Combining IPPC and emission trading: An assessment of energy efficiency and CO_2 reduction potentials in the Austrian paper industry

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Abstract

In the frame of an innovative project partnership E.V.A. – the Austrian Energy Agency accompanied the Austrian paper industry for the last 2,5 years in developing a branch specific climate change strategy. Within the scope of this project an assessment of the energy efficiency status of the branch was carried out as well as an evaluation of still realisable energy savings and CO_2 reduction potentials.

The paper presents the methodology applied, which combines a top down approach (benchmarking & best practice) with a bottom up approach (on-site interviews & energy audits), supported by a huge data collection process.

Within the benchmarking process all Austrian paper industry installations affected by the EU emission trading directive were benchmarked against their respective IPPC/BAT values. Furthermore an extensive list of best practice examples derived from existing or ongoing studies was compared with the energy efficiency measures already carried out by the companies ("early actions").

These theory-oriented findings were complemented by several on-site interviews with the respective energy managers as well as by detailed energy audits carried out by a consulting company, covering in total more than 80% of the Austrian paper industry's CO_2 emissions.

The paper concludes with the main results of the project, presenting the pros and cons of working with IPPC documents and BAT values in terms of energy efficiency assessments. Recommendations are presented on how to improve the allocation exercise for the next emission trading period from 2008 to 2012.

Introduction – Emission trading and the IPPC/BAT

With the adoption of the EU wide emissions trading scheme (2003/87/EC) to reduce GHG emissions [EC 2003] a new instrument entered the "energy efficiency market" creating a need for integration within the existing policy mix.

Within the EU emission trading scheme each concerned installation received absolute emissions allowances, which were reported to the EC in the so called national allocation plan (NAP). The time around 31 March 2004, the deadline for the first NAP covering the period from 2005-2007, was very turbulent almost in all EU countries, since negotiations between authorities and industry on how to agree on absolute emissions targets are a very "delicate" matter. For the industrial companies it meant for the first time that they got a cap on their emissions which could effect their economical growth considerably. Thus they were tending to get as many allowances as possible not to limit possible production increases.

For the authorities on the other hand it was important to make the system work and to achieve high environmental benefits (the later only if the ministries of environment were involved). National governments had to consider that the allocation plan should be consistent with the targets of their national climate change programmes as well as with the obligation under the EU burden sharing under the Kyoto protocol. They had also to make sure that the quantities of allowances match the actual (technological) potentials.

Of course this led to conflicting situations between industry and authorities and therefore transparent information on the available potentials was of utmost importance. This was the time when the IPPC directive and the BREF documents with their respective BAT values (best available technologies) played an important role [IPPC 1996]. The BAT values represent EU-wide accepted benchmarks which could be taken as an indicator for existing energy efficiency potentials. How this benchmarking process was applied in the case of the Austrian paper industry is explained in this paper.

In the frame of an innovative project partnership E.V.A. accompanied the Austrian paper industry since 2002 in developing a branch specific climate change strategy [Starzer et al 2005]. This included an assessment of the energy efficiency status of the branch, as well as an evaluation of still realisable energy savings and CO_2 reduction potentials. The project was closely connected to the EU emission trading scheme, since future potentials were considered as crucial information to determine the amount of emissions allocated.

The Austrian paper industry consists of 29 plants, of which 27 plants are covered by the ET scheme. The branch emits about 5 Million tons CO_2 per year (2001), of which about 2 Million tons per year are of fossil nature, the rest accounts from renewable sources (mainly black liquor, biomass, etc.). Many of the plants are now embedded in multinational entities.

Methodology to evaluate the Energy efficiency status of industry

How to consider energy efficiency when allocating CO_2 emissions? To answer this question E.V.A. developed a transparent methodology on how to evaluate energy efficiency potentials [Starzer et al 2003]. In the course of this project a transparent process was proposed to verify technological potentials. This process includes the elements energy benchmarking, best practice examples and energy audits (see Figure 1).

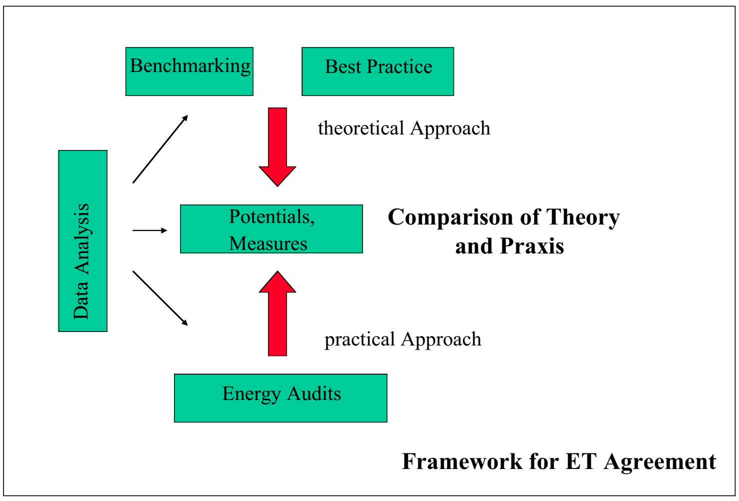


Figure 1. Framework for the assessment. Benchmarking, Best Practice and Audits.

In order to identify the technological potential of concerned emission trading installations a two-fold approach was applied:

On the one hand a theoretical top-down approach was applied:

Based on a comprehensive data analysis of all energy and CO_2 related data of an installation benchmarks were developed for each comparable type of installation. This work was based on previous experiences gained within several EU SAVE II projects [IEC 2001, BPI 2002]. In many cases the values presented in the BAT (best available technologies) documents of the IPPC directive [IPPC 1996] served as master benchmarks to define a "best" value. The benchmarks take into account the thermal as well as the electricity consumption. The distance from the best value gives a first indication on the technological potential.

However, it is essential to know that benchmarking is not a perfect instrument. Therefore in parallel checklists of theoretically possible best practice measures were developed, based on the knowledge of the most recent potential studies in the EU [Haworth 2000, Drasdo 2000, Martin 2000, Alsema 2001, De Beer et al 2001]. By commenting this check list the companies pointed out which measures they already accomplished since 1990 (early actions) and which are still open to be realised. Pay back time and risks concerning product quality were important criteria to justify that measures are not yet undertaken.

On the other hand the process was complemented by a practice-driven bottom-up approach:

To be able to compare the theoretical results with "real life", the companies undertook energy audits in order to show the realistic potentials applicable on their site. The audits were carried out by a consultant (in the most cases by ALLPLAN) who in general was paid on the basis of energy costs saved. The audit followed clearly defined audit procedures, to ensure the quality and comparability of the results [Väisänen et al 2003]. E.V.A. was able to check all audit reports and had detailed talks with the respective project managers of the consultant. E.V.A. also carried out on-site interviews with the responsible company staff, in order to ensure the quality of the results.

The top-down approach – energy benchmarking

In the course of the national discussions when developing the national allocation plan benchmarks were seen as one element to derive emissions allowances on an installation basis. By comparing internationally valid indicators the Austrian companies should be judged whether they had done their energy efficiency "homework" and whether early actions could be taken into account. This approach takes into account the fact that in Austria (and in many other countries) not many comparable sites by type of installation do exist.

In the course of the project a set of indicators was derived using branch specific values and approaches. Installations were distinguished by production, i.e. whether they represented pulp, paper or integrated mills. Furthermore different types of pulp as well as different types of products had

Table 1. Schematic suggestion for a set of indicators.

Type of installation	electricity	heat	CO_2
integrated production	MWh / tonne of paper	TJ / tonne of paper	CO_2 / tonne of paper
pulp production	MWh / tonne o pulp	TJ / tonne of pulp	CO_2 / tonne of pulp
paper production	MWh / tonne of paper	TJ / tonne of paper	CO_2 / tonne of paper

to be distinguished to develop a useful set of indicators. For each indicator the thermal and the electricity consumption were related to the relevant production data (see Table 1).

A special problem presented the system border in terms of energy losses. In a first attempt all energy losses were included within the benchmarks. Thus the indicator was calculated by using the primary energy consumption, initially the heat benchmark was calculated with the fuel heat minus the own production, the electricity benchmark with the electricity consumption, including own production and imported energy (see Figure 2).

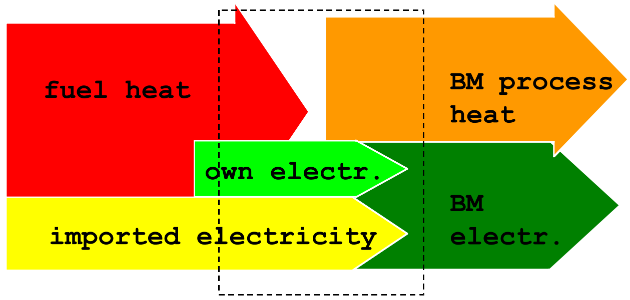
In the course of the project this method was changed because of two reasons: firstly, to make the data and results compatible with the data collection project of the UBA (the Austrian environmental agency) and IIÖ (consultant) carried out to support the ministry in the preparation of the allocation plan. And secondly, the investigation of the BREF document [IPPC 2001] made it necessary to modify the process to be able to use the published benchmarks for comparison.

It was concluded that a third benchmark should be calculated to compare the efficiency of the energy production process (production of process heat, district heat and electricity related to primary energy consumption). Thus the benchmarks for electricity and process heat consequently included only the energy consumption used for the paper and/or pulp production process.

Due to the lack of information within the BAT documents concerning system borders some open questions are still remaining. It is not clear whether the energy consumption always is calculated without energy losses, or if sometimes the energy losses are included e.g. for integrated plants. Of course this might lead to completely different benchmarking results. For plants with black liquor recovery system only the produced heat should be taken into account for the benchmark.

According to the above mentioned procedure the Austrian paper mills were put into different benchmarking groups and by using confidentially reported data a benchmarking comparison was carried out for all emission trading installations. The different benchmarking groups and the BAT benchmarks derived from the BREF document [IPPC 2001] are presented in Table 2. Possible process related differences had to be evaluated individually.

The benchmarks were discussed in detail with each company and possible mistakes could be corrected. The companies could chose whether they wanted to use these benchmarking results within the "distance to best practice" exercise carried out by IIÖ and UBA.



Basis for Benchmarks:
BM process heat = Fuel heat – own electricity
BM electricity = Own electr. + imported electr. – exported to grid

Figure 2. *Calculation of heat and electricity indicator (first attempt).*

The bottom-up approach

The bottom-up assessment distinguished three types of energy efficiency measures:

- *Measures on the supply side:*
  These measures deal with the energy production on-site incl. CHP, fuel switch and renewable energies.
- *Measures on the demand side:*
  These measures are split into two groups: process technologies i.e. technologies to be applied in the paper and pulp production process (such as shoe press etc.) and cross-cutting technologies such as motors and drives, compressed air, heat recovery, heating, air conditioning, lighting etc.
- *Organisational measures:*
  These soft measures focus on energy management systems, purchase of efficient appliances, energy efficient behaviour of the staff and similar issues.

In order to distinguish technical potentials from economic feasible potentials, E.V.A. together with the relevant companies carried out several case studies. Within this study a potential was defined as economic feasible when the pay back time of a measure was equal or below 5 years, a value presenting common practice among Austrian paper makers.

SUPPLY SIDE MEASURES

Combined heat and power (CHP)

Within the Austrian paper industry 27 paper production sites were assessed in detail, of which 20 are equipped with this efficient technology. The majority of CHP plants are

Table 2. Benchmarking Groups for the Austrian paper mills (source: [IPPC 2001]).

Benchmarking group	BAT electricity kWh/t		BAT process heat GJ/t	
Mechanical Pulp	from	to	from	to
Integrated				
Newsprint (>50% mechanical pulp)	2 000	3 000	0	3
LWC mill (> 50% mechanical pulp)	1 700	2 600	3	12
SC mill (> 50% mechanical pulp)	1 900	2 600	1	6
Kraft (Sulphate) Pulp				
Non-integrated				
Bleached Kraft pulp	600	800	10	14
Integrated				
Kraftliner, unbleached	1 000	1 300	14	18
Sackpaper, unbleached	1 000	1 500	14	23
Sulphite Pulp				
Non-integrated				
Bleached sulphit pulp	700	800	16	18
Integrated				
Bleached sulphit pulp and coated fine paper	1 500	1 750	17	23
Bleached sulphit pulp and uncoated fine paper	1 200	1 500	18	24
Recovered paper processing				
RCF based Testliner and Wellenstoff without de-inking	700	800	6	6,5
RCF based cartonboard or folding boxboard, no de-inking	900	1 000	8	9
RCF based newsprint, de-inked	1 000	1 500	4	6,5
RCF based tissue, de-inked	1 200	1 400	7	12
Paper production				
Non-integrated				
Uncoated fine paper	600	700	7	7,5
coated fine paper	700	900	7	8
Tissue mill (process heat up to 25 GJ/a)	600	1 100	5,5	7,5

Box 1.

$$PES = (1 - 1/(\eta\ CHP_{th}/\eta\ REF_{th} + \eta\ CHP_{el}/\eta\ REF_{el})) \times 100\%$$

- PES: primary energy savings
- $\eta\ CHP_{el/th}$: is the electrical/heat efficiency of the cogeneration production defined as annual electricity from cogeneration / annual useful heat output divided by the fuel input used to produce the sum of useful heat output and electricity from cogeneration.
- $\eta\ REF_{el}$: is the efficiency reference value for separate electricity production (here 40,6%).
- $\eta\ REF_{th}$: is the efficiency reference value for separate heat production (here 90%).

based on back pressure turbines, but also several gas turbines are in operation, partly in combined cycles. Additionally 16 installations are equipped with small scale hydro power plants.

The overall efficiency of the energy production (heat and power) results in 80,3%, the efficiency for electricity production is 15,7%, the heat production amounts to 64,5%. In order to assess the quality of the CHP plants E.V.A. calculated the primary energy savings (PES) compared to the separate production of power and heat by applying the PES formula of the CHP directive [EC 2004].

If all installations of the Austrian paper industry are treated as "one singular plant" the PES amount to 9,4% which is very close to the benchmark for high efficiency cogeneration of 10% mentioned in the CHP directive (annex III).

Re-powering

According to a SAVE Study carried out by CEPI – the confederation of European paper industries [CEPI 2002] – a high CO_2 reduction potential can be realised by re-powering existing CHP units into combined gas-steam cycle. In detail this means to replace a common steam boiler (mainly gas fired) by a gas turbine with heat recovery boiler. The potential mentioned by CEPI results in a CO_2 reduction of 2,4 Million t/a.

The figures mentioned in the CEPI study seem far too high for Austria. The evaluation of the technical potential for repowering leads to an additional power production of about 713 GWh, which is comparable to about 214 000 t CO_2/a, if the emission factor of the Austrian fossil electricity mix is applied. However, according to the CEPI study repowering for Austrian plants is so far not economic feasible.

Fuel switch

A classic possibility to reduce CO_2 emissions is to switch to less climate relevant fuels, e.g. from coal or oil to gas. Within the Austrian paper industry the share of coal and oil is still about 20% of the fossil fuel consumption. In order to assess whether this amount can still be switched to less CO_2-intensive fuels, E.V.A. together with the relevant companies carried out several case studies. These case studies resulted in a technical potential of about 17 500 t CO_2/a of which about 9 000 t CO_2/a are also economic feasible. Due to technical reasons it is very difficult to reduce the share of coal and oil further.

Electricity production from biomass

With nearly 50% the share of renewables is already high within the Austrian paper industry. This is due to the big share of black liquor (79% of all renewables) which is a by-product of the pulp production. So far several Austrian companies use black liquor for their energy production, others use biomass boilers with fluidised bed combustion.

In order to quantify the future potential to increase electricity production from biomass E.V.A. undertook several case studies together with the concerned companies. In total a technical potential for further CO_2 reduction of about 28 000 t CO_2/a was identified, of which about 38 000 t are economic feasible. This potential could be realised by co-firing units or with new biomass boilers.

DEMAND SIDE MEASURES

Process technologies

A check list plus questionnaire was filled in by the majority of companies. The list of measures was reduced from 120 down to about 70 energy efficiency measures which are really relevant for the branch. The companies reported which measures they already realised and which are still open. The "open" measures where analysed in case studies. They amount to a technical potential of about 44 400 t CO_2/a. None of the measures were economic feasible which leads to the conclusion that these type of measures are rather realised in the course of production increases.

The same counts for optimisation measures which consequently lead only to specific energy savings (i.e. energy reduction per tonne of paper/pulp), which are applied hand-in-hand with production increases. The potential for these savings is very difficult to evaluate and is not included in this study.

Cross-cutting technologies

12 companies which represent more than 80% of the energy consumption were checked by energy audits carried out by consultants (mainly by ALLPLAN). The results show that the companies deal very carefully with energy matters. In the most cases energy issues are well integrated in common business routines of the companies. Some companies even try to integrate their staff in the identification of measures via employee suggestion systems.

On the electricity side the consultants checked motors and drives, lighting systems as well as compressed air systems and vacuum pumps. On the heat side they investigated the heating systems, several heat recovery options and air conditioning. Also the efficiency of boilers was evaluated. In total the audits identified a technical potential of about 68 000 t CO_2/a of which about 62 000 t/a are economic feasible.

ORGANISATIONAL MEASURES

It was not possible to get quantitative results for organisational measures. Allmost all companies have very sophisticated energy management systems in place and some involve their staff in employee suggestion systems.

Main results

From both perspectives – from the top-down as well as from the bottom-up approach – it can be concluded that the Austrian paper mills show very good results. In total 25 installations were included in the benchmarking process. Only in 3 cases the benchmarks for process heat were slightly less efficient than the BAT reference. In 4 cases the electricity benchmark was less efficient than the BAT range. Of these installations one was out of both heat and electricity ranges.

One possible explanation is that plants might have reported wrong energy consumption data (e.g. high instead of low pressure values). A correction lowers the process heat indicator considerably. High differences from BAT reference values only were found among some companies where the product spectrum differed considerably from the spectrum used for the BAT reference. In these cases the BAT values are not representative. Differences also can be explained by partly integrated plants, i.e. if only a part of the produced pulp is used for paper production on site or if additional (imported) pulp has to be added. This leads of course also to very different benchmarks.

By far the majority of plants were within the given range of the BAT reference. 13 plants even had better values than the lower BAT value (see column "from", Table 2). The same counts for 15 plants for the electricity benchmark.

In the course of the Bottom-up analysis several case studies were analysed resulting in a total CO_2 reduction of about 413 000 t CO_2/a of which about 109 000 t CO_2/a are also economical feasible (see Table 3). In average this leads to an economic feasible CO_2 reduction potential of at least 1% per year, not yet including day-to-day optimisation measures. In comparison in 2001 the Austrian paper mills were responsible for 1,93 Million tonnes of fossil CO_2 emissions and for 3,09 Million tonnes of CO_2 resulting from biogen fuels.

The highest identified technical potential of about 214 000 t CO_2/a results from CHP re-powering. However, to be able to realise this potential, industrial sites have to be used more intensively for power production. Also a stronger

Table 3. Summary of identified CO_2 reduction potentials.

	Groups of measures	Technical Potential [t CO_2/a]	Economic Potential [t CO_2/a]
1	Fuel switch	17 508	9 000
2	Electricity production from biomass	282 380	38 000
3	Production process	44 414	-
4	Cross-cutting technologies	68 390	61 704
	Total	412 692	108 704
	Re-powering of CHP	214 000	Not done
	CHP with back pressure turbines	20 000	Note done

cooperation between industry and energy industry might be necessary.

Conclusions

Benchmarking with BAT values from IPPC seems to be a very easy-to-apply methodology for the allocation of emissions. The ideal situation would be like this: If an installation fulfils the benchmark it has no further potential for improvement, if not the difference to the benchmark is per definition the potential. The easiness of application would present the main pro of the benchmarking approach.

However, real life is not that easy. Benchmarks have to reflect different types of products and processes, sometimes even different sizes. If not, this could result in very different values of energy used per product unit. Therefore not only several categories are introduced in the BREF document, but also each category covers a wide range of BAT values. Here the main conflict for benchmarking can already be seen: Either the benchmark is so general, that many aspects of installations are neglected. Then some plants would not fulfil a strict BAT value, even if they perform well. Or the benchmark is very tailor-made. Then it could happen that it fits only for one particular plant. How to perform benchmarking then?

The present set of BAT values within the BREF document tries to take into account both aspects. Within this set the Austrian paper plants amount to max 3 plants per BAT category. The majority of plants are within their given ranges, many of them have even better values than the lower BAT value. This leads to the question whether the BAT references really present the best available technology. However, to be able to answer this question it would be necessary to compare the BAT references also with the benchmarks of paper mills from other EU countries. In any case, a revision of the BAT values and a clearer definition of the system borders can be recommended, especially if they should further be used in the international context such as for benchmarking exercises. And this could already happen in a couple of years when the next NAP has to be developed for the 2nd emission trading period 2008 to 2012. However, given the history of the IPPC process, coming up with new BAT-values may go well into future trading periods.

In the actual NAP process the presented benchmarking results were included. If the installations performed well within their respective BAT range, no "energy efficiency malus" was put on their emissions allowances. Thus, the method of combining IPPC and emission trading in principle seems suitable to integrate energy efficiency aspects into the allocation process. However, as the above mentioned cons point out, the BAT values need to be revised. Furthermore it has to be taken into account that such detailed BAT values are not available for all concerned industrial branches.

The emissions trading scheme can actually present a strong driver towards industrial energy efficiency. The IPPC documents and their respective BAT references could play a crucial role in monitoring the effects of the EU emissions trading scheme, however, it needs credible and transparent benchmarks to do so and they have to be applied throughout the EU. Therefore quick action is needed if such benchmarks should be ready for the forthcoming allocation period.

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