FACTOR 5: Transforming the Global Economy through 80% Improvements in Resource Productivity

Online Industry Sector Study – The Pulp and Paper Industry

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Online Industry Sector Study – The Pulp and Paper Industry

1) The Potential for Factor 5 Improvements in Pulp and Paper Manufacture

Resource Productivity

Pulp and paper manufacture contributes over 4 per cent of estimated global energy consumption, and contributes approximately 290 MT CO₂ (million tons), or about 1.3 per cent, of annual global CO₂ emissions from fossil fuel combustion – that is, the CO₂ emissions roughly equivalent to that of South Africa, the fourteenth highest emitting nation. Further to this according to the IPCC 4th assessment, ‘The EDGAR database indicates that, in 2004, the share of CO₂ emissions from deforestation, and the loss of carbon from soil decay after logging, constituted approximately 7–16% of the total GHG emissions’. Hence it is important that the sector ensures it sources wood from sources that have been certified by groups such as the Forrest Stewardship Council, and it may in fact become the case that such certification will be essential for the credibility of the pulp and paper industry. Not only does deforestation cause massive levels of greenhouse gas emissions, the improper management of forested areas can lead to large losses in topsoil, and as UNEP in its Fourth Global Environment Outlook points out, ‘Loss of topsoil means loss of soil organic matter, nutrients, water holding capacity and biodiversity, leading to reduced production on-site. Eroded soil is often deposited where it is not wanted, with the result that the off-site costs, such as damage to infrastructure, sedimentation of reservoirs, streams and estuaries, and loss of hydropower generation, may be much higher than the losses in farm production’. Such impacts can not only damage the ecosystem and affect biodiversity but can also become life threatening. The 2000 State of the World Report by the Worldwatch Institute reported that Bangladesh suffered its most extensive flood of the century in the summer of 1998 leaving 30 million temporarily homeless. Ten thousand miles of roads were heavily damaged, and the rice harvest was reduced by two million tons, with damage estimates exceeding US$3.4 billion. Logging upriver in the Himalayas of northern India and Nepal exacerbated the disaster, as did the fact that the region’s rivers and floodplains have been filled with silt and constricted by development. UNEP reported in 2007 that, ‘In 2004, 3000 people died in Haiti after a tropical storm, while only 18 people across the border in the Dominican Republic died. The difference has been linked to extensive deforestation in Haiti where political turmoil and poverty have lead to the destruction of 98% of original forest cover’. For this and other reasons many countries are recognising the economic, social and environmental costs associated with deforestation, with China, New Zealand, the Philippines, Sri Lanka, Thailand, and Vietnam enacting total or partial bans on deforestation.

Due to the potential for paper and pulp operations to damage significant ecosystems, this sector receives close scrutiny from ‘green’ groups, and this, combined with the potential for improving brand equity and lowering operating costs, has led many in the sector to undertake a range of progressive environmental initiatives. For instance, fossil fuel use by the US pulp and paper

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industry declined by more than 50 per cent between 1972 and 2002, largely through energy efficiency measures, power recovery through co-generation and increased sourcing of energy from biomass sources. Since 1990, CO₂ emissions in the sector globally have decreased by approximately 25 per cent in Europe, 20 per cent in Australia, and 40 per cent in Canada through investing in similar measures.

According to the Innovest Group (the top ranked provider of extra-financial research for the investment community), the performance of such USA ‘Environmental leaders’ in the forest and paper products sector has led to a 43 per cent stock price performance difference over the four-year period from 1999 to 2003, as the following Figure 3.10 shows. Yet despite these significant efforts, there are still many opportunities for further improvement.

![Figure 3.10: Percentage change in total return of environmental leaders vs. laggards in the forest and paper products sector 1999-2003](image)

Source: Based on data from the Innovest Group (2004)¹¹

Factor Four looked at ways to reduce paper usage through for instance email and utilising CD’s to store information, and also showed how, since 1900, best practice in the amount of water used per kg of paper produced has improved from 500-1000 litres per kg to 1.5 litres per kg of paper.

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produced – a Factor 100 improvement.\textsuperscript{12} Here in Factor Five we will outline how this sector not only has the potential to achieve, 80 per cent, Factor 5, reductions in energy consumption, but that it could then become a positive electricity generator from renewable energy sources. Factor 5 energy improvements can be achieved through a combination of improving energy efficiency of the process and infrastructure, heat recovery and co-generation onsite as part of the process, sourcing energy from biomass, and increasing recycled paper fibre content, as according to Bureau of International Recycling, recycling paper can result in up to 64 per cent energy savings, compared to virgin production.\textsuperscript{13} In addition, this case study will show that along with improved energy performance, a Factor 5 in materials efficiency is achievable, as paper fibres can be recycled up to five times. Finally, this case study will show that paper and pulp mills can and have achieved Factor 5 in water efficiency improvements.

One of the companies showing what can be achieved is Catalyst Paper International, one of Canada’s largest pulp and paper companies. Catalyst Paper International sources 89 per cent of its energy from renewables and has reduced greenhouse gases by 71 per cent since 1990. Its Powell River Paper Mill uses biomass to produce most of its energy and is very close to carbon neutral.\textsuperscript{14} Visy Industries Tumut Mill in Australia is another that is close to climate neutral. These mills which have exceeded Factor 5 and are approaching climate neutrality,\textsuperscript{15} have done so by taking a whole system approach, which has included:

- Improving energy efficiency in processing, equipment and buildings - with up to 25 per cent still existing.\textsuperscript{16}

- Heat recovery and co-generation technologies that provide onsite energy generation - currently contributing to 40 per cent and 30 per cent of paper and pulp mill energy in USA\textsuperscript{17} and Europe\textsuperscript{18} respectively.

- Sourcing energy from biomass renewable energy - for OECD countries, paper and pulp mills currently source 49 per cent from renewables,\textsuperscript{19} with Black Liquor Gasification-Combined Cycle technology significantly improving this process, as outlined below.

- Increasing recycled paper fibre content - with up to 70 per cent able to be sourced from recycled feedstock. (recycling paper can result in up to 64 per cent energy savings.\textsuperscript{20})

- In addition to these advances, over the next few decades, the pulp and paper sector has the potential in both existing and new mills to become renewable electricity power generators through the use of Black Liquor Gasification-Combined Cycle (BLGCC) technologies.\textsuperscript{21}

\begin{thebibliography}{9}
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Black Liquor is a by-product of de-lignifying wood chips, and as a result, contains many of the chemicals used in the delignification process. Typically, these chemicals are recovered by combusting the black liquor in a recovery boiler. However, the efficiency of this process is relatively low due to the black liquor’s relatively high water content limiting combustion efficiency, and the recovery boiler’s low pressure steam (for safety reasons) limits electricity production. The new alternative, BLGCC, enables both efficient use of black liquor, and also of other biomass fuels, to generate a synthesis gas (syngas) that is cleaned and combusted in a gas turbine or combined cycle system with a high electrical efficiency, (as shown in Figure 3.11). BLGCC increases the conversion efficiency significantly for biomass (black liquor) to electricity.

Syngas generated from low-quality solid fuels such as biomass consists largely of hydrogen and carbon monoxide. If additional fuel is not required in the mill, syngas can be synthesised into clean liquid transportation fuels or chemicals, by processing with an appropriate catalyst. Syngas can also be efficiently converted into pure hydrogen fuel. The opportunities to create energy products such as electricity, heat and fuels enable paper and pulp mills to generate additional income while displacing the carbon intensive options currently used.

![Figure 3.11: Schematic Representation of a Black Liquor Gasifier Integrated with a Combined Cycle (BLGCC)](http://i234.photobucket.com/albums/ee274/biopact3/biopact_BLG_process.jpg?t=1187891491), accessed 18 March 2009.

Larson et al.\(^\text{23}\) performed a cost-benefit analysis of BLGCC for a typical Kraft pulp and paper mill. The total capital costs of a BLGCC system were estimated to be about 60-90 per cent higher than that of a standard Tomlinson boiler system. The capital costs for a plant with a capacity of 550,000 tons of pulp were estimated at US$194 million, compared to US$122 million for a Tomlinson system. However BLGCC was identified as a robust strategic investment with the annual return on investment estimated at 16-17 per cent, based on electricity sold back to the grid at 4 cents/kWh.


However, if a premium of 2.5 cents/kWh is added to the price of electricity produced from pulp and paper biowaste (as part of a renewable energy policy, or a carbon price) the annual return on investment may go up to 24-26 per cent. This high rate of return is the result of increased power sales to the grid, despite the increased capital costs. Ernst Worrell, US representative of the IPCC Mitigation Working Group, in 2004 wrote that, ‘In the US paper and pulp industry, over the next 10-20 years, most traditional recovery boilers will be retired, providing excellent opportunities to introduce advanced Black Liquor Gasification-Combined Cycle technology’. 

Although few pulp and paper manufacturing facilities currently export electricity and none export transportation fuels, the existing network and infrastructure for collecting and processing biomass resources provides a strong foundation for future BLGCC ‘Bio-Refinery’ facilities that produce a variety of renewable fuels and chemicals as well as electricity and pulp and paper products.

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**Figure 3.12:** Future ‘Bio-Refinery’ concept based at a pulp and paper manufacturing facility

*Source: Larson (2006)*

In 2006, Larson *et al* expanded their cost benefit analysis to consider the costs and return on investment of a full bio-refinery, compared to a transitional pulp and paper mill that uses a Tomlinson power recovery system. Larson *et al* concluded that, ‘Compared to installing a new Tomlinson power/recovery system, a bio-refinery would require larger capital investment. However, because the bio-refinery would have higher energy efficiencies, lower air emissions, and a more diverse product slate (including transportation fuel), the internal rates of return (IRR) on the incremental capital investments would be attractive under many circumstances. For nearly all of the cases examined in the study, the IRR lies between 14 and 18 percent, assuming a 25-year levelized world oil price of $50/bbl – the US Department of Energy’s 2006 reference oil price

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projection. The IRRs would rise to as high as 35 percent if positive incremental environmental
benefits associated with biorefinery products are monetized (e.g., if an excise tax credit for the
liquid fuel is available comparable to the one that exists for ethanol in the United States today).
Moreover, if future crude oil prices are higher ($78/bbl levelized price, the US Department of
Energy’s 2006 high oil price scenario projection, representing an extrapolation of mid-2006 price
levels), the calculated IRR exceeds 45 percent in some cases when environmental attributes are
also monetized. 27

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Best Practice Case Studies

As mentioned briefly above, three companies, Catalyst Paper International, Visy Industries and ChemRec are demonstrating in practice that Factor 5 can be achieved for the pulp and paper sector. Here we consider each of these leaders to learn from their example.

Catalyst Paper International – Powell River and Port Alberni Mills, Canada

Catalyst Paper International (CPI), formerly NorskeCanada, is a leading producer of mechanical printing papers28 with 2,700 employees and a production capacity of 2.5 million tons of pulp and paper per year.29 Production at CPI’s Powell River paper mill has become almost carbon-neutral,30 which they have achieved mainly through installing a new power boiler and motors at the mill, and using biomass as a fuel to produce most of the energy required.31 In September 2005, Catalyst received eco-logo certification for 51 MW of power capacity from biomass at two mills.32 The company also reuses waste products, such as sludge and wood refuse by-products as fuel sources for the mills.33 At one of CPI’s other mills, Port Alberni, the company has trialled a heat recovery process where heat is extracted from effluent to heat the water needed to make the paper. This has reduced the mill’s energy requirements while simultaneously cooling the effluent stream.34 The company is leading the paper making industry with the manufacture of lighter basis weight papers, as these use less fibre to produce and overall reduce the amount of raw materials, chemicals and energy needed.35 The company also seeks to maximise the proportion of pulp which comes from post-consumer and waste sources. Catalyst is one of the few manufacturers in the world to de-ink and pulp 148,000 tons of post-consumer paper to provide 17 per cent of the pulp needs, with a further two thirds of the pulp salvaged from sawmill residues. The remaining 20 per cent of their fibre needs come from pulp logs – wood which is unsuitable for sawmilling.36

The company has received recognition for their environmental efforts from a wide selection of organisations and continues to work towards greater energy efficiency and environmental performance as part of their ISO14001 accreditation, World Wildlife Fund’s Climate Savers Project and their membership in The Climate Group.37 Overall, CPI has improved their energy efficiency by 20 per cent across all operations since 1990, saving the company close to US$26 million between 1994 and 2004. At the same time, they’ve reduced their greenhouse gas emissions by 69 per cent38 and provided US$7.1 million in benefits to the local energy provider, BC Hydro, as a result of reduced consumption.39 CPI’s progress towards energy efficiency and reducing their greenhouse

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emissions show how the paper and pulp and paper industry can invigorate their products and processes to dramatically reduce their environmental impact while saving money and gaining community and industry recognition.

**Visy Industries – Tumut Mill, Australia**

Visy employs more than 8,000 people worldwide in its packaging and recycling operations and has a turnover of over AUD$3 billion per year. The company collects and recycles more than 800,000 tons of waste paper and cardboard in Australia alone each year. Visy developed its Tumut Mill to complement its existing production of recycled fibre-based paperboard and to close the company’s own recycling loop. Philip Toyne, co-Director of Eco-Futures and former CEO of the Australian Conservation Foundation, in the Australian Council of Infrastructure and Development Council’s Sustainability Framework, 40 outlined in great detail the steps taken by Visy to achieve close to climate neutral operations, as summarised below:

- Visy pioneered the incorporation of energy efficient technology into the mill, creating a low cost alternative to the traditional process. The heat for the highly efficient process is then sourced by renewable sources (black liquor and waste wood), and while two-thirds of its electricity is generated on-site from biomass fuels (including bark) through a co-generation system, the remainder is sourced from hydroelectricity generation nearby.
- It has been certified as a Green Power generator by the then Sustainable Energy Authority of NSW and is able to sell green power into the electricity grid.
- No water is discharged off the site, and treated wastewater is used for the irrigation of pastures. Total water usage is 80 per cent lower than the average water used by standard industry pulp and paper mills elsewhere in the world.
- As part of a wider environmental commitment, the mill uses only plantation grown pine softwood, wood waste and recycled paper as raw materials. The plantation timber which is used comes from pine forest thinnings and sawmill offcuts, which previously had no economic value.

The Visy Tumut Mill has shattered a number of traditional beliefs and myths in the paper industry, in particular, the belief that a mill of its size - small by world standards - must be inefficient because of the high cost of energy required to break down the wood fibre feed stock, therefore needing an increased level of production to offset this expense. Visy’s example shows that whatever the size of the pulp and paper mill a Factor 5 improvement can be achieved cost effectively and profitably.41

**ChemRec - Black Liquor Gasification Combined Cycle**

ChemRec, have pioneered the Black Liquor Gasifier Integrated with a Combined Cycle technology, which is currently used in two mills – one in the US and another in Sweden.42 ChemRec is part of an extensive multi-party research program of which one goal is to pioneer applications of the new technology. An example of such an application is the BioDME project,43 which commenced in 2008. The project will demonstrate the potential for black liquor to be used to fuel trucks with BioDME (bio dimethyl ether – a second generation biofuel). Second generation biofuels were developed to

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address the issue of biofuel crops competing with food stocks for land and water, instead, second generation biofuels use biomass from agricultural and forest residues and non-food crops. The BioDME project is seeking to achieve Factor 10 reductions in both greenhouse gas emissions and land required for biofuel production by using this new type of biofuel. For the project, ChemRec will build and operate a plant in Piteå, Sweden, where black liquor will be gasified to produce BioDME. The plant will enable ChemRec to acquire data to inform the design and operation of commercial scale gasifiers for syngas production. By the time the plant is built, other program partners will have built some of their contributions – oil company Preem will have built filling stations, and automotive manufacturer Volvo will have built the first of 14 DME-fuelled trucks. According to the Swedish Bioenergy Association, having a similar BioDME plant in all Swedish paper mills provides the capacity to replace one third of the country’s diesel fuel.

ChemRec’s biofuels perform favourably when compared to both oil based fuels and other second generation biofuels. A study that reviewed the ‘Well-to-Wheel’ carbon footprint of a variety of biofuels and fossil fuels, found that Chemrec’s biofuels do, in fact, reduce their carbon footprint by more than a Factor of 10 compared to diesel. In addition, compared to other biofuels, BioDME has one of the highest land use efficiencies of second generation biofuels. Finally, being a second generation, ChemRec’s biofuels do not compete for food or agricultural land.

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2) A Whole System Approach to Factor 5 in the Pulp and Paper Sector

IPCC Strategy One: Energy Efficiency Opportunities

A 2001 analysis of US pulp and paper mills identified more than 45 cost effective (3 year or less payback) energy efficiency technologies and measures that could reduce energy use by a further 25 per cent.48 An example of one such technology is impulse drying, which reduces energy consumption by 15 per cent compared to conventional current paper drying machines.49 Impulse drying involves pressing the paper between a very hot (150-500°C) rotating roll and a static concave press (the nip) with a very short contact time. Impulse drying greatly increases the paper’s drying rate, although there may be challenges with paper delaminating or sticking to the roll.

Other energy efficiency opportunities involve assessing the plant itself and removing any redundant pieces of equipment still using electricity. Catalyst Paper International, for example, has begun changing its equipment configurations to better suit changing raw materials, processes and product specifications. In 2007, Catalyst’s Crofton Division’s mill was simplified by identifying and removing redundant and unnecessary sources of energy use. One such source was a set of motorised agitators on pulp storage tanks that were used in the bleaching process. This simplification initiative now saves the Division about US$1 million per year.

IPCC Strategy Two: Fuel Switching

The pulp and paper industry use more biomass for fuel than any other industry. In developed countries, 64 per cent of the fuel used in the wood products industry is biomass (mainly manufacturing residuals) and 49 per cent of the fuel used in pulp, paper and paperboard mills is biomass (mainly spent pulping liquor).50 Several studies have shown, however, reductions in the carbon intensity are possible through the use of biomass. For instance, a study of the Swedish pulp and paper industry found that a set of commercially available measures, including using biomass instead of conventional mains electricity, can reduce CO₂ emissions from 5.5 MtCO₂/yr to 5.0 MtCO₂/yr (1.54 to 1.4 MtC/yr) at negative cost.51

IPCC Strategy Three: Heat and Power Recovery

In 2002, co-generation was used to supply 40 per cent of the US pulp and paper industry’s electricity requirements,52 and 30 per cent of the EU pulp and paper industry’s requirements.53 Already, 93 per cent of onsite generated electricity in European paper and pulp mills forms a part of a combined heat and power (CHP) system.54 Studies performed in the late 1990s identified combined heat and power (CHP) as one of the most important technologies for greenhouse gas reduction in the United States. CHP is particularly viable in the paper and pulp industry due to the high demand for steam loads, which in the pulp industry accounts for around 80 per cent of their

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electricity demand. Also, the industry generates biomass which can be burnt onsite to generate both electricity and heat. The studies found that although the paper and pulp industry, along with the chemical industry, represent the largest industrial producers of CHP, there is potential for an additional 50GW of CHP to be generated between the two industries. This would reduce their greenhouse gas emissions by 44 per cent, for the most part at negative cost, or with short payback periods.55

As mentioned above, Black Liquor Gasification with Combined Cycle technology dramatically increases the conversion efficiency and enables more electricity to be produced and recovered onsite than is needed by the pulp and paper mill. As Worrell et al explain, 'Existing recovery boilers consume roughly 27 MBtu of black liquor and other biomass per short ton of air-dried pulp. Power production efficiencies using steam turbine systems in current Tomlinson boiler systems are estimated at 10 percent, resulting in the generation of 790 kWh/ton of pulp, sufficient to cover part of the internal power demand in a pulp mill. While (with) gasification systems, power efficiencies are much higher, thereby allowing for significant primary energy savings. Based on an electricity production capacity of 1740-1860 kWh/ton, and the performance of a typical Kraft-plant in the Southeastern U.S., a plant will be able to export 220-335 kWh/ton of pulp.'56

IPCC Strategy Four: Renewable Energy

In addition to being the sector which uses the most biofuels, pulp and paper mills are often located in rural areas, typically in areas that grow forests and hence have good water supplies, and are then often located close to sources of hydro-electric power. As mentioned in the introduction, Catalyst Paper International currently sources 89 per cent of its energy from renewables, and sourcing renewable energy from hydro-electric sources has helped them to achieve this.

IPCC Strategy Five: Feedstock Change

The main way that the paper and pulp industry can reduce its energy consumption and greenhouse gas emissions through feedstock change is by using higher levels of recycled paper fibres to make recycled paper and paper products. As mentioned earlier, the Bureau of International Recycling estimates that recycling paper can result in up to 64 per cent energy savings, compared to virgin production.57 The US EPA58 and EU59 have all identified and investigated paper recycling as an energy consumption reduction option, as well as a means to reduce GHG emissions. Catalyst Paper International is a leader in recycling paper fibres, and its recycling division has the largest pulp and paper recycling facility in Western Canada. In 2007, the Division processed more than 170,000 tons of old newspapers (including 72 per cent of all newspapers collected in British Columbia and Alberta), magazines and telephone directories. The Division has also increased the supply of Forest Stewardship Council (FSC) certified old newspaper use from 40-60 per cent. Paper fibres can be recycled up to five times before their fibres disintegrate, and this is important


There is significant potential to improve recycling rates of paper around the world - for example on average only 52 per cent of North American paper is currently recycled while some European cities recycle 75 per cent. This suggests that better recovery programs will likely improve waste-paper availability over time for the paper and pulp industry in the USA.

IPCC Strategy Seven: Material Efficiency (Water)

The original Factor Four publication it showed how since 1900 best practice in the amount of water used per kg of paper produced has improved from 500-1000 litres per kg to 1.5 litres per kg of paper produced.

A North German paper manufacturer had managed to avoid waste-water altogether for the production of paper for packaging purposes. All water from the manufacturing process is collected and filtered for reuse, and is only supplemented by tiny amounts of fresh water to provide the water molecules needed for the mechano-chemical stability of paper and to make up for evaporation. This plant uses no more than 1.5 kg of fresh water per kilogram of packaging paper...In the factor language; the achievement by the manufacturer is roughly a factor of 20 against the current European average.