

Waste-2-Wealth generation using biomass and e-waste: Feasibility analysis for a way towards sustainable India



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One of the ways towards waste-to-wealth (W2W) creation is optimal extraction and utilization of bio-fuels from bio-waste. India is yet to tap the full potential of the bioenergy sector despite 70% population depending on forest and agriculture. The national initiatives towards blending 20% biofuels with fossil fuels are a catalyzing fact for research in this direction. Though significant progress in research has been achieved while devising novel routes for bio-energy conversion from different biomass resources, a novel approach has been adopted by GOKUL to provide holistic solutions to these problems from the supply chain (SC) network designer point of view. Similarly, another research direction towards W2W creation by GOKUL is to design of smart city through e-Waste management, which talks about the utilization of electronics waste to the best extent possible before disposal, leading to minimization of pollution to mother nature and optimum utilization of usage of otherwise very scarce resources.

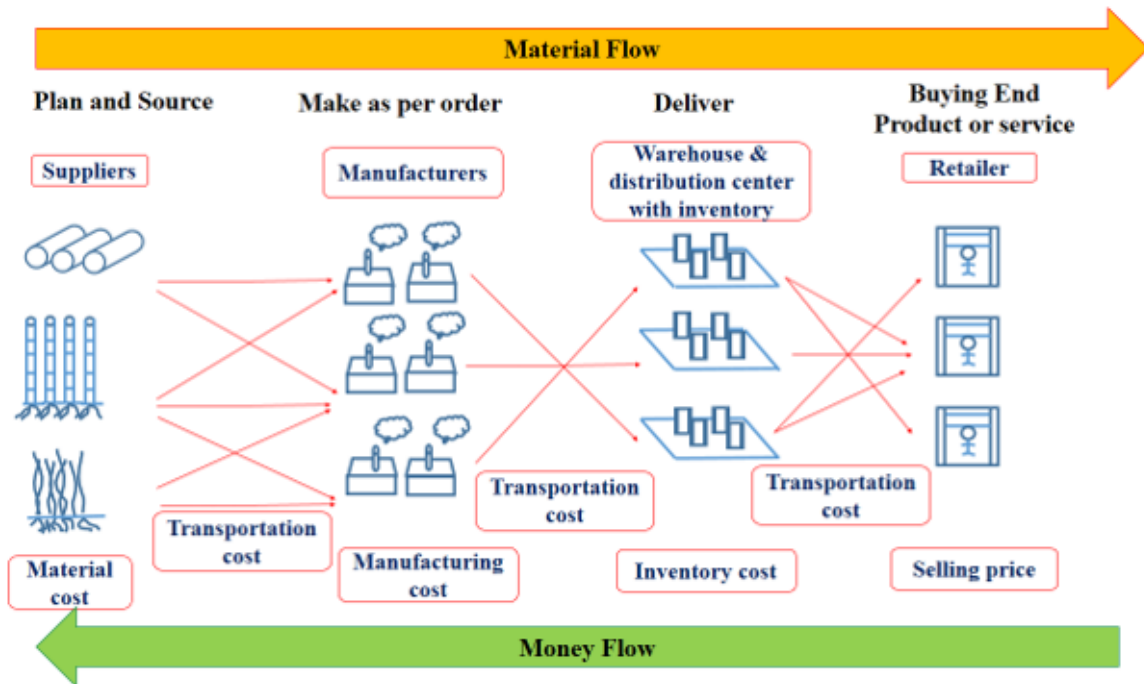


Fig. A: Bio-Supply Chain Network Design

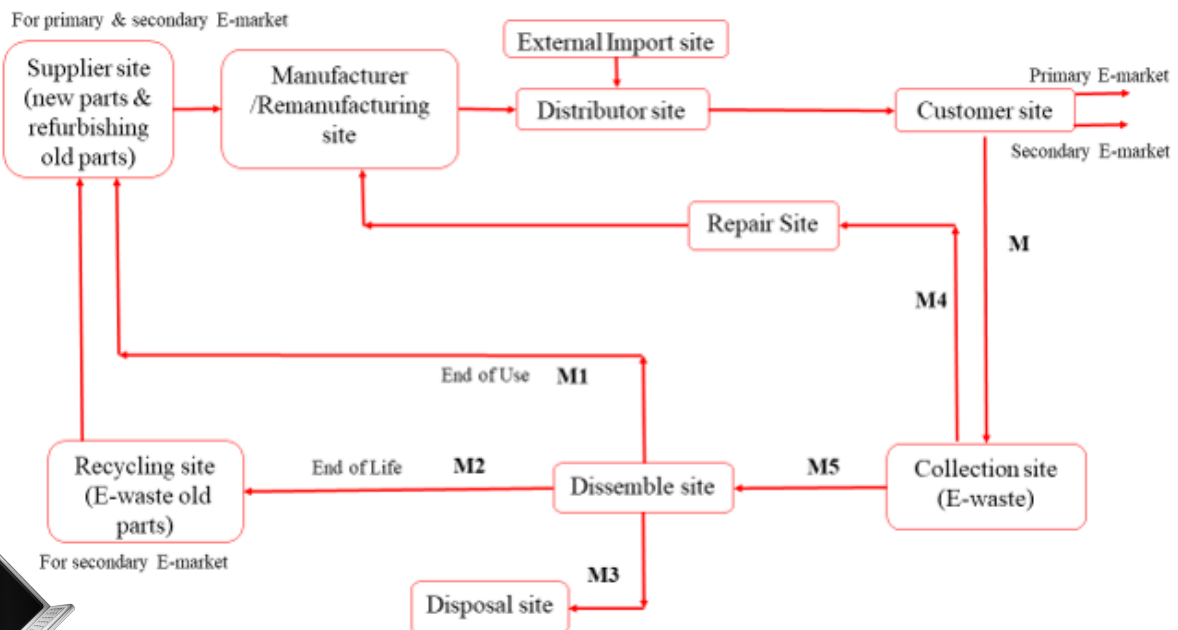


Fig. B: Closed-loop Supply Chain for e-Waste



A forward SC integrates several stakeholders in different echelons (material supply, manufacturing, distribution, and collection – see Fig. A & B) who help in reaching the finished goods to the customers, manufactured from raw materials, with an endeavour of improving the whole product life cycle. Such an effort for designing country wide supply chain network has been successfully attempted for the first time considering the target of blending 20% of both bioethanol and biodiesel for a future time horizon (2018-2026) using 2nd generation biomass. Aiming the dual objective of maximizing net present value and minimizing greenhouse gas emissions (GHGe) production (covering technology, economy, and environment), the target has been achieved through mixed integer linear programming, which is NP-hard to solve.

Further, to make the SC design realistic, stochasticity in biofuel demand, import price, and biomass feed supply has been modeled using a robust data-driven optimization approach. To mitigate electronic pollution and overcome the imbalance of the demand-supply ratio of electronic products, namely laptops, mobile phones, etc., the design of novel closed-loop SC has also been attempted for a 12-year time horizon (2014-2025) following 5R (refuse, reduce, reuse, repurpose, and then recycle) principle.

Here, the target of the mixed integer non-linear programming model is to find the exact site locations of various nodes in different echelons of forward and reverse SC (collection centres, repairing centres, dismantling points, recycling points, and waste disposal points in addition to nodes of forward SC - see Fig. A & B) to perform the techno-economic-environmental analysis. For the first time, such a scenario for Pune city is considered with a ten-layered pull-based closed loop SC network for a smart city development scenario involving end-of-life and end-of-use.

The multi-period, multi-feed, multi-product, multi-site, and multi-echelon model has been shown to save 98.49% of electronic waste carbon emissions.

In addition to being bestowed with the best paper award by the International Federation of Automatic Control Conference (ACODS 2020), the results are published in the prestigious International Journal of Cleaner Production and many other leading forums on several occasions.

GOKUL is extremely happy to acknowledge the collaborations with IIM, Jammu, and CMET, Hyderabad in some of these research activities through the IITH-CMET joint Master's program on E-Waste Resource and Engineering Management.

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