West Coast Forum Research Workgroup Topic 6 – Optimal Waste Management Pathways

Summary of Research Findings and Gap Analysis

Topic 6: Optimal Waste Management Pathways

RESEARCH QUESTION(S)

- Which materials flow pathways provide the greatest greenhouse gas (GHG) reduction benefit or make end-use markets most viable? (Pathway evaluation could compare, for example, managing food compostables and green yard and wood wastes separate from municipal solid waste (MSW), versus managing yard and wood waste in one stream and merging food compostables into the MSW waste stream for segregation). Include technologies such as anaerobic digestion, pyrolysis, gasification, etc.
  Note: Given time and budget constraints, the literature review for this topic was limited to research that addresses GHG reduction benefits, not how different pathways could influence the viability of end-use markets.
- How sensitive are the results (identification of optimal vs. sub-optimal pathways) to different local conditions as well as different modeling assumptions (e.g. energy displaced by waste-to-energy, treatment of land-use related fluxes including carbon storage in landfills, use of 20-year vs. 100-year global warming potentials, etc.)?
- How do the costs of the various materials flow pathways compare, both for recyclers and local governments?
- What market factors drive the cost effectiveness of various materials flow pathways in a given location/situation?

SUMMARY OF KEY FINDINGS

<u>*Waste Management Hierarchy*</u>

The solid waste management hierarchy generally holds true when examining optimal waste management pathways for GHG reduction benefits.

- Source reduction (e.g. drinking water from a glass versus purchasing bottled water) and recycling were confirmed at the top of the hierarchy. Recycling tends to provide the most benefit in terms of net energy.
- Recycling of some materials such as paper and plastics is generally favored over waste-to-energy (WTE) and landfilling, however the end use of plastics as a wood substitute makes incineration more favorable. So recycling can potentially fail against WTE in some life cycle analysis (LCA) categories in certain conditions.
- WTE is generally favored over landfilling, except in certain instances (e.g. the waste is transported over long distances).
- A pathway's environmental impact depends on both the properties and the life cycle impacts of the product being substituted.
- There were quite a few studies on which organics diversion strategies (e.g. anaerobic digestion (AD), gasification, hydrolysis) maximized GHG reduction. Anaerobic composting and AD seems to give better results than WTE or landfill gas-to-energy (LFGTE).

- One study found that pyrolysis was better than WTE on four LCA categories.
- Another study found that on a global scale, landfilling ranked the worst, behind WTE and material recovery when considering energy and material balance factors.

Life Cycle Analysis

Life cycle analyses (LCAs) are being used to assess GHG emissions of different solid waste management pathways.

- Some LCA's were used to compare the landfilling of waste to the WTE option. Some studies show WTE to be the superior method relative to GHG emissions while another LCA methodology yields results that indicate varying results which are determined by a series of study factors.
- If upstream considerations of MSW as fuel are calculated, MSW is a very GHG intensive fuel.
- Many robust (e.g., peer-reviewed) free and proprietary LCA tools are being used for this purpose, however there are few studies available that compare the results of lesser-known models with the results of the more publicly available models (e.g. EPA's Waste Reduction Model (WARM)). Local boundary conditions and inputs vary greatly from study to study including but not limited to waste composition, electricity conversion efficiency, scrap metal recovery and LCA time horizon.
- Using a GHG lens may mask other environmental opportunities/impacts such as abiotic (soil, minerals, etc.) depletion, human toxicity potential etc. Many LCA studies seemed to use some but not all LCA categories in their evaluations.

Specific Waste Streams

- Domestic end uses for PET plastic seem to have slightly smaller impacts when compared to shipment to end markets abroad. Compared to other scenarios, remanufacture into clothing at end markets abroad generates the highest impacts.
- Studies of paper and plastic film packaging were also evaluated.
- Recovery of scrap metal from MSW is consistently cited because of its upstream high water and energy footprint.
- Successful recycling of televisions can be maximized in the design phase by minimizing the usage of plastics, such as PVC. This approach advocates mechanical recycling of plastics, which yields lower GHG emissions when compared to WTE.
- Upstream considerations including material design and selection can provide significant downstream environmental benefits.
- Wood fiber environmental impacts can be influenced by forest management practices, fuels used and discard management.
- Recycling, incineration and landfilling, is the generally preferred pathway for paper (multi-aspect lenses).

Zero Waste Strategies

- Existing LCA models to various degrees inform the zero waste approach as a policy solution but may not account for all environmental and economic impacts of a proposed action. A few studies used MEBCalc™ (Measuring Environmental Benefits Calculator) to summarize its results to estimate costs to human health and ecosystems in dollar values.
- Some environmental problems must be solved step by step due to technological, economic and social constraints. Achieving reuse and approaching the ideal target of zero emissions may require that we have to first make decisions at the state or local level which may appear to some to contradict the zero waste approach (e.g., issuing a permit to continue operations of an existing landfill for five more years).

Government Actions

Policies and regulations can drive and shape strategies:

- Waste diversion is a powerful policy tool, but results require a long lead time.
- Methane recovery for historic waste is important to capture GHG emissions and may provide economic benefit.
- Policy options are available to prevent waste from entering landfills including Extended Producer Responsibility and landfill bans on specific materials.
- If strong diversion policies do not exist, then a stronger methane recovery program can developed.

Other Key Findings

- Several sources offered proposals to integrate end-of-life EOL strategies in the early design phases of specific products, such as electronics and electrical equipment.
- Some sources were devoted to the theory and methodology of select LCA models. While these sources give useful yet very technical background knowledge, there appears to be little research on what are the barriers to more widespread acceptance or usage of LCA models in planning (e.g. incorporation into state and county Integrated Solid Waste Management (ISWM) plans) or in more ministerial applications (e.g. how they can better inform the state solid waste permitting process).
- None reviewed gave attention to impacts of ISWM actions on an individual or personal scale. The sources reviewed focused on either a model, evaluated life-cycle impacts of several ISWM methods, and/or were case studies of towns, cities, counties, a few states, or even on a global scale.

STATE OF KNOWLEDGE AND INFORMATION GAPS

LCA Modeling

While some tools for measuring GHG emissions and reduction benefits are available, there seem to be few studies available that compare the results of lesser-known models with the results of the more publicly available models (e.g. WARM).

LCA tools need to be enhanced to have the capacity to account for local conditions including MSW processing & separation infrastructure, WTE facilities, and local markets for reuse and remanufacture (reman).

Perhaps further research is needed on what are the barriers to more widespread acceptance or usage of LCA models in planning activities (e.g. incorporation into state and county ISWM plans) or in more ministerial applications (e.g. how they can better inform the state solid waste permitting process).

Furthermore, there appears to be a dearth of research on the LCA impacts of ISWM actions on a more personal scale (e.g. home composting). Of course there are exceptions, such as EPA's iWARM (individual Waste Reduction Model), but iWARM was not among the list of sources reviewed.

Optimal EOL Strategies

There is a lack of research showing the benefits from a carbon standpoint on different recycling end uses. For instance, what is the GHG emission difference between turning glass into glasscrete locally versus shipping out-of-state for reman; or local reman of tires into playground surfacing versus delivery to the local WTE plant or shipment to mills abroad.

Optimization studies should also be conducted for hard-to-recycle wastes such as auto-shredder residue (ASR), aka "fluff," and sterilized contaminated sharps.

End use evaluations for individual material types are needed to better understand processing and economic development options.

Better understanding of pros and cons for single-stream and multi-stream recycling is needed.

Cost Studies

Only a few studies by economists were found that link ISWM decisions to monetary values, or that estimate the environmental results of an LCA model in terms of dollars.

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