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SOLID WASTE CARBON PLANNING TOOL

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ABSTRACT

The EPA has developed the Waste Reduction Model (WARM) to help solid waste managers estimate greenhouse gas (GHG) emission reductions from several different waste management practices. This model is useful for high level analysis but breaks down when applied to specific local systems. This paper will discuss new work currently being done by HDR to provide more reliable analysis of local conditions. This capability is of growing importance given the emergence of national carbon regulations which will require solid waste managers to develop greenhouse gas reduction strategies for their local systems.

INTRODUCTION

Public and governmental interest in climate change has increased dramatically over the past ten years. State and local governments have taken the lead in developing regulations and mandates related to reducing greenhouse gas emissions (GHG). Recently, momentum has been building in the United States (U.S.) Congress to pass some type of national climate change legislation. Politicians are being pressured by concerned citizens who would like to reduce GHG emissions and by private companies who would like to replace the current uneven policy environment with a uniform federal regulation. According to the Pew Center on Global Climate Change, the lawmakers in the 110^{th} Congress have introduced 180 bills, resolutions and amendments focusing on global climate change and GHG emissions by February 2008. Only 106 pieces of similar legislation were submitted in 2005 and 2006 combined. Solid waste management is one of the largest sources of GHG emissions within local governments. As a result, many solid waste managers are beginning to evaluate their GHG emissions and explore system changes to reduce their carbon footprint.

In an article published in the proceedings for the National Waste-to-Energy Conference (NAWTEC) in May 21-23, 2007 and recently in the October issue of the MSW Management Magazine called "Low Carbon Solid Waste Management Systems", HDR described a process for developing strategies to lower the carbon footprint of a given solid waste management system. The process includes establishing a baseline, setting a goal, calculating emissions, developing internal polices to meet the goal, and reporting results to stakeholders. In a panel discussion at the WASTECON 2007, HDR professionals discussed their experience in applying the high level process described in the NAWTEC paper to a specific solid waste system. To further help solid waste professionals begin to understand how to develop a greenhouse gas emission reduction strategy for their own systems, HDR is working with the Solid Waste Association of North America (SWANA) to develop a carbon accounting planning tool to provide solid waste managers with a methodology to evaluate program change impacts on system carbon emissions to meet carbon reduction goals, which are likely to be set; and eventually take advantage of potential carbon credits. The planning tool will allow managers to evaluate potential offset-generating strategies for their various solid waste system components as they develop their solid waste plans (although addressing issues such as additionality and certification of reductions would be a separate process). The solid waste carbon accounting tools currently available to solid waste managers can help them begin to determine the carbon footprint of system components. However, these tools do not allow solid waste managers to easily evaluate a number of program options from their entire solid waste management system that are available to them to reduce GHG emissions. HDR is developing a Solid Waste Carbon Assessment Planning Tool (Waste CAPT) to allow solid waste managers to better evaluate the impact of changes to system components and waste diversion efforts on their overall carbon footprint over time. HDR is planning to have the Waste CAPT ready for peer review by summer 2008.

POLICY ENVIRONMENT

Over the past 20 years, the level of awareness and action in response to climate change has moved from the international level to the local governmental level; from providing information and establishing high level goals to state and municipal initiatives and regulations; and from governmental concern to private initiative. The U.S. participated in the initial international efforts by signing and ratifying the United Nations

Framework Convention on Climate Change (UNFCCC) and creating the U.S. Global Research Program to facilitate scientific understanding of climate change issues. The U.S. also began maintaining and annually updating the U.S. GHG Emissions Inventory and encouraging voluntary reporting of emissions through the Department of Energy (U.S. DOE) and the Environmental Protection Agency's (U.S. EPA) Climate Leaders program. Many state and local governments took a more proactive role in responding to climate change after the U.S. withdrew from the Kyoto Protocol. Since 2005, over 800 mayors have signed the Mayors Climate Protection Agreement which commits each mayor to meet or surpass the goals established under the Kyoto Protocol. [1]

Regional Initiatives:

States are also working together through new and existing regional organizations to promote GHG reduction. New York, New Jersey, Maine, New Hampshire, Vermont, Maryland, and Delaware are developing a regional mandatory GHG emissions reduction and trading program through the Regional Greenhouse Gas Initiative (RGGI). In February 2007, the Western Climate Initiative was formed by five western states, including California, Oregon, Washington, New Mexico, Utah, and Arizona to develop a regional GHG emissions trading program. Since February, the state of Utah and the provinces of British Columbia and Manitoba, Canada have joined the WCI. Colorado, Kansas, Nevada and Wyoming in the U.S.; Ontario, Quebec, and Saskatchewan in Canada; and Sonora in Mexico are participating in the WCI as "official observers". Both the RGGI and the WCI program are anticipated to include a form of cap and trade system. Any federal legislation will likely be guided by the format and experience of these two programs.

Federal Initiatives;

In October 2007, the Commerce and Energy Committee in the U.S. House of Representatives (House) released the first in a series of white papers on the potential scope and structure of future climate change legislation. The paper, "Climate Change Legislation Design White Paper: Scope of a Cap-and-Trade Program" (House White Paper), is the first step in a bipartisan approach to develop climate change legislation. The House White Paper analyzes each sector of the U.S. economy to define the best approaches for achieving a 60 to 80 percent reduction in the U.S. GHG emissions. The House White Paper defines the scope and coverage of a climate change program and focuses on the most appropriate economic sectors for implementing a cap and trade program: the electrical generation, transportation, and industrial sectors. Performance and efficiency standards, financial incentives, and tax policy changes are recommended to encourage GHG reductions in the other three major sectors: commercial, residential, and agricultural sectors. The paper identifies landfills with energy recovery systems, in the commercial sector, as a potential source of cap and trade credits. The House White Paper does not describe how a federal system would relate to the regional cap-and-trade programs currently being established. This paper is the first of a series to "lay out the basic design and key principles of a program, and also identify issues about which further information and discussion is needed." [2]

In December 2007, the U.S. Senate Environment and Public Work Committee voted to favorably report S.2191, the Lieberman-Warner Climate Security Act (Act). The Act is the first GHG cap-and-trade bill that has ever been voted out of a Congressional committee. The bill is scheduled to be taken up on the Senate floor in 2008. The Act proposes reducing GHG emissions from 80 percent of emission sources by 70 percent by 2050. The Act divides GHG gases into two categories: Group I (carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, and perfluorocarbons) and Group II (hydrofluorcarbons). The bill establishes a cap for Group I facilities and a cap for Group II facilities. Facilities would be able to satisfy up to 15 percent of their compliance obligation with domestic offsets. A Carbon Market Efficiency Board would be created to monitor the program. [3]

International Initiatives

Recently, a U.S. State Department negotiator agreed to a new climate change mitigation plan that was adopted at the December 2007 U.N. Conference in Bali, Indonesia. The Bali Action Plan (BAP) provides a first step in beginning an important discussion about how to achieve a global solution to the problem. The BAP states that "deep cuts in global emissions will be required to achieve the ultimate objective of the Convention (UNFCCC)" and emphasizes "the urgency to address climate change." The BAP aims to negotiate a successor to the Kyoto Protocol, which expires in 2012.

The BAP is characterized as a "shared vision for long-term cooperative action," with a global goal for emissions reductions, without specific numeric guidelines. The plan allows for common but differentiated responsibilities, appropriate to national circumstances, which are "measurable, reportable, and verifiable" which include:

- Offering incentives for developing countries to curb destructive practices such as deforestation, a problem in South America and Southeast Asia.

- Offering technological and financial support to mitigate GHG emissions and adapt to the irreversible effects of climate change in developing countries.

The Intergovernmental Panel on Climate Change (IPCC) submitted a 2007 panel report which stated that global warming is unequivocal and more rapid than expected, making prompt action essential. The IPCC report recommendation was for emissions reduction of 25 percent to 40 percent by 2020, halved by 2050.

TOOLS AVAILABLE

GHG Protocol Initiative

The GHG Protocol Initiative is a "multi-stakeholder partnership of businesses, non-governmental organizations, governments, and others convened by the World Resources Institutes and the World Business Council for Sustainable Development in 1998" to develop international standards for GHG accounting.[4] The GHG Protocol Initiative has developed guidance documents for designing an individualized accounting strategy. The GHG Protocol is based on five principles: relevance, completeness, consistency, transparency, and accuracy. The GHG Protocol does not currently provide a solid waste specific accounting tool.

RTI International Decision Tool

RTI International is an international research institute which has developed a "computer-based decision-support tool and database" to help solid waste managers evaluate their solid waste management systems in terms of cost-efficiency and environmental soundness. [5] The model is a very complex and proprietary tool that utilizes life-cycle analysis to compare the economic and emission impacts of various solid waste options throughout each step in the process. GHG emissions are just one aspect of the overall information analyzed with the tool. The complexity of the tool and its proprietary nature requires the developer or other trained personnel to be directly involved in the analysis. The tool is not available to the general public.

EPA WARM Model

The EPA developed the Waste Reduction Model (WARM) in 1998 to help solid waste managers "track and voluntarily report GHG emissions." [6] The WARM model provides solid guidance for high level decisions regarding the benefits of such options as increasing recycling programs or promoting composting. The EPA has updated the model periodically since its introduction with additional composition categories and other updated information. The WARM model, available on-line or as downloadable spreadsheet-based product, allows a solid waste manager to compare one alternative scenario to the current situation in terms of the GHG emissions. The solid waste manager can enter composition data, amount landfilled, amount recycled, and amount combusted at a WTE plant for the existing system and the proposed system. In addition, the solid waste manager can enter information describing limited transportation distances and landfill characteristics such as whether or not landfill gas is collected and utilized. The WARM model provides solid waste managers with a good, easy-to-use, high-level decision analysis of the impact of potential solid waste system changes on that system's carbon footprint. A solid waste manager can perform a coarse evaluation of the change in GHG emissions of an aggressive recycling program or of increased composting, etc. However, the scenarios that can be evaluated using the WARM model are limited to the solid waste management options specifically included in the WARM model. Solid waste program specific items such as use of transfer stations to improve system efficiency, recovery of ferrous metals other than cans from a WTE facility, collection route changes, collection vehicle fuels switches, etc., cannot be evaluated using the WARM model. In addition, factors such as landfill gas collection and utilization percentages, ferrous recovery rates, etc. are hard-wired to national default values in the WARM model.

CARBON ASSESSMENT PLANNING TOOL

In order to provide a more local focus to the GHG emissions analysis, HDR is developing Waste CAPT to allow a solid waste manager to evaluate planning impacts, over time, of various potential program changes to their current solid waste system. The goal is to develop a tool that can be used to determine the best strategy for reducing GHG emissions to meet reduction goals and to identify potential carbon credits than is possible with the current EPA WARM calculation tool. Waste CAPT will offer the flexibility to enter local data when known or use default national average data when local data is not available.

Waste CAPT will allow users to enter local solid waste system descriptions (type of vehicles and equipment, transportation distances, various fuel types and usage levels, facility energy consumption data) to account for emission reductions resulting from program adjustments such as collection route and/or vehicle improvements. Users will be able to enter system-specific waste diversion and operating data information for recycling, hauling and transfer, composting, landfills, and WTE facilities/programs. The recycling or composting facilities, the level of ferrous or non-ferrous recycling at WTE facility or the capture efficiency of a landfill gas recovery system will influence the quantity of GHG emissions avoided. To further increase accuracy, users will be able to enter local data on the energy/fuel mix for electric or steam utility offsets. In addition, Waste CAPT will account for emission changes for equipment changes at transfer stations, material recovery facilities (MRF), compost facilities, WTE facilities, and landfills. Finally, Waste CAPT will include an estimation of the BTU content of a system's residue (i.e., the portion of the waste stream that is not recycled, composted, or otherwise recovered prior to final disposal), to account for carbon offsets that may be available for recovered energy based on the local energy market and disposal of the residue in a WTE facility.

Components of Waste CAPT

Waste CAPT will allow solid waste managers to establish their own planning horizons for evaluating system changes over time. Due to the current lack of consensus in state and federal regulations on GHG reduction credits, Waste CAPT will not, at this time, be a tool for solid waste managers to use to audit their current system for GHG credit purposes. Once state or federal regulations are promulgated, Waste CAPT can serve as the foundation to develop a more detailed audit tool. While there is some indication as to the format that future regulations will take, it is impossible at this point to determine the exact format and develop a model to match that format. Waste CAPT will allow solid waste managers to evaluate all aspects of their solid waste system including collection, transfer stations, MRF, composting facilities, thermal recovery systems, and landfills.

Input. Waste CAPT will allow comparison of multiple future scenarios and evaluate and compare them simultaneously over time. Solid waste managers will be able to enter changes to their current system such as switching to cleaner fuels or increasing recycling rates, using a timeline that matches their planning schedule. The user can select their planning horizon (5, 10, 15, 20 years, etc.), as well as intermediate planning period milestone intervals. Waste CAPT is currently divided into three input pages: General Energy Use Assumptions, Program Variables, and Waste Generation/Diversion Data. The user will be able to enter the information they have available and use default information to fill in the information they do not have available. The default information is based on national averages for fuel usage, distance between sites, electricity sources, and composition data. The inputs only cover the impacts from the programs and facilities that are directly controlled by the solid waste manager, whether operated by their own crews or under operating contracts. Although this includes landfill disposal of residuals, it does not include an analysis of the transportation of recovered materials after separation into marketable byproducts.

The General Assumptions sheet will be used to enter the current system information. This sheet is divided into components of a solid waste management system:

- Collection System
- Transfer Stations
- MRF
- Composting Facility
- Thermal Recovery Systems
- Landfills

The user will enter collection vehicle fuel usage, building size, equipment fuel usage, equipment electrical usage, transportation hauling distances to and between facilities, energy and material outputs from thermal recovery systems, and landfill gas management and operations data.

The Program Variables sheet will allow the user to enter the planned program changes, over time, to compare with their current system. The user enters population estimates and Waste CAPT estimates future generation, based on a current average waste generation rate (U.S. EPA default of four pounds per person). The other inputs on this sheet include collection fleet size and fuel usage, other mobile equipment usage, and electrical usage for the transfer station, MRF, compost facility, thermal facility and/or landfill.

The Waste Generation Rate sheet allows the user to enter their waste diversion goals either by category of material or by specific material. For example, if the solid waste manager is going to target business recycling to capture more recyclable paper, they can enter their waste diversion goals of increased paper recycling. Future versions of the Waste CAPT will allow the user to enter their specific waste composition data, if available. Until then, the Waste CAPT will use U.S. EPA default composition data.

Data Sources. Waste CAPT analyzes system changes based on composition data, emission factors data, and electricity fuel source data. This data was compiled from U.S. EPA and U.S. Department of Energy sources. The composition data used in Waste CAPT as the default data is from EPA's publication "Municipal Solid Waste in the United States - Facts and Figures", for calendar years 1995-2001, 2003, and 2004-2006. These publications describe the MSW stream with over 70 categories. Composition data for the years not included in the EPA document (i.e. 2002 and 2004) are linearly interpolated from data that was included. Waste CAPT will assume the most recent data (i.e. currently calendar year 2006 data) as the future composition of MSW throughout the planning period. As EPA publishes the composition data for subsequent calendar years, Waste CAPT will be updated to incorporate that updated information.

The material emission factors used in Waste CAPT were obtained from the EPA document titled "Solid Waste Management and Greenhouse Gases – A Life Cycle Assessment of Emission and Sinks", 3rd Edition, September 2006. Waste CAPT does not change the basic assumptions behind the emission factors. Instead, the following national default value contributions to the emission factors will be adjusted to allow a substitution of more site-specific factors for evaluation of a local solid waste management system:

- Waste inter-facility haul distance of 20 miles (subtracted from the emission factors for recycling, composting, landfilling, and combustion)
- Compost equipment turning impacts (subtracted from the emission factors for composting)
- National mix of utility electric generation (subtracted from the emission factors for landfilling and combustion)
- National average ferrous recovery at combustion facilities (subtracted from the emission factors for combustion)
- National average landfill gas collection, flaring, and electrical generation (subtracted from the emission factors for landfilling)

Waste CAPT will be updated as EPA provides updated emission factor information.

EPA estimates for the biogenic portion of the CO_2 emitted during the solid waste management process are not included in the GHG emissions. Currently, this includes those emissions from composting, combusting organic materials, etc. At some point in the future, EPA might adjust the % biogenic carbon dioxide from waste combustion, based on recent studies using ASTM D-6866 standards, but at this time it is unknown when or if EPA will address this item.

Some other assumptions that underlie EPA's emission factors, and thus Waste CAPT, include:

- Estimates of GHG emissions associated with electricity used in the raw materials acquisition and manufacturing steps are based on the nation's current mix of energy sources, including fossil fuels, hydropower, and nuclear power.
- Estimates of GHG emission reductions attributable to utility emissions avoided are based on an assumption that the electricity use displaced by waste management practices is 100 percent fossil fuel. EPA adopted this approach based on suggestions from several reviewers who argued that fossil fuels should be regarded as the marginal fuel displaced by waste-to-energy and landfill gas recovery systems. [7] Since this assumption may not always be the case for local analysis, Waste CAPT will include the flexibility of using either the average utility fuel mix or a specific fuel offset.
- Although aerobic composting results in the generation of methane, EPA says that compost researchers believe that the methane almost always oxidizes to CO_2 before it escapes from the compost pile. Since the biogenic emissions are not included, the only GHG emissions associated with composting are those that result from the transportation of materials to the compost facility and mechanical turning of the piles. EPA does not address anaerobic composting methods. The trend toward incorporating food waste into the composting process may lead the industry toward anaerobic digestion. HDR will evaluate this trend to determine whether it needs to be incorporated into Waste CAPT in the future.
- Composting results in some soil storage of carbon. According to EPA, and a review of literature, the N_2O emissions from composting are minimal. Most composting nitrogen is emitted in the form of ammonia, not N_2O. EPA states that the N_2O emissions from composting operations are one of the limitations of the report, "based on a screening analysis, N_2O emissions were estimated to be less than 0.01 MTCE per wet ton of compost inputs." Therefore, following EPA's approach, N_2O emissions from composting are not currently included in Waste CAPT.
- The EPA emission factors do not include Landfill Gas (LFG) fugitive emissions or the percent capture over 100 year landfill life. Instead, it assumes the total emissions from each ton of landfilled waste at the point of disposal and uses a national mix of collection efficiency (and, by extension, fugitive emissions), flaring, and energy recovery. Waste CAPT will use these assumptions as the default data, but allow the user to enter landfill-specific LFG projection, collection efficiency, and flaring or energy recovery data if it is available.
- EPA's methodology includes the following differences between manufacture from virgin and recycled inputs, although they do not completely document development their values (especially, for instance, the transportation energy impacts).
  - Energy-related GHG emissions (both in manufacturing process and transportation),
  - Process non-energy-related GHG emissions, and
  - Forest carbon sequestration.
- According to EPA, "the fuel mixes used in these calculations reflect the average U.S. fuel mixes for each manufacturing process. However, it is worth noting that U.S. consumer products (which eventually become MSW) increasingly come from overseas, where the fuel mixes may be different. For example, China relies heavily on coal and generally uses energy less efficiently that the United States. Consequently the GHG emissions associated with the manufacture of a material in China may be higher than those for the same material made in this county. In addition, greater energy is likely to be expended on transportation to China than on transportation associated with domestic recycling. However, such analysis is beyond the scope of this report, which focuses only on domestic production, transportation, consumption, and disposal."
- EPA's methodology accounts for the fact that not all of the materials for recycling can actually be recycled. The reductions associated with recycling are calculated by taking the difference of:
  - The GHG emissions from manufacturing a material from 100% recycled inputs, and
  - The GHG emissions from manufacturing an equivalent amount of the material (accounting for loss rates) from 100% virgin inputs.
- Because EPA's methodology begins at the point of waste generation, the baseline case includes the GHG emissions from raw materials acquisition. Since the methodology is a comparison of emissions, the emissions decrease associated with avoided raw materials acquisition because of recycling is then inherent in the calculated difference. EPA's methodology does not account for the transportation to markets of the recovered metals.

- The WARM model makes general assumptions for the fuel usage for each component of the solid waste system. Waste CAPT will allow the user to enter specific fuel usage for each component (i.e. biofuel).
- The WARM model assumes all solid waste programs use the same methods and energy efficiencies. Waste CAPT will allow the user to enter variable methods and energy uses.
- Waste CAPT uses energy conversion data for various types of fuel from DOE Energy Information Administration (EIA) and manufacturer's data on typical engine sizes and fuel consumption for mobile and processing equipment.

Output. Waste CAPT will provide the solid waste manager with a differential comparison of GHG gas emissions between the current situation (baseline) and potential future option. Waste CAPT will not provide the absolute GHG emissions values. To provide absolute values, the calculation methodology would need to include a complete life cycle analysis instead of focusing only on the emissions associated with the solid waste management process directly under the control of the solid waste manager. The differential emissions are provided in Metric Tons of Carbon Equivalent (MTCE), Metric Tons of Carbon Dioxide Equivalent (MTCO2E), and MTCE per person.

CONCLUSION

Solid waste managers must consider many variables when assessing future solid waste management decisions. Traditionally, these variables have included annual and capital costs, environmental impacts to land and water, and air emissions/quality. Tools currently exist to help solid waste managers evaluate all of these variables. As national regulations take shape, solid waste managers will soon be asked to consider GHG emissions as they make capital and operational decisions in their planning process. The tools currently available to solid waste managers do not allow them to make informed decisions related to reducing their GHG emissions based on their local situations. Each component of a solid waste system impacts the overall GHG emissions of the system. However, changes to some components will create a greater impact than others in reducing the overall emissions. For example, switching to cleaner fuel collection vehicles may not have as significant an impact on the carbon footprint for a smaller community with less overall fuel usage than a larger community than others will help small and large communities determine system changes that will best help them reach their GHG emissions reductions goals.

REFERENCES

[1] Accessed March 2008 http://www.usmayors.org/climateprotection.
[2] U.S. House of Representatives Committee on Energy and Commerce Staff, "Climate Change Legislation Design White Paper: Scope of a Cap-and-Trade Program." October 2007.
[3] Pew Center for Climate Change. http://www.pewclimate.org/
[4] GHG Protocol
[5] Accessed March 2008 www.rti.org.
[6] Accessed March 2008 http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html.
[7] U.S. EPA "Solid Waste Management and Greenhouse Gases - A Life Cycle Assessment of Emissions and Sinks", 3rd Edition, September 2006,