Energy Efficiency and CO₂ Reduction in the Pulp and Paper Industry

In brief

The pulp and paper industry is one of the most energy-intensive sectors of the EU. To improve energy efficiency the industry has invested in combined heat and power (CHP) generation and, in Europe, now produces almost half the electrical energy it consumes. Due to efficiency improvements over the last 20 years, direct CO₂ emissions have decreased while paper and pulp production has increased. Potential breakthrough technologies now need to be tested to demonstrate market viability and increase efficiency even further.

The technology

There are two main paths to producing pulp for the paper industry: from virgin wood or from recycled material. To make pulp from virgin wood, two main kinds of process are used – chemical and mechanical. In Europe, about 18 % of all mills produce both virgin pulp and paper, on the same site. Integrated pulp and paper mills can be more efficient than stand-alone mills. Paper can also be made from recycled fibres. Europe has the highest recovery and utilisation rate of fibres in the world (71.7 % in 2012).

The pulp and paper industry is energy-intensive, with average energy costs around 16 % of production costs, and in some cases up to 30 %. In 2011, about half (55 %) of the energy used by the industry came from biomass and most of the rest (36.2 %) from natural gas. Mechanical pulp making is usually more electricity-intensive and less heat-intensive than chemical pulping.

Because heat is produced in the pulp and paper making process, this can be captured to generate electricity, in combined heat and power (CHP) installations. In Europe, the industry produces about 51 % of the electricity it consumes, most (95.2 %) from CHP.

Ongoing research

Although papermaking technology has developed significantly, improvements in the quality and strength of printing paper have also meant that some of the energy efficiency gains have been offset by higher energy requirements for producing these higher quality papers. Nevertheless – mainly because it already makes extensive use of biomass fuel and also recycles heat energy to generate power – the industry is in a unique position, both in terms of improving energy efficiency and reducing CO₂ emissions. It could even become a clean energy supplier. This will mean replacing less efficient machines with new ones, which can be expensive. The prime candidates for improvement are the boilers, followed by the most energy-intensive part of paper production, the drying of the paper.

The main target for the industry is to make its technology more energy efficient. There are several potential emerging and breakthrough technologies, although most are currently at a standstill. The bio-route aims to develop integrated bio-refinery complexes producing bio-pulp, bio-paper, bio-chemicals, biofuels, bioenergy and possibly bio-Carbon Capture and Storage (CCS). This route includes further development of the gasification of black liquor, which is an energy rich by-product from Kraft pulp production. It is currently burned in a recovery boiler to produce electricity and steam for the pulp mill. However, it may be that production of transportation fuels is a better option in economic terms. Lignoboost is another bio-route process. This is a complete process that extracts lignin from Kraft black liquor and uses it as a biofuel.

After some initial attempts to introduce innovative drying technologies, R&D in this area seems to be at a standstill. Meanwhile, there is ongoing work, at laboratory level, to optimise the mechanical production of pulp.

As the pulp and paper industry also produces energy, it could join with the power sector or other energy-intensive manufacturing industries (like cement) in implementing innovative initiatives to reduce CO₂ emissions, such as carbon capture and storage (CCS). The 2050 roadmap for the pulp and paper sector, however, does not include CCS as an option.

The industry continues to invest about 4% of its turnover (EUR 3 billion in 2012) in improving its capacity. However, many companies mainly focus their R&D investments on new products, leaving most of the investment in technology and process R&D to a small number of specialised machine and equipment suppliers.

The industry

Europe currently accounts for about 23% of world paper production (92.1 Mt in 2012). This represents a decrease of 1.6% over 2011. After being hit hard by the economic downturn in 2009, the industry has partly recovered, though production is still below levels in 2008 (97.9 Mt). Some grades of paper, like newsprint, are not expected to reach pre-crisis levels again.

In 2012, the annual turnover estimated by CEPI was EUR 75.2 billion, slightly down on 2011 (EUR 78 billion). Also in 2012, 3.9 Mt of pulp was exported to third countries (outside the EU) and 7.8 Mt of pulp was imported. For paper and board, 19.9 Mt was exported and 5.2 Mt imported (CEPI, 2013). The future outlook for the industry depends largely on the extent to which export markets grow, which in turn depends on Europe’s competitiveness.

Barriers

In the short- and long-term, the availability of raw materials (wood and recycled fibre) will be crucial for the pulp and paper industry. Currently, there is increasing pressure on the availability of biomass. The pulp and paper industry is competing with other bioenergy producers for their main virgin feedstock (wood). Almost 5% of the EU gross energy

FACT FILE

- In 2011, EU paper and board production was 23.5% (92.1 Mt) of world production.
- In Europe, about 18% of all mills are integrated mills producing both virgin pulp and paper.
- Europe has one of the highest recovery and utilisation rates of paper in the world (71.7% in 2013).
- Energy costs account for between 16% and 30% of paper and pulp production costs.
- In 2010, 50% of the electricity the industry consumed came from its own Combined Heat and Power plants.
- Europe’s paper industry contributes about 20% of Europe’s bioenergy consumption, most of it used for its own energy needs.
- In 2011, about half (55%) of the energy used by the industry came from biomass and most of the rest (36.2%) from natural gas.
- In 2011 the industry bought 63.6 TWh of electricity, sold 10.5 TWh of electricity, and produced 55.1 TWh of electricity (CEPI, 2013).
- From 1991 to 2011, specific primary energy consumption improved by 14.6% and electricity consumption by 11.8%.
- From 1991 to 2011, direct absolute CO₂ emissions decreased by 7.8%, whereas pulp production increased by 0.6% and paper production by 1.7% over the same period.
- In 2012 the CO₂ emissions from the sector totalled around 34.5 million tonnes. This represents a 43% reduction since 1990.
- In 2012 Europe (CEPI countries) accounted for about 21.1% (38.4 Mt) of the world’s total pulp production.
- From 1991 to 2010, EU pulp production (in CEPI countries) grew on average by 0.6% annually and paper by 1.8%, whereas the number of pulp and paper mills decreased by around 40%.
- Sweden and Finland are the countries with the highest number of pulp mills (around 35 each).
- Italy and Germany are the countries with the highest number of paper mills (around 170 mills each).
- The 10% most efficient (wood-free) paper machines produce roughly 40% of all paper manufactured in Europe.
- In 2012 in Europe, the sector had a total turnover of EUR 75.3 billion, employing some 185 000 people directly.
- 60% of employment in the European pulp and paper industry is located in rural areas.

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demand is covered by biomass resources, while biomass accounted for almost two thirds (67.6%) of all renewable primary energy consumption in 2010. At the same time, waste paper is exported on a large scale, mainly to China, where new large paper mills have been built. This leads to shortages in recycled fibres for some European paper producers. This is exacerbated by the relatively high cost of recycling and transporting fibres, when paper consumption is mainly centred on urban areas, whereas pulp and paper factories are usually close to forests, in rural areas.

Despite the high penetration of cogeneration in the pulp and paper industry, it is estimated that only 40% of Combined Heat and Power (CHP) potential capacity has been installed in this industry. One of the main barriers to expansion is the ‘spread price’ – the difference between the price of the fuel used by the CHP and the price of the electricity generated. Priority grid access and dispatch for CHP electricity sold back to the national grid might improve quicker and wider implementation.

The lack of detailed and consolidated information about consumption and emissions for most of the pulp and paper technologies is a barrier in itself.

Needs

Large-scale demonstration plants could help the breakthrough technologies to show their market viability. Under the European Commission’s Sustainable Bio-refineries Call, the EU is co-funding four projects: Star-CO-LIBRI, SUPRABIO, EuroBioRef and BIOCORE for EUR 51.6 million of a total budget of EUR 79.1 million. Part of the support needed to develop the bio-route can be channelled through the European Industrial Bioenergy Initiative. However, the large investments needed to jump from pilot plant to full-scale application may require an additional push.

Installed capacity

In 2013 there were 170 pulp and 789 paper mills (all grades) in Europe, mostly in rural areas (CEPI). Sweden and Finland have the highest number of pulp mills (around 35 each), followed by Germany (19). Their production share in 2012 was 31.4% for Sweden, 26.9% for Finland and 7.4%, for Germany. Italy and Germany have the largest number of paper mills – around 170 mills each – followed by France (around 95 mills). Germany also had the largest production share of paper and board in 2012 at 24.6%, followed by Sweden (12.4%) and Finland (11.6%), albeit with far fewer paper mills (around 40 each). This is because a small number of new mills are able to account for most of the production. The most efficient 10% (wood-free) paper machines account for roughly 40% of total production.