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Bio-Hub Ecosystems: Profitability through Circularity for Sustainable Forestry, Energy, Agriculture and Aquaculture

Authors : Kimberly Samaha

Abstract : The Bio-Hub Ecosystem model was developed to address a critical area of concern within the global energy market regarding biomass as a feedstock for power plants. Yet the lack of an economically-viable business model for bioenergy facilities has resulted in the continuation of idled and decommissioned plants. This study analyzed data and submittals to the Born Global Maine Innovation Challenge. The Innovation Challenge was a global innovation challenge to identify process innovations that could address a 'whole-tree' approach of maximizing the products, byproducts, energy value and process slip-streams into a circular zero-waste design. Participating companies were at various stages of developing bioproducts and included biofuels, lignin-based products, carbon capture platforms and biochar used as both a filtration medium and as a soil amendment product. This case study shows the QCA (Qualitative Comparative Analysis) methodology of the prequalification process and the resulting techno-economic model that was developed for the maximizing profitability of the Bio-Hub Ecosystem through continuous expansion of system waste streams into valuable process inputs for co-hosts. A full site plan for the integration of co-hosts (biorefinery, land-based shrimp and salmon aquaculture farms, a tomato green-house and a hops farm) at an operating forestry-based biomass to energy plant in West Enfield, Maine USA. This model and process for evaluating the profitability not only proposes models for integration of forestry, aquaculture and agriculture in cradle-to-cradle linkages of what have typically been linear systems, but the proposal also allows for the early measurement of the circularity and impact of resource use and investment risk mitigation, for these systems. In this particular study, profitability is assessed at two levels CAPEX (Capital Expenditures) and in OPEX (Operating Expenditures). Given that these projects start with repurposing facilities where the industrial level infrastructure is already built, permitted and interconnected to the grid, the addition of co-hosts first realizes a dramatic reduction in permitting, development times and costs. In addition, using the biomass energy plant's waste streams such as heat, hot water, CO_2 and fly ash as valuable inputs to their operations and a significant decrease in the OPEX costs, increasing overall profitability to each of the co-hosts bottom line. This case study utilizes a proprietary techno-economic model to demonstrate how utilizing waste streams of a biomass energy plant and/or biorefinery, results in significant reduction in OPEX for both the biomass plants and the agriculture and aquaculture co-hosts. Economically viable Bio-Hubs with favorable environmental and community impacts may prove critical in garnering local and federal government support for pilot programs and more wide-scale adoption, especially for those living in severely economically depressed rural areas where aging industrial sites have been shuttered and local economies devastated.

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