Renewable gas for tissue drying hoods to enable carbon-negative tissue production

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Figure 1. *A Meva Energy gasification unit at a paper mill supplying renewable gas.*

ABSTRACT

One of the main CO_2 challenges in tissue production is finally solved. Combustion of fossil gas (natural gas and LPG) for generating high-quality process heat for tissue drying hoods has been the conventional solution and no efficient alternatives have been in sight. Until now: renewable gas can finally become a viable replacement for fossil gas!

Tissue, needs to be soft and with high absorption capacity, whether in the form of toilet paper, kitchen paper, napkin or diaper. Tissue producers are therefore constantly trying to improve tissue quality while keeping a low production cost.

A critical part of the production is the drying of tissue without pressing it, which can result in a loss of softness and fluffy character of tissue. To achieve this, the best practice today is to let the paper travel over a large, heated steel cylinder – the yankee cylinder – at high speed. The yankee is generally heated with steam from the inside and hot air from the outside. Direct gas combustion in gas burners are used to generate this hot air, wherein the hot flue gas is blown into a drying hood to dry the tissue paper.

The hot air is in direct contact with the paper which puts high demands on the quality of the hot air. Avoiding any smell or black particles being deposited on the tissue paper is crucial. To achieve low cost, stable and high quality of the process heat, the

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solution today is to combust fossil gas, i.e. natural gas or LPG, in tissue drying hoods.

However, tissue is generally a single-use product, thereby the tissue producers strive to compensate for this by producing tissue from the most sustainable resource. The use of fossil gas creates a massive CO_2 footprint and could be described as the "black sheep" in sustainable tissue production.

For instance, the steam used to heat the inside of the yankee can be generated through combustion of wood residues and other biomass. Biomass has a heterogeneous character, thereby combusting biomass will not give a stable process as compared to fossil gas. Morever, it risks the tissue becoming contaminated with particles and odour.

DECENTRALIZED ENERGY PRODUCTION

A new type of biomass gasification, developed by the Swedish company - Meva Energy (spun out of Luleå Technical University and Center for Energy Technology), has proven to overcome the above-mentioned issues. The gasification is based on entrained-flow principle, which produces a clean and stable gas quality. The technology is also suitable for various feedstocks, even fine fraction residues such as sawdust and wood fibre.

Meva Energy's ision is to produce and deliver gasification units that use local biomass residues to generate energy at site. Hence, without need of costly and complex upgrading, unnecessary transport and parasitic losses. The gas needs to fulfil the function of its use, rather than to simply meet a standardized gas quality just for the sake of it. These factors are key to creating a cost-efficient solution that could be cheaper than existing fossil-fuel based solutions.

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The technology was first developed for industrial-scale combined heat and power production. The first full-scale plant is situated in Hortlax – a small village outside the city of Piteå in northern Sweden. The plant is connected to the district heating grid and the power grid with a capacity of 1,2MWe and 2,4MWth respectively. A Swedish tissue mill contacted Meva Energy after being part of the"Fossil free tissue drying" feasibility study (Energiforsk, report 2016:231), which investigated the effects of replacing LPG with syngas using mathematical models. The conclusion was that such replacement is possible. It also recommended a test plan to understand whether the combustion products of syngas could damage the tissue. The question from the tissue mill was whether Meva Energy's technology could be utilized to replace the fossil gas in the drying hoods. As this was not investigated, the research institute RISE ETC (Research Institute of Sweden, Energy Technology Center) were tasked with evaluating the suitability and resolving the uncertainties.

A major test campaign was pursued: syngas from Meva Energy's full-scale

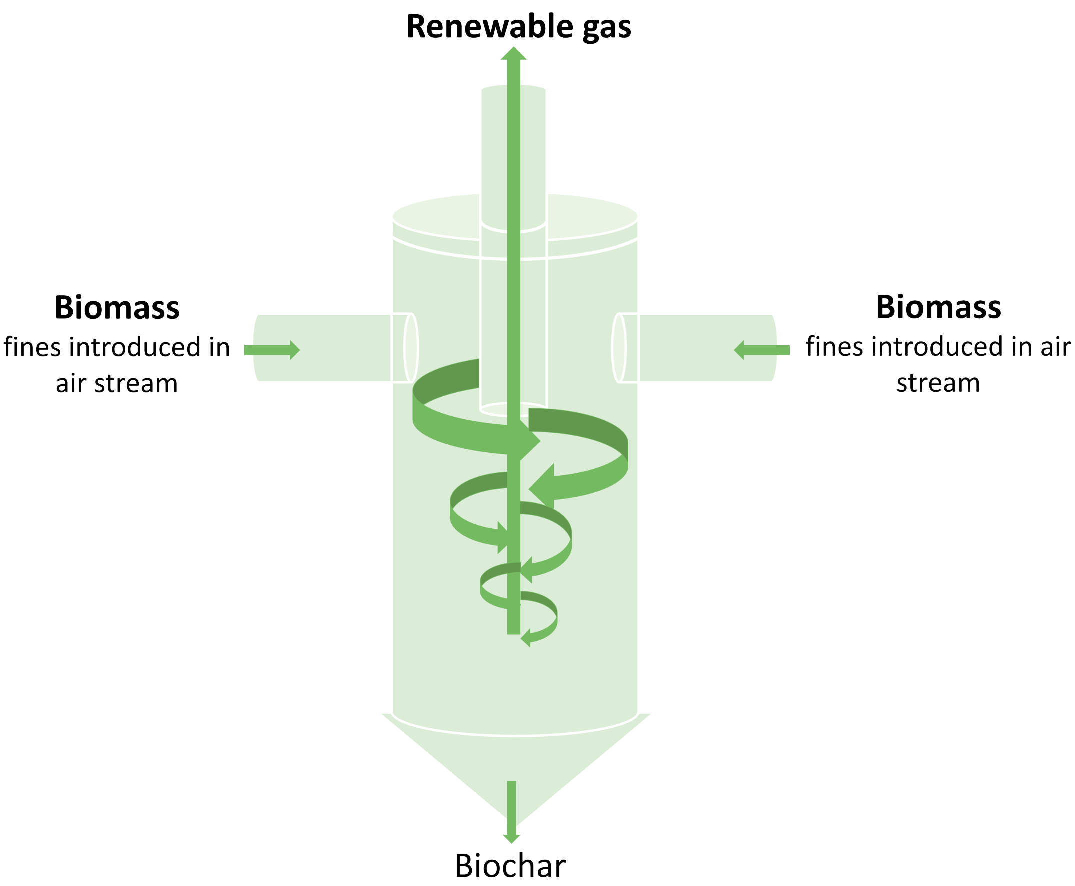

Figure 2. *The Meva Gasification Principle*

biomass gasification plant was burnt and the combustion gases were analysed in terms of particle content and combustion efficiency. RISE also investigated tissue drying with a mini-Yankee cylinder, whereupon the tissue paper samples were analysed in terms of odor and visual damage.

The result showed:

- No odour or visual damage
- Sufficient heating value
- Low level of particles in the exhaust gases
- Stable and very even combustion without any need to enrich the syngas

These tests were conducted with a swirl burner. Since then, the tests have been followed up by commercial burner manufacturers to investigate whether more conventional burners for tissue drying hoods can accept multi fuels.

- It works in both duct and corner burners
- It is possible to co-fire LPG/NG and renewable syngas in the same burner
- No need to redesign or expand existing burner chambers

These results mean that the transition from fossil fuels to a renewable gas alternative can be achieved relatively simply. It also therefore permits the existing infrastructure to be kept as a redundancy, with only the burners needing to be exchanged for multi-fuel types.

Syngas is normally associated

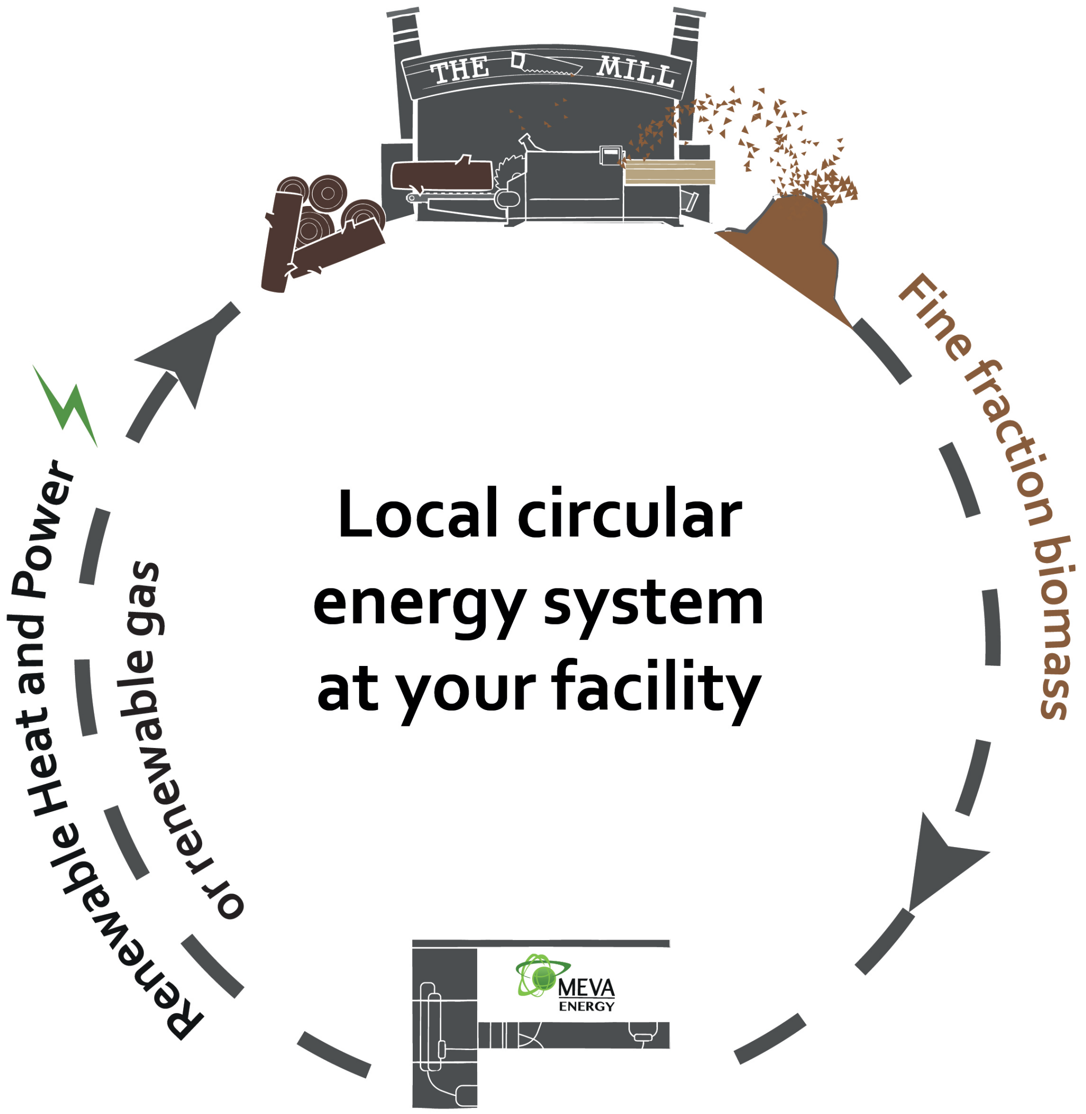

Figure 3. *The Meva Circularity Process.*

with gas produced from anaerobic digestion of sewage sludge or manure, i.e. a wet slurry. The technology developed by Meva Energy is a thermochemical conversion process which uses solid biomass, e.g. wood or agricultural residues. The energy content in the feedstock differs with a factor of one thousand between these production methods; this means that in order to achieve the same output, the reactor of the anaerobic digestion plant must be much larger than the thermochemical conversion process.

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Hence, the capital expenditure for a thermochemical conversion process is lower, per MWh of energy.

There are several technologies for thermochemical conversion: fixed bed, updraft, downdraft, fluidized bed etc. What makes the technology of Meva Energy so interesting for this application is the patented entrained flow principle. Biomass particles are entered into the hot reactor at a continuous flow, leading to a process that gives a stable gas quality.

Figure 4. *The Hortlax Plant.*

DRAMATIC CO_2 REDUCTIONS

An investigation into the sustainability and economic impact of replacing fossil gas with the renewable syngas was required. This was conducted at a Swedish tissue mill where a Meva Energy gasification unit was about to be installed next to the mill.

The CO_2 calculation showed:

- 9 211 tonnes of CO_2 reduced annually from removing the existing LPG solution
- 551 tonnes of CO_2 added from the new renewable solution
- 1 640 tonnes of CO_2 reduced from the CCS effect of utilizing the residue biochar
- **In total: an annual reduction of 10 300 tonnes of fossil fuel-derived CO_2**

Introducing renewable gas not only reduces CO2 emissions to zero, it also dips into negative territory.

These figures shows three interesting things: Firstly, renewable solutions also contain some fossil CO_2 footprint (deriving from transporting fuel etc,), as calculated by the Swedish Environmental Protection agency. Secondly, the residue from the gasification process – biochar – works as a secret weapon in reducing the CO_2 due to its ability to store CO_2 in the ground. Thirdly, introducing renewable gas not only reduces CO_2 emissions to zero, it also dips into negative territory as the mill does not emit this much CO_2 to begin with!

THE SECRET WEAPON: BIOCHAR

What, then, is biochar? One clue might be to think of barbecue charcoal. Following a full combustion process, the residue turns into ashes. In a gasification process, less oxygen is allowed in the reactor and some of the carbon from the fuel remains in the residue, i.e. biochar. The biochar has a high porosity and surface area.

Active carbon is produced in a similar process, mainly produced from coconut fibre. The biochar can be used as soil improvement, working like a sponge in the soil because of its ability to soak up moisture and nutrition, then slowly releasing it when the plants need it. The biochar is stable – more so than carbon from the natural degradation of fallen woodland trees – and will stay in the ground for centuries. It thus also has a carbon storage effect if used correctly.

FINE FRACTION BIOMASS RESIDUES ENABLE LOWER COSTS

Whilst the driving force for converting to a renewable solution is sustainability, the economic aspect is of great importance when considering replacing fossil gas in tissue drying hoods. Energy constitutes a considerable share of the cost for a mill. Fossil gas is subject to a global market where price fluctuation is both frequent and hard to predict. It is subject to far greater regulations and surcharges such as emission allowances, carbon tax and so on – all of which only serve to increase the overall cost of combustion. Switching to locally produced renewable syngas could be favourable: biomass prices are more stable, having less sensitivity to market fluctuations.

The single most important parameter affecting the production cost of syngas is the feedstock price. Buying standardized wood pellets or being charged a gate fee from receiving a local residue will definitely impact operating expenses. Meva Energy's technology uses fine biomass fraction; this means that residue that is normally considered as waste can be ultitized. In fact, recent studies have shown that the technology is also suitable to be applied in the manufacturing of MDF and other engineered wood dust which normally struggles from elevated NOx emissions (derived from solid nitrogen in added glue). In the gasification process, the solid nitrogen is transformed into normal inert nitrogen gas which of course is not harmful.

A fluctuating fossil gas price, together with different site conditions (in terms of access to local biomass) means that overall profitability needs to be carefully assessed in each case; but in the case of the Swedish tissue mill discussed earlier, the cost of renewable gas could match the cost of combustion with fossil gas.

PREMIUM PRICING OF SUSTAINABILITY

Cost, as we know, is only one part of profitability. Recent public opinion and media attention has shown an ever-increasing concern over climate change.

"Green" products are therefore susceptible to premium pricing. A recent study (published in Bioresources) describes sustainable products used within the tissue industry as being up to 85% more expensive. However, many public studies have already highlighted this situation. McKinsey has, for example, estimated that within the packaging industry, 80% of customers are willing to pay an extra 5% for specifying a green product. 65% would even be willing to pay an extra 10%. A recent German study shows that two thirds of bio-based product suppliers, who were questioned, reported that customers are willing to pay a premium of at least 10% for green products. Furthermore, the second strongest green argument is "lower greenhouse gas emissions". The study also finds that end users – particularly within the consumer-goods industry – are increasingly willing to pay a premium for green products.

Maintaining leadership in sustainability and increasing such a gap to competitors' activities in the tissue industry is often key to achieving the increasingly desirable trend for environmental labelling and, even more importantly, private labelling. The share of private label is increasing in FMCG; this is also the case within the tissue industry, with 21% private labelling worldwide and 55% in Europe (according to Euromonitor International). An incomparably low CO_2 footprint would also enable access to the private labels' own sustainable brands in order to secure an enviously strong market position.

An increase of either sales or price by only one or two percentage points can, in this business, make a huge difference and would more than justify a change to new, renewable technology.

In conclusion, it would appear that biomass gasification can play an important role in the future of the tissue industry. When considering machine developments, most initiatives designed to achieve higher quality paper or increase productivity usually result in a need for more gas. For instance, when attempting to recirculate the heat from the hoods back into the yankee cylinder (and thus reducing the need of external heat into the yankee), there will be an increasing demand for gas to heat the drying hoods. Another technology, Through Air Drying, where the heat goes through the yankee has made a recent comeback but it also requires higher gas consumption. Renewable energy sources allow more environmentally sustainable production; they can and should be the way forward!

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