Converting Biomass to Energy: A Case Study in Avoiding Greenwashing

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Introduction

Biomass is defined as any plant matter used directly as fuel or converted into other forms before combustion. This includes wood, vegetal waste (including wood waste and crops used for energy production) and animal materials and wastes.[1]

Biomass is a valuable resource in achieving energy transition goals at the global level. It is one of the most promising options for decarbonizing the energy sector and has seen an annual growth rate of 6% since 2000.[2] However, it is a complex and scarce resource. It requires integration of wood science, forest management, engineering, economics, climate change, land-use, water quality and biodiversity into the overall extraction, sourcing and burning processes to ensure sustainable availability and use of biomass.

Changes in land use or forest management practices driven by bioenergy or biomass consumption may have either positive, neutral, or negative impacts on biodiversity. This depends on the scale, location and context of the changes.[3] These changes are difficult to track due to lack of data and coverage across the globe. In fact, a study conducted by the European Commission on the impact of bioenergy on habitats and species states that coherence of data sets, specifically the ones that link biomass demand with land use and land management change, is key to enable informed dialogue on risks and impacts to biodiversity.[4]

In principle, biomass can be renewable and sustainable. However, certain challenges with that assessment have been highlighted in the following section and explored at an investment decision-making level in the case study that follows.

The sustainability challenge in burning biomass

The premise of biomass being a sustainable and renewable energy source stems from the notion that its natural energy source is solar (stored energy from the sun), and it can regrow in a relatively short period of time. Trees produce biomass through photosynthesis by capturing carbon dioxide from the atmosphere. When they die and decompose, they release most of the CO_2 back into the atmosphere. Therefore, burning the biomass should release the same amount of carbon dioxide. As forest wood is the most combustible material used for biomass,[5] it is imperative to explore the following **three challenges** to understand the issues with that assessment.

Forest management practices

Forest wood usage proponents argue that thinning out forests – removing dead trees from overcrowded forests and harvesting the by-products such as logging residue, treetops, limbs, leaves and needles – lessens the risk of wildfires and improves the health of the overall forest ecosystem.

However, there are some drawbacks to this approach. Harvesting and removing limbs, leaves and plant parts from forests can diminish soil fertility and hasten erosion. This is because the nutrients that would have been recycled back into the soil when these parts decay are no longer recycled.
In addition, heavy machinery used for logging compacts soil and increases runoff, affecting water quality. Removing vegetation from the ground also impacts wildlife habitats on the forest floor.

Assumed carbon neutrality

The "carbon neutrality" of forest biomass relies on the carbon cycle assumption that new trees regrow at the same rate as the harvested trees are being burned, and the burned trees would also emit the same amount of carbon dioxide when they die and go through a natural decomposition process. But, the reality is much more challenging and can in fact breach the balance of the natural carbon cycle. Chopping and clearing trees for energy releases carbon that would have otherwise been sequestered had the forests remained untouched. Further, recapturing carbon by replanting trees can take decades or even a century.[6]

Carbon neutrality cannot be assumed from the beginning. It depends on several factors such as time, combustion technology, type of fossil fuels and emissions that are being replaced, forest harvesting techniques employed, as well as multiple supply chain and logistics elements. All of these must be accounted for to look at the lifecycle emissions.

Quantity of wood required

Producing even a small volume of biomass-fuelled energy requires a significant amount of wood. For instance, a new biomass powered heat-only boiler with an installed capacity of 48 megawatts of thermal capacity needs about 408 tonnes of biomass, delivered by 17 trucks every day. Further, the furnace burns 18 tonnes of wood chips from trees and forest residue each hour. Additionally, if the biomass is transported over long distances, the increase in lifecycle emissions would be significant. These numbers illustrate the amount of pressure that can be brought to forest ecosystems and biodiversity in case of overuse of biomass.

BaltCap Infrastructure Fund: Vilnius heat-only biomass plant

In 2017, BaltCap Infrastructure Fund considered a greenfield investment in a 48MW heat-only boiler, which would produce heat and hot water for residents of Lithuania's capital city, Vilnius. The project's financial feasibility depended on its capital expenditure and the ability to provide cheaper heat energy than gas-fired plants in the monthly auction system.

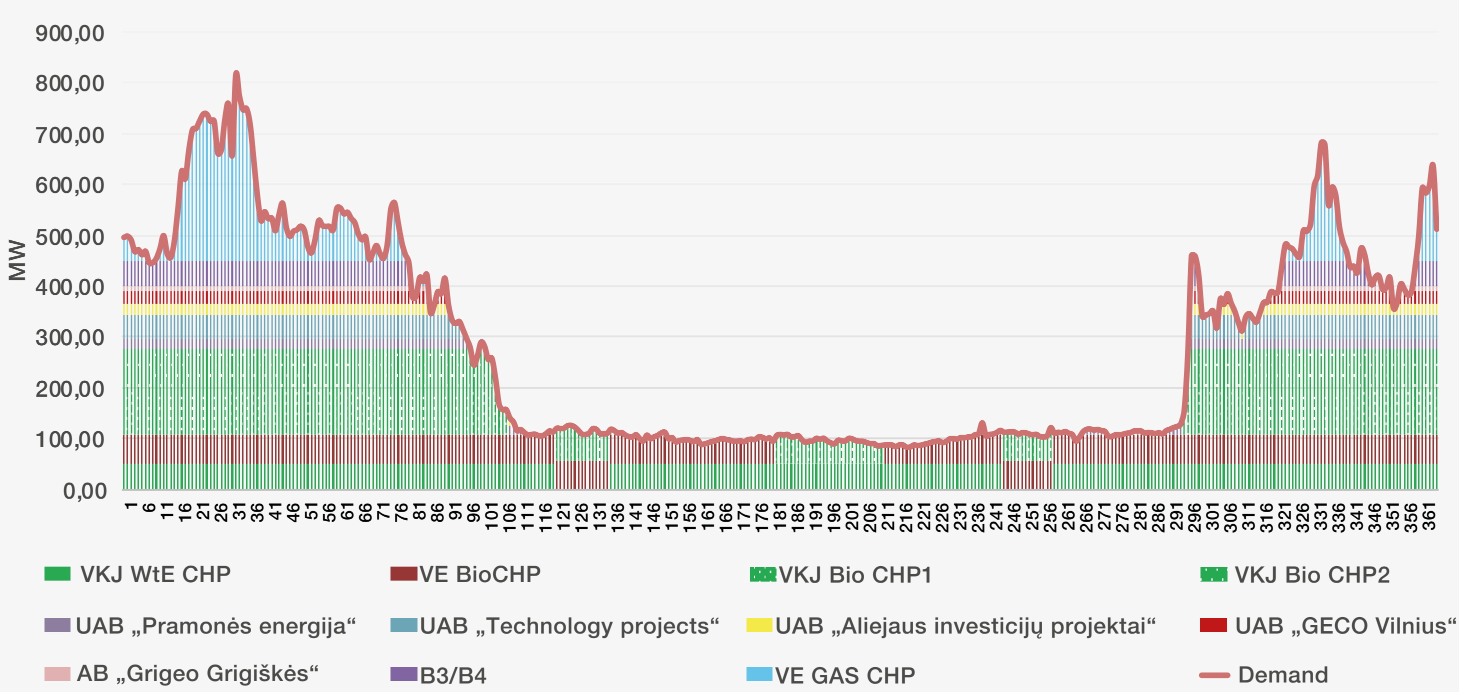
The heat-only boiler competes in district heating system auctions monthly, where all heat producers compete for a projected demand of megawatt hour (MWh) of heat to be supplied the following month. Therefore, it was critical to ensure that the asset gained competitive advantage by using biomass and had lower variable costs than gas fired plants. At the time of decision-making, the district heating system in Vilnius was still heavily reliant on gas – over half of the heat was produced using imported gas.[7] This provided BaltCap with an attractive opportunity to reduce the city's reliance on gas, produce cheaper heat by using biomass and as a result, also reduce emissions.

FIGURE 1. **Image of the biomass plant in Vilnius, Lithuania**

Financial considerations

Based on BaltCap's conservative estimate of projected market share, it was assumed that the asset would be active during the winter season, which lasts 4.5 months in Vilnius. Projected work hours were found to be sufficient to generate an internal rate of return of 8% on capital expenditure basis. Further, optimizing the capital structure with a 50% leverage in the form of bank financing enabled the fund to reach a required double-digit equity return projection.

FIGURE 2. **Projected market share (asset name B3/B4)**



Environmental and social impact considerations

BaltCap's aim was to not only generate attractive financial returns, but also to have a positive environmental and social impact. The fund had to address several key sustainability-related questions as a part of the investment decision-making process:

What is the expected reduction in carbon dioxide emissions?

Based on the fund team's estimates, the biomass-fired, heat-only boiler would be operational for at least 4.5 months in a year and save at least 30.470 tonnes of CO_2 per year as this heat would otherwise be produced using gas. This reduction is equivalent to CO_2 emissions produced by 6,685 passenger vehicles.

What type and source of biomass should be used?

A combination of SM2 and SM3 type would be used to ensure minimum impact on biodiversity (see Table 1 for description).

TABLE 1: **Types of biomass sources**[8]

Type	Description
SM1	Biomass source is the most expensive and high-quality stem wood that could have high value creating alternative use than being burned. Due to its high quality, it results in relatively minor damage to the boiler and furnace. Investors usually favour it due to lower maintenance costs.
SM1W	A niche source of biomass produced from residues of the wood processing industry. It is mainly consumed by the wood processing industry itself. Only a small fraction of it is available for independent heat producers on the biomass exchange. It has a higher moisture content and smaller amount of particles.
SM2	Biomass source is fallen trees that normally have limited alternative use and mostly remain in the forest if they are not used as a fuel. It has a lower price than SM1 but contains branches and other admixtures, which lower the quality.
SM3	This is the lowest quality of biomass sourced from forests. It usually contains logging residues and undesired admixtures. Due to high extraction costs, it usually costs the same as the SM2 type of biomass. SM3 has several disadvantages: – Has leaves and needles that contain chlorine, which can damage the boiler – High ash content – Higher utilization costs – High moisture, which can form ice at negative temperatures and hence, damage the equipment

Is there a stable supply of biomass that would ensure competitiveness against gas-fired plants?

Competitive fuel price was one of the most critical aspects of operational resilience and financial feasibility. Based on studies,[9,10] the Vilnius region is rich in forests. It had enough forest management waste to ensure a stable supply for the planned heat-only boiler as well as existing biomass assets in Vilnius city district heating system with a significant buffer left for forest ecosystem sustainability.

Is the supply of biomass sustainable?

Locally sourced biomass is vital to limit scope 3 CO_2 emissions and ensure competitive pricing as transportation of biomass over longer distances would increase the cost for the user. The fund's market research demonstrated that biomass can be transported using trucks, from certified forests and scope 3 emissions can be limited by obtaining it from forests that are within a radius of 50 kilometres from the plant.

Is there any adverse impact on the forest ecosystem?

Certain types of dead wood (such as fine woody debris including slash) have a very low risk of negatively impacting forest biodiversity,[11] provided it is extracted properly and the extraction is below the locally defined threshold for removal. For Lithuania, it is recommended to leave at least 20%[12] of fine woody debris on the forest floor, as complete removal would be detrimental to the ecosystem. Coarse woody debris, such as snags, logs, etc., is ecologically more important for forest habitat, species, nutrients and productivity.[13] Another key dimension is the impact of shredding biomass in the forest using machinery. This process for preparing biomass is usually undertaken in the forest as transportation of shredded biomass is cheaper. To minimize any negative impact, attention must be paid to these points as a part of supplier due diligence.

Does the type of biomass impact the technology considerations?

Yes, it will have an immediate effect on maintenance costs. Any moisture, ash content, main fraction, small particles fraction, chlorine content, raw material allowable admixtures, etc. can affect boiler tubes. In this case, BaltCap's decision to use SM2 and SM3 meant that the higher levels of moisture and chlorine content could impact the plant operations. BaltCap decided that higher maintenance costs will be acceptable if footprint on biodiversity can be mitigated.

Does this project impact the heat energy costs for Vilnius' habitants?

Yes, end-users benefit given that the project's financial feasibility is based on producing heat energy at a lower cost compared to gas-fired plants. According to the projections by the fund team, the annual cumulative saving because of this biomass plant would approximately be €140,000, or 3% of the average heating bill.

2020 key metrics

Snapshot of the heat-only boiler	
Location	Vilnius, Lithuania
Commissioning date	2019
Thermal capacity	48MW
Fuel	Biomass (wood chips)

2020 performance dashboard	
Operation period	7 months
CO_2 emission savings	56.347 tonnes
Discount on heating bills	€219,000
Thermal energy produced	283.398 MWh
% of city heat demand	11.05%
Biomass used	100.608 tonnes
SM1 (stem wood)	0%
SM2 (energy crops, fallen trees)	33.80%
SM3 (forest logging residue)	66.20%

Lessons learned

Type of biomass used
To avoid negative impact on the certified forest system as well as greenwashing when it comes to CO_2 emissions, BaltCap decided to opt-out of using the SM1 type of biomass, even though it is the most efficient type. Instead, the fund opted to use the SM3 type for two-thirds of generation along with the SM2 type for the remaining one-third. The plant could not use only SM3 biomass since icy weather conditions in Vilnius would freeze it. Hence, the fund team decided to supplement it with SM2 during the coldest weather period.

Supplier quality check
The quality of the biomass fuel plays an important role in determining the heat generation as well as the wear and tear of the biomass plant. There were many instances where the team found pieces of furniture containing chemical additives during fuel quality check. While operating a plant with SM2 and SM3 type biomass, it is imperative to develop a quality control mechanism to keep a check on the source and contents of the fuel. In some cases, harsh actions such as sanctioning or banning certain suppliers have been taken by the fund.

Maintenance costs
An estimated 66% of the biomass used in this plant is of the SM3 type. Given its high chlorine level, it resulted in a flattened boiler tube, which had to be replaced in its entirety. This added an additional cost of €70,000 along with lost working hours. The fund team estimates that such replacement will have to be done every two years and will amount to approximately 2% of earnings before interest, taxes, depreciation, and amortization (EBITDA). For BaltCap, this additional amount is the cost of environmental protection that the fund has accepted, to align with its ambition to have a positive environmental and social impact.

Conclusion

Biomass can be considered a renewable energy source only when it is produced with low lifecycle emissions and if does not harm the forest ecosystem and its biodiversity. Investors must implement control mechanisms to ensure that there is no negative impact on biodiversity. What type of control mechanisms are required then to ensure that biomass is truly a renewable source of energy?

Strong supply chain review programmes
Supply of sustainable biomass with low lifecycle emissions is limited. Therefore, stringent supply chain review and sourcing programmes have to be implemented to ensure that the biomass comes from certified forests, and forbidden wood origin additives (such as shredded furniture containing glue, varnish, paint or other dangerous chemical additives for the environment) are added. Specific attention also needs to be given to ensure that it does not trigger land use change. While making an investment decision, technology such as spatial mapping and planning can be used to de-risk biomass projects when it comes to supplier and sustainability risks, in the absence of clear standards from policy-makers.

Strict standards related to residues and debris
Certified and managed forest residues and fine woody debris can be used as a sustainable source of biomass. However, extraction needs to be managed carefully to ensure that sufficient logging residues and fine woody debris are left in the forest to nurture its ecosystem. Excess removal of residues might result in loss of nutrients, carbon and substrate, and at the same time disturb the habitat structure, which would directly impact biodiversity.

Use of SM2 and SM3 type biomass
Lower-quality biomass can be used to ensure that high-quality wood with other alternative uses is not used as fuel, but for higher value-added activities. For instance, logging residue and sick trees can be used instead of high-quality stem wood. Additionally, care must be taken that forest waste is used as biomass and not trees planted specifically for use in biomass plants.

Use of professional advice
Since biodiversity is a complex and technical area, investors may also benefit from the services of specialized professional services firms to help them with environmental impact and technical due diligence. Engaging multiple stakeholders such as the local community by dialoguing with them, academics, forest officers and others is also beneficial to gain key insights.

Active focus on minimizing biodiversity impact
Forest management and extraction of biomass are inherently going to have some adverse impact on biodiversity of a region. It is important, therefore, for investors to actively focus on minimizing the harm to the ecosystem. This can be done by adhering to the guidance above as well as by avoiding sourcing from protected areas and working with providers who can identify areas where removal of waste is essential to mitigate the risk of fires. Investors can also coalesce to push regulators and policy-makers to develop standards that biomass plant operators must adhere to in order to avoid negative impact on biodiversity.

In conclusion, biomass investors and users must recognize that granting unconditional carbon neutrality to biomass for energy could significantly affect the forest ecosystems and biodiversity. As nature-related reporting evolves, there is scope to consider additional metrics other than greenhouse gas emissions, such as water and pollination. Concrete measures must be taken to ensure that this well-intentioned technology does not become a tool for greenwashing.

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Endnotes

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