Quantification of environmental effects from fuel production: An LCA study to help enhance the sale of torrefied wood products to the European Union

Principal Investigator: Stephen M. Shaler

Affiliation/Institution: University of Maine

Email: shaler@maine.edu

Mailing address:

Collaborators and Affiliations:

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Torrefied wood pellets produced in Maine have the potential to significantly reduce Global Warming Potential (GWP) of electricity by partially replacing coal in conventional power plants.

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http://www.nsrcforest.org

Project Summary

Torrefied wood pellets are an energy source that has the potential to partially displace coal use in power plants, reducing the global warming impact of electricity produced from coal. Torrefied wood is produced by heating wood for a short period of time without oxygen at high temperatures (200 - 300°C). The final product is stable towards moisture and biological degradation, like mold, has an energy density close to that of coal, and can be ground up easily. These properties allow for the pellets to be easily stored, transported, and directly co-fired with coal without costly adjustments to existing plants.

The life cycle emissions of torrefied wood pellets (TOP) produced in a case study plant in Maine and shipped to the European Union (EU) for combustion were accounted for in this study. Due to EU legislations to reduce greenhouse gasses there is a high incentive for power plants to increase their use of renewable energy sources. A life cycle assessment takes into account all resources and associated emissions a product requires and sets free over the course of its life (i.e. from growing tree to ash waste after combustion). In order to more easily compare results from different studies and products, environmental impact factors are commonly used. One of the most often applied is the global warming potential (GWP) of carbon dioxide equivalents (CO_{2eq}) over 100 years. Results indicate that the highest impact on GWP is created by the transportation of TOP from Maine to the EU. Truck, rail, and transatlantic shipping require significant amounts of fossil fuels and therefore emit significant amounts of CO_2.

Other aspects are the source of electricity at the torrefying and pelletizing facility and whether emissions from burning biomass are included in the calculation. The studied case study plant is in the unique position to have access to clean hydro powered electricity. On average, depending on system boundaries and scenarios, 90% net savings of CO_{2eq} of pure TOP compared to pure coal can be realized.

Using TOP to (partially) replace coal use in power plants has a large potential to reduce the associated GWP. TOP are tolerant for a wide variety of wood input forms and represents a new value added forest product which will put a significant new demand on the Northern Forest. Further research will investigate if this demand can be met by currently unused logging residue or if additional harvesting will be required.

Background and Justification

- Torrefied wood pellets are a fairly new product and at this point there is little data and literature on this topic
- Life cycle assessments (LCA) can help to establish a product on the market, especially if its main advantage are its environmental benefits over an established product

- Due to legislative regulations in the EU, there is a higher incentive to use more renewable fuels
- However, use of renewable fuels often requires modification of supply chains and plant design

- TOP offer the possibility to be directly co-fired in conventional coal power plants without major modifications

Methods

Goal and Scope:

- To conduct a life cycle assessment to evaluate the environmental impacts of TOP produced in Maine for export to the EU

- TOP are a new forest product and little data and literature exist on the topic

Life Cycle Inventory and Impact Assessment

- In order to assess environmental impacts of a product, detailed information of associated resources, emissions and waste streams needs to be gathered
- Accounting of resource consumption and environmental emissions for each process in the product systems

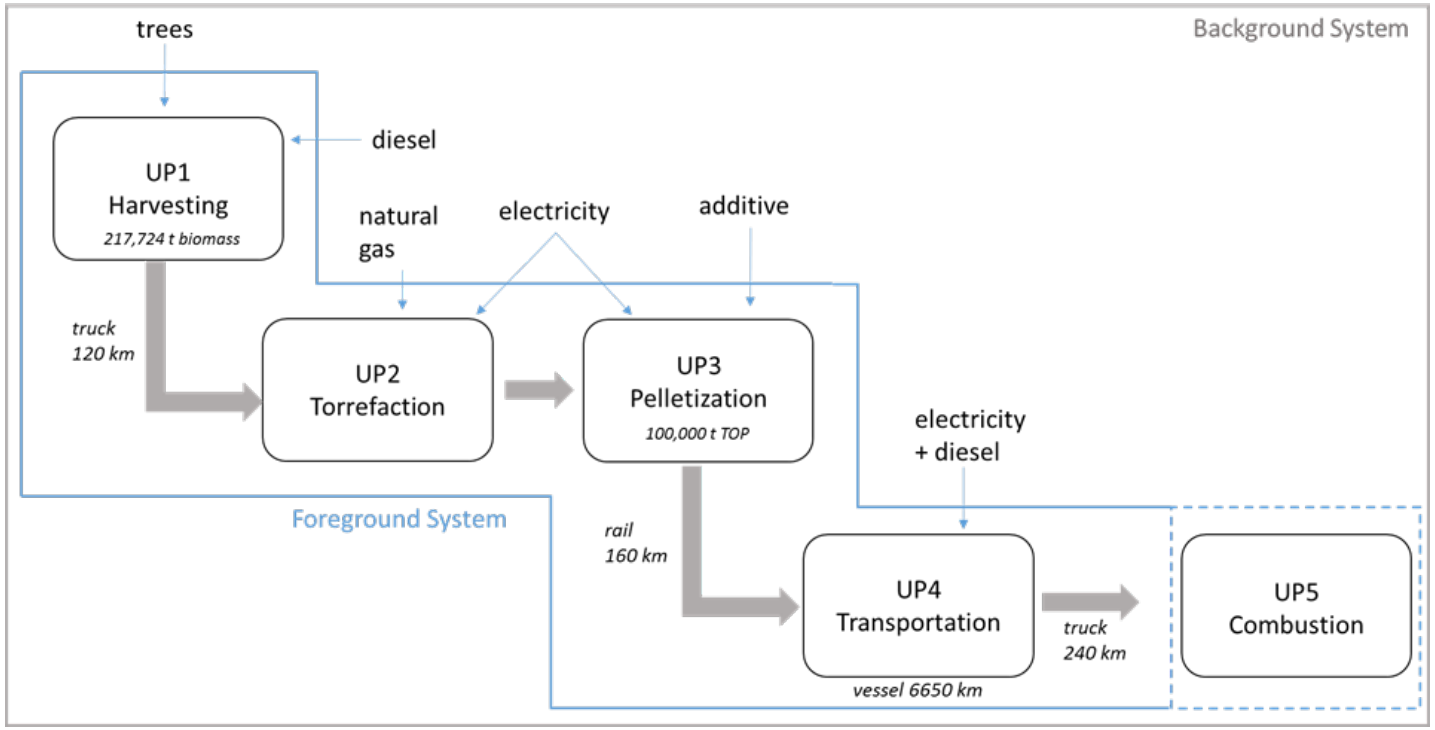
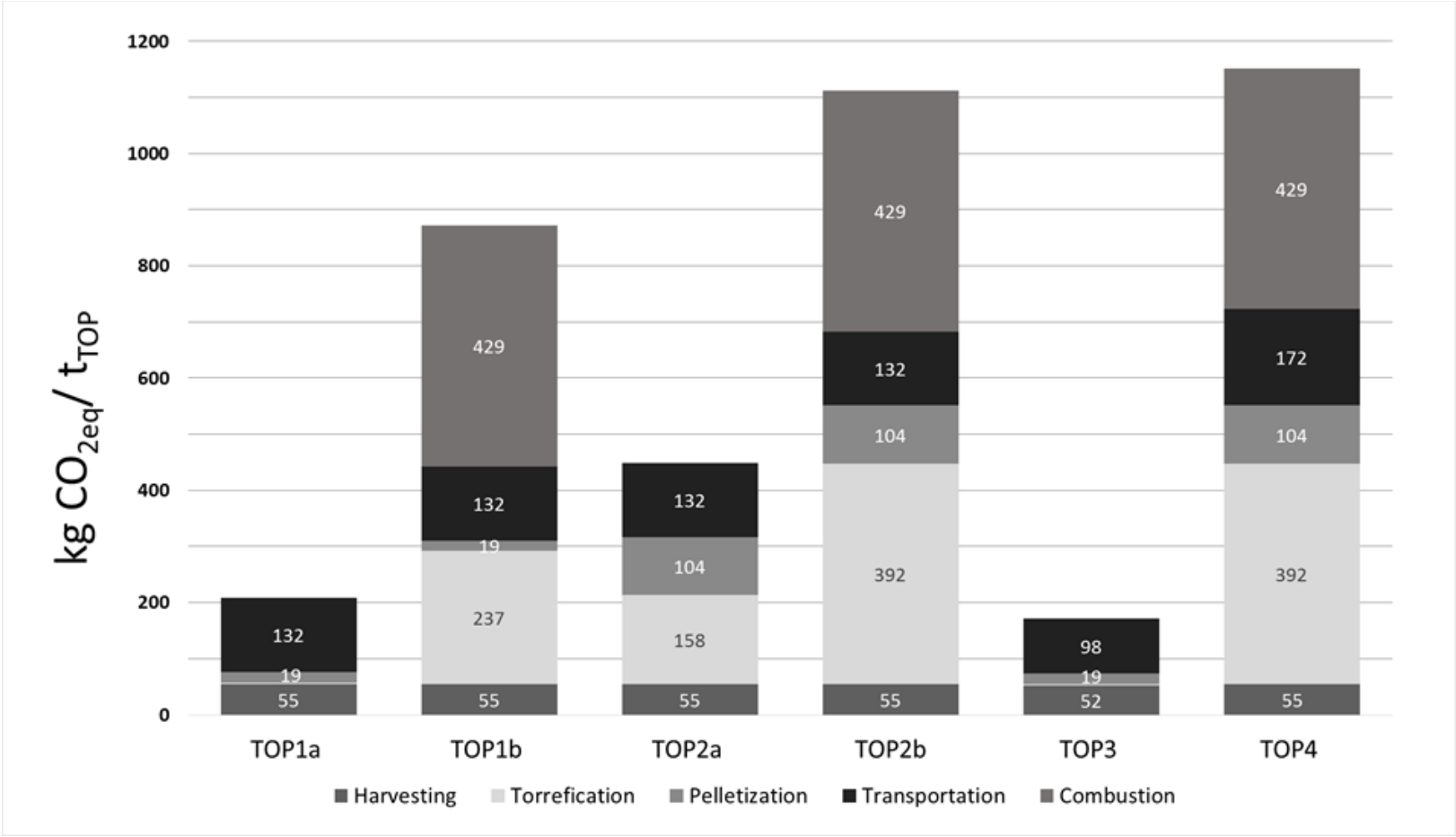


Figure 1 - System boundary and unit processes (UP) of production and transportation logistics of torrefied wood pellets (TOP) from the Maine forest to the European market, including some process flows.

Results

- (partial) replacement of coal by TOP can realize a significant reduction in GWP
- transportation contributes the most to GWP
- little impact of harvesting and only small difference between harvesting techniques (whole tree vs. cut to length model)



GWP in kg CO_{2eq} t_{TOP}^{-1} per unit process for different scenarios. TOP1 with electricity from hydropower and TOP2 with electricity from the Maine grid, a) and b) without and with emissions from biomass. TOP3 represents the best and TOP4 the worst possible scenario.

- studied plant in unique position of being situated on site of an old pulp- and paper mill with access to clean electricity from hydropower
- GWP is increased significantly if electricity from the grid has to be used (Scenarios TOP1 vs. TOP2)

- need to explore local customers
- need to investigate assumed carbon neutrality of TOP combustion and removal of logging residues from the ecosystem

Implications and applications in the Northern Forest region

- TOP are a new forest product that will place additional demand on the Northern Forest

- This demand is anticipated to be small since logging residue, usually remaining in the forest, is intended to be used as main wood source

Future directions

- plant is still in the development stage, therefore no real data and wood demand
- most of the data used relies on estimates and design values

- Need to reevaluate the TOP process once production has been established

List of products

Other publications and conference presentations :

M. Blumentritt, S. Howes and S.M. Shaler (2014): Life Cycle Assessment of Exported Torrefied Wood Pellets (TOP) from Maine to the European Union. 2014 SWST International Convention, June 23-27, 2014, Zvolen, Slovakia.

M. Blumentritt, S. Howes and S.M. Shaler (2014): Life Cycle Assessment of Exported Torrefied Wood Pellets (TOP) from Maine to the European Union. NESAF 2014 Annual Winter Meeting, March 25-27, 2014, Nashua, NH.