Minimizing Environmental Impact

Executive Summary

Health, safety and environmental issues are key concerns for Valmet, and they are addressed with the same sense of responsibility as quality, productivity and cost-efficiency solutions. In the area of environmental responsibility, Valmet’s focus is particularly on developing environmental technologies that offer eco-efficient solutions to mills. Our products and services reduce the environmental load and improve the quality of mill operations.

Examples of technological approaches that minimize environmental impact include:

- Effective water management concepts which use ultrafiltration technology
- GreenSound silencers for use in urban mills
- Machine design and dimensioning to minimize CO₂ emission
- Sustainable energy production with bubbling fluidized bed conversions
- Project of the Year 2012 - Best Bioenergy Project (Nacogdoches Generating Facility).

This paper presents case examples and the environmentally proven technologies behind them.
Effective water management concepts utilize ultrafiltration technology to achieve stringent environmental demands

Paper cannot be made without water. By reducing consumption of fresh water and raw materials, papermakers can promote sustainable production while also saving energy and money without compromising product quality.

Over the past few decades paper mills have significantly reduced their use of fresh water for many reasons, including the limited availability of fresh water, increased cost of effluent and fresh water treatment, tighter environmental legislation, or even the desire to improve a mill’s public image in some cases.

This lower fresh water consumption has been facilitated by the reuse of process water, and also by a better understanding of process chemistry. Nearly every mill recognizes water emissions as a problem area. However, these environmental loads can be reduced by modifying and developing traditional papermaking processes.

Good water management improves mill efficiency

Today’s demand for better product quality and the increased use of recycled fiber both require higher quality process water for good machine runnability. Our focus has to shift from individual process components to the overall quality of process water and the entire process concept.

The goal is to master the whole papermaking line (machinery, equipment and processes) in detail. It is necessary to understand the big picture, all the way from fresh water treatment and internal water circulations right to the purification of effluent. Water management means planning, developing, disseminating and managing the optimal use of water, according to applicable water policies and regulations, throughout an integrated paper and pulp mill complex. The primary challenges in water management include environmental legislation, cost-effectiveness, and runnability. Optimized water management helps to support an efficient papermaking process.

Whether and how to close your water systems depends on the types of technology you are prepared to use. Along with the economics of the investment, it might also be necessary to consider the potential disadvantages that low fresh water consumption might entail.

Every papermaking line has its own minimum level of fresh water consumption that can be achieved with conventional process solutions. This level is reached when process engineering is based on the best available technology.

The closing of water systems has to be carried out without any negative effects on paper machine runnability, final product quality, or the environment. This means that the water used needs to be as close to fresh water in quality as possible.

The remainder of this water management section explains how a modern papermaking line utilizes ultrafiltration technology to achieve stringent environmental demands.
Reducing fresh water consumption by 1,500 m³ per day

The less water you use, the more you help to conserve the environment and save on water treatment costs. By using Valmet’s ultrafiltration technology, it is possible to purify the paper machine’s clear filtrate and use it instead of fresh water. Fresh water consumption will be reduced, as well as the amount of waste water. If fresh water needs to be heated, savings will also be achieved through lower heating costs and related airborne emissions.

Figure 1 shows how a 25% reduction in total water-related costs can save one million euros per year. Actual savings naturally depend on local unit costs.

Water management concepts for a variety of needs

The key to water and effluent cost savings is an efficient water management concept. Valmet has developed a full range of water management concepts for different paper grades and fresh water consumption levels. They are all based on extensive knowhow accumulated through our reference projects, process evaluations and simulation studies at many paper and board mills around the world.

Process evaluation studies and the benchmarking of similar machine lines have enabled Valmet to evaluate a multitude of targets, technologies, successful solutions, and possible improvements. This prior experience is invaluable when carrying out a feasibility study or the pre-engineering stage for a project.

Valmet’s solution today is to treat white water with internal kidneys (ultrafiltration, microflotation) to reduce the accumulation of harmful substances and prevent their uncontrolled growth in the water system. Ultrafiltration technology removes all bacteria, colloids and solids from the white water and microflotation is used for press section waters to remove fines and pitch.

The purpose is to reject unwanted compounds in the white water, which would otherwise affect the production process. In the past, some white water would be discharged from the process and replaced with fresh water. With today’s ultrafiltration technology, white water can be returned back to the process, which reduces both fresh water consumption and the amount of waste water generated.

One important part of Valmet’s solution is to treat white water in an internal biological treatment plant. Efficient biological treatment is needed, with a sufficient amount of biofiltrate recycling back to stock preparation, in order to maintain a constant process water balance and control COD and Ca levels.

Figure 2 shows the basic Valmet solution for low fresh water consumption liner/fluting mills.
Step by step toward cost savings

Figure 3 explains how to proceed with new or existing papermaking lines. Water management has an effect on the whole papermaking line. The paper machine and stock preparation must always be considered as one integrated system.

With existing papermaking lines, it is necessary to know the background of a problem before it can be solved. This means gathering information from different processes and considering a variety of solutions from every possible angle. If you do not understand the overall system, any efforts to solve a specific problem may actually create more problems.

Process evaluation studies, including taking and analyzing samples, are carried out at the mill when process chemistry needs to be clarified. Process chemistry can provide an indication of what might be wrong.

It is up to the mill to decide whether it wants to address possible problems maintaining the present fresh water consumption, or whether it wants to reduce fresh water consumption while retaining current machine runnability, or perhaps even improving it. It does not matter whether we are talking about a new or existing papermaking line since the process concept, equipment and process connections employed should always be based on the targets set. This is the best way to control lifecycle costs.

Optimized process conditions and major savings cannot be achieved immediately after start-up. They are attained a bit later when the process conditions are stable and water treatment processes are operating at their maximum capacity. A long-term cooperation agreement with Valmet enables paper mills to succeed and meet their growing challenges by offering a fruitful basis for implementing ongoing improvements and controlling their lifecycle costs.

OptiCycle W process

The OptiFilter CR ultrafilter process (Figure 4) for the paper mill white water system is called the OptiCycle W process. The process is dimensioned to replace fresh water in very demanding places, such as in crucial forming section high-pressure showers or in chemical dilutions and especially in places where the quality of save-all filtrates (solids, colloids and bacteria) creates too much of a risk. The bigger the system is, the bigger the
effect it has on overall white water quality.

The required amount of ultrafiltrate is produced by the appropriate number of CR ultrafilters which are connected together. The process connection is presented in Figure 5. The feed water is save-all filtrate (clear and cloudy filtrate) with low solids content.

The feed water is prescreened to recycle long fibers back to the process. In this way fiber loss is minimized. Permeate is used in the process to replace fresh water. The final concentrate is directed away to waste water treatment.

All filters have a common "Cleaning In Place" (CIP) system. Ultrafilters must be washed regularly to maintain optimal capacity. Alkalic washing is an automated action that is normally done once a week for all filters. Acid washing is normally done once a month.

The ultrafiltrated water is free of suspended solids, colloidal material, bacteria, latex and other microstickies. As the anionic trash is cut to approximately half of the original level, the quality of the filtrate enables trouble-free recycling to the process.

The operational costs of the OptiCycle W process normally amount to EUR 0.2 – 0.4/m³. Half of this is energy costs, and the other half is accounted for by washing chemicals, membranes and other spare parts. About half of the consumed energy is gained as heating energy for paper machine process water. The permeate temperature is 1 – 2 °C higher than the feed, which helps the PM thermo balance.

Ultrafiltration’s positive impact on the environment is definite. At the same time savings in the paper mill’s running costs are achieved. Both the use of fresh water and release of waste water can be reduced by 2 – 4 m³ per tonne of produced paper. This means that less energy is needed for the heating of the fresh water due to the recycled thermal energy of the ultrafiltered water and lower fresh water need. Even lower CO₂ emissions are achieved, depending on the method of energy production. The savings are about EUR 0.5 – 1.5/m³, depending on the price of fresh and waste water and the required amount of water heating energy.

**Competitiveness and sustainability go hand in hand**

The success of Valmet’s water management concepts is based on the countercurrent principle, internal kidneys at the paper mill and stock preparation, and comprehensive knowhow of water treatment and handling. Computer simulations with mathematical models have been an important tool in evaluating different concept alternatives.
Valmet provides papermakers with solutions and knowhow that cut production costs and save natural resources. Our key objectives are to enhance papermakers’ competitiveness, product quality and machine runnability. Valmet also recognizes its responsibility for the way process water affects papermaking and the environment.

It is important to remember that the savings or losses resulting from mill runnability and product quality are much more critical for mill profitability than the level of water treatment costs. With wisely organized water management, it is possible to turn water costs into savings.

**GreenSound silencers in the modern urban mill site**

Pulp and paper mills, particularly in Europe, are becoming increasingly aware of and interested in emission reduction and control. Noise reduction and control is an important issue in environmental protection requirements. In Europe, external noise levels have been covered by guarantees for several years. Legislation and standardization on emissions also exist in China, for example. One good example is the National Chinese standard, "Emission standard for industrial enterprises noise at boundary" from 2008. The standard sets targets for daytime and nighttime noise levels.

*Figure 6* shows a general overall trend in noise reduction in Europe. The distance from mills to the immission or reference points with an equivalent sound pressure level of $L_{Aeq} = 45$ dB has decreased over the years.

Internal noise level targets have also become important – the objective is to create a better working environment for the papermakers themselves.

**Sound attenuation of external noise**

At modern urban mill sites, noise control is an essential element that requires much attention and measures that must be taken to improve the image of mills and keep the people living in the vicinity of the mills happy.

So how can the difficult task of reducing noise that can’t physically be collected from the air be done? It requires overall knowhow and experience of industrial conditions, of the properties of sound and its attenuation. Noise abatement must happen as close to the noise sources as possible.

Immission or reference points where the sound level requirements are to be defined must be set. This is usually done by consultants or authorities. If there are no predetermined points, these can be defined by Valmet together with the mill. The immission points are usually at the boundary of the mill in different directions away from the building or at different important locations in residential areas.
Noise abatement engineering is based on the coordinates of the reference points and their target sound levels. Valmet provides complete guaranteed solutions of ventilation noise control systems, including noise surveys, sound level measurements and reference point sound level calculations.

The first things that must be considered are ventilation layout, directivity considerations and screening possibilities. Other important factors (Figure 7) are air absorption and distance attenuation (or divergence). When the distance is doubled the sound is attenuated by 6 dB. The distance attenuation of 100 m is 40 dB.

Based on the immission points’ guarantee levels, the required sound levels for each separate noise source are calculated at a 1m distance. These levels are usually also the guarantee sound levels.

After this the GreenSound silencers are dimensioned to fulfill the guarantee sound levels. If fans or other equipment are installed outside they will need sound insulation hoods.

The design of noise abatement measures is very important in the early stages of a project as this will lower sound attenuation costs.

The guarantee value at the noise sources is either one of the following with their typical levels:

- the A-weighted sound pressure level at 1m distance \( L_{pA}(1m) = 65-75 \) dB
- the A-weighted sound power level \( L_{WA} = 75-90 \) dB

The guarantee value at the immission points is the equivalent A-weighted sound pressure level \( L_{Aeq} \) for a specified period of time.

**GreenSound silencers**

GreenSound silencers have been optimized for good performance over a wide frequency range based on long experience at mills and silencer development in an acoustics laboratory. There are two main types of GreenSound silencer: absorptive or resistive silencers and reactive silencers or resonators.

**Absorptive silencers for middle and high frequencies**

Absorptive silencers operate over a wide frequency range at middle and high frequencies. The heart of these silencers is a porous absorption material that needs to have certain properties i.e. good absorption and tolerance for higher temperatures, moisture and cleaning. As a result of numerous tests in an acoustics laboratory and long-term experience at paper mills, three materials have been chosen. Certified polyester for lower exhaust air temperatures, mineral or glass wool for higher temperatures and finally, glass fiber thread for very high temperatures.

In the pores of the absorption material sound energy is partly transformed into heat energy.
The absorptive silencers are shown in Figure 8. There are different types for different applications both with a fixed structure (PV and PVK) and an opening design for cleaning on-site (AVB, BVN, LBV and BVNV). The BVN and LBV silencers are designed for big air flows and strict noise level requirements.

The absorptive silencers are effective for broadband attenuation of fan and vacuum blower noise.

Reactive silencers for low frequencies

Reactive silencers work at lower frequencies. According to their function principle, they are built as pipe resonators and membrane resonators.

In pipe resonators the sound waves are reflected backwards due to cross section changes (PRV and MPRV). In membrane or plate resonators (MBV), the airborne sound is transformed into plate vibration that transfers the sound energy into heat (Figure 9). The MBV silencer is designed for big air flows and for positions where the exhaust air is dirty.

Reactive silencers normally work at lower frequencies and have narrow band attenuation. Therefore they are often used in combination with absorptive silencers. The BVN and MBV silencers are modulated for optimal simultaneous control of low and high frequencies.

Sound measurements

To verify the guarantees after the pulp or paper machine start-up, the sound levels are measured at a 1m distance from each noise source as well as the equivalent sound levels at the immission points.

However, the immission point measurements are often difficult or impossible to perform due to background noise from traffic or other activities around the mill. In this case the only way to determine the immission point noise levels is to calculate them.

Sound pressure levels at a 1m distance are measured according to ISO and DIN standards, e.g. DIN 45635-47-KL3 or ISO 3746. Because the sound power levels cannot be measured, the sound pressure levels (or sound intensity levels) are measured and the sound power levels are calculated according to the measurement standard in question.
Immission point sound level calculation

The equivalent A-weighted sound pressure levels at the immission points are calculated according to ISO or VDI standards (attenuation of sound during propagation outdoors). The measured sound pressure levels, and the calculated sound power levels of all noise sources and their coordinates, are needed for the procedure.

Things to be taken into account are the directivity correction and the attenuation due to geometrical divergence, atmospheric absorption, ground effects, barriers and miscellaneous other effects.

Mill cases: overall implementation of noise control

A recent example of a customer requiring overall implementation of noise control is Propapier PM 2 in Eisenhüttenstadt, Germany. The environmental concerns of the mill also include noise control. The authorities have defined three immission points in the vicinity of the mill.

The noise control targets were strict and the process ventilation systems were designed with extensive sound attenuation. Figure 10 shows the silencers for the seven heat recovery stack exhausts. The silencer types are absorptive BVN and reactive MBV silencers.

<table>
<thead>
<tr>
<th>Immission point</th>
<th>Target $L_{Aeq}$/dB(A)</th>
<th>Calculated $L_{Aeq}$/dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IO6</td>
<td>29</td>
<td>21</td>
</tr>
<tr>
<td>IO16</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>IO19</td>
<td>30</td>
<td>21</td>
</tr>
</tbody>
</table>

The contribution of the mill to the sound levels at the immission points could not be measured because of too much background noise from activities taking place in residential areas, such as mowing the lawn, or natural sources, such as birds. Hence the contribution of air systems to immission points’ sound levels had to be calculated. The results from these calculations are presented in Figure 11.

Some other reference cases with overall implementation of noise control are Mondi Świecie PM 7 in Poland, Hokuetsu Niigata PM 9 in Japan, Rhein Papier Plattling PM 1 in Germany and Stora Enso Kvarnsveden PM 12 in Sweden. Figure 12 shows the Plattling case as another example.

Summary of noise control

Responsible actions from mills, as members of the community, are needed in order to decrease environmental noise emissions. Valmet is ready to help mills reduce noise emissions to an acceptable level throughout the
lifetime of the mill. This is achieved by means of developed technologies and proven solutions for noise abatement.

**Machine design and dimensioning major determinants of paper line CO₂ emissions**

The most significant factor affecting the carbon footprint of a papermaking line is the amount of energy consumed in the course of its full lifecycle, which is largely determined at the technology and concept selection stage. Choices made at this point define an operating window, of sorts, within which the line can function. In other words, if the wrong alternatives are adopted, even life-long efficiency measures cannot bring the line’s carbon footprint down to the desired levels.

**Carbon footprint of paper, and factors affecting it within the papermaking environment**

The carbon footprint of paper products can vary greatly depending on geographic location and the resources and technology available to the manufacturer. A study by VTT, Technical Research Centre of Finland, found that the carbon footprint of newsprint ranged from 891 to 1,066 kilograms of CO₂ equivalent per paper tonne, based on the waste management and recycling methods employed. For magazine paper, meanwhile, this figure was 905 kg of CO₂ equivalent per paper tonne (Figure 13).

The most notable differences in the carbon footprints of newsprint and magazine paper stem from the respective papermaking and printing processes. The newsprint raw material used in these calculations mixes slightly over one-third of mechanical pulp with recycled fiber. As we know, mechanical pulping is very energy intensive, and the carbon dioxide emissions of newsprint production therefore somewhat exceed those of fine paper based magazine paper manufacturing. End product quality requirements, in turn, can be seen most clearly in the carbon footprint of printing.

But what do the above carbon footprints actually mean in practice? If a newspaper comes out 356 times a year, the carbon footprint of one full-year daily subscription is then roughly 75 kg of CO₂ equivalent, and the carbon footprint of a single newspaper is about 210 grams. Using the European Union’s 2012 emission targets for new passenger automobiles (120 gCO₂/km), this means that one newspaper subscription would contribute the same amount of CO₂ as 625 kilometers of car travel. This figure doesn't seem particularly high, but when we consider the fact that a paper machine making 300,000 tonnes of paper per year supplies 4.1 million daily newspaper subscriptions, the annual emission volume starts to get quite significant.
How then can this carbon footprint be reduced at the line technology and concept selection stage? Figure 14 shows the key determinants.

Limiting the carbon footprint of new lines consequently calls for open cooperation between paper producers, consultants, and equipment and systems suppliers, as no individual player is able to deliver the best possible overall outcome by itself.

**Energy efficiency plays a major role in reducing emissions**

Efficiency improvements are expected to play a big part in responding to the world's energy challenges. In terms of emission reductions and incremental energy availability, the contributions of efficiency measures will outweigh those of any single form of energy generation technology severalfold. According to an IPCC study, efficiency measures will account for half of the energy sector's emission reduction opportunities by the year 2030. In the IEA's low carbon scenario, meanwhile, more than two-thirds of all emission reductions are based on energy efficiency measures. This will be particularly evident in the forest products industry where renewable energy sources have traditionally already been used to a high degree and international challenges therefore need to be met by using energy more efficiently.

Figure 15 illustrates the effects of energy efficiency on air emissions. Let us assume that a paper machine's high-pressure showers need a flow rate of 108 m³/h, which means a related hydraulic power requirement of 94 kW. When we track the full chain of efficiency ratios all the way back to the power plant, we see that producing this flow rate requires 1 MW of electric power from the power plant, which implies a certain level of CO₂ emissions depending on the mix of fuels used.

In practice, however, an integrated mill's power plant primarily produces process steam, which makes the overall situation somewhat more complicated than implied above, and always requires a more comprehensive assessment. What is essential, though, is that improving energy efficiency right at the point of use can already produce notable companywide, or even national, savings.

What could these efficiency measures at the point of use entail? An equipment supplier can shape the greater whole at the machine dimensioning and design stage, which sets the energy efficiency "window" within which the line will operate. Returning to the above pumping example, the following items need to be addressed at the dimensioning stage:
Minimizing Environmental Impact

- Proper dimensioning of motors and equipment for applicable loads.
- Use of frequency converters to adjust motor speeds for partial loads.
- Use of energy efficient motors.
- Prevention of unnecessary power losses in pipes and cables.

Operating personnel can also affect the energy consumption of equipment through various control settings, but to what extent depends on the sophistication of the machine's controls and the energy awareness of its operators. The lower a machine's degree of automation, the more important the knowhow of its operators.

Effects of production efficiency

Production efficiency improvements also reduce CO₂ emissions, although the matter has traditionally not been viewed from this perspective. If we look at the total output, electricity consumption, and emission volumes of the European papermaking industry between 1990 and 2008, we see that while production has increased by a factor of 1.6, electric power and primary energy consumption have decreased by almost 20%. Total emission volumes, meanwhile, have declined even more than energy consumption, with carbon dioxide emissions falling nearly 40% (Figure 16).

Examining the background of the above figures we find that particularly the share of energy purchased from outside sources has dropped nearly by a third over this time period. The use of primary fuels has also declined, but not as much as electricity purchases. In practical terms, much of the decline in CO₂ emissions is therefore explained by reduced electricity purchases, given that most of the energy generated by the power plants of integrated mills is based on renewable sources. More prevalent combined heat and power (CHP) generation also contributes to this emission reduction. We should note, however, that improved production efficiency has also had a significant effect on emissions as recent production increases have been achieved with less energy.

One good example of technology helping to improve the production efficiency of papermaking lines is the shoe press. A drying-constrained existing machine cannot necessarily effectively exploit its full process capacity, in which case a shoe press rebuild will pay for itself very quickly. In actuality, investing in a shoe press typically increases electric power consumption, mainly as drive power and hydraulic power.
requirements grow, but hood ventilation power consumption may, in turn, decline as the air volume needed to remove airborne moisture falls, assuming that humidity levels remain constant. We naturally also save steam and, more importantly, increase our output. This example leads us again to one of the basic ideas of energy efficiency, i.e. looking at the big picture. In other words, if we focus only on parts of the whole, we may concentrate on piecemeal optimization of individual items and fail to reach the desired overall outcome.

**Effects of location and available resources**

The third significant set of factors affecting the level of CO₂ emissions is so obvious that it tends to escape notice, namely the mill location and available resources. When a new line is considered at the feasibility assessment stage, perhaps the most significant concern is finding the optimal location for the line/mill. As shown by Figure 17, the continent on which a line is situated makes a difference. In other words, if the line examined operates in China instead of Brazil, its carbon dioxide emissions will be 30% greater per tonne.

The differences illustrated derive simply from the energy resources available. Location also has a bearing on transportation distances, adequate and easy access to water, what type of fiber is available, etc. Even though mill location decisions are not based on emission considerations, it is still useful to keep in mind that they do include elements that have an effect on the carbon footprint of the paper produced.

<table>
<thead>
<tr>
<th>Area</th>
<th>Specific Emissions kg CO₂/t paper</th>
<th>CO₂ Factor kg CO₂/t paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>210.3</td>
<td>69.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>161.9</td>
<td>45.7</td>
</tr>
<tr>
<td>Europe avg.</td>
<td>195.0</td>
<td>62.1</td>
</tr>
<tr>
<td>Asia avg.</td>
<td>192.5</td>
<td>60.9</td>
</tr>
<tr>
<td>South America avg.</td>
<td>177.1</td>
<td>53.3</td>
</tr>
<tr>
<td>World avg.</td>
<td>192.4</td>
<td>60.8</td>
</tr>
</tbody>
</table>

*Figure 17. Average papermaking CO₂ emissions by country and continent*

**Conclusions of machine design**

Increasingly early consideration of the energy and environmental aspects of investment decisions will be very important in the future. It will be particularly vital that everyone associated with an investment project will commit to advancing this perspective and bringing it up all the way from the feasibility assessment stage up through the actual operation of the line.

**BFB conversions - One step towards more sustainable energy production**

Converting an existing boiler to bubbling fluidized bed (BFB) combustion provides many advantages. In most cases the driving force for a boiler conversion is fuel change or the need for fuel flexibility. Combustion technology based on the fluidized bed is known to be applicable for a wide range of solid fuels. Another reason might be stricter emission requirements. Compared to boilers with old design and not optimized for today’s emission limits, the emissions from a BFB boiler are considerably lower.
Often the main incentive for a conversion is to switch from fossil fuels like coal to renewable fuels such as biomass. There are many motivations for changing from fossil to renewable fuels. The main reason is of course the concern for the environment and the need to decrease the production of CO₂. At the same time as CO₂ emissions are decreased drastically, other emissions like SOₓ and NOₓ will be reduced as well.

Based on this global objective to reduce CO₂, many national initiatives have been created with the aim of increasing the use of renewable fuels, such as emission regulations, green certificates, limitations on fuel mix, and a better price for biomass-based electricity.

**Power boiler conversions to BFB firing**

Valmet has experience with different types of BFB conversion dating back to the early 1980s. More than 60 boilers have been converted to Valmet BFB, also known as HYBEX. The converted boilers include different grate type boilers, pulverized coal and peat-fired boilers, and recovery boilers. Fewer than ten of these boilers were originally made by Valmet, with the majority being manufactured by other boiler OEM suppliers. The boilers are located around the world in Europe, South and North America, and Asia. The customers come mainly from the power generation sector and pulp & paper mills.

The main reason for selecting a boiler conversion instead of a brand new boiler has been the significantly lower investment cost, typically from 30 to 50% of the cost of a new boiler. Other important reasons have been a faster delivery schedule (about half the delivery time for a new boiler), and an easier building permit procedure.

Valmet’s recent conversion references in Europe include many pulverized coal (PC)-fired boilers (**Figure 18**) and one coal-fired CFB (circulating fluidized bed) boiler converted to biomass-fired BFB boilers.

In 2011 in Canada (Howe Sound Pulp and Paper Mill, BC), a bark-fired hydro grate boiler was converted to BFB in order to increase capacity, replace gas with biomass, and improve boiler performance. Other old recovery boilers were converted to biomass firing in 2012.

**PC to BFB conversion references**

Typically, a boiler that was originally designed for pulverized coal firing is very suitable for biomass BFB conversion. Nevertheless, the heating value for biomass is much lower than for coal, therefore the capacity has to be reduced. Usually the required boiler modifications can be kept at a reasonable level if the boiler capacity after the biomass conversion is reduced to about 80% of the original capacity. Most often the capacity limiting factors are the furnace size and the flue gas flow generated in the combustion. The capacity is selected so that the flue gas flow does not increase much from the original design.
Valmet’s latest references of PC to biomass-fired BFB boiler conversions can be found in Poland and Slovakia, where five boilers have been converted since 2008.

**OP 140 boiler conversion in Bialystok and Wroclaw in Poland**

The OP 140 boiler is a very typical PC boiler type in Poland, originally designed to generate 140 t/h steam. OP 140 boiler No. 5 in Bialystok was converted to BFB in 2008, and a similar boiler (No. 6) at the same power plant will be converted and commissioned in 2012 (Figure 19). The same type of OP 140 boiler conversion was done in Wroclaw in 2010.

After conversion to biomass, these boilers are designed to burn wood-based biomass together with 20 mass % of agro fuels and energy crops. As a heat input this amount corresponds to about a 30% share of agro/energy crop. Each of these boilers in Bialystok and Wroclaw is capable of replacing about 100,000 tonnes of bituminous coal annually by burning biomass. This corresponds to 60,000 tonnes of fuel oil per boiler.

**OP 230 boiler conversion in Lodz**

In the city of Lodz, an existing PC-fired OP 230 was converted into a biomass-fired BFB in 2011. As the name suggests, the boiler is larger than an OP 140 and was originally designed to generate 230 t/h steam using coal. Since the biomass conversion the boiler can generate 190 t/h steam. The modified boiler will burn mainly different wood-based fuels and residues together with agricultural wastes like sunflower husks, straw and miscanthus. It is notable that the furnace has been extended by moving the front wall in order to increase the furnace volume and residence time for fuel combustion (Figure 20).

**Reduction of CO₂ and other emissions**

When changing the fuel from coal to biomass there will be significant reductions in flue gas emissions. Naturally, the largest reduction will be for CO₂, but also SOx and NOx emissions become much smaller.
Reduction in SOx emissions is a result of the difference in the fuel sulfur content, which is close to zero in biomass fuels compared to typically 1% or more in coal. Normally, a biomass-fired boiler does not need any sulfur removal system, since the emissions are almost negligible.

NOx emissions from a biomass-fired BFB are far lower than from a coal-fired PC boiler. This reduction is achieved mainly due to the lower combustion temperature and lower nitrogen content of the fuel. However, future emission requirements may require even more efficient NOx reduction. It is possible to achieve this by installing a secondary NOx reduction system called SNCR, where ammonia or urea is injected into the furnace.

When these emission reductions are calculated for the largest BFB conversion in Poland (Lodz), the main emission components will decrease drastically. The yearly reduction based on 8,000 hours of annual operation time will be:

- CO2 400,000 tonnes
- SOx 3,300 tonnes
- NOx 280 tonnes

**Scope of the BFB conversion project**

In the BFB conversion project, the required scope of the boiler modifications naturally depends greatly on the design of the converted boiler and on customer requirements.

The typical scope, however, is presented below:

- The lower sections and the bottom of the furnace are replaced with new furnace walls and a hydro beam fluidizing grate (Figure 21). The downcomers and water supply pipes are modified to ensure proper water circulation in the furnace and in other evaporation sections.
- Superheaters and other heating surfaces must be checked regarding heating surface area and tube bank structure. Tube spacing and flue gas velocities must be suitable for different biomass grades.
- Coarse material removal equipment is installed to manage the bed quality. This equipment consists of bottom ash hoppers, ash chutes, and water-cooled screws or chain conveyors. Additionally, a makeup sand system is installed to provide fresh sand to the bed. A sand screening and recirculation system is an option.
- A new biomass silo, feeding conveyors and fuel chutes are installed to provide even and continuous fuel flow to the furnace.
- The combustion air system is completely modified. A new fluidizing air fan (primary air fan) together with ductwork is installed to supply air for bed fluidization. An overfire air system, including secondary and tertiary air nozzles and ductwork modifications, is also installed. Usually the overfire air can be taken from the existing main air fan.
- One or more start-up burners are installed to provide heat during the initial bed heating.
- The suitability of other auxiliary equipment such as the induced draft fan, sootblowers, fly ash system, etc., needs to be checked and modified, if necessary.

**Figure 21. Valmet’s patented hydro beam fluidizing grate**
• The performance of the existing emission control system (ESP, NOx, SOx) must be ensured in the new operating conditions. An SNCR system for NOx reduction may be needed depending on the emission limits. An ESP extension or replacement with a baghouse filter may also be required.

• Electrification, instrumentation and automation systems will be updated.

• The fuel yard including the receiving station, pre-handling system and conveyors to the boiler house must be updated or a completely new system must be installed.

Summary of BFB conversions

A BFB boiler conversion is a cost-efficient alternative to building a new boiler, if the existing plant is not suitable for new operating conditions or requirements. New circumstances that can lead to the decision to convert an existing boiler to fluidized bed combustion include a change of fuel or fuel mix, stricter emission regulations, or a change in boiler load.

Several types of boilers have been converted through the years into environment-friendly biomass BFB boilers. When fossil fuels are replaced by renewable biomass, CO₂ emissions are reduced drastically and emissions of SOx and NOx decrease as well. Stricter emission requirements have also been a reason for boiler conversions since the emissions from a BFB are considerably lower than those from many old boiler designs.

The extent of the conversion project varies a lot, depending on the existing equipment, but the main part of the conversion is always the lower furnace, including the fluidizing grate. A conversion project is both cost efficient and less time consuming than the delivery of a new boiler.

Valmet has long experience of conversions, dating back to the 1980s and including over 60 plants. The large number of projects and successful operational experiences prove the reliability of this technology.

World’s largest BFB boiler wins award

The Nacogdoches Generating Facility in Sacul, Texas was awarded the 2012 Project of the Year in the Biomass category by Power Engineering Magazine at the Power-Gen international conference on December 10, 2012 in Orlando, Florida.

The Nacogdoches Project represents a Valmet-supplied boiler island with the world’s largest BFB boiler. The project also included Valmet Automation Flow Control Devices and a Valmet DNA plant-wide distributed control system.

The boiler features efficient energy conversion of a wide range of biomass. Thanks to the advanced technology of the boiler island the Nacogdoches Generating Facility is prepared to deliver electricity whenever needed.

Dave King, Area President, North America, Power business line, Valmet, explains that "the Nacogdoches project is a success since it plays a key role in preparing the City of Austin to meet its goals for sustainable power generation. Furthermore, this project would
never have been possible if not for the excellent track record of Valmet's existing global BFB base, and the ability to design a utility-grade biomass boiler capable of low emissions and high availability."

**Tight with fuel consumption, generous with energy**

This boiler is the largest HYBEX boiler in service, designed to produce 930,000 lbs/hr (117 kg/s) of steam and generate 100 MW of renewable electrical power. The entire boiler island, including air pollution control equipment and the plant-wide controls, was provided and erected by Valmet under an EPC contract.

**Clean and environmentally responsible power**

The 100 MW capacity of the largest BFB biomass power plant in the United States can generate enough power to supply approximately 60,000 homes with electricity. The plant was built to serve a 20-year contract with Austin Energy to help meet the state's renewable portfolio standard, with the output serving the City of Austin.

The plant is fuelled entirely by non-merchantable wood biomass materials, with a base load renewable energy option that helps strengthen the nation's energy security. Abundant fuel supply in the proximity of the plant enables wood waste recycling from the local timber operations, manufacturing facilities, and municipalities. All of the fuel needed can be procured within a 75-mile radius.

Nacogdoches has made a significant impact in the surrounding towns. During construction, more than 100 vendor contracts for services and maintenance were established, as well as 25 fuel supply contracts. The facility allowed for more than 1,000 construction jobs, which was a boost for the local economy in the 200-resident town of Sacul. The facility is also set to employ 40 full-time workers.

**Summary**

Environmental solutions are an integral part of total performance management at power plants and pulp and paper mills. Governmental directives in each country are requiring improvement in environmental performance and these requirements are becoming more stringent in the future.

Valmet’s advanced technology combined with our process and environmental expertise will help you to meet the latest directives, as well as optimize your plant's emission levels. As a result, you gain in competitiveness through increased environmental compliance and enhanced eco-efficiency.

*This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.*

*Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet’s pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.*

*We are committed to moving our customers' performance forward.*