10.7.C.

Memorandum Date: January 12, 2010
Board Order Date: January 27, 2010

TO: Board of County Commissioners

DEPARTMENT: CAO/Economic Development Standing Committee

PRESENTED BY: Mike McKenzie-Bahr, Community and Economic Development Coordinator

AGENDA ITEM TITLE: ORDER/IN THE MATTER OF APPROVING & ACCEPTING THE LANE COUNTY FOOD WASTE TO ENERGY FEASIBILITY STUDY FINAL REPORT

I. MOTION

Move to approve and accept the Lane County Food Waste to Energy Feasibility Study Final Report.

II. AGENDA ITEM SUMMARY

The Board is being requested today to approve and accept the Lane County Food Waste to Energy Feasibility Study Final Report.

The Report was funded by a $50,000 grant from the Oregon Business Development Department (OBDD) Renewable Energy Feasibility Fund (REFF), which was matched by the County with $25,000 from the solid waste management "Other Fees" for "waste diversion opportunities to conduct a food waste to energy feasibility study.

Approval and acceptance of the Final Report is required by the OBDD as part of the final elements of the grant process. Upon submission of the Final Report, the approval and acceptance Board Order and the final grant disbursement request, OBDD will send the County the final grant payment and close out the grant.

The County was awarded the REFF grant to answer the question: "Is it possible to divert local food waste from the landfill and process it at a cost that allows for financing the construction and operation of a county-owned anaerobic digestion facility to process the food waste into energy?"

The vast majority of the work on this project was contracted out to experts to gather information and assemble the data. They have brought together information, models and data upon which the County can make informed decisions related to renewable energy opportunities.

Accepting and adopting the Final Report does not commit the County to any future course of action, nor does it commit the County to favoring one waste stream resource over another, one technology over another or one energy project over another.

III. BACKGROUND/IMPLICATIONS OF ACTION

A. Board Action and Other History

Food waste is the single-largest component (10-30% depending on region) of the municipal solid waste stream by weight in the United States, amounting to more than 29 million tons/year.

The Oregon Department of Environmental Quality estimates that municipal food waste (MFW) comprises approximately 13% of the waste stream from the Eugene – Springfield Metro area. This percentage applied to Short Mountain Landfill's total tonnage equates to about 40,000 tons/year of municipal food waste.

Food waste landfill diversion programs are being undertaken in more and more communities. The majority of communities that divert food waste, compost it. However there are communities in the U.S. and around that world already creating renewable energy from food waste. And others communities are studying ways to do it.

Among the identified advantages of converting food waste and other ogranic materials into energy: it helps to reduce methane emissions from landfills; saves space in landfills; and creates energy that can be used in homes, businesses and public buildings. It also often takes an expense, burying garbage, and turns it into a revenue source.

In an effort to explore those opportunities, the Lane County Community & Economic Development Coordinator submitted a grant application to the OBDD Renewable Energy Feasibility Fund (REFF).

The REFF was established "to encourage the widespread adoption of renewable energy projects that reduce Oregon's dependence on fossil-based energy sources and promote sustainable economic development for communities throughout the state."

The County was awarded a REFF grant on February 11, 2008.

The Lane County Board of Commissioners accepted the grant and authorized match from the solid waste "Other Fees" in Board Order, 08-4-2-9.

The Board established the solid waste "Other Fees" by Board Order 07-6-13-6. The fee has two elements, nuisance site cleanup and waste diversion opportunities. Lane Manuel 60.875 codified the waste diversion opportunities element as follows: "A portion of this fee collected will be used for projects approved by the Board that are designed to divert or prevent waste material from entering the landfill, including but not limited to, research and development".

The Community and Economic Development Coordinator selected consultants to gather information and assemble data regarding food waste to energy issues. In the Final Report, they have brought together information, models and data upon which the County can make informed decisions related to renewable energy opportunities. The Report recommendations are listed below in the Analysis section.

The Lane County Food Waste to Energy Feasibility Study Final Report is the next step in a progression of County initiatives that began several years ago as part of an effort to study the economic development opportunities for local renewable energy projects. It also builds on other work being done in the community.

B. Policy Issues

Should the Lane County Board of Commissioner approve and approve and accept the Lane County Food Waste to Energy Feasibility Study Final Report?

C. Board Goals

This project meets the Board Goal to "Maintain a healthy environment with regard to air quality, water quality, waste management, land use and parks." In addition, if projects are created from the feasibility study findings, it will also meet the goal to "Work for a strong regional economy to expand the number of family-wage jobs available in Lane County."

D. Financial and/or Resource Considerations

All funds have been expended on the study. Approval and acceptance is part of the final steps of the grant. To submit for final grant fund reimbursement, the

County must submit the final report and a copy of approval and acceptance by the governing board.

The study was funded by $50,000 of state grant funds from the Oregon Business Development Department and $25,000 of waste diversion opportunities fees collected by the County.

E. <u>Analysis</u>

This grant offered an opportunity to bring a number of experts together to study the feasibility of turning food waste to energy.

Numerous recent studies and reports have identified the opportunities for biomass, like food waste, to be converted to energy.

Annually, approximately 40,000 (forty thousand) tons of food waste ends up at the County-owned Short Mountain Landfill. A 2007 local food waste study identified and geospatially located 700 of the large non-residential food waste producing facilities within the Eugene metro area and estimated that they produce 17,870 tons of food waste annually. The study determined that the food waste could generate at least 1.2 megawatts of electricity from the anaerobic digestion process.

The feasibility study built upon the previous study and completed a comprehensive analysis including costs and options for six project elements: 1) Identification, Collection and Transportation of Food Waste; 2) Anaerobic Digester Facility Options; 3) Anaerobic Digester Facility Energy Outputs; 4) Siting of Anaerobic Digester; 5) Revenue and Expense Review and ROI Estimates and 6) Recommendations from Feasibility Study Finding.

This study examined the feasibility of converting the organic fraction of municipal solid waste as feedstock for renewable energy generation using anaerobic digestion.

The findings show anaerobic digestion is viable and commercially available technology that is presently deployed in numerous sites across the country. AD technology is mature and proven. The study also finds that food waste is a suitable feedstock for an anaerobic digestion process, especially when combined with other organic feedstocks, such as grass straws.

Given the initial viability of a potential project, the most pressing remaining questions are:

- Do sufficient volumes of readily available food wastes exist in the Eugene-Springfield and surrounding areas to supply an anaerobic digestion facility?

- What would be the costs and the logistics to set up a source-separated food waste collection program in the Eugene-Springfield and surrounding areas?

- Do the costs of a food waste source separation and collection system make it a financially feasible undertaking?

- How would a food to energy project impact the current contract between Lane County and EPUD?

- What would be the best ways for local government to help support the development of a source separated food waste collection system?

Given the findings, and the above questions that still need to be answered, the study team makes the following recommendations regarding moving forward with a food waste to renewable energy project.

- The municipal partners, in cooperation with restaurants, cafeterias, grocery stores, waste collectors/haulers and other stakeholders, should conduct a robust food waste collection pilot to gather more data about the actual amount of food waste generated by commercial and institutional organizations in the Eugene-Springfield area.
- Planning for a food waste diversion program to renewable energy system should encompass an overall look at the current waste system process, because so many factors of the current system would impact a food waste program.
    - Collection and transportation systems exist, but collection and can options will need to be offered to operations that create food wastes.
    - Methane collection is mandated at Short Mountain and will continue for decades at the landfill.
    - Emphasis should be given to the current contract between Lane County and EPUD. Current language in that contract creates potential financial liability to Lane County for implementing a food waste diversion program.
    - The planning process should include the other municipalities in the County and all other stakeholders.

- A pilot scale anaerobic digester should be set up at Short Mountain as part of the proposed "Short Mountain Landfill Renewable Energy Park."

- Food wastes should be co-digested with other organic substrate(s) to improve biological stability, increase methane production and solve other waste management challenges.
- Methane should be fed to the current EPUD system for conversion to electricity.
- The amount of methane and electricity yield should be analyzed to determine if the pilot project produces more methane and electricity per ton than the landfill.
- A mutually beneficial agreement between the County and EPUD for the AD methane should be explored.

- The "Bioenergy Production Facility" being considered for Junction City should be considered as a site option for a future food waste to energy project.

- Further explore opportunities for a food waste to energy project with the Metropolitan Wastewater Management Commission.

- Both public and private financing should be pursued in order to create a feasible and sustainable food waste to energy project.

IV. TIMING/IMPLEMENTATION

Upon Board acceptance of the Lane County food waste to energy feasibility study will be completed and the process to close this grant will begin.

V. RECOMMENDATION

The Lane County Community & Economic Development Coordinator recommends the Board of Commissioners approve and accept the matter of approving & accepting the Lane County food waste to energy feasibility study final report.

VI. FOLLOW-UP

The Final Report contains specific recommendations regarding food waste and a renewable energy program.

I would like to request the Board of Commissioners take separate action to schedule a Board work session to discuss some of the specific recommendations in the Final Report. As preliminary to that work session, I would also request the Board appoint a multi-departmental committee to review the recommendations, meet with community stakeholders to discuss recommendations, and bring to the Board work session specific possible action steps for next steps.

VII. <u>ATTACHMENTS</u>

A: Board Order

B Food Waste to Energy Feasibility Study FINAL Report

IN THE BOARD OF COUNTY COMMISSIONERS
OF LANE COUNTY, OREGON

ORDER NO.	) IN THE MATTER OF APPROVING &) ACCEPTING THE FOOD WASTE TO) ENERGY STUDY FINAL REPORT)

WHEREAS, The State of Oregon established The Renewable Energy Feasibility Fund "to encourage the widespread adoption of renewable energy projects that reduce Oregon's dependence on fossil-based energy sources and promote sustainable economic development for communities throughout the state," and

WHEREAS, The Oregon Business Development Department awarded Lane County a $50,000 Renewable Energy Feasibility Fund grant to conduct a food waste to energy feasibility study, and Lane County approved a $25,000 cost sharing match from solid waste "Other Fees" for "waste diversion opportunities," and

WHEREAS, The Lane County Community and Economic Development Department conducted a Food Waste to Energy Feasibility Study;

NOW THEREFORE, IT IS HEREBY ORDERED THAT: the Lane County Board of Commissioners approves and accepts the Lane County Food Waste to Energy Feasibility Study Final Report

DATED this 27th day of January, 2010

____
Bill Fleenor, Chair,
Lane County Board of Commissioners

APPROVED AS TO FORM
Date 1-14-10 lane county
[signature]
OFFICE OF LEGAL COUNSEL

Lane County
Food Waste to Energy
Feasibility Study

Final Report
Renewable Energy Feasibility Project #A08007

December 31, 2009

Prepared by
Lane County Community & Economic Development
Lane Council of Governments
Resource Innovations, Institute for a Sustainable Environment, UO
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This project is being funded in part from the Oregon State Lottery Funds, Special Public Works Fund received from the Oregon Business Development Department – Infrastructure Finance Authority (OBDD-IFA) by Lane County on January 22, 2008.

This project is also funded in part from the Waste Diversion Opportunity Fund from Lane County Public Works, Waste Management Division

Acknowledgements

We owe a special thanks to all of the individuals who participated in this study. In addition, we thank Oregon Business Development Department for providing the funds to support the assessment.

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Executive Summary

Introduction

The goal of the Lane County Food Waste to Energy Feasibility Study is to determine if it is financially feasible to construct and operate a Lane County owned anaerobic digestion facility to process local food waste into energy.

Funding for the project was $50,000 from the Oregon Business Development Department Renewable Energy Feasibility Fund matched with $25,000 in County funds from the Lane County Solid Waste Management Division.

This food waste to energy study is Lane County's next step in a progression of initiatives that began several years ago as part of an effort to study the economic development opportunities for local renewable energy projects. It also builds on other work being done in the community.

In the 2007 food waste study, *Sustainable Energy Planning: Using Waste to Energy Feasibility Study as a Guide*, conducted by Ethan Nelson, identified 700 of the large non-residential food waste producing facilities within the Eugene metro area and estimated that they produce 17,870 tons of food waste annually. The study determined that the food waste could generate at least 1.2 megawatts of electricity from the anaerobic digestion process.

The recommendations of Nelson's study included the following next steps:

- Confirm food waste quantities (survey)
- Establish biogas production potential (sampling)
- Analysis of land-use issues for sitting

This study incorporates the above recommendations of Nelson's study. The study team also wanted to learn if food waste, rather than being an expense to the County to bury, could be a revenue by turning it into electricity and compost.

This final report is organized into six project elements:

1) Model Communities
2) Identification, Collection and Transportation of Food Waste;
3) Anaerobic Digester Facility Options;
4) Anaerobic Digester Facility Energy Outputs;
5) Conceptual System Description
6) Potential Sites;
7) Revenue and Expense Review and Return On Investment (ROI) Estimates

Benefits of Food Waste to Renewable Energy
Currently, food waste diversion is not mandated by any of the municipalities in Lane County, the State of Oregon or the federal government.

The Oregon Department of Environmental Quality estimates that municipal food waste (MFW) comprises approximately 13% of the waste stream from the Eugene – Springfield Metro area. This percentage applied to Short Mountain Landfill's total tonnage equates to about 40,000 tons/year of municipal food waste.

Both the US EPA and USDA recommend following the "food waste recovery hierarchy" below as the preferred options to make the most of excess food. The food waste recovery hierarchy comprises the following activities:

- Source Reduction – Reduce the volume of food waste generated
- Feed People – Donate extra food to food banks, soup kitchens and shelters
- Feed Animals – Provide food to farmers
- Industrial Uses – Provide fats for rendering and food discards for animal feed production
- Composting – Convert food scraps into a nutrient rich soil amendment
- Landfill

Lane County supports the food hierarchy. The food waste being discussed in this study is that food waste that is bound for the landfill.

Food waste is the single-largest component (10-30% depending on region) of the municipal solid waste stream by weight in the United States, amounting to more than 29 million tons/year.

Food waste diversion programs have been proven to work in many communities. The factors that need to be considered to implement a program include logistics and routing, equipment and costs.

The majority of communities that divert food waste, compost it. However several communities in the US and Canada have already created renewable energy projects using food waste. In the "Model Community" section of this study we include two of those projects: East Bay Municipal Utility District in Oakland California, and the City of Toronto Canada. Additional communities are studying such opportunities.

Food waste and other organic municipal solid waste (MSW) can be utilized in waste-to-energy facilities to generate electricity and/or combined heat and power (CHP). The processes can be divided into two categories: thermo-chemical and bacterial.

In the thermo-chemical processes, MSW can be directly combusted as a fuel with minimal processing, known as mass burn. MSW can undergo moderate to extensive processing before being directly combusted as refuse-derived fuel; or it can be gasified using pyrolysis or thermal gasification techniques.

Anaerobic digestion is a bacterial process that is carried out in the absence of oxygen. Anaerobic digestion generates biogas with a high proportion of methane that may be used to run engines to create electricity and create heat. Anaerobic digestion can also be used on municipal sewage and agricultural organic wastes.

In a previous study, "Assessing the Feasibility of Converting Annual Ryegrass Straw to Renewable Energy in the Southern Willamette Valley," the study team examined thermo-chemical and bacterial waste to energy processes. The study team determined that for many reasons, bacterial processes were preferable for the conversion of organic wastes.

Landfill gas recovery, another MSW-to-electricity technology, permits electricity production from existing landfills via the natural degradation of MSW by anaerobic fermentation (digestion) into landfill gas.

Currently there is a state mandated landfill gas recovery to electricity project at the County-owned Short Mountain Landfill. Methane, created in the landfill cells, is provided by Lane County to the local electrical utility: Emerald People's Utility District (EPUD). The landfill gas recovery and electricity conversion system is owned by EPUD. After converting the methane to electricity, EPUD sells the electricity.

The main goal of landfill methane collection systems is to prevent methane from leaking into the atmosphere. Methane is one of the most destructive of the green house gases. It has up to 25 times the global warming impact of carbon dioxide.

According to other studies, in a well-designed landfill collection system approximately 66% - 75% of the methane is recovered. The balance of the methane escapes to the atmosphere.

In addition to the methane created by the break down of organics, there are other negatives of putting food waste into a landfill:

- Adding food waste, which is approximately 70% water, to a landfill increases the quantity of leachate that is generated. That leachate must be treated and disposed.

- All of the nutrient value of the food waste is lost in the landfill. There is no opportunity to use the compost that is created from the breaking down of the food waste.

Summary of Study Findings

Community Models

- Other communities have successfully implemented municipal food source separation and collection programs.
  - There are successful examples that show that value and the financial return of utilizing the organic fraction of the waste stream for renewable energy or other bio-products.
  - Some of these efforts employ anaerobic digestion to process the food waste, often mixed with other organics waste.
  - Others turn food waste into compost.

- Some pilot programs in these communities have employed curbside collection systems of food waste alongside existing garbage, recycling, and yard waste collection systems.
  - This approach takes advantage of existing equipment and, potentially, rolling stock for transportation.

Identification, Collection and Transportation of Local Food Waste

- There are no local municipal policies in place requiring or recommending the separation of food waste from municipal waste streams.

- The quantity of food waste available from local, large commercial, institutional, and academic institutions is not well known.

- Many local businesses and organizations do not track how much food waste they dispose of.

- Data collected as part of this study suggests there may be less potential actual food waste that could be collected in Lane County than previous reports estimated.

- While some kind of separation for composting of food waste is in place at many organizations in the Eugene - Springfield Metro area, it appears the bulk of food waste makes its way to the landfill.

- Source separation of food waste is occurring at some local grocery stores. In addition coffee grounds are being separated at many local shops and restaurants to be used for composting.

- Organizations generating food waste are generally interested in a food waste recycling or collection program and would be likely to participate.

- Most food waste is contaminated with packaging and other paper products, but not chemicals such as cleaning supplies or antibiotics.

- Sorting garbage in order to improve the quality of food waste would be constrained by education (signage), labor cost, and space.

- There is no local solid waste company with a source separated post-consumer food waste program.

- There are some haulers collecting source separated food waste from some local grocery stores for composting. Volunteers are collecting coffee grounds to be use for composting for community gardens.

- Waste disposal companies expressed interest in a food waste program, provided some logistical obstacles could be overcome.

- Generally, those interviewed did not know what garbage hauling cost their organizations paid.

- Respondents in Eugene - Springfield are generally interested and likely to participate in the program if concerns could be addressed.

- A food waste collection model resembling the grease collection process is generally acceptable.

- A second dumpster dedicated to food waste was concerning to those interviewed due to space and odor concerns.

Anaerobic Digestion Facility Options

- Anaerobic digestion has a wide range of applicability to the organic fraction of MSW.

- The process needs significant amounts of organic feedstock.

- Food waste is an excellent feedstock for anaerobic digestion.
    - It exhibits good methane yield
    - It can easily be mixed with other available organic feedstocks, such as annual rye grass straw.

- The two Anaerobic Digestion technology processes are "wet" and "dry."
    - Wet is good for feedstocks that are composed of 30% to 100% moisture
    - Dry is good for feedstocks that are composed of 5% to 30% moisture
    - There are multiple technology options in each process.

- Anaerobic digesters are more efficient than landfills for capturing methane.
    - In a typical landfill methane capture system, 25% of the methane escapes to the atmosphere.
    - No methane escapes to the atmosphere in an anaerobic digester.

- This additional methane captured by an anaerobic digester (AD) means more electricity is produced per ton of food waste in an AD compared to a landfill

Anaerobic Digester Energy Outputs and Co-Product Options

- Numerous operating anaerobic digesters have shown that more methane is produced with a regiment of mixed feedstocks.
  - Co-digestion with multiple feedstocks is the best way to ensure a well-balanced biological system.
  - A good mix of feedstocks could be 50% grass straw, 25% food waste, 25% other organic wastes.

- The methane can be converted to electricity via a modified diesel engine.

- Waste heat is produced from the co-generation process.
  - Recovery of waste heat can raise the overall efficiency to roughly 80%, greatly improving the energy balance of the project.
  - Waste heat could be used to heat green houses
  - Waste heat could be used for some industrial processes
  - Waste heat could be run through chillers to be converted to cooling

- Hot water is produced from the Anaerobic Digestion process
  - Hot water could be used in green houses

- Anaerobic digesters have a valuable bi-product: Digestate
  - Digestate can be directly applied to agriculture land
  - Digestate can be turned into compost, thus increasing the revenue streams to the project

- Anaerobic digestion project is eligible for renewable energy credits and carbon offsets.

Conceptual System Description

- The biogas plant would likely consist of the following components:
  - One reception hall with feedstock storage, fiber storage, CHP unit(s), control/lab room, dewatering and nutrient recovery equipment
  - One feed reception pit for dry matter
  - One feed storage tank for liquid feed
  - One hydrolysis mix tank
  - Two anaerobic digester tanks
  - One post digester with integrated biogas storage

- One permeate storage tank with the size dependent upon nutrient recovery technology utilized and storage retention time required
- Access road and long-term feedstock storage would require additional land
- Close proximity to the electrical grid or natural gas grid would be required if the biogas plant intends to sell electrical power or upgraded methane

- The system will use multiple substrates
  - Substrates identified in this study and other studies: 50,000 tons grass and wheat straw; 20,000 tons of food processing waste; 5,000 tons of municipal food waste; 5,000 tons of dairy manure to promote anaerobic bacteria development.

- System will be designed to implement heat co-generation, renewable energy credits, carbon credits, tipping fees and co-product sales in order to increase project revenue.

Potential Sites

- An anaerobic digestion facility will require approximately 5-8 acres of land, preferably zoned industrial.

- The site will also require:
  - Ingress/egress for commercial haul trucks
  - Proximity to utility interconnect
  - Water and sewer
  - Relative proximity to available feedstocks
  - A series of state and local permits

- The preparation of the permit application for a food waste to energy project will require specific site and project details that will need to be developed by project proponents.

- Each sites studied has advantages and disadvantages
  - The Short Mountain Landfill has food waste being delivered to it, but under the current use and future landfill site designs, there is not enough space to conduct a full-scale food waste diversion program.
  - The Glenwood Transfer Station has food waste being delivered to it, but under current use and future site designs, there is very little space to do a food waste to energy project. Creating an area to sort food waste, would appear to impact other uses on the site.
  - The MWMC Treatment Plant has an existing anaerobic digester, but it may take several years before studies can be done to see if food waste can be added to the digester.
  - The MWMC Biocycle Farm was identified in the grant application as a potential site. Since that time the site has been committed to a different project.

- The Junction City Municipal Wastewater Treatment Ponds site has been identified as the site for the Lane County BioEnergy Production Facility, but being outside of the Eugene-Springfield Metro area may limit the use of the site.

Revenue and Expense Review and ROI Estimates

- Investment in renewable energy generation through anaerobic digestion hinges on an evidence-based estimate of the total amount of food waste available for feedstock.
- Having private partners as part of the ownership and financing package of an anaerobic digester would allow the use of all financing options, including the Business Energy Tax Credit and the Federal Tax Credit.
- There are several power purchase options available for selling the electricity to the grid:
  - Local utility: Can purchase the power directly or wheel the power to another utility.
  - Regional utility: Can purchase the power once it is wheeled to them.
- Currently, there is a price variation between what the public utilities will pay for "green" energy and what the regional investor owned utilities will pay.
  - The implementation of a feed-in tariff in early 2010 for the investor owned utilities would dramatically increase this price difference.
- The capital required to build a 2 MW anaerobic digestion facility is between $8 and $9.5 million depending on equipment specifications.
  - Using the conceptual system description for the proposed project, a $12.5 million project that included $3 of property improvements, would generate a net present value of $6.41 million and an internal rate of return of 16.4%.

Recommendations

This study examined the feasibility of converting the organic fraction of municipal solid waste as feedstock for renewable energy generation using anaerobic digestion.

The findings show anaerobic digestion is viable and commercially available technology that is presently deployed in numerous sites across the country. AD technology is mature and proven. The study also finds that food waste is a suitable feedstock for an anaerobic digestion process, especially when combined with other organic feedstocks, such as grass straws.

Financial projections calculated for the anaerobic digestion project estimate a positive rate of return and positive net present value. Several suitable sites exist to construct a 3 MW facility. Acquiring the required permits is not viewed as problematic.

Given the initial viability of a potential project, the most pressing remaining questions are:

- Do sufficient volumes of readily available food wastes exist in the Eugene-Springfield and surrounding areas to supply an anaerobic digestion facility?
- What would be the costs and the logistics to set up a source-separated food waste collection program in the Eugene-Springfield and surrounding areas?
- Do the costs of a food waste source separation and collection system make it a financially feasible undertaking?
- How would a food to energy project impact the current contract between Lane County and EPUD?
- What would be the best ways for local government to help support the development of a source separated food waste collection system?

Given the findings, and the above questions that still need to be answered, we make the following recommendations regarding moving forward with a food waste to renewable energy project.

- The municipal partners, in cooperation with restaurants, cafeterias, grocery stores, waste collectors/haulers and other stakeholders, should conduct a robust food waste collection pilot to gather more data about the actual amount of food waste generated by commercial and institutional organizations in the Eugene-Springfield area.
- Planning for a food waste diversion program to renewable energy system should encompass an overall look at the current waste system process, because so many factors of the current system would impact a food waste program.
  - Collection and transportation systems exist, but collection and can options will need to be offered to operations that create food wastes.
  - Methane collection is mandated at Short Mountain and will continue for decades at the landfill.
  - Emphasis should be given to the current contract between Lane County and EPUD. Current language in that contract creates potential financial liability to Lane County for implementing a food waste diversion program.
  - The planning process should include the other municipalities in the County and all other stakeholders.
- A pilot scale anaerobic digester should be set up at Short Mountain as part of the proposed "Short Mountain Landfill Renewable Energy Park."
  - Food wastes should be co-digested with other organic substrate(s) to improve biological stability, increase methane production and solve other waste management challenges.

- Methane should be fed to the current EPUD system for conversion to electricity.
- The amount of methane and electricity yield should be analyzed to determine if the pilot project produces more methane and electricity per ton than the landfill.
- A mutually beneficial agreement between the County and EPUD for the AD methane should be explored.

- The "Bioenergy Production Facility" being considered for Junction City should be considered as a site option for a future food waste to energy project.

- Further explore opportunities for a food waste to energy project with the Metropolitan Wastewater Management Commission.

- Both public and private financing should be pursued in order to create a feasible and sustainable food waste to energy project.

Section 1: Community Models

Introduction

Communities across the West have successfully implemented municipal food source separation and collection programs. Some of these efforts employ anaerobic digestion to process the food waste and in others the food waste becomes compost. Portland, Seattle, Olympia, San Francisco, Alameda, San Jose, and Toronto have all implemented successful examples that show the value and financial return of utilizing the organic fraction of the waste stream for renewable energy or other bio-products.

In general, the common practice among the food waste programs in the jurisdictions reviewed is to combine the food waste collection with existing garbage and recycling collection programs. Adding the food waste collection service to an already existing infrastructure for waste collection is a lower cost alternative to the development of new collection services. This approach takes advantage of existing equipment and, potentially, rolling stock for transportation.

The focus of the study was Commercial Food Waste Programs because the opportunity to get sorted food waste for a project from commercial operations may be simpler than from residential operations.

See the appendix for Community Models' references.

Communities Studied

- Portland, OR
- Seattle, WA
- Olympia, WA
- San Francisco, CA
- Alameda County, CA
- San Jose, CA
- Toronto, Canada

Questions we asked

- What do they collect?
- How is it collected?
- Is it mandated or voluntary?
- Who are the targeted participants?
- What is the purpose of the program?
- What are the benefits of the program to municipality?
- What is the responsibility of food waste producer?
- What is the cost to generator to dispose of material?
- What is responsibility of collector?
- How much material is collected annually?

- Where does the material go?
- How is the material used?
- How is the product created from food waste used?

Communities Studied

Portland, Oregon

The City of Portland Bureau of Planning and Sustainability and Metro formed a partnership in order to organize a food waste collection program for businesses that dispose of large amounts of food. It is estimated that around 54,000 tons of food waste and food contaminated paper enter the commercial waste stream each year in Portland. "Portland Compost!" is a program designed to divert this stream. According to an EPA model estimating that 45,000 tons of organic waste would be diverted from landfills and composted, greenhouse gas emissions may be reduced by approximately 44,000 metric tons of CO_2 per year. Portland Compost! saves space in the landfill and reduces greenhouse gas emissions.

Portland Compost! is a voluntary program for Portland area businesses. However, the City of Portland's Climate Action Plan calls for mandatory commercial food waste collection and implementation of a residential collection program by 2012.

The program accepts all food waste, including meat, uncoated food-soiled paper and plants and other yard debris. Portland businesses who want to participate in the program must contact local garbage haulers who are currently providing food scrap collection. Terms of collection must be negotiated between the business and hauler so prices and pickup schedules vary. The City of Portland assists participating companies with set-up assistance, employee training and free collection containers. There are also financial benefits for participating businesses. Participants may be eligible for a Capital Improvement grant or credit and may also reduce their operational expenses by eliminating the City of Portland's Extra Strength Sewer Discharge fee and/or reducing garbage fees.

According to Metro, haulers use the same trucks they use to pick up trash and yard debris, but the haulers make "food waste-only" runs with their trucks. Haulers are responsible for ensuring their trucks are capable of transporting the food waste without creating nuisances. No collection is allowed between 10 a.m. – 10 p.m. in the downtown corridor.

Portland International Airport, who has been recycling post-consumer food waste since 2005, and its partners collect between 132 – 192 short tons of food waste per year. It is estimated that a full-scale food waste collection program in the City of Portland would yield 44,000 tons of recycled food waste from commercial and residential sources, plus an additional 25,000 tons from yard waste.

Currently food waste is taken to Metro's transfer station at 6161 NW 61st Avenue. From there the food waste is examined for any contamination (i.e. glass, metal and plastic). All loads without contaminants are loaded into trailers and taken to Cedar Grove Composting, Inc.'s facility in Maple Valley, Washington.

Once the food waste reaches the Maple Valley facility it is ground up in a building where the air is filtered prior to being released outside. The ground up debris is placed into windrows on outdoor cement slabs. These windrows, approximately 12 feet tall and 150 feet long, are covered with a breathable, waterproof fabric called GORE. GORE fabric allows water and vapor out but contains the odor. The windrows are aerated to allow oxygen in and keep temperatures stable. The windrows are kept coved for six to eight weeks. After the allotted time, the compost is set out and then blended for a variety of soil amenities and compost products. Cedar Grove compost can be purchased at local home improvement stores.

Currently there are no further plans for use of food waste. However, Cedar Grove in conjunction with the City of Portland has been searching for a more local, Oregon based, site where a compost facility could be built to deal with the potential level of food waste collection should Portland Compost! expand to include residential collection. There has been little progress made in site selection and recently Cedar Grove announced it has stopped its site search and informed the municipalities that it would end its compost contract. Other companies are now applying for permits to compost the food waste.

Seattle, Washington

Seattle Public Utility is in charge of Seattle's food and yard waste collection service. The food and yard waste collection service is required for all single-family households in Seattle. Significant benefits of this program include reductions in garbage resulting in saved landfill space and reductions in landfill methane. The program was motivated in part by the following goals established by State legislation: to achieve a 50% recycling rate where half of the waste stream will be recycled; to make recycling as affordable and convenient to the ratepayer as mixed waste disposal; and to consider source separation as a fundamental strategy.

All food waste, uncoated paper products and yard trimmings are accepted for recycling. Seattle Public Utility recently changed its collection policy to include meat, fish and dairy products.

Food waste is collected weekly with yard waste in the same bin. Garbage is collected at the same time as the food waste. There are three cart sizes that residents may choose from: 13-gallon (mini-can) at $3.60/month, 32-gallon at $5.40/month and 96-gallon at $6.90/month. Rates will increase slightly on January 1, 2010 to the following: 13-gallon (mini-can) at $4.10/month, 32-gallon at $6.10/month and 96-gallon at $7.85/month. Residents who have their own compost system may opt out of the program.

Responsibilities of the food and yard waste collectors are to deliver an outdoor compost collection container to new participants and empty all containers at least once per week.

In 2008, over 100,000 tons of food and yard waste from Seattle residents and businesses were converted into compost. Seattle Public Utility estimates that an additional 15,000 tons of food and yard waste will be collected in 2009 due to the new stipulation that took place in April, 2009, requiring all single-family homes to have a food and yard waste bin. It is estimated that 48% of Seattle's waste is currently being composted. The City hopes to increase it to 60% by 2012.

Cedar Grove, Inc.'s facilities in Maple Valley and Everett, Washington convert the food and yard waste from Seattle into compost through the same process described for the Portland model. Once the compost is created, it is used in local parks and community gardens and is also distributed to local stores for purchase. There is no information available about future uses for food and yard waste in Seattle.

Along with residential food waste recycling, Resource Venture, a service of Seattle Public Utility offers a voluntary food waste-recycling program for Seattle area businesses. It is estimated that Seattle businesses throw away 64,000 tons of food each year and spend around $7.8 million every year to dispose of food waste as garbage. This is about 37% of all waste generated by Seattle businesses. Businesses that compost can cut their garbage bill by up to 30 percent. Compost collection rates are 20 percent less than garbage rates.

Resource Venture provides free staff training, signs and troubleshooting along with technical assistance and a cost savings estimate. Businesses that wish to participate must either contact Resource Venture or one of the three certified food waste hauling companies: Cedar Grove Composting, Clean Scrapes or Allied Waste. Once food waste collection has been confirmed, a business will receive the appropriately sized receptacle.

The number of businesses participating in the food waste program has gone from 330 to 800. In 2008, approximately 1,780 tons of food waste was diverted from the waste stream and turned into compost.

Olympia, Washington

The Olympia City Council adopted a zero waste resolution in June 2006. The resolution set the goal of eliminating the need for landfill space. By 2013 Olympia hopes to be capturing at least 50% of the organic waste sent to the landfill.

In July 2008 the yard waste collection program was transformed to include food scraps. Accepted items now consist of all food scraps including meat and dairy, food-soiled paper and yard debris. The new Organics and Yard Waste program delivered countertop pails to all existing participants during the first month of the program.

The voluntary program costs a total of $7.72 per month for either a 35- or 95-gallon cart. The cart is delivered to the residents along with the every-other-week curbside pickup schedule. Residents are able to cancel the service at any point but will incur a $25 re-delivery fee if service is resumed within 12 months. Participants of the Organics and Yard Waste program could save money on utility bills if garbage is reduced to such a degree that a smaller garbage cart can be used.

It is estimated that the new program has increased curbside organics by 400 tons per year, raising the total amount of compostable materials collected to 4,000 tons per year.

The compostable material is delivered to Silver Springs Organics in Rainer, Washington. Once there, Silver Springs composts the material using Engineered Compost Systems aerated static piles. The process consists of air being pulled through the piles of feedstock and exhausted into a bio-filter. This reduces odor and speeds up the decomposition process. The bio-filter system is able to reduce 96% of Volatile Organic Compounds. Once the compost has completed the necessary decomposition and has been cured then filtered through a screen, it is ready for distribution. Some of the compost is sent to local schools for student gardens. The biggest consumer of Silver Springs Organics compost is Washington Sate Department of Transportation. The Department of Transportation uses the compost for landscaping along roadsides and to prevent erosion.

There are no known plans for other uses of the compostable material collected through the Organics and Yard Waste program.

San Francisco, California

San Francisco has designed an effective recycling system called the 3-Cart Recycling Program for residents and businesses. This program has helped San Francisco surpass California's 50% recycling law, AB939, and put the San Francisco Board of Supervisors' mandated goal of 75% waste diversion for the entire City by 2010 within reach. San Francisco hopes to send zero waste to landfills by 2020. Currently, about 36% of the waste stream sent to landfills is composed of food and paper products. Saving landfill space is a top priority to the City partly because it has a contract with the landfill it uses, stipulating the amount of space available for non-recyclable garbage.

San Francisco residents and businesses may potentially be fined, starting on October 21, 2009 if they do not compost. The fines range in size from a minimum of $100 up to $1000. The new law will require all building owners to signup for the City's composting and recycling program which will provide compost and recycling services to many more apartment tenants and businesses.

Recology is the waste management company for San Francisco and is charged with compost, recycling and garbage collection. Each bin is designated a color: the green bin is for compost and yard trimmings, the blue bin is for recyclables and the black bin is for garbage. All food scraps, soiled paper and yard trimmings are accepted in the green bin. Curbside collection is weekly for both residents and businesses.

It is possible for residents who minimize their trash generation to save money by reducing the size of their garbage bin. For houses that are able to use the 20-gallon garbage bin, $5.83 will be discounted from the monthly bill. The garbage bin is the only bin that costs money to get collected, the recycling and compost bins are pickup at no additional fee. The monthly garbage fee for a 32-gallon bin is $25.48.

All collection and transfer trucks in San Francisco are required to run on either biodiesel or liquefied natural gas. After making a collection of food and yard waste, the trucks head to the Organics Annex, located at 401 Tunnel Avenue, San Francisco. At the Annex, food waste is transferred to long-haul trucks and taken to Recology's Jepson-Prairie composting facility located in Vacaville, California.

Currently over 400 tons of food scraps and other compostable material are sent to Jepson-Prairie each day from San Francisco residents and businesses. That is around 146,000 tons of compostable material every year.

Material is turned into compost at Recology's Jepson-Prairie composting facility in a 90-day cycle. The compostable material is fed into a grinder and mixed. Once the necessary physical and chemical characteristics for microbial decomposition are present, the material is pushed into the Ag-Bag Composting system with an in-vessel, forced aeration composting process. The Ag-Bag is a 200-foot plastic pod, which is filled with feedstock and left for 60 days. During this period the temperature and oxygen levels are monitored. After the allotted time, the compost is placed in windrows. The windrows are mixed and conditioned with moisture to breakdown the particles and add oxygen. After 30 days the compost is put through a trommel screen that takes out the larger materials. Compost is then purchased by local farms and vineyards and mixed with soil. During the peak of spreading season Jepson Prairie Organics compost sells out.

Alameda County, California

The Alameda County Waste Management Authority and Source Reduction and Recycling Board partnered to create an integrated agency called StopWaste.org, whose goals are to achieve over 75% diversion from landfills by 2010 and to promote sustainable consumption and disposal patterns. Food scraps and soiled paper makeup the largest waste stream for households, representing nearly 38%. Under StopWaste.org's management, Alameda County has a thriving food scrap and yard waste recycling program. In 2007, food scraps composed 24% of the organics waste stream in Alameda County. In 2009 Alameda County enacted a law restricting yard debris from being disposed of as garbage.

There are 14 participating cities who provide food and yard waste curbside pickup to residents: Alameda, Albany, Berkeley, Castro Valley, Dublin, Emeryville, Fremont, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro and Union City. Each program provides weekly pickups and accepts all food waste, yard debris and food soiled paper. No liquids, plastics or metals are accepted. Program costs vary by city entity and size of cart. For specific pricing refer to the following link: http://www.stopwaste.org/docs/residential_recycling_services_in_alameda_county.pdf.

In 2007, it was estimated that 25% of residents participated in voluntary food waste collection. This created an estimated 10,000 tons per year of compostable material. The material is taken to different compost facilities in the area including: Allied Newby Island in San Jose, Grover Environmental in Vernalis and Z-Best Composting in Gilroy.

At the composting facilities the feedstock is sorted, removing contaminants, ground into smaller pieces and then placed in windrows to decompose for three to four months. After this process the feedstock becomes compost and is cured and screened into different sizes. Local farmers use the compost as well as residents who use it for community gardens.

Another use for food scraps was investigated through a grant provided by the Environmental Protection Agency, Region 9 to the East Bay Municipal Utility District in Oakland, California in 2006. The grant was focused on comparing anaerobic digestion of food waste to digestion of municipal wastewater solids. The results found that processing the food waste by creating a slurry to break down the waste material size prior to digester feeding was effective. Anaerobic digestion produced methane and fertilizer. According to the results, food waste provides around three and a half times more methane production per volume of digester than does municipal wastewater solids digestion. The findings showed that anaerobically digesting 100 tons of food waste per day, 5 days a week provides sufficient power for an estimated 800 to 1,400 homes for one year.

Currently, the East Bay Municipal Utility District (EBMUD) processes the food scraps from area restaurants, which amounts to between 100 to 200 tons per week, with the sludge at its wastewater treatment plant. Waste haulers pickup the food scraps on their normal garbage pickups and deliver the food scraps to the EBMUD wastewater treatment plant.

EBMUD is the first wastewater treatment plant in the country to convert post-consumer food waste to energy using anaerobic digesters. The co-digestion of the food and sludge process begins with the food waste being treated to remove contaminants and then being grinded into pulp. The pulp is then added to the anaerobic digester with wastewater sludge. During the digestion process methane gas is released. This gas is captured and converted to energy. The energy powers the EBMUD treatment plant. After the digestion process is complete, the remaining material can be used as natural fertilizer.

The goal is to increase the amount of food waste processed to around 100 to 200 tons per day. It is unclear from the resources available whether Alameda County plans on diverting the residential organics and other commercial organics collected to EBMUD. According to EBMUD's director of wastewater, if EBMUD were able to process all commercially generated food waste, 1,800 tons daily, it could produce enough electricity to power over 25,000 homes.

Pacific BioGas Energy LLC, an organics recycling, renewable energy and composting company in northern California, estimates that there is 150,000 to 200,000 tons of compostable organics currently disposed in Alameda County that can be utilized as a energy and nutrient resource. Pacific BioGas Energy estimated that the potential energy value of this resource is 4 megawatts of continuous renewable electricity production.

San José, California

The City of San José is working to reach a 100% recycling rate by 2022. The City's green vision includes 100% waste diversion as well as 100% energy from clean and renewable sources. By 2013, the City's goal is to reach 75% diversion. Currently, San José has a 62% recycling rate. San José is getting even closer to its goal with a recent decision by the City Council to execute a Memorandum of Understanding to develop an organics-to-energy biogas facility. The facility is sited for 40-acres close to the San José/Santa Clara Water Pollution Control Plant. Zanker Road Biogas will be responsible for construction and operation of the facility. The technology planned for use at the facility is a process called dry fermentation anaerobic digestion. The resulting product is renewable biogas and high-quality compost. The facility will help reduce the need for landfill space and provide an alternative to organics composting, where capacity is filling quickly.

While dry anaerobic fermentation is used commonly in Europe, it would be the first facility of its kind in the United States. The difference between wet and dry fermentation technology is that the dry process does not need to be processed into a liquid state (described as pulp in the Alameda County example).

Approximately 12.2% of San José's waste stream is made up of food waste and compostable paper. Commercial food waste and compostable paper comprises 8.4% of total disposal.

San José's recycling program is called Recycle Plus. The program allows residents to set out an unlimited amount of yard trimming either as loose piles (no more than five-by-five feet each) or in carts. There is no fee for collection of piles. For monthly cart service a $4.00 fee is incurred. There is not currently a residential food scrap recycling program. Over 130,000 tons of yard debris is collected annually and is either processed into compost or other products, such as wood chips for landscaping. Currently all yard debris is collected by GreenWaste Recovery. Zanker Road Resource Recovery processes the material at their Z-Best composting facility in Gilroy. San José maintains a policy of highest and best use for all materials collected. Contract provisions stipulate that at least 50% of the material collected must be made into finished compost.

There is some commercial and apartment organics waste collection but program details are unclear. San José's Organics Team is working on implementing strategies to capture compostable material from all generation areas, including residential, commercial and schools. Pilot projects are taking place to determine the best strategy to capture this waste.

Once the Zanker Road Biogas facility is running at full capacity it will be able to convert up to 150,000 tons of organic waste per year into renewable energy and compost. The facility will be completed in three phases; each phase will be able to process 50,000 tons per year of organic waste. The facility plans to process materials from source separated food waste and the organic waste remaining after materials including Municipal Solid Waste are processed at GreenWaste's Material Recovery Facility.

The energy produced could potentially be used to power the San José/Santa Clara Water Pollution Control Plant or be sold back to the grid. The Zanker Road Biogas facility will also create jobs, employing approximately 30-40 workers during the development phase, and creating 50-60 direct and supporting jobs when fully operational.

Toronto, Canada

The City of Toronto established the Waste Diversion Taskforce in 2001. The taskforce was charged with finding local solutions for waste diversion from landfills. Incremental goals were set by the taskforce: 30% diversion by 2003, 60% diversion by 2006 and 100% diversion by 2010. Since 2001 the goal for 2010 has been readjusted to 70% waste diversion. To meet this goal, the City developed the Green Bin Program to collect organic waste.

The Green Bin Program is voluntary and serves Toronto single-family households. 90% of all single-family homes participate in the program, approximately 510,000 households. The Green Bin Program is being developed for apartments also; currently 5,000 apartments, condos and co-op buildings are participating.

Participants must purchase the outdoor organic collection container but there is no fee for organic collection or recycling collection. Materials accepted in the organic collection container include: all food scraps, plant debris, food soiled paper, diapers and sanitary products, animal waste, and animal bedding and kitty litter.

Curbside collection of organic material is weekly. Collection trucks have two separate compartments, one for organic material and one for recyclables or garbage, which are collected on alternating weeks.

Once the collection trucks pickup the organic material they take it to the organics processing facility. Once at the processing facility the organic material is sorted then mixed with a hydropulper, which mixes water with the material, turning it into liquid organic pulp and separating the plastic bags and other contaminants. The liquid organic pulp is then placed into an anaerobic digester. The necessary conditions are created for anaerobic bacteria to breakdown the organic material. After 20 days the material is converted to biogas and organic solid material (compost). Approximately one metric ton (1.10231 short tons, referred to as tons below) of organic waste produces 670-kilowatt hours of energy. The biogas is transferred to an onsite cogeneration plant and converted to electricity and heat. The compost is given away to local residents.

The City is in the process of expanding the existing Dufferin Organic Processing Facility, located in the North York community area, as well as reconstructing the Disco Transfer Station, located in the Etobicoke community area. This will increase processing capacity by 60,630 tons. Current processing capacity within the City boarders is 121,250 tons a year. Toronto collection of organic material is around 110,230 tons per year.

Section 2: Identification, Collection and Transportation of Local Food Waste

Introduction

This element of the project sought to understand the amount and type of food waste generated by businesses and select institutions in the Eugene-Springfield area of Lane County, Oregon. The study focused on hospitals, grocers, hotels & restaurants, and higher education. It did not explore the food waste generated by all sources, such as schools, food processors, or residential collection, for example.

While a recent report of estimated food waste in the Eugene-Springfield area calculated total and average tons per year on a per-facility basis (Nelson, 2007), developing a workable food waste collection, transportation, and digestion program requires confirmation of the type and amount of food waste available for use as an anaerobic digestion feedstock.

Section Goals:

- To quantify the food waste generated by commercial and institutional organizations in the Eugene-Springfield area. Specifically, grocers, hospitals, restaurants, and institutions of higher education were within the scope of the project.
- To understand the current fate of food waste from the organizations identified and any obstacles to food waste separation.
- To gauge the interest of organizations to participate in a voluntary food waste recycling program, including waste disposal companies.

Methods

Study Area

The study area for this project is the Eugene – Springfield metropolitan area in Lane County, Oregon.

Interview Participants

To conduct interviews, we identified potential commercial and institutional organizations by concentrating on top generators, as outlined by Nelson (Table 1, 2007). Focusing on those organizations described as Hospitals, Colleges / Universities, Supermarkets, and Restaurants, we contacted individuals by telephone or email that were either responsible for purchasing and preparing food or responsible for waste disposal in their respective organizations.

Table 1

Potential Food Waste Calculated by Facility Type
Eugene-Springfield Metro Area, 2007

Type of Facility	Number of Facilities	Potential Food Waste (tons/year)	Average per facility (tons/year)
Hospitals	3	612	203.89
Colleges / Universities	2	728	363.95
Supermarkets	40	3,203	80.06
Restaurants	516	11,810	22.89

Source: Nelson, E. (2007)

Individuals reached by telephone or email were asked for a face-to-face meeting to administer a short survey, as outlined by an introductory script (Appendix I). The survey (Appendix II) is the basis for the findings of this study.

The interview respondents had varying levels of responsibility with food purchasing, preparation, and waste disposal. The majority of participants (70%) purchased or prepared food, such as produce managers, chefs, or food service managers. The remainder of participants worked in recycling, composting, or sustainability for their organizations.

Qualitative telephone interviews of representatives of waste disposal companies followed, in order to collect disposal and hauling cost estimates and general impressions of a food waste to energy program as proposed.

Interview Data Collection

We conducted face-to-face interviews with representatives from food waste generating organizations from December 2008 through February 2009. During each interview we used a survey instrument that contained 32 quantitative and open-ended qualitative questions (Appendix II). Interviews lasted between 15 to 60 minutes. Data gathered during the interview process was coded and sorted by project goal. Of the 20 organizations contacted, eight (8) interviews were performed, recorded, and transcribed. We explained to participants that participation in the study was voluntary, that their names would not be associated with the findings, and that the recorded interview transcription would be a tool for verifying information.

We also conducted qualitative telephone interviews with representatives of waste disposal companies in March 2009. During each interview we inquired about the estimated costs of disposal of food waste and asked open-ended questions regarding their interest in and perceived obstacles to a food waste to energy system in the Eugene – Springfield Metropolitan Area.

Food Waste Sample Collection

In order to verify the estimates of food waste provided by previous literature and study participants, research staff collected a convenient sample of food waste from three different organizations, consisting of two hospitals and one restaurant. Empty 33-gallon garbage cans clearly labeled "FOOD SCRAPS" and a memo describing acceptable food waste were supplied to sample collection participants. The participants used the cans to dispose of their meal preparation food scraps and post-consumption food scraps. Research staff collected the cans after a 24-hour collection period and transported them to the Glenwood Central Receiving Station, where a truck scale calculated the weight of the food waste disposed. The truck scale is considered accurate to +/- 20 pounds.

Photo: Food Scrap Collection at Sacred Heart Hospital

Verification of Calculated Potential Food Waste

To confirm the potential food waste calculated in Nelson's 2007 study, we obtained copies of the Connecticut and Massachusetts Departments of Environmental Protection studies that were cited in Nelson, 2007. The studies outline formulas for calculating food waste in multiple categories from a variety of data. Categories relevant to this study are presented in Table 2.

Table 2
Food Waste Generation Estimates by Generator Category
Hospitals Food waste (lbs/yr) = N of beds * 5.7 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Colleges, Universities, and Independent Preparatory Schools ***Residential Institutions*** Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 405 meals/student/yr ***Non-Residential Institutions (e.g., community colleges)*** Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 108 meals/student/yr
Supermarkets Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr
Restaurants Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr

Source: Massachusetts Department of Environmental Protection (2002)

Findings

Quantity of Food Waste

The interview findings strongly suggest that few of the respondents have a clear understanding of the quantity and quality of food waste generated at their facilities. Of the eight respondents, two facilities were actively engaged in the quantification and verification of their organic wastes. These two facilities had begun to calculate the availability of their food waste and had initiated organic waste diversion programs, such as composting. However, neither could provide a figure which captured the quantity of organic waste at each facility as the facilities are large and contain multiple sites.

The food waste collection trials were conducted to gauge the accuracy of the estimates produced in prior studies using the Connecticut and Massachusetts Food Waste Calculator. Table 3 provides a quantitative estimate of the food waste available from a representative restaurant, supermarkets, hospitals, and university using the Connecticut and Massachusetts calculator.

Table 3
Food Waste Estimates from Major Food Waste Generators in Eugene-Springfield
Connecticut and Massachusetts Food Waste Calculator

Food Waste Generator	Employees	Patient Beds	Students	Annual Estimate (pounds)	Annual Estimate (tons)
Restaurant	170			510,000	255
Supermarket Chain (5 stores)	490			1,470,000	735
Hospital A		386		481,844	241
Hospital B		114		142,306	71
Hospital C		104		129,823	65
College / University					
residential			3,572	506,331	253
non-residential			16,804	635,191	318
Total				**3,875,495**	**1,938**

Source: Resource Innovations and Massachusetts Department of Environmental Protection (2002)

The information provided by Table 3 provides a marker to examine the accuracy of previous attempts to quantify food waste availability in the study area. We conducted food waste collection trials at three facilities to gather actual data on daily food waste availability with the intent to extrapolate these numbers to an annual estimate. Information provided by facility managers offers other data on the quantity of food waste from large facilities in the study area.

The findings from the food waste collection and the interviews with facility managers estimate significantly less food waste available than previously published reports for the Eugene-Springfield area that rely on formulas based on the number of employees, patients beds, or number students. The food waste collection trials and quantities provided by the facilities range between twenty-five to over fifty percent less than amounts estimated using the Massachusetts and Connecticut calculator.

It is clear that the sample sizes for both the food waste collection trials and the interviews are small and the findings cannot be extrapolated to the larger population. However, despite these limitations, the findings raise questions about the accuracy the model as an estimate of available food waste. It is understood that Nelson's work was intended as a starting point—not the definitive analysis—for a conversation about the possibilities of food waste in the Eugene-Springfield area. The findings from this effort indicated that a more rigorous and comprehensive analysis is needed to accurately characterize the quantity and quality of food waste available in the study area.

Current Fate of Food Waste

Overall, study participants reported that nearly all food waste currently disposed of is comingled with paper and packaging and is transported to the landfill. The exception to this finding is coffee grounds, as several organizations source-separated coffee grounds for composting. The University of Oregon currently operates a composting program. Nearly all of the participants reported that the success of source-separation depends on training, labor, and space for storage of the waste.

Organizational interest

The organizations and businesses interviewed express interest and a willingness to participate in a food waste separation effort if the program resulted in lower waste disposal fees and addressed logistical and odor issues. Respondents from the hospital sector noted that storage and the potential for odors were important to consider. Many respondents noted a food waste collection system could be modeled on the grease and cooking oil collection system.

> "We are committed to collecting the food waste, diverting it from the waste stream, keeping it out of the landfill, and taking it somewhere. If there were a system to offset the cost of waste diversion, then it would be a great reason to participate."

> "We would be interested in participating in a food waste to energy program, especially if food waste disposal could run as smoothly as the grease and cooking oil collection system."

> "There would not be many obstacles to separating food waste from the normal waste stream as food services scrapes all the current food scraps into the garbage. Storage, however, is a major concern due to the cleanliness requirements of a hospital setting."

Recommendations

The purpose of this study was to determine the amount and type of food waste generated by commercial and institutional organizations in the Eugene-Springfield area of Lane County, Oregon. Food waste may be a suitable feedstock for producing renewable energy through anaerobic digestion, and reliable data is required as justification for investment in such a system. The findings of this assessment suggest that further study is required in order to develop a comprehensive, evidence-based understanding of food waste generation in the study area. Specifically, we recommend:

- Conducting a robust food waste collection studying to gather more data about the actual amount of food waste generated by commercial and institutional organizations in the Eugene-Springfield area.

Section 3: Anaerobic Digestion Facility Options

Introduction

Project Opportunity:
Biomass to energy projects are generating notable excitement, however evaluating these emerging technologies requires objective assessment. As such, Lane County Community & Economic Development retained ECOregon to review Anaerobic Digester Facility Options and determine energy output of a project.

The objective of these two research elements is to determine if anaerobic digestion is a near-term viable option for diverting MFW from Short Mountain landfill for conversion to energy. ECOregon has assessed the technical feasibility of utilizing MFW as anaerobic digester feedstock. To that end, MFW degradability will be determined, digester technology options will be reviewed, energy/co-product outputs and system costs will be estimated.

Food waste is the single-largest component (10-30% depending on region) of the municipal solid waste stream by weight in the United States, amounting to more than 29 million tons/year. Oregon Department of Environmental Quality estimates that MFW comprises approximately 14% of the waste stream from the City of Eugene. This percentage applied to Short Mountain Landfill's total tonnage equates to about 40,000 tons/year of MFW potentially available for renewable energy conversion.

A recent thesis from University of Oregon (*Nelson, 2007*) estimated that "large", non-residential sources in the Eugene-Springfield generate 17,870 tons/year of MFW in the Eugene-Springfield area. These generators include restaurants, supermarkets, schools and hospitals. Including typical residential generation would more than double the amount of MFW available for potential conversion to renewable energy. However, uncertainties surrounding the implementation, cost, participation level and contamination complicate the reality of residential curbside collection of residential food waste. For these reasons, the scope of this study will be limited to source-separated MFW from "large" commercial generators.

A voluntary commercial collection system in the Portland Metro area captures approx. 20% of the MFW generated. For this study, an initial capture rate of 30% or less of the non-residential generation has been deemed realistic. It is therefore assumed the amount of available MFW that can logistically be source-separated, collected and delivered to a hypothetical anaerobic digester facility is 5,000 tons/year (average ~14 ton/day).

Anaerobic Digestion Background

Biogas is a renewable natural gas replacement, produced through the controlled decomposition of organic matter in a process referred to as anaerobic digestion (AD).

Biogas production is the result of a complex sequential biological process, in which the substrate is continuously broken down. Hydrolytic enzymes reduce complex organic polymers to monomers and oligomers; acidogenic bacteria utilize these simpler compounds to form organic (volatile fatty) acids; acetogenic bacteria then convert the long chain acids to acetic acid; finally, methanogens create methane (CH_4), H_2O and CO_2 from precursors formed in the previous steps (Figure 1).

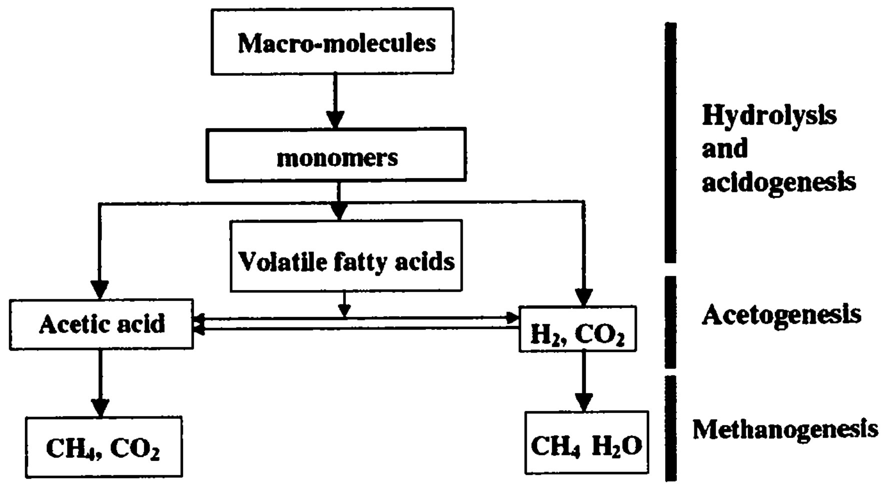

Figure 1. Microbial degradation processes of anaerobic digestion

AD is wide spread throughout the European Union (EU) and Asia but is under represented in the United States primarily due to historically low energy costs. The technology can be instrumental in providing renewable energy to industry and the agricultural community while closing the loop on the nutrient cycle (Figure 2). Digester systems, or "biogas plants" as they are referred to in the EU, are applicable to a wide range of situations, but synergy is most realized at facilities that:

- Have access to sizable organic feedstock at little to no cost
- Require electricity and heat, that can be provided by a biogas-powered combined heat and power (CHP) unit or a direct use of biogas such as boilers
- Can utilize or market the digester effluent as compost and liquid fertilizer

Traditionally, the primary use of anaerobic digestion has been to sanitize waste materials associated with livestock operations, industrial facilities or municipal waste water treatment plants. As the utilization of bio-methane as a renewable fuel has increased, more research and pilot projects have begun to utilize various waste streams, known as feedstocks, specifically for energy production.

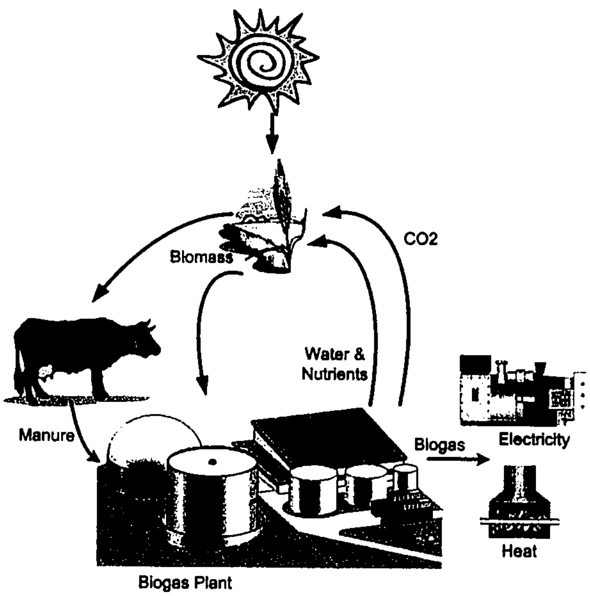

Figure 2. Schematic illustrating the sustainability of anaerobic digestion (ECOregon)

The use of AD for sewage sludge stabilization is well established, as is its use as a treatment step for industrial wastewater. Over 35 types of industries have been identified as having wastewaters amenable to AD treatment, including processors of beverages, chemicals, food, meat, milk, pulp and paper, and pharmaceutics. The use of agricultural residue, as well as purpose grown energy crops, is rapidly increasing at European biogas plants. The most recent application of AD is to the organic fraction of municipal solid waste streams; waste managers have found that AD provides environmental benefits allowing waste disposal facilities to meet increasingly stringent regulation. A partial summary of biogas facilities illustrates the widespread use of the technology (Table 4).

Table 4. Anaerobic digestion facilities worldwide (ECOregon)

Region	Feedstock Type	Number of Facilities	Source	Year Published
Worldwide	Municipal Solid Waste (MSW)	185	International Energy Agency, Bioenergy Taskforce	2002
United States	Municipal wastewater	3500	US Dept of Energy, (EERE)	2005
Worldwide	Industrial wastewater	1600+	Journal of Chemical Engineering	2003
Europe	Agricultural wastes	2430	European ADNETT (Anaerobic Digester Network)	2005
Worldwide	Ethanol distillery stillage	149	Journal of Biomass and Bioenergy	2000
China	Village & farm waste	~15 million	UN Economic and Social Commission for Asia	2005
United States	Livestock manure	140	AgSTAR Program (USDA, EPA, Dept of Energy)	2009

Co-digestion refers to the process of using multiple feedstocks in an AD system for the purpose of increasing the biogas yields and optimizing the treatment of the waste. Importing outside feedstocks can allow industrial users to increase their renewable energy generation beyond facility demands, thereby producing surplus electrical power or pipeline-grade methane for supply to the grid and/or surplus heat energy to supply co-located facilities. For agricultural users, certain energy crops can be grown and stored for the expressed purpose of co-digestion, buffering seasonal processing feedstocks while adding value to rotational crops.

Effluent from the anaerobic digestion process, called digestate, includes a wet fraction that can be utilized as a marketable agricultural fertilizer and a solid fraction which makes an ideal compost component. By coupling anaerobic digestion and fertilizer/compost production, the feedstock is optimally utilized and provides excellent soil amendments while reducing the amount of material in local landfills and wastewater treatment plants. Anaerobic digestate could become an important source of certified organic fertilizer as petroleum-based fertilizer costs rise and conventional acreage is converted to organic.

There are myriad reasons for the increased interest in biogas, foremost being energy efficiency. Based on life cycle analyses, biomethane has two to three times more energy yield from an acre of land than other biofuels (Figure 3). It also has versatility as fuel for electricity, heat or vehicle fuel and can be transported efficiently via natural gas pipeline to optimal end-users. Biomethane can be created from numerous high-yielding energy crops, from multiple harvests and – perhaps most significantly – from a wide variety of waste streams. In Germany, the world leader in renewable energy production, biogas plants produced over 5.4 billion kWh in 2006. There are over 3800 biogas plants in Germany alone with electrical production of 15,000 MWh, including large scale facilities that produce over 20MW.

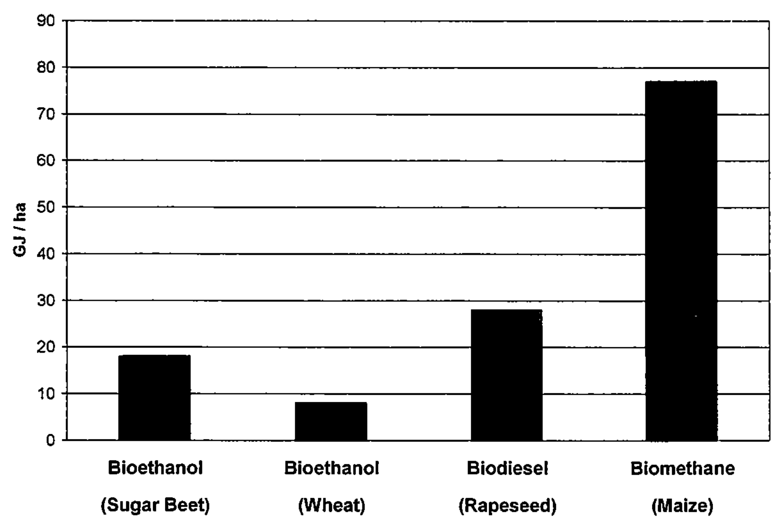

Figure 3. Net energy output of various biofuels (DeBaere, 2007)

Feedstock Digestibility Assessment

Content Analysis:
Rigorous, statistically-significant sampling and analysis of actual Eugene-Springfield MSW food waste fractions is outside the scope of this study. Instead, literature values for generic food waste have been reviewed and have been reasonably applied to the current research element. MFW quality and composition are greatly variable depending on source, region and collection method.

MFW is a typical biodegradable organic material composed of carbohydrates, lipids, cellulose and proteins. Moisture content ranges between ~70-90%. A large percent of the total solids in MFW are volatile solids (a.k.a. organic), ~85-95%. Average carbon to nitrogen ratio (C:N) for MFW from the literature is around 15, slightly low for optimized biological processes but not a precluding factor. The ideal C:N for anaerobic digestion and composting is typically quoted between 25 and 35. Nutrient levels in MFW vary widely but are relatively high, especially in nitrogen, which increases digester effluent fertilizer value.

A characterization of food waste (*Zhang et al, 2007*) in the San Francisco area assessed daily and weekly variability of MFW collected from 500 commercial sources, including restaurants and groceries, over the course of two months. This study is similar enough to our scenario that the results bear repeating here (Table 5).

Table 5. Average compositional data for MFW (modified from *Zhang et al, 2007*)

Parameter	units	Value
Moisture	*as is %*	69.10
Total Solids (Dry Matter) (TS)	*as is %*	30.90
Volatile Solids (Organic Matter) (VS)	*VS/TS*	85.27
Carbon (Total)	*dry matter %*	46.78
Nitrogen (Total)	*dry matter %*	3.16
Ammonia	*dry matter ppm*	973
Phosphorus (Total)	*dry matter %*	0.52
Potassium	*dry matter %*	0.90
Calcium	*dry matter %*	2.16
Magnesium	*dry matter %*	0.14
Sulphur (Total)	*as is ppm*	2508
C:N ratio	*w:w*	14.8

Existing Academic Research:
Volatile Solids (VS) is the fraction of an organic material that is available for biodegradation and is therefore indicative of the potential biogas production. It is often expressed as a percent of Total Solids (TS). Typically, not all of the available VS are completely degraded in a continuously operating digester. The proportion of degradation, known as VS destruction rate, is dependent on feedstock type, digester design and residence time. Much of the reviewed literature on MFW reported VS destruction rates of 80-90%, indicating that MFW is significantly more biodegradable than other common digester feedstocks. For example, dairy manure and municipal wastewater solids have an average VS destruction of 35-40% and 50-60%, respectively.

Biochemical Methane Potential (BMP) is an analytical tool that describes the volume of methane (CH_4) that can be produced from a given amount of VS for a particular feedstock; it is expressed as m^3 CH_4 / *kg* VS. The BMP is a batch assay designed to simulate a favorable environment where degradation will not be impaired by nutrient or bacterial deficiencies, toxicity, oxygen, pH, over-feeding, etc. In this way, relative biodegradability of various materials can be compared. It should be noted that BMP values reflect the ultimate methane production from a feedstock. Actual yields in commercial applications can vary.

Numerous studies have investigated the methane potential of MFW under various scenarios. In all cases, specific methane yield for MFW is relatively high compared to other commonly used feedstocks. The reported specific methane yield for "food waste" – most similar to the current study's assumptions – ranges from 0.300 to 0.490 m^3 CH_4 / *kg* VS. These values are impressive considering that the methane yield for manures, the most frequent agricultural feedstock, is often quoted at 0.200 m^3 CH_4 / *kg* VS or lower. Since the 2007 Zhang study is most directly applicable to the scenario of the current study a specific methane yield of 0.435 m^3 CH_4 / *kg* VS will be used for biomethane production calculations throughout this paper. A summary of peer-reviewed and industry literature references for MFW are presented below (Table 6).

Table 6. Potential methane yield of various feedstocks (ECOregon, 2007)

Feedstock	Methane Yield (m^3 CH_4 / *kg* VS)	Reference
SSO (restaurants, grocery, hotel, businesses)	0.435	Zhang et al, 2007
SS OF-MSW	0.399	Mata-Alvarez et al, 1990
SS OF-MSW	0.459	Hansen et al, 2006
OF-MSW (hand separated)	0.430	Pauss et al, 1984
OF-MSW (hand separated)	0.390	Cecchi et al, 1986
OF-MSW	0.440	Lee et al, 1999
Food waste	0.490	Forster-Carneiro et al, 2008
Food waste	0.350	Steffen et al, 1998
Food waste	0.472	Cho & Park, 1995
Food waste	0.489	Heo et al, 2004
Food waste	0.300	Xu et al, 2002

The high VS destruction rate combined with the relatively high proportion of VS/TS (85-95%) makes food waste an excellent candidate for degradation. In fact, the degradation rate of MFW is so rapid that it can disrupt the balance of the bacterial consortium in a digester. As discussed, acidogenic bacteria beak down hydrolized matter into organic acids for use by methanogenic bacteria. If allowed, fast-acting acidogens can produce acids at a rate that can overwhelm the reactor, dropping pH to a level that is toxic to the slower-acting methanogens. This can be corrected by simply reducing the organic loading rate to the digester – a variation of which is to blend MFW with a lesser-degradable "buffer" material – or by using a multi-staged system that separates the acidogenic and methanogenic phases.

Similar Facility Case Studies:
At least two demonstration digesters are currently using MFW in North America; one digests solely commercial food waste while the other incorporates mixed residential food waste. In addition, one well documented case of co-digesting MFW at a waste water treatment plant exists. A number of full scale biogas facilities for the entire organic fraction of the municipal solid waste stream (which includes MFW) are in the planning stages. The examples below are not the only cases of MFW being utilized in AD systems; it is used throughout Europe and Asia in conjunction with other feedstocks.

The Biogas Energy Project pilot plant in Davis, California using anaerobic phased solids (APS) digester technology came on line October 24, 2006 and for the first six months used local food waste and restaurant scrapes collected by Norcal Waste Systems that were transported 70 miles to the digester. UC Davis professor Ruihong Zhang and Onsite Power Systems Inc. designed and built this thermophilic, two phased anaerobic digester based on small scale laboratory studies that showed methane yields of 320 *L/kg VS* with a VS reduction of 80%. The scaled up demonstration plant was expected to handle 3-5 ton/day green waste or food waste, digest solids within 12 days, yield 11,400–22,900 ft^3 biogas/day and produce an electrical output of 600–1200 kWh/day. The original design of this APS digester required green waste to be screened through a 2–4 inch trammel and then the screened feedstock would be augured to a mix tank heated to 180 °F. The waste stream is introduced to one of four hydraulic thermophilic (135°F) mix tanks where biomedia colonized with hydrolytic and other anaerobic bacteria breakdown the feedstock to organic acids. Organic acids are transferred to a fifth thermophilic (135°F) hydraulic tank where ultimately the methanogens attached to biomedia produce methane. After the initial six months of inefficiently sourcing feedstocks from long distances the demonstration plant was shut down. Efficiency improvements, such as insulating the tanks and modifying the material handling equipment were made. With long term plans to test mixtures of corn waste with food waste and then grass clippings, the demonstration project is up and running again using soup waste from a local soup processing plant.

The Dufferin Demonstration Biogas Plant in Toronto, Ontario, Canada has been in operation since 2002. The facility has a throughput of 25,000 tons/year (approximately 100 tons per operational day) of source-separated organic wastes. A pilot residential, curbside organic waste program collects food waste, soiled paper and food packaging, paper plates, cups, towels and tissue, pet waste and bedding/litter, houseplants and baby diapers. Canada Composting Inc. operates the complex that uses wet, complete-mix (biogas injection), mesophilic technology developed by the German company BTA International. One 3,600 m^3 anaerobic digester allows for a hydraulic retention time of 15 days and a solid retention time of 25 days. Pretreatments include running the incoming waste stream over a trommel screen, then through a hydropulper where plastic bags and other floating debris is raked off and finally through a hydrocyclone for grit removal. The facility reports a specific methane potential of at least 360 m^3 CH_4/*ton* VS; or 110-125 cubic meters of 55-60% methane-content biogas per ton of waste processed. Due to the inconsistent feeding schedule (weekdays only), the plant has no utilization of the biogas; it is currently flared. The plant is located in a residential area – within 100 meters of homes – and utilizes a biofilter to reduce odors from the tipping floor of the reception building. Toronto has expanded the curbside source-separated organic system city-wide and also has a commercial collection system in place. The city is planning an expansion of the Dufferin biogas plant to 55,000 tons/year and construction of a second, similar sized second facility by 2011.

The East Bay Municipal Utility District (EPMUD) in Oakland, California co-digests food waste with wastewater solids and other high strength wastes at its wastewater treatment plant (WWTP). Under a pilot program started in 2004, EBPUD WWTP receives 20-40 tons / day of sorted, pre-ground food waste from a hauler that is then diluted and routed through a pulper/trommel to the digesters. The process utilizes excess capacity and existing infrastructure to increase methane production at a suitable facility without the need for additional permitting. Methane production per digester volume increased 3.5-fold over digestion of wastewater solids alone. In an effort to quantify the contribution of food waste to the system, a bench scale study evaluated the digestion of incoming MFW at different residence times and temperatures. MFW had more biodegradable solids (VS/TS of 86-90%), a higher VS destruction rate (74-81%), required less retention time (10 vs. 15 days) and allowed for higher organic loading rates (up to 5 times) compared to wastewater solids. The study concluded the MFW has a specific methane yield of 426–603 m^3 CH_4/*ton* VS. This equates to 130 to 320 kWh per wet ton of MFW under the EPMUD WWTP scenario.

Co-digestion

Co-digestion refers to the process of utilizing multiple waste streams in an AD system for the purpose of increasing the biogas yields and optimizing the degradation of the waste. Co-digestion is typically synergistic; a combination of feedstocks results in higher methane yield than if the feedstocks were digested separately. This effect is thought to be due to improved micro-nutrient availability and optimized rheological qualities for multiple sources. The bacterial colony utilized in anaerobic digestion requires a wet environment; the high solids content of a dry feedstock will require a suitable low solids feedstock for co-digestion (or dilution water). Similarly, a single feedstock rarely contains the proper balance of micro nutrients for optimal methane production. Multiple feedstock co-digestion is often the best way to ensure a balanced biological system. The frequency distribution of anaerobic digester systems utilizing multiple feedstocks (i.e. substrate) in the EU is presented in Figure 4.

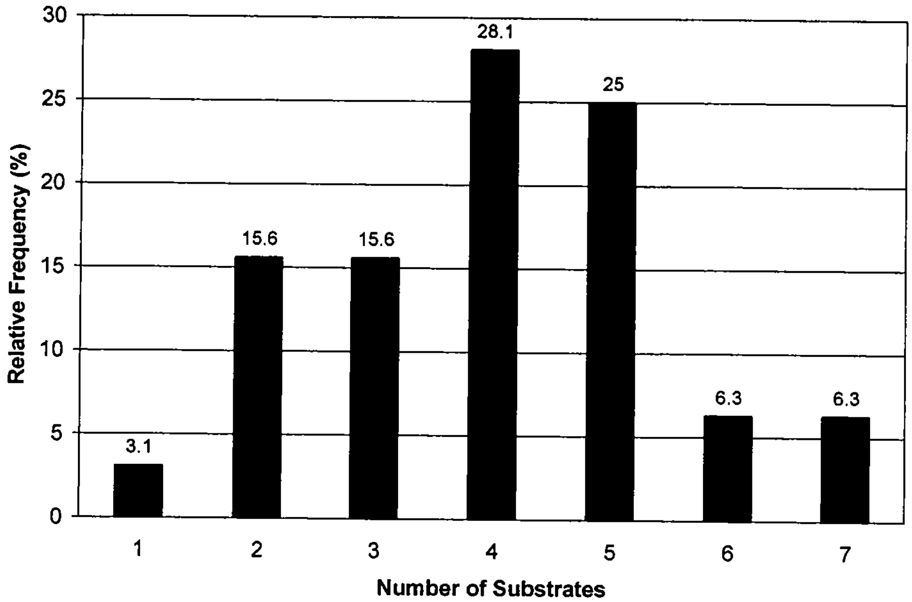

Figure 4. Frequency distribution of "number of substrates" for anaerobic digester facilities built in EU, 2003 - 2005 (Hopfner-Sixt, et al. 2005)

A number of potential feedstocks exist in Lane County in sufficient quantities that are suitable for co-digestion with MFW. Some of these materials (including manures, grass straw, "green" (yard/garden) waste, and wastewater sludge) currently have relatively low end-use value. The high degradability, methane potential and tipping-fee revenue for MFW would provide a biological, financial and energetic boost to digester systems primarily designed for waste management of these substrates. All anaerobic digestion feedstocks are not equal in terms of methane potential (Figure 5).

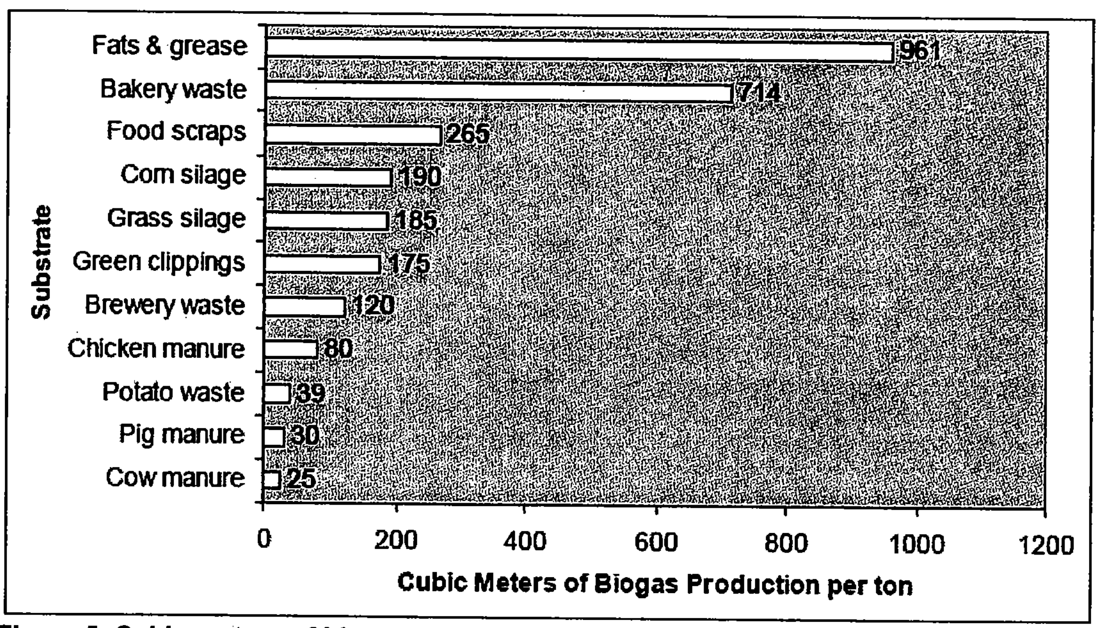

Figure 5. Cubic meters of biogas production per ton of substrate (from Kramer, 2008).

The following categories of substrate were selected for assessment based on knowledge of availability in the southern Willamette Valley by ECOregon and following input from Lane County Community & Economic Development. They were considered to be the most viable near term, locally-sourced feedstock available. It is not intended to be an exhaustive list; other sources of co-digestion feedstock exist.

Annual Ryegrass Straw

Annual Ryegrass Straw (ARS) is a relatively dry, lignocellulosic material. According to the Lane County Ryegrass Straw Conversion to Renewable Energy and Biofuel Production Project/Feasibility Study there are approximately 200,000 tons of ARS which could be available each year in the Southern Willamette for conversion to renewable energy.

A large fraction (94%) of total solids in ARS are considered volatile solids (a.k.a. organic or degradable). The ideal carbon to nitrogen ration (C:N) for anaerobic digestion is typically quoted below 30:1. Literature indicates C:N for straws is highly variable, between 50:1 and 100:1. Lab results on C:N from an ARS grab sample from the 2008 harvest were 39:1 (Table 7). This may be due to an abnormally high nitrogen level in the sample: total nitrogen, and hence protein, from this particular sample is roughly 2-5 times higher than some literature values.

Table 7. Proximate data on ARS 2008 harvest grab samples

Parameter	*units*	Value
Moisture	*as is %*	8.16
Total Solids (Dry Matter) (TS)	*as is %*	91.84
Acid Detergent Fiber	*as is %*	41.92
Crude Protein	*as is %*	8.85
Crude Fat	*as is %*	0.93
Total Carbohydrate	*as is %*	76.28
N-Free Extractive Matter	*as is %*	34.36
Ash	*as is %*	5.81
Total Nitrogen (TN)	*as is %*	1.42
Total Phosphorus (TP)	*as is %*	0.09
Potassium	*as is %*	1.07
Sulfur	*as is %*	0.17
Magnesium	*as is %*	0.14
Calcium	*as is %*	0.36
Sodium	*as is %*	0.42
C:N ratio	*w:w*	38-1

While ARS is less valuable as animal feed than bluegrass, perennial ryegrass or tall fescue straws due to low protein content, it has more nutritive value than some cereal straws. It has high energy and fiber contents relative to other grass straws. No other constituents are found at levels that are obviously problematic.

ARS shows good digestibility. While the biochemical methane potential is not as high as some purpose-grown energy feedstocks (i.e., whole crop grasses and grains) it does exceed other commonly used agricultural waste feedstocks such as dairy manure. The methane yield per fresh weight is even more impressive due to the high total solids and volatile solids content of ARS – the equivalent of 7.6 MMbtu/raw ton. The returned average BMP value for ARS was 286 m^3 CH_4 */ tonne VS.*

Bottom line: Anaerobic digestion of ryegrass straw, with its high solids content, has the potential for very high energy yields, on a weight-to-weight basis, compared to more common low-solids feedstocks. The bacterial colony utilized in anaerobic digestion requires a wet environment; the high solids content of ARS will require a suitable low solids feedstock, like MFW, for codigestion (or dilution water).

Dairy Manure

According to Oregon Department of Agriculture's Concentrated Animal Feedlot Operation (CAFO) permits, there are at least 38 operating dairies in the southern Willamette Valley (south of Salem); 11 of those are permitted for 1000 head or more. A 1000 head dairy produces approximately 20,000 tons/year of raw manure, and perhaps another 10% in organic bedding material. If all the manure from all of Oregon's 120,000 dairy cows were anaerobically digested, the captured methane could be converted into 14MW of electricity.

Dairy manure is the most common agricultural digester feedstock in the United States. Most on farm digesters in Europe also use some percentage of livestock manure. While dairy manure has relatively low methane yield, it is a good buffering agent for higher energy feedstocks. In a codigestion scenario, manures will buffer pH, supply nutrients and provide consistent feedstock from a point-source. In combination with ARS (at less than 10% moisture), dairy manure (at approximately 90% moisture) would also provide the water content required for anaerobic digestion.

Manure digestion systems also have related environmental advantages. The Oregon Department of Energy acknowledges that manure digesters in conjunction with livestock operations reduce odor levels (by 90% or more), reduce bacteria/pathogens (by 90% or more) and improve nutrient management options. As for digestate final products, fiber can be reused as stall bedding material and liquid effluent can be land applied to the surrounding acreage to irrigate and fertilize incoming forage crops. In addition, significant emission reduction benefits are realized; methane is 21 times more potent than carbon dioxide as a greenhouse gas.

Anticipated methane yields for dairy manure depend on type and quality of livestock feed, rearing and handling practices, bedding type, potential antibiotic/hormone treatments and digester performance parameters such as hydraulic retention time and temperature; literature values range from 126 - 208 *l CH4 /kg VS*. Volatile Solids destruction is low for dairy manure, typically 35-40%. In comparison, food wastes can have destruction rates of 80-90% or higher. Co-digestion can produce synergistic effects related to methane production and VS destruction. Feedstocks high in lipids and/or carbohydrates with high VS are good feedstocks for co-digestion with manure. Protein rich feedstock, such as whey, can also be beneficial.

Table 8. Sample proximate data for dairy manure

Parameter	units	Value
Moisture	*as is %*	89.5
Total Solids (Dry Matter) (TS)	*as is %*	10.5
Volatile Solids (Organic Matter) (VS)	*VS/TS*	80
Total Nitrogen	*lb/ton*	10
Total Phosphorus (as P2O5)	*lb/ton*	5
Total Potassium (as K2O)	*lb/ton*	8.1
pH	*as is %*	6.8
C:N ratio	*w:w*	17.2

(compiled from lab analysis of local dairy manure and literature values)

ECOregon is performing anaerobic digester feasibility studies for some individual dairy farms in the Willamette Valley in 2009. Positive outcomes that proceed to development may provide a near-term destination for some ARS, at least on a demonstration basis.

Bottom line: Dairy manure is a fine buffering substrate, although with relatively low energy potential, and provides moisture and nutrients for co-digestion.

Poultry Litter

The Willamette Valley's mild year-round climate is ideal for growing broilers (or fryers) for the chicken meat industry. Most Oregon broilers are grown on family farms distributed west of the Cascades, from Eugene to the Columbia Gorge. Poultry litter, consisting of chicken manure, bedding material and feathers, is removed from the barns during down time between flocks; bedding material typically consists of wood shavings, sawdust or rice hulls. Currently, the litter is typically stored on site until it can be sold to area independent farmers, contract haulers or landscape material companies. There is over 1.1 million sq. ft. of barn space and up to 10 million broilers within a 40-mile radius of Junction City, Oregon. At typical production rates of manure, these sources have approximately 30 tons/day of poultry litter.

Poultry litter is very high in nitrogen compared to other manures, creating both an opportunity and a challenge. Since all nutrients pass through the digester, the digestate has potential for a high value fertilizer. The high nitrogen content could also result in high ammonia levels in the digesters, a potentially toxic situation for anaerobic microbes. However, when combined with high carbon ARS, the nitrogen in poultry litter will help balance the C:N toward the ideal ration of 30. The dry nature of poultry litter would require other wet substrates or dilution/recycled water. Chicken manure has better methane yields than dairy manure, especially on a fresh weight basis (due to less water), but yields from total litter are dependent on bedding material.

Table 9. Sample proximate data for poultry litter

Parameter	units	Value
Moisture	*as is %*	30
Total Solids (Dry Matter) (TS)	*as is %*	70
Volatile Solids (Organic Matter) (VS)	*VS/TS*	70-80
Total Nitrogen	*lb/ton*	70.1
Total Phosphorus (as P2O5)	*lb/ton*	50.2
Total Potassium (as K2O)	*lb/ton*	47.6
pH	*as is %*	6.82
C:N ratio	*w:w*	3.0-10

(compiled from lab analysis of local poultry litter and literature values)

Wood shavings and sawdust, as with all wood products, are relatively refractory to anaerobic degradation – but at such small particle size may not present a problem. Grass seed screenings, which are plentiful in the Valley, cannot be currently used for broiler bedding material because some of the weed seeds remain viable through the composting process making it unsuitable for market. However, weed seeds are rendered unviable by the digestion process. This would allow for use of grass seed screenings as bedding and provide cost savings to chicken farmers while increasing the degradability and methane potential of the litter.

Bottom line: Poultry litter has high methane potential for a manure, and high nitrogen would help to balance high carbon codigestates. Low moisture content allows for economic transportation, but would require water addition.

Food Processor Residue

The productive agricultural area of the southern Willamette Valley also gives rise to a number of food processing operations, including fruit/vegetable, grains, bakery, dairies, creameries, breweries, wineries and others. The larger operations with more viable waste streams are concentrated in the Eugene and Salem areas. These by-product sources often have end-uses other than landfilling – including animal feed, composting and direct land application. The variability in quantity, biodegradability, energy potential, contamination and cost or expense of available food processor residue is vast and would require specific case-by-case analysis before utilization in a co-digestion scenario. However, some general observations are made below.

Certain food process wastes are extremely seasonal:

- NORPAC Foods, with multiple plants in Salem, produces about 125,000 tons of vegetable waste during 4 harvest months, an average of over 1,000 tons/day.
- National Frozen Foods in Albany has a similar pattern, though not as extreme: 2.3 tons/day of vegetable waste increases to 20 tons/day from July through October.

These sources could be balanced by those with alternative production seasons:

- Northwest Onion Company, with one storage shed in Salem and three others nearby, produces about 180 tons/day of onion waste from September through April.
- Grain Millers in Eugene produces oat hull waste at a rate of 2 tons/hour, 24 hours/day and 355 days/year. Select food processing residues between Eugene and Salem are summarized in Table 10.
- Breweries, creameries and bakeries have steady daily output on an annual basis.

The content of waste from a single food processor can likewise be wildly variable or incredibly consistent. Unlike MFW, impurity problems can be monitored relatively easily; if the waste is currently going to animal feed, contamination minimization is likely already in place. Most food processors already have procedures and equipment in place for handling, storing and hauling their organic wastes.

Some food processing residue can garner tipping fees if used in a biogas plant, which can offset transportation costs and allow for sourcing from a larger radius. For example, Oregon's four largest breweries produce approximately 10 tons/day of spent yeast, the strength of which presents a disposal challenge. Co-digestion of yeast waste has been shown to greatly increase methane yields so long distance trucking (over 100 miles from Eugene) may be feasible in this case.

Table 10. Sampling of available food processor residues in the southern Willamette Valley

Facility	Material	Daily Amount	Comments
Oregon Fruit Products	Fruit waste	1.5 tons	4 tpd, Jun-Aug
Kerr Concentrates	Fruit waste	15 – 35 tons	
Franz Bakery	Bread waste	1.4 tons	
Grain Millers	Grain waste	48 tons	
Kettle Foods	Potato waste	9 tons	
Kettle Foods	Chip waste	9 tons	
Kettle Foods	Brown grease	650 gals	
NORPAC	Vegetable waste	1000+ tons	Jul-Oct only
National Frozen Foods	Vegetable waste	2.3 tons	20 tpd, Jul-Oct
Northwest Onion Company	Onion waste	180 tons	Sep-Apr
Truitt Brothers	Fruit waste	40 tons	Jul-Nov only
Toby's Foods	Produce waste	0.1 tons	
Springfield Creamery	Creamery waste	1.7 tons	
Golden Temple	Cereal waste	0.2 tons	
Ram Brewery*	Spent grains	0.3 tons	

**there are 15 comparably-sized breweries in the southern Willamette Valley*

The following graph of 181 samples is provided to give insight into potential methane yield values for food processing residue (Figure 6). Some samples are blends, such as food waste, market waste and salads, but most samples represent individual components expected to be found in food processor residue.