Abstract

The utilization of municipal solid waste (MSW) as a renewable resource could overcome waste disposal issues, generate power for fossil fuel displacement, and mitigate CO2 emissions from landfill. However, the availability of waste feedstock varies with the effectiveness of waste management while the profitability and the environmental impact are mostly dependent on the conversion technology, plant location, and plant capacity. This study aims to evaluate the complexity of waste-to-energy (WTE) supply chain networks for energy production and the CO2 mitigation potential through a spatially explicit approach. The Malaysian peninsular is selected as a case study area. This study adapted the IIASA techno-economic engineering model for optimizing renewable energy systems (BeWhere) and developed a WTE optimization component. The model minimizes the full supply chain cost of WTE, optimizes the capacity and location of WTE production plants, and assesses the energy and by-product potentials. Several scenarios were designed to analyze the impact of energy and carbon mitigation potential of WTE with varying the fossil fuel prices or carbon tax in the supply chain. The results show that incineration and hydrothermal for power production are the preferred options, primarily because of the low economic investment and the high energy conversion efficiency. Apart from the power as the main product, the system produces biofuel as by-product. It is found that most of the plants are installed in more highly populated cities with large potential for waste biomass, hence reducing logistical costs and emissions from transportation. The preliminary results show that WTE could be substituted for about 9% of the Malaysian power production following a business-as-usual scenario. The study proved that BeWhere for MSW provides a robust spatial explicit solution for WTE with assessment of the energy production and CO2 mitigation potential.
Renewable energy production from municipal solid waste: a spatial explicit assessment for Malaysia

SieTing Tan(1), (2), Sylvain Leduc(2), Florian Kraxner(2)
(1) Faculty of Chemical Engineering, Universiti Teknologi Malaysia, UTM Skudai, 81310 Johor Bahru, Johor, Malaysia
(2) Ecosystems Services and Management Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Motivation of Study

- Improvement of waste management in developing country:
  » Rapid increase of MSW with the population growth and development.
  » 95% of waste in Malaysia is dumped in landfill site without further treatment.
  » Uncontrolled landfill amplifies the share of total global anthropogenic greenhouse gas (GHG) emission.
- Potential of waste-to-energy (WTE) in Malaysia:
  » Technologies for WTE production have been rapidly evolving and yielding dual benefits from effective solid waste management practices.
  » Trade-off in waste-to-energy practices: cost, efficiency, CO₂ emission, location, & transportation.

Research Objectives & Methodology

- To optimise the WTE supply chain network and evaluate the energy and climate change mitigation potential of MSW in Malaysia.
- The model optimizes the scale and location of waste treatment plants with potential energy and fertilizer co-generation, given the locations of feedstock and energy demand.
- Applied BeWhere Model:
  » Techno-Economic Optimization Model,
  » Geographic explicit,
  » Mixed integer linear program (GAMS),
  » Determines the available potential and suitable areas for renewable energy (RE) production sites.

Results

- WTE may substitute about 12% of the Malaysian power production, following an optimal scenario.
- BeWhere for MSW provides a robust spatial explicit solution for WTE with assessment on the energy production and CO₂ mitigation potential.

Acknowledgement

The IIASA Malaysian NMO, the Academy of Sciences Malaysia, is gratefully acknowledged for the financial support of the participation of Mrs SieTing Tan at the YSSP 2015.