is quite heterogeneous, and apart from pulp includes different kinds of paper such as graphic paper, paper and paperboard for packaging, or special types of paper (for example, paper for beverage labels). About 87% of the paper, and 37% of the pulp produced is exported, mainly to countries within Europe (in 2012, this amounted to 3,600 kt of paper, and 400 kt of pulp). The most important export countries for paper are Germany (966 kt), Italy (529 kt) and Poland (281 kt), and for pulp, Italy (140 kt), Finland (100 kt) and Germany (93 kt).

The largest cost drivers in the paper industry are raw material costs (40%), labour costs (20%) and energy costs (15%). Since the local availability of raw materials such as wood is decreasing, much of the resource input has to be imported. The total demand for wood added up to 8.22 million board feet in 2012, of which 32% were covered by imports (Austropapier, 2012).

The production of paper is a very energy intensive process. For the German case, which, with regards to technology used, is similar to the Austrian position, Fleiter et al. (2012) calculated that paper production accounts for 76% of total energy demand in the paper industry, while about 10% of the energy demand is needed for the production of chemical pulp and for recovered fiber pulp, and 4% for the production of mechanical pulp. They also note that chemical or mechanical pulp is produced directly from wood; whereas recovered fiber pulp is produced indirectly by means of recovered paper.

Overall, the Austrian paper industry consumed 4,650 GWh of electricity in 2012. This corresponds to 6.7 % of the Austrian electricity consumption in that year. The main part of the electricity demand is covered by on-site production. About 3,800 GWh were self-produced by means of on-site gas turbines or hydro power (Austropapier, 2012; Energie-Control Austria,

² See www.cepi.org (February 24, 2014)

³ See [www.austropapier.at/index.php?id=23&L=1%60%28\[%257B%255E~%2C](http://www.austropapier.at/index.php?id=23&L=1%60%28[%257B%255E~%2C) for a list of Austropapier members, including data about production capacity and employees (February 24, 2014).

2013). A high amount of fuel is necessary for this kind of energy production. In 2012, the total consumption of fuels was 66,600 TJ, 49.3% of which was based on fossil fuels (coal, oil, natural gas) and 50.7% on biogenic fuels (black liquor, bark, sludge, others).

When one looks at patterns of fossil fuel consumption since 1990, one can see that there has been a significant change in energy carrier. While the use of oil (-93%) and coal (-56%) has declined dramatically, the usage of natural gas has increased (+64%). There has also been an increase in biogenic fuel utilization, e.g. black liquor (+33%), bark (+16%), and, most of all, sludge (+322%). In sum, the share of biogenic components rose from 43.9% in 1990 to 50.7% in 2012. It also has to be noted that the paper and pulp companies nowadays not only produce energy for their own use, but also feed in surplus energy to the public grid (about 404.2 GWh in 2012 (Austropapier, 2012)).

From our transdisciplinary case studies on three of the largest mills in Austria (section 3) we know that considerable weight is placed on energy and resource management by the multinational companies that own the mills. We find that a number of mills have a facility for energy generation available on-site, usually a combined cycle gas turbine plant. Internal energy provision is seen as crucial in maintaining the necessary energy-intensive production processes. Raw material inputs as well as water and energy demand are all carefully monitored. We also find that environmental and energy management systems comply with ISO 140001 and with the Eco-Management and Audit Scheme (EMAS), and that quality management complies with ISO 9001, to name just a few of the relevant standards. Furthermore, the mills have gained accreditation from the FSC (Forest Steward Council) and the PEFC (Program for the Endorsement of Forest Certification).

The implementation of all these standards entails careful management of energy supply and demand, careful water handling (e.g. with regards to waste water treatment and steam generation), and also requires that considerable care be taken in the procurement and treatment of primary and secondary raw materials, such as timber, waste paper and chemicals. Overall, we can safely conclude that the Austrian paper and pulp industry is highly successful in fulfilling strict environmental and efficiency standards in production.

3 Methods

Our main methodological framework for this study is an integrated SWOT/AHP analysis based on an expert survey.

As a first step, we analysed the situation of the Austrian pulp and paper industry on the basis of secondary data and available reports (as reported in the previous section). Following an approach developed by Scholz et al. (Scholz et al., 2006; Posch & Steiner, 2006), we then conducted transdisciplinary case studies (TCS). In this approach, an interdisciplinary team of students and professors interact with experts from the field in order to jointly work on a common guiding question. In our case, the guiding question of the TCS was how strategic planning of energy intense pulp and paper companies is affected by volatilities and

uncertainties in the energy market. The teams of supervised students⁴ conducted semi-structured face-to-face interviews with experts from three leading companies in Austria. This process allowed us to identify the most relevant factors for a standard SWOT (strengths, weaknesses, opportunities and threats) analysis.

The four SWOT fields systematically represent positive and negative internal factors (strengths and weaknesses), as well as positive and negative external factors (opportunities and threats). A SWOT analysis is supposed to provide support for successful strategy development by identifying relevant factors in the internal and external environment (Kotler, Berger, & Rickhoff, 2010, 30). However, a SWOT analysis is merely a qualitative analysis. While it may be used to pinpoint specific factors, it does not provide information on the relative importance of these factors; there is no prioritizing or weighting of the selected factors in terms of their relative importance. In practice, this shortcoming complicates strategy development and means that the strategic planning process strongly depends on the individual judgements of the persons involved.

To overcome this shortcoming, we implemented a second step in our analysis, namely an integrated AHP/SWOT analysis. For this purpose we conducted an expert survey asking decision makers in the paper and pulp industry to judge the relative importance of the factors identified. Please note that we limited the number of SWOT factors to four per category. This was done not only to ensure sound analysis, but also to enable experts to complete the questionnaires within an acceptable period of time. To help validate the selected SWOT factors, we also included an open-format question in each SWOT section in the questionnaire, asking experts whether they would consider any other factors than the ones we had chosen as being more important. The resulting comments and responses are discussed in section 4 below. As can be seen, the comments provided by the experts largely support our original selection of factors.

After a pre-test, we contacted 24 persons in the upper management level of companies in the paper and pulp industry in Austria by telephone (CEOs, energy managers, product and R&D managers, production managers, facility managers, etc.). After obtaining their consent, we sent them a link to an online questionnaire. In the questionnaire, the experts were asked to undertake a pair-wise comparison of all factors in the same SWOT field, i.e. to state which factor for each pair is more important, and how much more important. Finally, the experts were asked to do the same with the four SWOT fields themselves, always bearing in mind the four factors in each field. Responses had to be provided in accordance with ordinal scales based on nine steps, from ‘factor *i* is much more important than factor *j*’ to ‘factor *j* is much more important than factor *i*’. After receiving a final reminder by email, 15 completed questionnaires were returned. The response rate was thus 62.5% and we can therefore safely state that a significant share of representatives from the Austrian pulp and paper industry were involved in the analysis.

⁴ The teams consisted of students from the University of Graz master’s programme in environmental systems sciences, and students from the International Joint Master’s Programme in Sustainable Development, offered by an international consortium of eight universities (see www.jointdegree.eu/sd/, accessed February 24, 2014).

Subsequently, we calculated the average figure for the results of all pairwise comparisons. For this, we applied the nine step scale suggested by Saaty (1986) which ranges from 9:1 to 1:9, deliberately leaving out the even numbers as intermediate steps. The center of the scale was thus 1:1, a position indicating that the respective factors were considered to be of equal importance. We normalized the average scores so that the less important factor always received a score of 1, and the more important factor a score within the possible range from 1 to 9. These values and the corresponding reciprocal values then form the elements of five judgment matrices: one matrix for each SWOT factor group, plus the matrix for the overall pairwise comparisons across the groups. In order to calculate the relative priorities of the factors, we applied the eigenvalue method: We raised the judgment matrices by squaring them, calculated the sums for each row, and normalized the sums in order to get the principal eigenvectors of the matrices. This procedure was repeated until the difference between the calculated eigenvectors of each matrix became marginal. In our case, one repetition sufficed in order to reach a maximum difference with an absolute value smaller than 0.001. The resulting 'eigenfactor' now constitutes an estimation of the relative weighting of the respective factors. As a next step, we calculated the consistency index (CI) and the consistency ratio (CR) for each judgment matrix according to the following equations:

$$CI = (\lambda_{\max} - n)/(n - 1) \quad (1)$$

$$CR = 100(CI/ACI) \quad (2)$$

Here, n is the number of factors (and equals the number of rows and columns of the matrix) and $\lambda_{\max}$ is the principal eigenvalue. The principal eigenvalue is calculated by summing each column of the judgment matrix, multiplying the sums by their corresponding eigenfactor, and adding up the products (Saaty, 1999). To arrive at index values which are independent of matrix size, CI values need to be converted into CR values. This is done by making use of the average consistency index (ACI) of randomly generated comparisons. According to Saaty (1999, 83) the ACI for a 4-order judgment matrix with the scale described above is 0.89; and as a rule of thumb, the value of the CR should be 10 percent or less. Higher values indicate inconsistent judgments and thus should be revised.

To calculate the overall weighting factors (global priorities) we multiplied the weighting factor of each factor within a SWOT group (local priority) by the value of the corresponding weighting factor for the whole SWOT group (Kurttila, Pesonen, Kangas, & Kajanus, 2000). The sum of all overall weighting factors is one.

4 Results and Discussion

4.1. Strengths, Weaknesses, Opportunities and Threats

Based on all of the above considerations, we were finally able to identify a set of the most relevant strengths, weaknesses, opportunities and threats with respect to the Austrian paper and pulp industry. These factors are discussed in this section.

Let us open this discussion with an overview of the strengths ($S_a - S_d$) identified. Due to the high energy intensity of the paper and pulp industry, high emphasis is put on energy

management measures that lead to increased energy efficiency in the production processes. The Austrian paper and pulp industry is continuously trying to increase energy efficiency, e.g. in the dewatering processes (optimizing the wet end forming, press section and dryer section in the paper machine), and efficiency rates are actually quite high (S_a : high energy efficiency). Moreover, the Austrian paper and pulp industry generates a large share of the energy needed on site, and does so in a rather efficient way, e.g. by means of combined cycle gas turbine plants (S_b : availability of co-generation on-site). Additionally, the availability of different sources of energy for production processes enables the Austrian paper and pulp industry to switch between different energy carriers. For example, when spot prices for electricity are low managers can buy electricity from the grid, or vice versa, they generate power on site when electricity prices are high. Hence, there is sufficient flexibility to change energy carriers if needed (S_c : flexibility regarding energy carriers). Fourth, collaboration with energy suppliers is quite common. These also include biomass and wood producers to assure supply security and strategy synergies (S_d : close collaborations with energy suppliers).

With regards to the weaknesses ($W_a - W_d$) of the paper and pulp industry, we were able to identify the following factors: As a direct consequence of the high energy intensity of the production processes, the industry is particularly dependent on price developments in energy markets (W_a : dependency on energy market and prices). Furthermore, the production processes are inefficient in the sense that they are accompanied by generation of much more heat than is needed in the process cycle, (W_b : Excess/surplus of thermal energy). In the survey, two of the experts mentioned the issue of unutilized waste heat, especially that occurring in association with low temperature processes. As another factor, the energy efficiency of production processes is highly dependent on the utilization of production capacity. Overhead activities account for a significant share of the production process. Consequently, the higher the amount of capacity used, the greater the level of efficiency that can be achieved (W_c : Capacity utilization). Furthermore, the possibilities for extending the use of renewables beyond that of wood biomass are rather limited. For topographic reasons, wind energy and photovoltaic power generation do not appear suitable, and hydro power is only possible in relatively few locations (W_d : renewable energy limited).

Various trends and developments with regards to energy costs and technology may generate opportunities ($O_a - O_d$) for the pulp and paper industry. One such opportunity is a possible decrease in energy prices in general, and in those for natural gas in particular – e.g. due to gas market liberalization, or the implementation of technologies such as fracking (O_a : Long-term low energy costs). Technological improvements still have the potential to increase efficiency and to decrease energy consumptions (O_b : Technological improvements). Promising technologies include pulp production from recovered fibers, application of combined heat and power, black-liquor gasification and bio-refinery, as well as more advanced paper-drying techniques (Fleiter et al., 2012; Kramer, Masanet, Xu, & Worrell, 2009). Another opportunity is the (expected) increase in competition on European energy and electricity markets (O_c : Competition on energy market). Although major liberalization of European energy markets took place more than a decade ago, international competition on the electricity and natural gas market has not yet fully developed. Finally, there might also be opportunities to become more active as an energy supplier (O_d : Opportunities as energy supplier), e.g. via the sale of excess

heat, or through new market possibilities arising in the renewable energy sector (Moshkelani et al., 2013; Stawicki et al., 2010).

The opportunities mentioned are all considered to be external factors that are not directly within the range of influence of the Austrian pulp and paper industry. The same is true for the potential threats ($T_a - T_d$) the industry has to face. While possible decreases in energy prices represent an opportunity, high energy costs represent a serious threat (T_a : High energy costs). As the direction of price developments cannot be foreseen, both possibilities need to be anticipated. In a similar vein, price volatilities make it difficult to plan for the long-term (T_c : Price volatilities), as is also reported by Laurijssen et al. (2012). Security of energy supply has reappeared as an issue in this context (Helm, 2002), and is particularly relevant with regards to electricity and gas (T_b : Security of supply). Another threat (T_d) is seen in CO₂ emission trading. The EU emission trading scheme might raise production costs in Europe, and therefore weaken Austria's (and Europe's) competitiveness on the international scale (Laurijssen et al., 2012; Moshkelani et al., 2013). This aspect is strongly confirmed by several of the experts interviewed, who see the introduction of such schemes as a form of twofold punishment for an energy-intensive industry which has already worked hard to improve efficiency levels and now has only very little room left for improvement. Occasionally they also raise criticism concerning Austrian policies with respect to renewables. They often consider these to be very harmful to Austria as an industrial location. A typical example here is the provision of public support for generating electricity from biomass, despite the latter's relatively low efficiency and despite the fact that such policies raise the price of wood and thus act as a serious threat to the pulp and paper industry. Another reported threat is the immense amount of bureaucracy required at different levels (local, national, European) in order to comply with statutory requirements such as detailed audits, official form-filling and report writing, and the increasing restrictions on hydro plants.

4.2. AHP Analysis

A traditional SWOT analysis does not provide any information on the relative importance of the factors, neither on those within a specific SWOT group/category nor in terms of the overall significance of the analysis. We thus complemented the SWOT analysis with an AHP analysis following the steps presented above. In this way, we were able to gain information concerning the priorities of decision makers working in upper management in the paper and pulp industry. The results are presented in table 1 and graphically illustrated in figure 2. The SWOT factors are displayed on straight lines in the four SWOT sectors. The lengths of the lines indicate the relative overall importance of the most important factor within the SWOT group. Generally, the longer the distance between the respective SWOT factor and the origin, the higher the overall importance of this factor.

The results of the AHP analysis indicate that cost-related factors predominate. The four factors with the highest global (overall) priorities, which are in our case simultaneously the four factors with the highest local priorities, represent factors that are directly linked to energy costs, energy efficiency, and the energy market.

Table 1: Priority of SWOT factors as results of the pairwise expert comparisons of factors and groups. CR indicates the consistency ratio for within-group comparisons.

	SWOT Factors	Group priority	Overall priority
Strengths Priority: 0.275 CR: 0.7%	S _a : Energy efficiency*	0.485 (1.)	0.133 (2.)
	S _b : Co-generation	0.286 (2.)	0.078 (5.)
	S _c : Flexibility in changing energy carrier	0.149 (3.)	0.041 (8.)
	S _d : Collaboration with energy suppliers	0.081 (4.)	0.022 (13.)
Weaknesses Priority: 0.140 CR: 0.9%	W _a : Dependency on energy market*	0.601 (1.)	0.084 (4.)
	W _b : Excess of thermal energy	0.109 (4.)	0.015 (16.)
	W _c : Capacity utilization	0.145 (2.)	0.020 (14.)
	W _d : Renewable energy limited	0.145 (3.)	0.020 (15.)
Opportunities Priority: 0.236 CR: 4.5%	O _a : Long-term low energy costs*	0.542 (1.)	0.128 (3.)
	O _b : Technological improvements	0.226 (2.)	0.053 (7.)
	O _c : Competition on energy market	0.125 (3.)	0.030 (10.)
	O _d : Opportunities as energy supplier	0.107 (4.)	0.025 (12.)
Threats Priority: 0.349 CR: 7.2%	T _a : High energy costs**	0.622 (1.)	0.217 (1.)
	T _b : Security of supply	0.075 (4.)	0.026 (11.)
	T _c : Price volatilities	0.194 (2.)	0.068 (6.)
	T _d : CO ₂ -emission trade	0.109 (3.)	0.038 (9.)

* Factor with highest local priority in respective SWOT group

** Factor with highest local and global priority

The factor with the highest priority is the (external) threat of high energy costs. This is not surprising since the paper and pulp industry sees itself as being under enormous economic pressure due to the high energy prices as a result of high raw material prices, i.e. high wood prices. One reason for the latter is clearly related to energy policy, namely the higher demand for wood stemming from rising biomass-based co-generation and/or local district heating plants. In this context, three experts pointed out in their additional comments that subsidized energy generation for wood biomass is intensifying competition on the wood market, and has resulted in growing scarcity and thus higher wood prices for the paper and pulp industry. Similarly, another expert complained that black liquor, which is the most important by-product in pulp production, is not considered a renewable source in the sense of the Austrian ‘Green Electricity Act’, and therefore cannot be utilized for subsidized energy generation.

The factor with the second highest global priority is the (internal) strength of high energy efficiency. On the one hand, this indicates that the Austrian paper and pulp industry perceives itself as being competitive due to its successful energy management and high existing energy efficiency. On the other hand, this might also be understood as a factor that even aggravates the threat of high energy costs since only little potential might remain for additional energy efficiency gains. In an additional comment, one expert endorsed the latter interpretation by stating that there might be a double penalty for Europe’s energy-intensive industry in future,

firstly, in the form of the European CO₂ emission trading system (EU-ETS), and secondly, in the form of the European Energy Efficiency Directive (European Commission, 2012). The expert explained further: “This means that for highly efficient installations (as in the paper industry) an annual percentage energy saving target will sometimes be no longer possible or economical.”

Some experts mentioned further strengths, mostly related to those identified in the SWOT analysis. For example, the relatively smooth demand curves (i.e. no sudden peaks), which is quite advantageous for energy providers. Apart from that, a further strength of the industry is perceived in the fact that different forms of competence in energy management are believed to be readily available, for example, biogas production from waste water, provision of district heating for entire neighborhoods, energetic utilization of residuals, and the widespread implementation of energy management systems.

Rank three, in terms of global priority, is occupied by the (external) opportunity of long-term low energy costs. Here it needs to be clarified that the relatively high ranking of this opportunity certainly does not mean that the industry expects energy prices to decrease over the long-term. The message here is simply that this would be important for the industry whatever the probability of long-term low energy costs. The industry’s weakness with respect to its high dependence on the energy market takes fourth place in the global priority ranking. This factor is obviously closely linked to energy costs. The latter are directly dependent on prices prevailing in the energy market. Here, one expert complained in an additional comment, that overambitious political goals, either regarding the target share of renewable energy, and/or the independence demanded from imports of electricity generated in nuclear power plants, were harmful to Austria as an industrial location and merely served to destroy jobs.

Interestingly, threats are considered to be the overall most important SWOT group, followed by the industry’s internal strengths. In other words, external factors are primarily perceived as threats, while strengths dominate with respect to the internal factors. Especially concerning the internal factors, the picture is very clear, since the three factors perceived as least important belong to the group of weaknesses. First place on the negative ranking is occupied by the excess of thermal energy, followed by the limited possibility to use renewable energy, and then by problems related to the utilization of the production capacity. Here it needs to be stated that the relatively low levels of importance perceived for these weaknesses does not mean that these weaknesses do not exist in the industry. In fact, there can still be significant mill-specific differences between companies. For example, some companies provide district heating for their neighbourhood. Thus, they have already solved the problem of excess of thermal energy. In one case, an expert even stated in an additional comment that the company has high amounts of low temperature waste energy which is not yet being recovered. Certainly, the low importance of these factors could also be caused by the fact that respondents simply do not like to admit to weaknesses at their company, i.e. in this case by stating that specific weaknesses are important.

Figure 1: Graphical representation of the overall SWOT factor weightings

In the analysis, we also checked the consistencies of the pairwise comparisons. The result turned out to be good; all consistency ratios are below 10 percent. Those for the local priorities of the strengths and weaknesses and those for the global priorities between the SWOT groups (CI = 0.89%) are even below 1 percent, and thus indicate a very high level of consistency among the comparisons.

It needs to be kept in mind, however, that AHP results are determined by the specific selection of the factors provided in the questionnaire. This could be one drawback of the method. For example, it is possible that expert decision making was subject to ‘anchoring’ as a result of the specific factors, or sequence of factors, originally provided (primacy effect). For this reason, we also integrated open questions into the questionnaire where we invited the experts to name additional SWOT factors (which could certainly not be included in AHP analysis). The answers show that the respondents mainly included information that put further emphasis on the original factors provided, especially on those related to energy price and/or energy market issues. There was only one additional factor mentioned which was not covered by the original list of SWOT factors: the threat of increasing bureaucracy. Apart from this, experts did not come up with further relevant SWOT factors. Thus, we believe that the results

achieved are valid, in the sense that they appear likely to represent a systematic analysis of strategic energy management in the Austrian paper and pulp industry.

5 Conclusions

The combined SWOT/AHP analysis presented here clearly reveals how important strategic energy management is for maintaining economic competitiveness in an energy intensive industry. The Austrian paper and pulp industry is a prime example of an energy intensive industry which is exposed to strong international competition. Not surprisingly, economic (cost-related) factors clearly dominate over environmental concerns; the main driver being the perceived need to minimize energy costs through reduced energy consumption. Although not necessarily their main intention, attempts to reduce energy costs may still contribute to a more sustainable production process since environmental and social impacts are more or less automatically diminished (Awan, Imran, & Munir, 2014). The focus on energy costs has probably gained in importance, in recent years since energy prices have continued to increase. Moreover, general awareness of energy-related costs has also grown owing to the impact of the EU emission trading system (EU-ETS) on industrial CO₂ emissions, including emissions in the paper and pulp industry. Although the price of CO₂ emission certificates recently fell to very low levels, the EU-ETS certainly provides at least some motivation for reducing CO₂ emissions by reducing consumption of fossil energy. The uncertainty regarding future price developments and the impact on emission permits is not something that business is likely to welcome (Braschel et al., 2014). Again, cost saving is the main driver, and ecological considerations such as a desire to mitigate global warming continue to take second place (Laurijssen et al., 2012; Stawicki et al., 2010). Consequently, there continues to be a large degree of overlap between energy management in the paper and pulp industry and energy costs.

However, reducing energy costs by optimizing the corporate energy system remains somewhat double-edged. Minimizing energy costs with respect to existing market prices is a rather static procedure. However, energy intensive enterprises also need to adopt a more dynamic approach by assessing and reducing their vulnerability to sudden swings on the energy market, in other words by increasing their overall resilience. While the concept of eco-efficiency, or in our case energy-efficiency, has been known for years, to date, neither companies nor researchers have paid much attention to raising resilience to energy market volatilities. This was also clear in the present study, as experts perceived price volatilities to be a markedly less important threat to the paper and pulp industry than the threat of high energy costs. Clearly, additional research is necessary to identify how energy intensive companies may develop strategies for coping with unexpected, or sudden, changes in energy prices.

One noticeable aspect revealed by the above analysis is the relatively low importance given to cooperation with suppliers. As Lehoux et al. (2010) state, market forces often force enterprises to improve their supply chains and change their ways of doing business. With respect to the paper and pulp industry, collaboration with or among energy suppliers, or wood suppliers could help optimize energy management, since wood residuals and lignin are important energy carriers in the industry. In this regard, the concept of industrial symbiosis

might be helpful for establishing inter-company collaboration (Posch, 2010). Self-generation of energy is one alternative that helps to protect the industry from negative impacts arising from energy market volatilities (Lucio, Lamas, & de Camargo, 2013), and thus might be an interesting option in terms of developing a long-term energy strategy for the paper and pulp industry.

Certainly, any attempt to generalize the current findings to cover other energy intense companies or industries in other countries, needs to be subject to certain contingencies and qualifications as no two companies, let alone countries, face the same conditions (Trianni et al., 2013). For example, within the European Union there is an ongoing debate concerning the trade-off between the need to increase energy prices so as to meet climate goals, and the need to stabilize prices so as to support the competitiveness of European industry. The trade-offs prevailing in other areas are likely to differ, e.g. in areas where new technologies such as fracking are acceptable. Furthermore, in complex industries with multiple energy flows, products and fuels, energy management becomes even more complicated (Giacone & Mancò, 2012).

Also noticeable in the above analysis is the fact that energy price volatilities were given only relatively little attention (ranked 6th in terms of global priorities). At first glance, this appears quite surprising since crude oil and natural gas prices have been quite volatile in recent years. At a second glance, however, this can probably be explained by the fact that one of the strengths of the paper and pulp industry is its ability to change from one energy carrier to another should the need arise. For technological reasons, other industries might be less flexible in this regard and thus more vulnerable to the impact of energy price volatilities.

Despite its limitations, the present study represents a significant improvement in terms of understanding the relative importance of the various SWOT factors in the Austrian pulp and paper industry. We conclude that an integrated SWOT-AHP analysis is definitely a valuable tool for strategic energy management, since it enables decision makers to take strategic decisions based on a much better understanding of what the main issues are. We therefore believe that SWOT-AHP should be considered for inclusion in the international standard ISO 50001:2011, and that it should become a standard tool for strategic energy management, both at company and at industry level.

Acknowledgments

We thank all those managers from the Austrian pulp and paper industry who participated in our study. We also thank Christoph Harg for his support in setting up the online survey.

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