Wood to Wing: Sustainable Site Design for a Biofuel Supply Chain

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Introduction

The Integrated Design Experience (IDX) team at Washington State University has been working in conjunction with Northwest Advanced Renewables Alliance (NARA) to research biomass to biojet fuel production in the Pacific Northwest. The biomass in this project, known as the Wood-To-Wing Project, is woody residues left over from the existing forest industry. This project has an associated production chain with multiple processes occurring at several different nodes; one such node is labeled as a liquids depot. A liquids depot is a site at which woody biomass is converted into a refinable sugar slurry. This portion of the supply chain is the focus of IDX team's case study design.

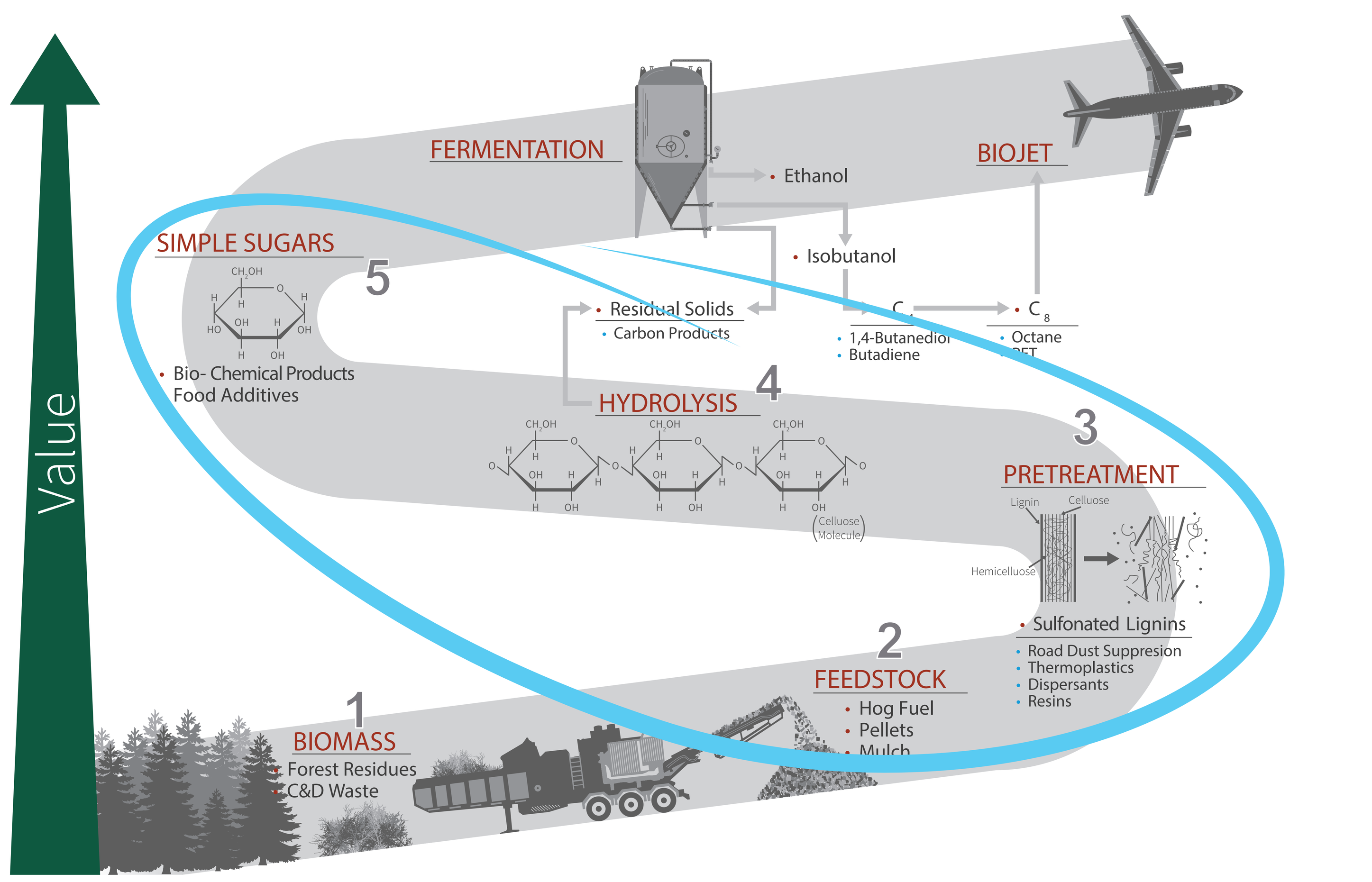


Figure 1: The NARA Supply Chain for a biomass to biojet fuel. The Liquids Depot process is outlined in blue.

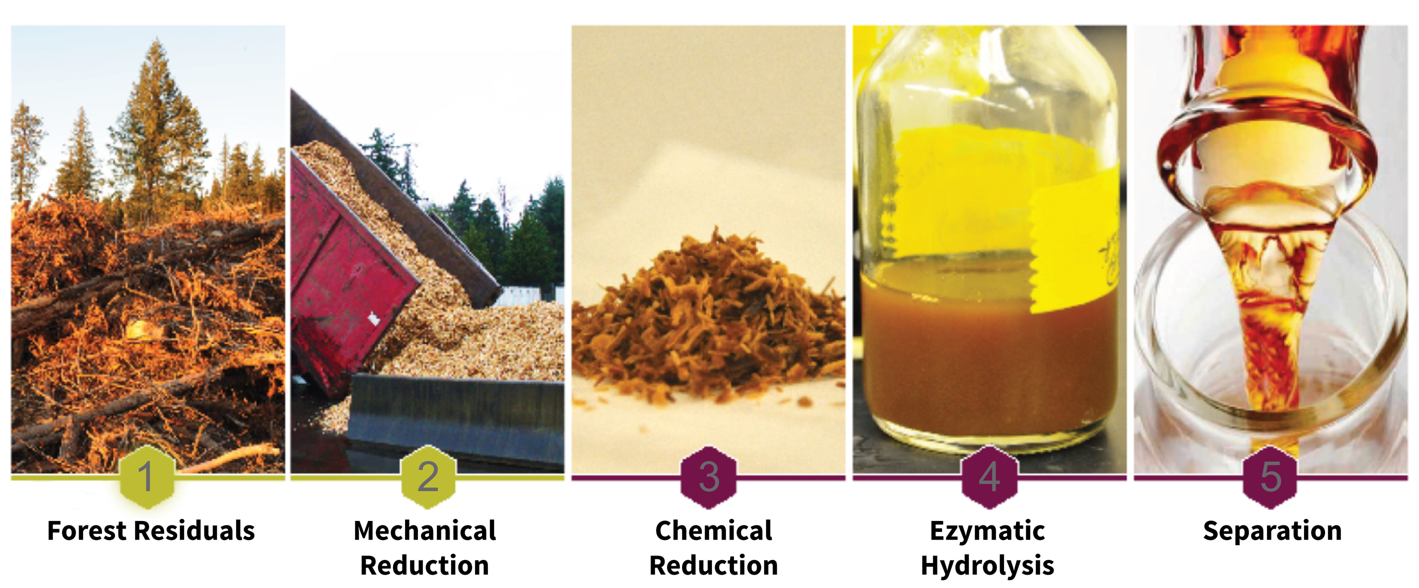


Figure 2: Images of materials and outputs of the processes found in the NARA Supply Chain.

Goals

The objective of the research was to develop a feasible site design for a liquids depot, taking into account process requirements, environmental, social, and economic factors. The unit processes for a liquids depot are outlined and the equipment corresponding to these processes are defined. Equipment sizes and necessary efficiencies are found using a resource flow analysis as criteria. A Techno-Economic Analysis (TEA) for the construction of a liquids depot is then developed by taking into consideration the equipment, capacities, and installation costs. The result of this TEA will coexist with the design of the liquids depot facility to assist in the sustainability and feasibility analysis of a liquids depot in the Wood-To-Wing Project.

What is a Techno Economic Analysis

A Techno Economic Analysis is a tool used to develop the feasibility of a project. The main goal of a TEA is to calculate the overall cost of a project and to understand where those costs are coming from. A TEA always starts with a process flow, how mass enter and exits each section of the process. Then, cost estimates are obtained from companies to describe the costs for the machinery needed for the sections. Finally, an analysis is done for additional costs such as permitting, construction, and engineering costs to calculate the complete cost of the project. This TEA obtains most of the cost estimates by research, with a bulk of the cost estimates coming from a biomass to ethanol plant TEA done in 2011. In order to scale the equipment, costs are adjusted by inflation and by a power sizing equation. Then with sized equipment footprints the site is ready to be designed and engineered.

Figure 3: Proposed site design for a liquids depot. The map is to scale with the areas colored according to the charts shown in the right column. The flow through the facility is represented by the green arrow.

Layers of Sustainability

From a broad view this project is built on the idea of sustainability: the creation of a renewable jet fuel. It is with this viewpoint that the IDX team has strived to design towards the idea of layers of sustainability. In order to accomplish this we focused on the three aspects of design that can push sustainability forward: Power Station, Wastewater, Stormwater.

The designed power station is a biomass boiler with turbines that provide electricity to the facility and the grid; the facility will be a positive net energy system that can sustain itself.

32 MW Electricity Produced

All of the materials burned in the biomass boiler are the byproducts of the processes within the facility: solid lignin left when sugars are extracted from wood, biogas from wastewater treatment, and the wasted sludge from wastewater treatment.

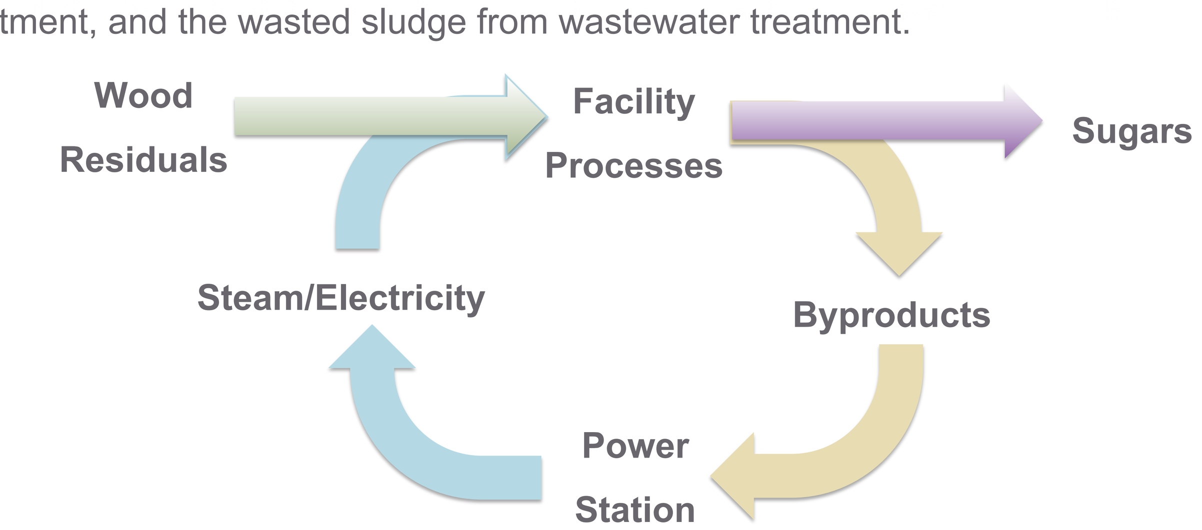


Figure 4: The closed loop energy cycle that the liquids depot facility will operate on.

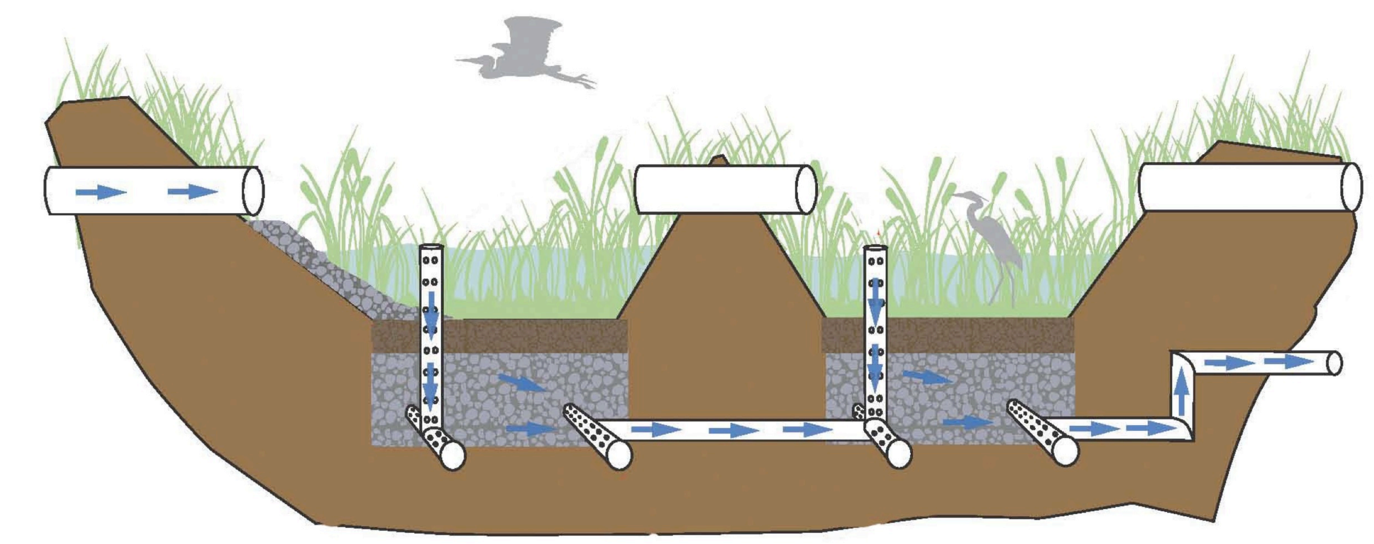
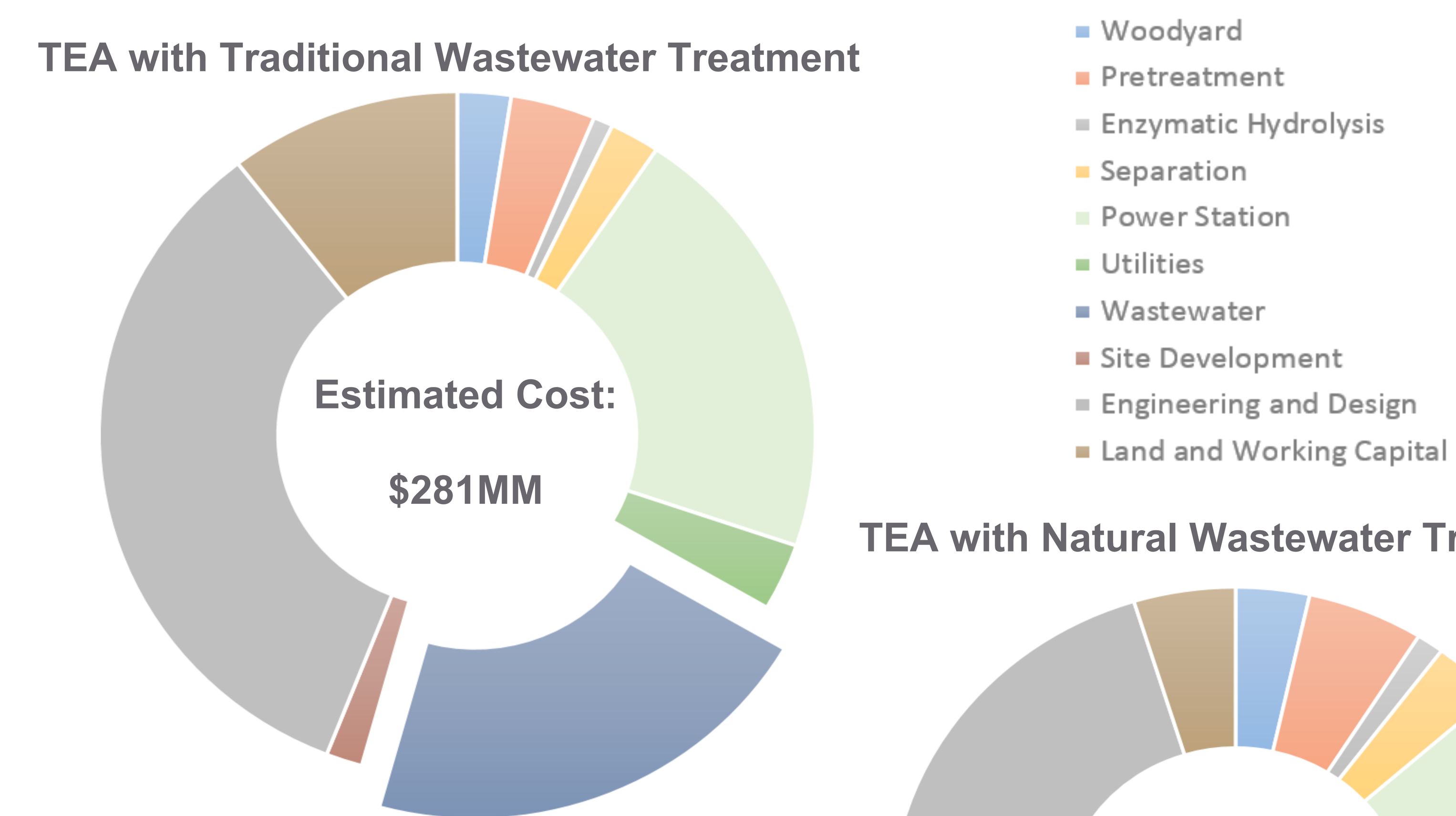
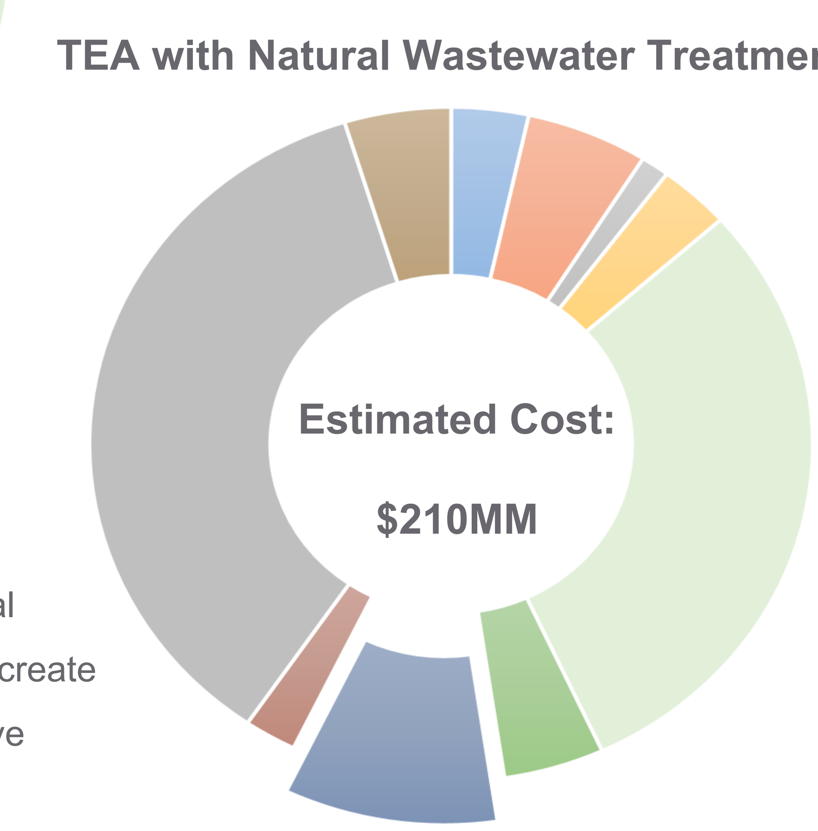


Figure 5: An example of a constructed wetland. This is just one part of a multiple step system to treat the wastewater and stormwater.

The wastewater treatment facility as seen in the first pie chart is an off the shelf design for an industrial facility scaled to NARA specific processes. However, our team proposes that we move forward in our design for sustainability and utilize land for a natural wastewater and stormwater treatment system. This idea moves the facility away from the traditional concrete structures for treatment, creates a diverse habitat for a variety of species to thrive, and saves capital and operational costs.





Conclusion

The natural landscapes and natural resources found in the Pacific Northwest create the opportunity for large industries to move towards sustainability. It is through these opportunities where projects such as the Wood to Wing project become feasible in creating the next generation of fuel as well as contributing to sustainable site design.

Resources

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NARA

Northwest Advanced Renewables Alliance

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