

## Popular Science Abstract

This thesis examines the repercussions of introducing carbon capture processes into pulp mill operations. Beginning with the modeling of a carbon capture process using flue gas data, I assessed the energy requirements for the mill. Furthermore, I explored avenues for process integration, aiming to reduce the energy footprint of the operation.

As everyone knows, the climate is changing all over the globe. One of the main drivers of this change is the constantly increasing CO<sub>2</sub> content in the atmosphere. Simply put, CO<sub>2</sub> is the gas emitted when carbon is burned. As you can imagine, most of the fuels used nowadays contain carbon. But why is it burned? It is burned because historically it has been the easiest way to extract the energy stored in carbon. After burning, the energy is released in the form of heat, which is then used to heat something else, such as water to produce steam. In conclusion, every time fuels are burned to extract energy, CO<sub>2</sub> is emitted into the atmosphere.

The energy content of fuels is used by many industries and power plants, including cement, steel, pulp and paper, and oil refineries. These sectors all face the same problem: they emit CO<sub>2</sub>. However, the pulp and paper sector utilizes biomass (wood from trees) as a raw material. The trees absorb CO<sub>2</sub> during photosynthesis, and then that CO<sub>2</sub> is released when burned. Hence, if that CO<sub>2</sub> could be captured, the net CO<sub>2</sub> emission would be negative. This underscores the relevance of capturing CO<sub>2</sub> from industries that use biomass as a raw material. However, despite its importance, it is not being done for three main reasons: the investment is high, the operation requires a lot of energy (money), and the technology needs to be proven and accepted.

In my study, I have addressed the second problem: high energy requirements. First, I modeled the CO<sub>2</sub> capture process and validated that model with experimental data from other research and lab experiments. The main outcome of this model is the size of the capture module, which gives us an idea of the capital cost and the energy requirements of capturing that CO<sub>2</sub>. These results show that capturing 1 kg of CO<sub>2</sub> requires 3.6 MJ, which is similar to the energy produced by one onshore wind turbine in one second. The case study of Montes del Plata emits 88 kg of CO<sub>2</sub> per second, hence 88 wind turbines spinning and producing 3.6 MJ each of energy every second that the mill is in operation. It should be remembered that pulp mills run around 350 days per year and 24 hours. It is clear that the energy requirements are huge. This is why the second part of my study focused on using the internal energy of the mill to satisfy the demand for the carbon capture process.

In the final part, I have dimensioned and shown how the different waste energy streams of the mill can be valorized. That means that energy that is being wasted can be useful again with an energetically feasible process such as heat pumps. Additionally, I have shown that other heat-exchanging processes can be optimized, and energy can potentially be saved. The main takeaway of this section is that carbon capturing is doable from an energetic point of view if waste heat is used through the implementation of heat pumps. Without the utilization of heat pumps, capturing the CO<sub>2</sub> will cause an immense reduction in energy production.