The Swedish bioeconomy startups branching out beyond forestry

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Forests cover more than 70% of Sweden's land area, the largest proportion of any EU country. Sweden is a world-leading producer of forest products and naturally, its bioeconomy is dominated by wood.

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wood-based chemicals and materials.

With close ties to regional and central government, the industry now positions themselves as a key actor in Swdens' decarbonisation. The country's 'green gold' , industry actors argue, offers a ready substitute for oil plastics, petrochemicals, and mined minerals in sectors as diverse as pharma, personal care, and construction.

Many of the standalone biotech startups coming out of Sweden today also depend on wood feedstock from the forestry industry, turning that preeminent pre–industrial material into novel materials. Thanks to them, wood is even entering renewable energy storage, for example through Cellfion's cellulose nanofibril membranes – wafer thin components made of wood-based biopolymers.

Yet the prominence of the forestry industry in Sweden's bioeconomy has whipped up controversy. Many scientists, activists, and NGOs are critical of the outsized influence it has in the biobased sector as well as over the very direction of Sweden's sustainable transition.

Replacing some uses of petrochemicals with wood and its derivatives can almost certainly contribute to carbon reduction. However, industry criticisms focus on its over-exploitation of natural resources and lack of attention to wildlife conservation.

The argument is that further intensification of forestry, even in pursuit of decarbonisation targets, would be a disaster for Sweden's biodiversity, identifying the industry as one of the main barriers resisting regulations that balances profit with preservation.

Sweden may be known for its wood products but many startups in the bioeconomy are going beyond the forest. Encouraging other forms of feedstock use would be one way to alleviate social conflicts over Sweden's forestry sector and foster more balanced developed in the bioeconomy.

Soil regeneration with carbon offsets

agriculture.

Jord has two types of products: plant-based, carbon-rich materials as a low or negative carbon alternative agricultural input (such as biochar for farmland) or stores the biomass in the natural environment and sells the offset associated with them. These carbon capture solutions are verified by Den Norseky Veritas, an independent auditor.

One of Jord's carbon offsetting products uses a patent-pending method that turns carbon-rich biomass into something it calls "bio-oil". It then pumps this carbon-rich oil into geological sinks where in theory it should remain for millions of years. The method is still undergoing verification as a carbon capture and storage technology.

The company's suite of agricultural solutions include planting a fast-growing grass known as C4 that takes up high levels of carbon in its root system. It offers a useful crop cover for farmers wanting to reduce their operational carbon emissions.

According to the company, this plant does not just increase soil carbon storage capacity but also its quality. In 2020, the company began a project to restore degraded farmland in Senegal, using its biochar and C4 grass as soil amendments.

The C4 grass' benefits do not stop at soil carbon enrichment. By harvesting C4 grass, the Senegalese farmers with whom the company worked can create a non-wood biofuel that avoids felling trees, upholding local biodiversity.

Interestingly, the CEO and founder of Jord, Peder Dagsánth, says he was inspired to set up the company as a counterpoint to Sweden's forestry industry which he saw as depleting nature without restoring it.

Sweden's algae startups

Absorb Earth is another biobased Swedish carbon capture company but its biotechnology centres around a single fast-growing algae species.

Algae are well known to be efficient carbon absorbers and the private sector is just beginning to try and scale this sequestration solution. Absorb Earth's approach to this has been to develop a floating farming system.

the ocean where the algae will soak up sun, water, nutrients, and above all, carbon from the atmosphere.

After a controlled period at sea, the pods are designed to sink, carrying their carbon-rich algal biomass down with them to the ocean bed. In theory, the carbon should stay there as CO_2 liquefies at 1000 metres depth and becomes heavier than water.

The Oceanpod is currently awaiting a patent. Once obtained, Absorb Earth plans to licence them for mass, distributed production throughout the world.

Carbon capture is not the only use of algae in decarbonisation. Mounid has created non-toxic ink for textiles made from microalgae, collaborating with textile companies towards a more sustainable textile industry. It recently received a Swedish patent.

According to the company, the textile industry makes up 4-8 percent of the total climate impact in the world, with conventional dyes taking up 80% of emissions released during production.

Like Absorb Earth, Mounid takes advantage of algae's carbon-absorbing powers to maximise the climate mitigation benefits of its product. During the growth period, the algae will be soaking up carbon from the atmosphere. After harvesting and processing, the algae dyes can further contribute to carbon reductions by displacing emissions that would have gone into making and applying conventional dyes.

Mushroom-based water treatment

MycoMine's tagline is "we turn waste into life". The company has developed a product that uses microbial processes to treat environmental pollutants. This biobased treatment method cuts down on the emissions and toxins associated with conventional treatment options.

MycoMine's main product is MycoCube, a "biological, portable, and scaleable" treatment module in which the active component is fungi. The reusable cube works in-situ to minimise transportation of pollution. The company says it achieves a 99.9% degradation of oils and a 100 times reduction in carbon emissions needed to achieve treatment.

feedstock is that it does not possess the large scale agricultural biomass that bioeconomic behemoths like Canada, the US, or China have access to.

Yet the startups detailed here show how Sweden's research capabilities could also help transform low-bulk biological resources into emission-cutting technologies. MycoMine's biotechnology shows how sustainability goals could be reached not through high volume replacements of fossil material but rather by replacing heavily polluting technological *processes*, such as chemical treatment.

Can forest bioeconomies reduce emissions?

Although 45% of Sweden's forested area is certified as being managed sustainably, felled natural forests even there are often replaced with planted monocultures of fast-growing and non-native species. These artificial tracts are generally less biodiverse than the mature growth they replace.

The social conflicts over Sweden's forestry industry comes back to a central question: does felling forests to replace oil with wood result in more carbon entering the atmosphere than simply leaving them intact?

"Part of the answer to this question lies both in the magnitude of the real substitution effect, as well as in the shape of public policy intervention", says one research paper on the question. Nobody is certain of the answer as models disagree over how much emissions may be avoided by replacing plastic and mineral with wood. Another uncertainty is the strength of recycling policies around wood products, which can impact the total emissions released by them over their entire life cycle.

The current scientific consensus is that wood harvests probably can reduce society's overall greenhouse emission replacing plastics and mineral goods. However, the carbon-reducing capacity of the forestry bioeconomy will likely come at the expense of forest biodiversity. A paper in Nature concluded recently that "targets for achieving high harvest demands for climate change mitigation are in conflict with targets for boosting multifunctionality and biodiversity".

goals – climate change versus ecosystem conservation – can be in conflict.

The bioeconomy must not lose sight of biodiversity targets even as it moves towards reducing the carbon emissions of industry. Having one feedstock dominating the bioeconomy can encourage an unbalanced sector, feeding into ecological imbalances where a single type of habitat is exploited for every end-use application.

With wood products used more selectively in end-applications where it performs best, it would leave other niches for alternative materials that may be more economically and technologically appropriate.

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