Recovered Biomass Energy Facility

A Zero Waste facility utilizing discarded resources to generate energy for central Vermont

CENTRAL VERMONT
SOLID WASTE
MANAGEMENT DISTRICT

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Credits

With the international effort to develop clean sources of energy that's underway, this faciltiy concept was influenced by the work of a variety of individuals and organizations in the environmental field. The CVSWMD in particular would like to thank the following local people and organizations for the time and energy they invested in this concept:

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- Donna Barlow Casey, Executive Director
- Dennis Sauer, Compost Specialist
- Tom Anderson, Special Programs Manager
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Background

The CVSWMD has adopted a Zero Waste Plan, one of the first of its kind in the country and the first in Vermont. Working toward Zero Waste involves much more than increasing recycling rates—it requires a change in the way we look at the "waste" we all produce, seeing these materials as resources that can be used to develop new products and processes needed in the region.

The CVSWMD's food scrap diversion programs are a critical offshoot of the District's Zero Waste Plan. With food scraps comprising 20% of the waste Vermonters throw away each year, food scrap diversion offers the chance to capture this resource, keep it out of landfills, and turn it into a valuable soil amendment to grow more food. The District's programs have already diverted more than 1,056 tons of food scraps from landfills and the food scraps have been converted into compost at on-farm composting facilities *(from April 2004-April 5, 2007)*.

On-farm compost operations offer a wonderful way to manage food scraps, but there are challenges inherent with incorporating multiple medium-scale composting operations into farming operations where farming is the primary focus, not food scrap composting. As more businesses, schools, and institutions come on board the program, it is in the District's best interest to explore other ways to manage the increasing quantity of food scraps being diverted.

One solution is to take these food scraps, combine them with manure from area farms, and use the combination to generate electricity at a centrally located Recovered Biomass Energy Facility (RBEF).

This isn't a new concept: Farm manure is presently being used to generate heat and electricity on some Vermont farms. Food scraps are being used to generate energy in Europe and Canada. In rural areas these two materials can be combined, resulting in higher amounts of energy production. Simply put, they are not "waste" products; they are resources.

An RBEF offers a variety of benefits to the region

- The food scraps currently composted on farms would first be used to generate energy and the end products can be used as compost—two end products from the same input.
- The energy produced by the RBEF would reduce the region's dependence on non-renewable sources of energy.
- By managing food scraps and manure (resources) in this way, we would reduce greenhouse gas emissions, improve regional air and water quality, and extend current landfill capacity.
- New jobs would be created to recover and distribute the resources utilized by the facility.
- An RBEF in central Vermont would serve as a model for other facilities that could be located in rural or urban areas throughout the country.

One solution is to take those food scraps and combine them with manure from area farms and use the combination to generate electricity at a centrally located Recovered Biomass Energy Facility (RBEF).

Why Build an RBEF?

A Recovered Biomass Energy Facility offers the opportunity to address a variety of issues facing the region.

1. Energy

Energy is increasingly vulnerable and costly. Weather conditions may disrupt domestic energy supplies, causing price spikes and power outages, while foreign supplies are subject to political forces beyond our control. Alternatives such as nuclear and wind power can reduce our dependence on foreign oil, but face opposition from various interest groups. Crops grown for energy production, such as soybeans for biodiesel, can help meet demand, but take huge amounts of energy to produce and use land that could be used for food crops.

2. Manure Management on Farms

Vermont dairy farmers are struggling to survive. As many small farms sell out, they're replaced by large, consolidated operations with thousands of cows. Manure management on large farms brings high labor and equipment costs, as well as environmental risks.

3. Water Pollution

Vermont's waterways are being polluted by nutrients that leach into waterways when liquid manure is spread on fields. These nutrients cause algae blooms which consume the oxygen needed by fish and other aquatic species to survive. The algae can also be toxic to humans and other mammals.

4. Odor from Spreading Manure

In the spring, the stench of raw manure can be overwhelming along rural roads as farmers empty their manure pits onto fields, threatening the state's pastoral image that's so important to the tourism industry.

5. Increasing Waste

As Vermont's economy and population both continue to grow, so does the amount of trash we produce. Despite the efforts of state and local agencies, trash generation rates are climbing while recycling is on the decline. New landfills are being proposed to handle this rapidly expanding pile of trash, but landfills are not an environmentally sound way to manage "waste."

6. Methane Gas in Landfills

Food scraps in landfills release methane gas to the atmosphere. This greenhouse gas has 21 times the heat-trapping capacity of carbon dioxide.*

These issues are indeed challenging, but together they provide the impetus to identify the connections and possible solutions. An RBEF is one such solution.

How Does An RBEF Work?

A Recovered Biomass Energy Facility (RBEF) generates energy from manure and food scraps. To do so, anaerobic digestion, a biological process that occurs in nature or in a controlled environment such as a biogas plant, is used to produce methane and other biogases. The methane gas given off by manure and food scraps in an RBEF is used to generate heat and electricity to run the facility and the energy is also sold to electric utilities for use in homes and businesses. Not only would the RBEF be a vital energy production facility, it would eliminate the negative impacts of food scraps in landfills and liquid manure on farm fields.

Manure as a Resource

Liquid manure would be transported from farms to the RBEF and used to produce energy in combination with food scraps through anaerobic digestion. After, the digested material would be made into compost. The compost could be used by farmers to fertilize crops or could be used as bedding for livestock.

Composted manure offers several benefits over spreading liquid manure:

- It does not leach into waterways and cause the problems created by spreading liquid manure.
- The odor problems associated with spreading raw manure are eliminated.
- Compost is used as needed on the farm, rather than over-applied as liquid manure may be.

Food Scraps as a Resource

Food scraps would be diverted from landfills, combined with manure at the RBEF, and used to generate energy. Together the two resources would generate the highest amount of energy, allowing the facility to be economically self-sustaining through the sale of energy, credits for reduced carbon emissions, and composted byproducts.

* *source*: EPA Agstar Program, "An Evaluation of Mesophilic, Modified Plug Flow Anaerobic Digester for Dairy Cattle Manure," www.epa.gov/agstar/pdf/godondale_report_final.pdf (accessed 12/4/06), p.3.

Mission Statement

The Recovered Biomass Energy Facility (RBEF) will reflect the values and goals of the CVSWMD's Solid Waste Implementation Plan and provide a non-polluting, economically self-sustaining facility to receive and convert food scraps to energy and other useful products via anaerobic digestion.

Introduction to this Document

The following proposal describes how an RBEF could be built in central Vermont, and explores the economic and environmental benefits of building and operating such a facility according to the CVSWMD's Zero Waste philosophy and commitment.

The proposal is presented in three sections:

- **Project Goals**
- **Design Goals**
- **Operational Goals**

As you will see, the goals presented in each are both distinct and interconnected.

Project Goals

The CVSWMD has identified a number of overall project goals to meet in building a Recovered Biomass Energy Facility (RBEF); they are explored here.

1. Assist the District in Meeting the 50% Diversion Goal Set by the Vermont Agency of Natural Resources.

By law, the state of Vermont is required to develop and maintain a solid waste plan. The state solid waste plan guides municipal solid waste planning, establishing the benchmarks and goals that municipalities must achieve in 10-year cycles. By law, solid waste districts, representing their member municipalities, are required to adopt solid waste implementation plans that conform with the state solid waste plan.

• As part of the state solid waste plan, a 50% diversion goal has been set. The diversion of commercial food scraps and residential organics throughout the District, in addition to the tons of material already diverted from disposal through reuse and recycling, will more than meet the 50% goal for CVSWMD member communities.

2. Meet the Zero Waste Goals of the CVSWMD Solid Waste Implementation Plan.

The CVSWMD adopted its current Solid Waste Implementation Plan in 2003; it is a Zero Waste Plan.

Zero Waste is a philosophy and a design principle that includes recycling but goes beyond recycling by taking a "whole system" approach to the vast flow of resources and waste through human society. (See *ZW in Practice* box.)

The District has made organics diversion the single most important activity to be undertaken in the first five years of this Plan. Since organic material represents approximately 40% of the total of both the residential and commercial wastestreams, it simply makes sense to target this commodity for diversion and use.

• Estimated tonnage of business, institutional, and school food scraps generated in the District is 3,750 tons per year. A facility located in the capital region that is designed to accept a minimum of 35 tons per week would divert approximately 50% of the total amount of food scraps generated by businesses and institutions in the entire District.

3. Operate as a Zero Waste Facility.

As a Zero Waste facility, the conservation and recovery of resources during the production process will be as important as the products being produced by the RBEF. All materials used by the facility will be chosen according to key guidelines, including the conservation of resources during their manufacture and transportation; ease of resource recovery when useful life is over; and limited negative impact to the environment. The goal will be to mimic the processes of nature, in which a cycle of regeneration is maintained through the

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Zero Waste in Practice

What is the value of a Zero Waste plan for communities? Is it worthwhile to set Zero Waste goals if we can only get *close*? Since our society commonly accepts "waste" as inevitable, these are logical questions to ask.

To begin to think about what Zero Waste can mean, it's helpful to first suspend the assumption that "waste," requiring management and disposal, is a basic byproduct of society. The second step is to accept that capturing and re-using discarded resources is simply a logical and perhaps wiser path to take in this era of increasing environmental challenges. This is the basic philosophy of the Zero Waste movement. The obvious next step is to look at how to save resources, conserve embodied energy, and act in a way that preserves environmental and human health—rather than managing "waste" through recycling easily sold commodities and landfilling the rest.

The RBEF project would do just this as it serves as a working model of Zero Waste through:

• capturing a larger quantity of discarded resources from landfills;
• re-using discarded resources (food scraps and manure) to generate energy and produce additional useful end-products (compost and animal bedding);
• conserving the energy embodied in food scraps and manure to produce necessary products; and
• reducing the quantity of food scraps (resources) sent to landfills for disposal.

continual recycling of materials. The following are sample ways the RBEF will operate as a Zero Waste facility.

• The RBEF will recover biomass already available and currently being treated as waste, and will utilize an existing infrastructure for its collection and hauling. In contrast, using biomass crops such as switchgrass and willow to generate energy first requires the conversion of food crop fields and/or forests to fields to grow the crops before the biomass can be converted to energy.

• The RBEF will utilize food scraps and other organic feedstocks (such as manure) in an efficient and economically and environmentally sustainable way. The specialized trucks fueled by biodiesel that will be used for the collection and hauling of food scraps and manure, and the close proximity to the farms, businesses, and institutions generating the material, will result in greater fuel efficiency and lower carbon emissions than hauling the same materials to a landfill or spreading it on fields with farm tractors.

• The RBEF will use electricity and heat generated by the facility for its own operation. Procurement policies will require that all products purchased for use at the facility contain a high recycled content, rate low for toxicity, and result in minimal waste at end of life.

• Liquids resulting from the anaerobic digestion of the feedstock(s) will be filtered and the clean water will be re-used at the facility. Whenever feasible, wastewater and run-off will be managed onsite and utilized by the facility.

4. Provide a Strategically Located Facility for Sustainable Organics Diversion.

The RBEF will be sited to allow for the most efficient, cost-effective, and environmentally sound diversion of food scraps.

• Food scraps and other organic feedstocks will be hauled directly to the facility, which will be located in close proximity to the major sources of food scraps in the District. The site of the facility will be chosen based on efficient travel distances and routes to available feedstock.

• An RBEF under the control of a regional government entity, and capable of operating with a variety of feedstocks, avoids the risks and uncertainties that come with farm-based facilities. For instance, if a farm should change hands or cease operations, the operation of a farm-based facility would be at risk and any investments by funding organizations or lenders to build and operate the facility could be lost. An RBEF operates outside of these risks and ensures continuity for the sustainable diversion of organics from the wastestream.

5. Shift CVSWMD reliance on tax-based revenue to economically self-sustaining projects.

The RBEF exemplifies Zero Waste programming in its holistic approach to sustainability inclusive of economic considerations. The RBEF would operate on revenues from the sale of energy and environmental credits, as well as the sale of composted byproducts. This would provide District member communities with an economically self-sustaining program.

The RBEF will provide a site where Zero Waste best practices for diversion of food scraps and other feedstocks can be realized in a facility that is economically self-sustaining.

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6. CVSWMD Will Seek to Maximize the Educational and Research Potential of the RBEF.

The planning and research process for development of the RBEF will provide a useful reference for other waste management districts, municipalities, and for-profit firms, encouraging its replication and expanding its economic impact.

• The RBEF will be designed to allow for visits by educational institutions, government agencies, and the general public in order to provide the highest level of visibility to the Zero Waste practices at work in the facility.

• The operations of the facility will be broken down into independent activities that can stand on their own, such as feedstock collection, hauling, and processing; digester operation; energy generation; compost production; and marketing. Data will be collected on all aspects of the operation of the RBEF and will be available to the public. Each of these activities will serve as models for business and job creation related to this type of resource recovery.

• Research and education activities that are run in conjunction with the RBEF could enrich curriculum and program resources for post-secondary institutions, supporting programs in environmental education; electrical, mechanical, and chemical engineering; sustainable agricultural practices; watershed and water resource management; etc.

Design Goals

The RBEF will be designed as a Zero Waste facility. This means that the facility's impact on the community—the people and the environment—where it is located is as important as the conversion of "waste" materials to useful resources and renewable energy. Thus, the entire site, including buildings and grounds, will be developed, operated, and maintained with this in mind.

The goal in building the RBEF will be to go beyond current "green" or "sustainable" design and building practices which focus on minimizing damage to the environment and human health and using resources more efficiently. Although superior to more conventional building processes, the "green design" approach merely slows the degradation of the environment, rather than seeking to regenerate it.

To this end, we will follow a building process known as "regenerative design," a process that acknowledges humans and their built environments as part of nature. As in nature, where the process of regeneration is constantly at play, the goal in designing the RBEF will be to build a facility in which all aspects of the operation of the facility regenerates, rather than degrades, the natural system where it is placed.

The RBEF will be designed to protect and maintain the health of the people who live near the facility and the natural systems (the water cycle, meadow, wetland, and forest environments, etc.) at work where it is located. The design goals listed below relate to individual aspects of the proposed facility. The goals are intended to serve as guidelines rather than specific design parameters. Specific design parameters will be determined during the design phase of project development.

Location

The facility will be located within an optimal distance to the highest concentration of food waste generators in the region in order to maximize its sustainability and minimize negative environmental impacts. Hauling efficiencies will require the facility to be in close proximity to Class 1 roadways. Agricultural, commercial, and industrial sites could all be potential locations for the RBEF. Due to the truck traffic through this facility and the amount of land required for the site, dense residential areas would not be appropriate sites for the RBEF.

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Buildings and Structures

There are innumerable choices relating to building materials that achieve the goals of regenerative design. Many factors come into play when assessing the suitability of materials. For this reason, a matrix will be created that will allow the designer of the facility to rank building materials according to criteria developed by the CVSWMD in order to help inform material decisions.

For example, the criteria may include local source, high recycled content, low toxicity, low energy use and waste creation in the production process, etc.

Landscaping and Grounds

The site chosen for the RBEF will be assessed to determine the current use of the surrounding landscape and design decisions will be made that reflect a preferable, compatible state for this property with its surrounding area.

The grounds will be planted according to permaculture design principles defined as "consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber, and energy for provision of local needs."

The potential for community use will be explored for the areas immediately around the RBEF. Examples of community use could include community gardens, walking trails, or test plots utilizing composted products produced by the facility.

Wastewater and Other Discards

The goal will be to manage as many of the discards created at the facility on site. The design of the RBEF will include facilities that will allow for discards to be processed and reused at the facility whenever possible. For example, cardboard and paper could be shredded and composted with material processed in the digester, rather than shipped off for recycling.

Alternative and innovative systems for treating wastewater on site will be considered in the design of the RBEF. The CVSWMD will seek support from the state of Vermont to use the facility to test the feasibility of emerging technologies in these areas.

Construction Practices

Zero Waste practices will be utilized during the construction phase of the project and specified in the design of the RBEF. Examples would include re-use of construction debris and packaging and the use of erosion control systems utilizing compost at the building site.

Educational Opportunities from the Design Process

The design of the RBEF will allow for the creation of passive educational opportunities for visitors to the facility. Examples include signs throughout the building identifying the building materials chosen and the process used for choosing them; interpretative trails around the facility with signage explaining the uses of the species chosen for the landscape; viewing areas to observe material handling, discard management, and energy production; and more.

Operational Goals

The goal of the RBEF is to convert food waste and manure into energy and composted products utilizing anaerobic digestion at a Zero Waste facility. The collection and hauling of materials, digestion and energy production, and composting and sales of composted products will be managed as separate business enterprises. The RBEF will be economically self-sustaining through the sale of energy and digester byproducts. Operational goals relating to various aspects of the RBEF are listed below.

Capacity

The RBEF will be designed to digest a minimum of 35 tons of food scraps per week. The quantities of manure accepted at the RBEF will be determined by the proximity to farms within a feasible hauling distance of the facility.

The proposed minimum size of the facility is based on a requirement that at least 50% of the estimated food scraps generated in the District go to the RBEF. The size of the facility could be larger and the type and quantity of feedstocks could differ depending on the size.

Inputs

- Food scraps accepted at the facility will be source-separated and free of contaminates, resulting in the need for minimal equipment and processes for contaminate screening at the facility. This will be achieved by training food scrap generators to separate food scraps and screen for contaminates.
- Manure accepted at the facility will be free of agricultural products that would disrupt the biological process of anaerobic digestion. Farmers sending manure to the RBEF will agree to suspend the use of such products.
- Feedstocks may vary based on facility configuration. An RBEF could operate accepting only food scraps and other organic discards.

Outputs

- The RBEF will generate approximately 13,000 kilowatt hours per day. *
- Excess heat from the production of electricity will be used to heat the facility and the digester unit.
- Compost for crop nutrients or animal bedding will be used by participating farms or sold to landscapers or homeowners.

Management

The RBEF will be managed and operated by a staff performing duties that will include: food scrap/manure hauling and processing, maintenance, office and accounting, biodigester operations and management, feedstock and end-product testing, compost management, and end-product sales and delivery.

Workplace

- Design parameters will include features that provide for high safety, health, and worker comfort standards.
- Employees will be paid a livable wage as determined by Livable Wage Figures from the Vermont Joint Fiscal Office.

Revenue Sources

Revenue will be generated from the sale of the following products and services:

- Sales of electricity
- Sales of renewable energy and carbon credits
- Sales of compost
- Sales of livestock bedding
- Tipping fees for food scraps
- Tipping fees for manure

* *source for KW generation:* Zhang, Ruihong; El-Mashad, Hamed M.; Hartman, Karl; Wang, Feng yu; Liu, Guangqing; Coate, Chris; Gamble, Paul. Characterization of food waste as feedstock for anaerobic digestion. University of California, Davis, CA. 2006.

Definitions

Anaerobic Digestion: Anaerobic digestion is a natural process where micro-organisms convert the degradable organic materials in manure and food wastes into methane (CH4), carbon dioxide (CO2), and other trace gases in the absence of oxygen. This gas mixture is called biogas. The treated effluent from anaerobic digestion is substantially odor free and retains nutrients. In nature, anaerobic decay is one of the earth's oldest processes of decomposition. Anaerobic digestion can occur naturally or in a controlled environment such as a biogas plant.

Biomass: Biomass can be broadly defined as all the plant and animal matter on the Earth. Biomass is a term that's used to describe material that can be used either as a source of energy or for its chemical components. As such, it includes trees, crops, algae and other plants, as well as agricultural and forest residues. It also includes many materials that are considered waste by society, including food and drink manufacturing effluents, sludges, manures, industrial (organic) byproducts, and the organic portion of household waste.

Feedstock: The material used to fuel energy manufacture in the Recovered Biomass Energy Facility.

50% Diversion Goal: The waste diversion goal set by the state of Vermont that each solid waste district and alliance, as well as indivdual towns not part of a district, must meet. To divert waste is to alter the flow of materials from landfilling to useful enterprises. Reuse businesses, composting operations, and the RBEF are all examples of waste diversion.

Food Scraps: The scraps generated through food preparation as well as the "waste" left on plates in restaurants, cafeterias, home kitchens, etc.

Greenhouse Gas: A greenhouse gas is a gas that contributes to the Greenhouse Effect. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities. Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Certain human activities increase the levels of most of these naturally occurring gases in the atmosphere.

Methane Gas: Methane is a colorless, odorless gas with a wide distribution in nature. It is the principal component of natural gas. Anaerobic bacterial decomposition of plant and animal matter produces methane. Methane is a relatively potent greenhouse gas with a global warming potential. When averaged over 100 years, each kg of methane warms the Earth 23 times as much as the same mass of carbon dioxide.

Recovered Biomass Energy Facility: A facility that uses recovered biomass to generate energy (in this case, food scraps), instead of using biomass that's grown specifically to fuel an energy-producing facility.

Regenerative Design: This design process acknowledges that humans are an integral part of nature and that human and natural systems need to be in alignment in order to achieve a state of continual and healthy evolution. A facility designed according to "regenerative design" would regenerate, rather than degrade, the natural system where it is placed. See **www.integrativedesign.net/resources/articles.htm** for more information.