2013/2014

Recology Oregon Recovery Inc.

Metro Central Transfer Station Sustainability Report

Commercial Organics Sustainability Report

2013/2014

Recology
WASTE ZERO

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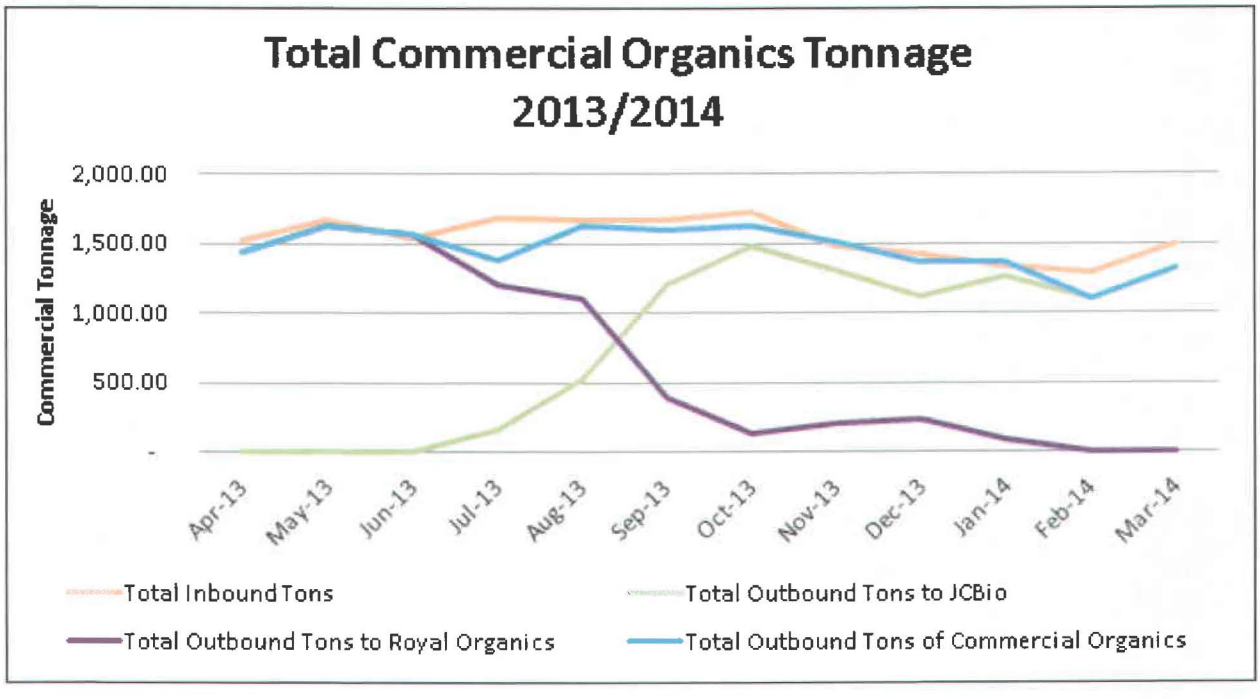
Summary

Recology Oregon Recovery Inc. (ROR) is pleased to submit this annual commercial organics sustainability report, as appropriated by our commercial organics contract number 931125, section G. This report covers the period April 2013 – March 2014.

Sustainability is an evaluative approach to making operational and managerial decisions through economic, social, and environmental perspectives. Central to sustainability is the concept of WASTE ZERO – making the best and highest use of all resources. This includes recycling, composting, and engaging our employees as well as the general public through educational efforts.

Achieving sustainability in our commercial organics operation is a process and this report provides a detailed look into each component of that process. In 2013/2014, ROR maintained a high degree of commitment to sustainability in all aspects of the operation and will continue to build on those efforts in the years to come.

The chart below identifies the total commercial organic material tonnage received and transported from April 2013 – March 2014. Commercial volumes varied slightly month to month, coinciding with the season, yet remained static compared to residential fluctuations and seasonality.



History of the Commercial Organics Program[1]

The Commercial Organics Program began in 2004 when Metro was seeking a processing facility in the Metro region. Initially, the plan was to haul commercial organics from the Metro Central Facility to Cedar Grove's Maple Valley compost facility in Seattle. The long term plan was to site a facility in the Portland area to process the material.

By 2009, a local site was still not developed and hauling organics was becoming a great expense due to the growth in volume. By October 2010, Metro signed a contract with Recology, who had just purchased "Nature's Needs," a composting facility in North Plains. By May 2011, Recology began to haul commercial organics to Nature's Needs. However, due to odor-causing potential, commercial organics were no longer accepted at the site.

Recology began conversations with JC-Biomethane, LLC., to discuss the possibility of sending their commercial organics to the plant to be converted into clean biogas.
In February 2013, a contract was signed between Recology and JC-Biomethane. JC-Biomethane completed construction that summer, and Recology began hauling loads to the plant in July 2013.
By October 2013, all commercial organics were heading to the JC-Biomethane facility to be processed.

Trucks & Equipment

ROR was committed to utilizing Tier 3 compliant processing equipment in the commercial organics operation throughout 2013/2014 as outlined below.

ROR Equipment and Usage				
Unit	**Equipment Description**	**Type of Fuel**	**Tier**	**Location**
16226	19 Peterbilt 367 Tractor	B-20	4	Road
16227	20 Peterbilt 367 Tractor	B-20	4	Road
16210	03 OTTAWA Yard Tractor	B-5	N/A	Bay 3
20138	CAT 950H Wheel Loader	B-5	3	All Bays
20139	CAT 950H Wheel Loader	B-5	3	All Bays
20140	CAT 938H Wheel Loader	B-5	3	Commercial
20141	CAT 226B2 Wheel Loader	B-5	3	All Bays
20154	CAT 914G Wheel Loader	B-5	3	All bays
08125	Forklift	Propane	N/A	All
08126	Forklift	Propane	N/A	All

[1] Expanded history in Appendix A.

Idling

ROR enforces an anti-idling policy, documented below, and has placed stickers on all diesel equipment to remind the equipment operator about the idling time restrictions.

Statement of Policy

Recology best practices contain a limit on unnecessary idling. No vehicle or engines subject to this regulation may idle for more than five consecutive minutes. This limit applies to all off-road diesel vehicles subject to the regulation, unless the vehicle is idling for a specific, acceptable purpose as defined in the regulation or a waiver has been granted.

Off-Road vehicles effected

- Loaders, Compactors
- Dozer, Scrapers, etc.
- Forklifts (diesel engines)
- Man lifts

When is idling for more than five minutes allowed?

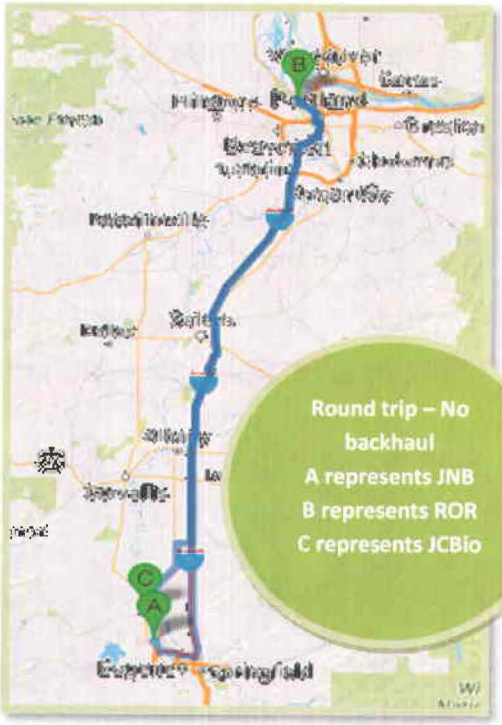
- When it is necessary for servicing, testing or maintenance
- The exemption for servicing includes idling necessary to regenerate exhaust filters which require the engine to be idled periodically to regenerate, or burn off solids collected in the filter
- When it is required for safety reasons
- Provide air conditioning or heat to ensure the health and safety of the operator is allowed
- Warming up a vehicle to operating temperatures specified by the equipment manufacturer
- When verifying that the piece of equipment is in safe operating condition

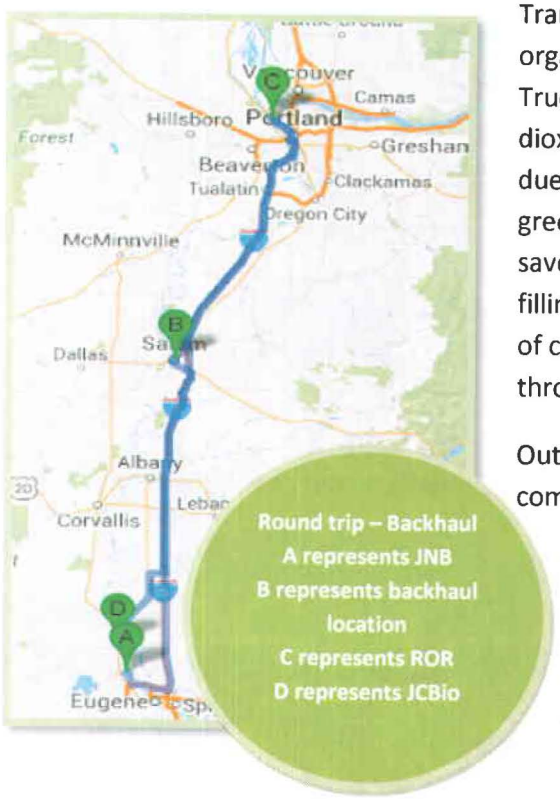
These diesel particulate matter reduction strategies are enforced by the operations supervisor, and lead operators at the transfer station. These policies carry consequences for employee non-compliance. All vendors and subcontractors are held to the same standard as outlined in the Metro commercial organics contract number 931125 when waiting to be loaded by ROR.

Fuel

ROR believes in using alternative fuels. As in nearly all of Recology operations, ROR purchases and fuels the onsite mobile equipment with B5 biodiesel blend.

ROR utilized JNB Trucking in 2013/2014 to transport commercial organics. Recology scheduled their trips in conjunction with JNB Trucking backhauls into Portland an average of 4 – 5 times per month. On average, Recology sends 60 tons of commercial organic waste to the JC-Biomethane site Monday through Friday. When scheduling these trips with JNB Trucking backhauls, 13.6 gallons of diesel fuel are saved and 305.7 lbs of CO_2 emissions are avoided.[2]





Transporting commercial organics through JNB Trucking generates carbon dioxide emissions; however, due to the amount of greenhouse gas emissions saved through avoided land filling of food waste and electricity generated through the creation of clean biomethane, the carbon dioxide emissions emitted through transportation is negated.

Outlined in the table below are the details of the daily transport of commercial organics to JC-Biomethane.

No Backhaul	Backhaul
CO_2 Emissions: 2,461.8 lbs	CO_2 Emissions: 2,190.6 lbs

[2] See Appendix B for sources.

Table of Comparisons		
Variables	**No backhaul**	**Backhaul**
Round trips	2	2
Backhaul trips	0	1
Total miles	466	397.7
Total gallons	110	98
Total fuel costs	$435.02	$381.74
CO_2 emissions (lbs)	2,461.8	2,190.6
CO_2 emissions saved (lbs)	0	305.7

Natural Resource Conservation

As part of Recology's commitment to making the best and highest use of all resources, ROR has facilitated an employee on-site recycling program at the transfer station. This practice has continued and enhanced recycling at our administrative office and break room. Paper, plastic bottles, aluminum cans, organics and glass used by ROR employees at the transfer station are diverted from the landfill through this program. Educational signs in both English and Spanish are in place to inform employees and others on the proper way to sort recyclables.

ROR installed an energy efficient dishwasher in the employee break room. Prior to the installation of the new, energy efficient dishwasher, ROR was purchasing up to 2 cases of single use paper cups per month. Since installation, ROR has not ordered a single box of paper cups, eliminating single use paper cups from the waste stream.

In 2013, ROR upgraded to energy efficient electric hand dryers, which not only reduced paper towel consumption but also eliminated battery purchases and disposal as ROR continues to purchase 100% wind powered energy. ROR also purchased new exit signs powered by LED lights in 2013, further reducing battery purchases and disposal. ROR will look to audit the office and exterior lighting in 2014, looking for opportunities to upgrade to a more energy efficient system.

Energy

In an effort to continue seeking the best and highest use for all materials, ROR partnered with JC-Biomethane, LLC., located near Junction City, Oregon. JC-Bio is the first biogas plant in the Pacific Northwest to produce energy from an anaerobic digester through the use of post-consumer food waste.

Through the decomposition of commercial organic waste, JC-Bio creates 12,250 megawatt-hours of clean renewable energy, used to power approximately 1,500 homes in Junction City annually. This food waste that would be disposed into landfills is alternatively used to produce the biogas that provides clean energy, successfully diverting greenhouse gas emissions that would accumulate in a landfill and carbon dioxide emissions that would otherwise be generated through the use of fossil fuels for electricity.

Table of Results		
Metric	**Value**	**Unit**
Commercial organic waste delivered to JC-Bio from Recology	9,470.3	Tons/year
Energy generated through anaerobic digestion	12,250	MWh/year
Replaced use of synthetic fertilizer	2,000	Acres/year

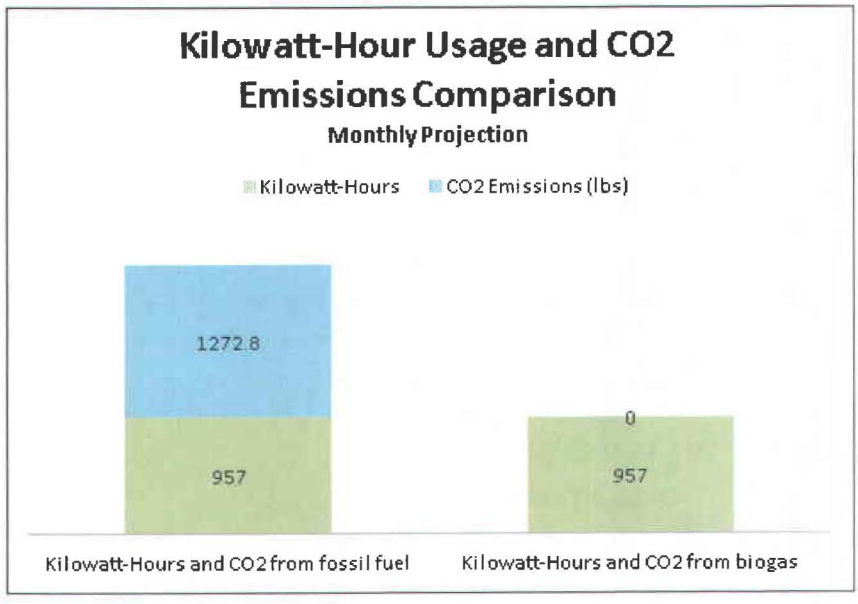
Methane is a greenhouse gas that is 21 times more potent than carbon dioxide. It has a greater ability to absorb heat and remains in the atmosphere longer than carbon dioxide over a 100 year period. Reducing methane gas is essential for diverting climate change.

In the ten months since the inception of this partnership, Recology and JC-Bio have successfully diverted greenhouse gas emissions from the atmosphere and 378,812 cubic feet of waste from the landfill. That is enough waste to fill 4.3 Olympic-sized swimming pools! However, Recology only began hauling green waste to JC-Bio in July 2013. In the years to come, it is projected that Recology will be sending approximately 15,000 tons of commercial organic waste to JC-Bio annually. This will further increase the diversion of greenhouse gas emissions.

According to the EPA, the use of fossil fuels to generate electricity is the largest source of carbon dioxide emissions in the United States (EPA, 2014). Powering approximately 1,500 homes in Junction City through the use of commercial organic waste prevents the generation of kilowatt-hours through fossil fuels and utilizes the energy potential of food waste converted into clean biogas.

While the combustion of biogas emits carbon dioxide, the carbon in biogas created from plants comes from the sequestration of CO_2 in the atmosphere through photosynthesis. Therefore, biogas is considered to be carbon-neutral.

A byproduct of the biogas production process is nutrient-rich liquid fertilizer. This fertilizer is used on 2,000 acres of local farm land annually, reducing the use of synthetic fertilizers which are harmful to bodies of water, normally causing eutrophication and aquatic dead zones.



Monthly projection based on average kilowatt-hour usage in Oregon and the EPA's metric for CO_2 emissions per kilowatt-hour. Sources in Appendix C.

Special Projects

ROR has and will continue to undertake good faith efforts for any new construction associated with the commercial organics program to achieve environmental performance consistent with Metro's sustainability goals.

In 2013, Metro began a pilot program with Recology to process their commercial organic waste at ROR's compost site in Aumsville. In order to avoid any odor complaints, only one load (approximately 25 tons) of green waste was delivered per week. A total of nine loads were processed, creating 225 tons of nutrient-rich compost that was sold to retail yards for landscapers, farmers and resale yards.

During the 2013/2014 year, Recology sent a total of 8,010.53 tons of commercial organic waste to Royal Organics located in central Washington.

Both Recology and Metro plan to provide more feedback to the haulers who pick up commercial organic loads. Providing written, detailed feedback is a strategy to help reduce contamination. When the hauler is aware of acceptance standards and acceptable loads, the message can be passed on to the generator. The generator is the customer of the hauler, therefore the hauler can facilitate the communication between businesses and local governments.

Metro would like to expand their processing capacity to accommodate the growing volume of residential organics and commercial food waste. A consultant was hired to examine what Metro can do and what role they can play in creating more capacity to process food containing feed stocks.

Recology is proud to have partnered with JC-Bio, who excels at odor control through the use of an ozone filtration system. Ozone is an oxidant that breaks down substances into their base components. This breaks the bonds between chemicals that cause odors, successfully eliminating any offensive smells.

"This study is designed to look at that gap in processing and see what Metro can do to build more processing capacity in or near the region."
—Bruce Philbrick, Transfer Station Operations Manager at Metro

Toxics Reduction

ROR has maintained its commitment to reducing toxics within all aspects of the operations. ROR does not currently utilize any product, toxic or not, to treat, handle or process commercial organic material.

Sustainable Procurement Policy

While there is no formal policy which mandates sustainable procurement, ROR has actively sought out and evaluated potential vendors and suppliers using a criterion that includes their MBE, WBE, ESB status, location and sustainable product offerings.

Quality Work Life

ROR embraces diversity by recruiting for the most qualified candidates; ROR casts a wide net to ensure we tap into numerous resources to create a qualified and diverse candidate pool.

Commercial organics at ROR has 4 – 5 employees dedicated to removing contaminants and ensuring clean loads.

Zdenka Novak – *Spotter/Sorter*

Zdenka has been working at ROR for three years. She believes the commercial organics operation is great for the environment. Collecting food waste and transforming it into a useful product (via anaerobic digestion) is what she likes about the operation. Zdenka contributes to sustainability by composting at home.

Kyle Crandell – *Spotter/Sorter*

Kyle started working at ROR 1-year ago in vector control while also spending time on the sort-line. Kyle currently works as a spotter/sorter in the commercial organics bay. Kyle is in charge of spotting trucks that drop off food waste. Kyle also removes contaminants, wax coated and regular OCC from the food waste, trying to keep as much non-food material out of the stream as possible.

Larry Vanderpool – *Spotter/Sorter*

Larry has been with ROR for over two years. He likes that the commercial organics operation keeps material out of the landfill and instead uses it to create energy. Larry was an avid recycler before working for ROR; he began a recycling program at his apartment complex to promote environmental sustainability.

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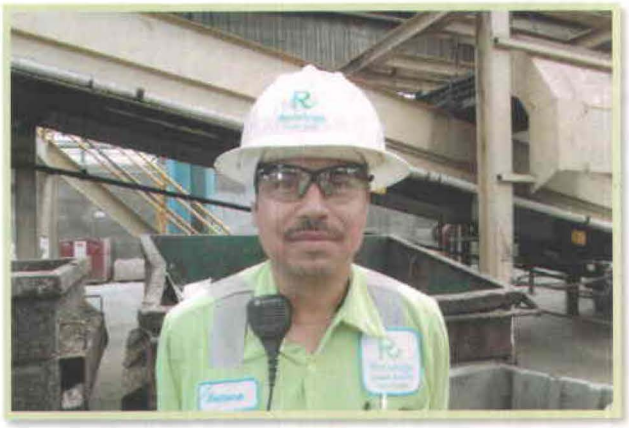
Jose Romero-Perez (Romero) – *Operator*



Romero has been at MCS for 17 years and with ROR since day 1 of the contract. Romero has been working in commercial organics for 3 months now and is responsible for separating heavy contaminants, isolating and building a clean feedstock as well as loading the JNB outbound trucks headed for JC Bio.

Additional efforts to locate and tap into this diverse pool of experience include ROR's Employee Referral Program which offers eligible employees a referral bonus for candidates who are subsequently hired.

ROR treats its employees in a way that ensures long-term workforce sustainability and is proud to provide a strong competitive compensation package to our employees that include excellent wages and benefit plans. ROR's benefits package is an important component of employee's total compensation. Benefits are intended to help employees' live well—both physically and financially.

ROR provides a living wage at or above market rate to all employees. In addition, ROR also provides an employee benefits package including paid time off, medical, dental, vision, prescription, life insurance, and long term disability insurance to employees and their registered domestic partners or spouses. ROR also provides a 401k with discretionary match, ESOP and has developed a workforce incentive plan. As part of our Employee Assistance Program, confidential, professional assistance made available to employees and members of their households to help them manage psychological, financial, legal, family-related and other life-balance issues.

ROR utilizes 4 – 5 employees to process inbound commercial organics at MCS, including spotters, sorters and operators. In addition to the safety trainings outlined below, all personnel dedicated to the processing of commercial organics at MCS have been trained in the following standard operating procedures.

- **Traffic:**
  1. **Call out to the bay where the vehicle will be sent and what material is in it**
  2. **If load is unknown by driver, call spotter for directions to proper area**
- **Spotters:**
  1. **Acceptable Source-Separated Commercial Organic Waste includes:**

a. Pre- and post-consumer food waste:
    i. Fruits
    ii. Vegetables
    iii. Dairy
    iv. Baked goods
    v. Grains
    vi. Meats, bones, eggs and fish
b. Coffee grounds, filters and tea bags
c. Food-soiled cardboard and food-soiled uncoated paper
d. Wax corrugated cardboard
e. Paper napkins and towels
f. Floral waste
g. Compostable bags
h. Compostable food service items listed as approved by the City of Portland

2. **Prohibited items include:**
    i. Glass
    j. Plastics
    k. Metals
    l. Pallets
    m. Treated or painted wood
    n. Yard debris
    o. Holiday trees
    p. Plastic-coated papers, containers, plates or cups
    q. Hazardous materials
    r. Grease, oil or other liquids
    s. Grease trap waste
    t. Gypsum or gypsum paper
    u. Sewage or septage
    v. Street sweeper and catch basin wastes

Source-Separated Commercial Organic Waste shall be considered unacceptable if it is possible to remove from the surface of an individual load at least 20-gallons or equivalent of prohibited items listed above. Unacceptable loads in their entirety shall be rejected and subject to the current MSW rate, with load information reported to the City of Portland.

- **Inspecting loads:**
    - Use caution when pulling material from waste stream.
    - Use proper lifting techniques when moving and handling material by hand.

- Ask for help when handling large, heavy, or bulky items.
- If a load exceeds the allowed contamination amount (20-30 gallons of prohibited items per ton of material), call your lead/supervisor and fill out proper rejected load form; take at least three pictures of the whole load, around the load and close up of contamination. Management will submit form to Metro within 24 hours.
- Spotters, notify an operator to push the load as soon as it has been cleaned or cleared of contamination. Operator will need to spread the load prior to being pushed to the stockpile for spotter to do a post-inspection.

Month	Training
April 2013	Hazard Communication
May 2013	Fall Protection/Housekeeping/Slips, Trips & Falls
June 2013	Emergency Evacuation & Spill Response/Electric Safety
July 2013	Fire Protection/Fire Extinguishers & Hoses/Compressed Gas
August 2013	Respirator/Hearing Protection & Conservation/Hazard
September 2013	Drug & Alcohol Awareness
October 2013	Globalized Harmonization System
November 2013	Lockout Tagout
December 2013	Driving & Working in Wet Weather
January 2014	PPE & Dust Masks
February 2014	Confined Space
March 2014	Bloodborne Pathogens

People Reaching People

A key component of employee quality of life is community service. Recology's employees do a tremendous job in volunteering their own time and resources to improve communities. We promote community service through the volunteer program, "People Reaching People." Employees are encouraged to participate in these events on their own time as well as on company time.

This summer, Recology reached out to members of the St. John's Neighborhood Association in order to identify a possible volunteer event for Recology Oregon. After evaluating the location, scope and timing of multiple potential projects, Recology contacted George Middle School's principal, Ben Keefer. Based on his list of dream projects, it was determined that the school would undergo a beautification project with Recology's help.

In collaboration with Green Earth Landscaping, who removed invasive ivy, and Panera Cares, who donated bagels and pastries for breakfast, Recology successfully laid compost and mulch throughout the courtyard and the front of the school. The nutrient-rich compost and decorative mulch was provided by Nature's Needs Compost Facility, where Recology's collected residential organic waste is processed into rich compost. In addition to laying out 15 yards of compost and removing ivy, Recology employees also pulled weeds, trimmed trees and bushes, repaired and cleaned the school's greenhouse and donated compost and seeds for the students to use in the greenhouse to facilitate a new learning space.

On July 19th, 2014, Recology interns volunteered at a school beautification project.

Rich compost laid down in the front of the school.

After group photo of 28 Recology employees who volunteered to beautify George Middle School.

Looking Forward

Metro plans to implement new commercial organics acceptance standards, working toward a food-only program. By November 2014, regular and wax-corrugated cardboard will no longer be accepted. Loads with compostable service ware will be accepted until March 2015. Metro is currently promoting commercial organics as a "food-only" program to prepare for the stringent standards that will go into effect March 1st, 2015.

ROR began hauling commercial organic waste to JC-Biomethane in July 2013 and delivered a total of 9,470.3 tons of food waste through the April 2013 – March 2014 contract year. In the years to come, it is projected that Recology will continue to send the majority of commercial organic waste to JC-Bio, approximately 15,000 tons annually.

In the upcoming year, ROR will remain committed to sustainable business practices in all aspects of its operations, and the successful management and diversion of commercial organics is no exception. Partnerships with Metro and local haulers to address contamination issues, as well as continuing to develop relationships with additional processing facilities (such as JC-Biomethane) will be areas of focus as we move forward.

Acceptance Standards

- **November 1st, 2014 –** Regular and wax corrugated cardboard will no longer be accepted in loads.
- **March 1st, 2015 –** Metro will impose a food-only standard on the program. Only compostable bags will be acceptable, but no other non-food items. No compostable cups, trays, clamshells, napkins, cutlery, etc., will be accepted.
- Yard Debris (rocks, sod, soil, etc.) is unacceptable.

"The acceptance standards encourage innovation and introduce opportunities to reduce waste. It encourages businesses to explore different business models, such as transitioning to reusables."

—Bruce Philbrick on new Acceptance Standards

Interview with Bruce Philbrick
July 17th, 2014

The Commercial Organics program started in 2004 when Metro was seeking a processing facility in the metro region, promoting sustainability through local operations. Initially, the plan was to haul commercial organics from the Metro Central Facility to Cedar Grove's Maple Valley compost facility in Seattle. The long term plan was to site a facility in the Portland area to process the material. Once the contract was in place, Metro worked with the local governments and City of Portland to develop the commercial organics collection program.

The volume grew over time, but by 2009, Cedar Grove was still unable to build a site in the area due to strict Oregon land use laws. By 2010, Recology purchased Nature's Needs, a composting facility in North Plains. During this time, Cedar Grove wanted to discontinue the contract; hauling compost up to Seattle was a great expense. Metro chose to do an assignment by terminating their contract with Cedar Grove and signed with Recology in October 2010.

By May 2011, Recology began to haul commercial organics to Nature's Needs. However, complaints of odors arose due to the heavy loads of food scraps from the commercial organics sector. Residential loads contained food, but they primarily consisted of yard debris. Commercial organic loads were heavy in fats, proteins and carbohydrates, which had tremendous odor-causing potential.

The Department of Environmental Quality issued a warning letter to Recology stating that they must improve their systems to mitigate odors. This was a challenge, as Recology was still working on building the infrastructure for Nature's Needs (paved paths, aeration systems, air filtration systems, biofilters, leachate treatment systems, etc.).

As of April 2013, Recology could no longer haul commercial organics to Nature's Needs. Recology decided to send the material to two composting facilities in Washington as a short term solution. At the same time, Recology was communicating with JC-Biomethane, LLC., on the possibility of sending commercial organics to their plant in order to be converted into clean biogas.

In February 2013, a contract was signed between Recology and JC-Biomethane. The facility was finished with construction that summer, and Recology began hauling loads to the plant in July 2013. By October 2013, all commercial organics were heading to the JC-Biomethane facility to be processed. However, Metro and Recology immediately received concern from JC-Bio regarding the contamination of the loads, which was a problem for their bioseparator.[1]

Metro opened discussion with local governments, JC-Biomethane and Recology regarding contaminated streams. It was increasingly clear that it was time for a big change in the acceptance standards in order to promote cleaner loads. Metro felt in order to have a successful commercial organics program, they had to clean up the stream.

Acceptance Standards

- November 1st, 2014 – Wax corrugated and regular will no longer be accepted in loads.
- March 1st, 2015 – Metro will impose a food only standard on the program. Only compostable bags[2] will be acceptable, but no other non-food items. No compostable cups, trays, clamshells, napkins, cutlery, etc., will be accepted.
- Yard Debris (rocks, sod, soil, etc.) is unacceptable.

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[1] The Bioseparator is a piece of machinery at the JC-Biomethane plant that uses water and air to create a pulverized load of food in order to process the load into biomethane.

[2] Metro views compostable bags as something that must be accepted due to the handling of compost. Most compost is collected in a compostable bag and the Bioseparator is able to screen the bags out. Other contaminants are too difficult to screen out.

U.S. Energy Information Administration

Frequently Asked Questions

How much carbon dioxide is produced by burning gasoline and diesel fuel?

About 19.64 pounds of carbon dioxide (CO_2) are produced from burning a gallon of gasoline that does not contain ethanol. About 22.38 pounds of CO_2 are produced by burning a gallon of diesel fuel.

EIA estimates[1] that U.S. gasoline and diesel fuel consumption for transportation in 2013 resulted in the emission of about 1,095 and 427 million metric tons of CO_2 respectively, for a total of 1,522 million metric tons of CO_2. This total was equivalent to 83% of total CO_2 emissions by the U.S. transportation sector and 28% of total U.S. energy-related CO_2 emissions.

Under international agreement, CO_2 from the combustion of biomass or biofuels are not included in national greenhouse gas emissions inventories.[2] Most of the retail gasoline now sold in the United States contains about 10% fuel ethanol (or E10) by volume. Burning a gallon of E10 produces about 17.68 pounds of CO_2 that is emitted from the fossil fuel content. If the CO_2 emissions from ethanol combustion are considered, then about 18.95 pounds of CO_2 are produced when a gallon of E10 is combusted. About 12.72 pounds of CO_2 are produced when a gallon of pure ethanol is combusted.

It is possible to buy biodiesel fuel in many states. Biodiesel fuel is sold with various amounts of biodiesel content. A commonly sold biodiesel fuel is B20, which contains 20% biodiesel and 80% petroleum diesel fuel. Burning a gallon of B20 results in the emission of about 17.90 pounds of CO_2 that is emitted from the fossil fuel content. If the emissions from burning the biodiesel in B20 are included, then about 20.22 pounds of CO_2 are produced. About 20.13 pounds of CO_2 are produced from burning a gallon of B100 (100% biodiesel).

[1] As of April 25, 2014.

[2] Environment (Section Note), *Monthly Energy Review*.

Learn more:

Carbon Dioxide Emission Factors for Transportation Fuels.

Historical U.S. energy-related CO_2 emissions by source (fuel type) and sector.

Historical data on U.S. ethanol and biodiesel production and consumption (Tables 10.3 and 10.4).

Metric Conversion Factors (U.S. Unit to Equivalent in Metric Units).

Last updated: May 21, 2014

Other FAQs about Environment

- Does EIA have projections for energy production, consumption, and prices for individual states?
- Does EIA report water vapor emissions data?
- How do I convert between short tons and metric tons?
- How does the hole in the ozone layer affect global warming?

EPA United States Environmental Protection Agency

Climate Change

Overview of Greenhouse Gases

ON THIS PAGE

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. In 2012, CO_2 accounted for about 82% of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle—both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere. While CO_2 emissions come from a variety of natural sources, human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution. [1]

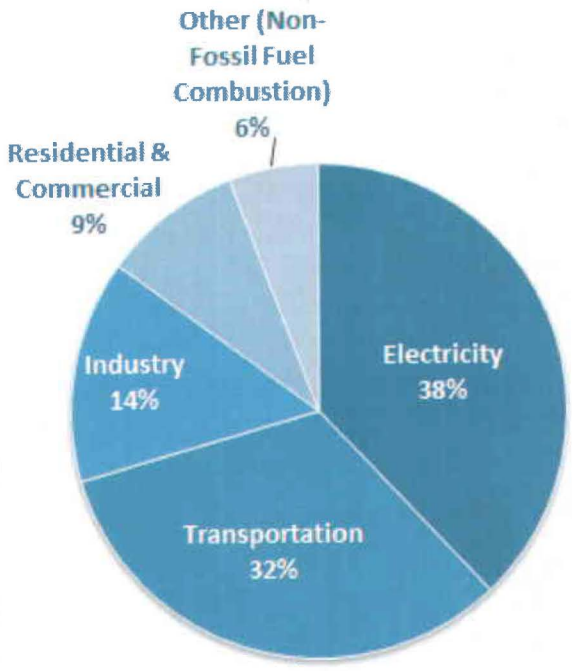
Properties of Carbon Dioxide

Chemical Formula	CO_2
Lifetime in Atmosphere	See below*
Global Warming Potential (100-year)	1

The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO_2. The main sources of CO_2 emissions in the United States are described below.

- **Electricity.** Electricity is a significant source of energy in the United States and is used to power homes, business, and industry. The combustion of fossil fuels to generate electricity is the largest single source of CO_2 emissions in the nation, accounting for about 38% of total U.S. CO_2 emissions and 31% of total U.S. greenhouse gas emissions in 2012. The type of fossil fuel used to generate electricity will emit different amounts of CO_2. To produce a given amount of electricity, burning coal will produce more CO_2 than oil or natural gas.
- **Transportation.** The combustion of fossil fuels such as gasoline and diesel to transport people and goods is the second largest source of CO_2 emissions, accounting for about 32% of total U.S. CO_2 emissions and 27% of total U.S. greenhouse gas emissions in 2012. This category includes transportation sources such as highway vehicles, air travel, marine transportation, and rail.
- **Industry.** Many industrial processes emit CO_2 through fossil fuel combustion. Several processes also produce CO_2 emissions through chemical reactions that do not involve combustion, for example, the production and consumption of mineral products such as cement, the production of metals such as iron and steel, and the production of chemicals. Fossil fuel combustion from various industrial processes accounted for about 14% of total U.S. CO_2 emissions and 12% of total U.S. greenhouse gas emissions in

U.S. Carbon Dioxide Emissions, By Source



Note: All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012*.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

47 watts x 3 hours / day x 365 days / year x 1 kWh / 1,000 Wh = **51.5 kWh / year / bulb replaced**

51.5 kWh / bulb / year x 1,637.5 pounds CO_2 / MWh delivered electricity x 1 MWh / 1,000 kWh x 1 metric ton / 2,204.6 lbs = **3.82×10^{-2} metric tons CO_2 / bulb replaced**

Sources

- EPA (2013). Savings Calculator for ENERGY STAR Qualified Light Bulbs. U.S. Environmental Protection Agency, Washington, DC.
- EIA (2013a). 2013 Annual Energy Outlook. Table A4 (PDF) (2 pp, 234K About PDF)
- EIA (2013b). 2013 Annual Energy Outlook, Table A8 (Total generation, use, and imports used for 7.5% T&D loss factor) (PDF) (2 pp, 230K About PDF))
- EPA (2014). eGRID year 2010 data. U.S. Environmental Protection Agency, Washington, DC.

Home electricity use

In 2012, 113.93 million homes in the United States consumed 1,375 billion kilowatt-hours of electricity (EIA 2013a). On average, each home consumed 12,069 kWh of delivered electricity (EIA 2013a). The national average carbon dioxide output rate for electricity generated in 2010 was 1,232.4 lbs CO_2 per megawatt-hour (EPA 2014), which translates to about 1,328.0 lbs CO_2 per megawatt-hour for delivered electricity, assuming transmission and distribution losses at 7.2% (EIA 2013b).

Annual home electricity consumption was multiplied by the carbon dioxide emission rate (per unit of electricity delivered) to determine annual carbon dioxide emissions per home.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

12,069 kWh per home × 1,232.4 lbs CO_2 per megawatt-hour generated × 1/(1-0.072) MWh delivered/MWh generated × 1 MWh/1,000 kWh × 1 metric ton/2,204.6 lb = **7.270 metric tons CO_2/home.**

Sources

- EIA (2013a).2014 Annual Energy Outlook Early Release. Table A4 (PDF) (2 pp, 234K About PDF)
- EIA (2013b).2014 Annual Energy Outlook Early Release, Table A8 (Total generation, use, and imports used for 7.2% T&D loss factor) (PDF) (2 pp, 230K About PDF))
- EPA (2014). eGRID year 2010 data. U.S. Environmental Protection Agency, Washington, DC.

Home energy use

In 2012, there were 113.93 million homes in the United States (EIA 2013a). On average, each home consumed 12,069 kWh of delivered electricity. Nationwide household consumption of natural gas, liquified petroleum gas, and fuel oil totaled 4.26, 0.51, and 0.51 quadrillion Btu, respectively, in 2012 (EIA 2013a). Averaged across households in the United States, this amounts to 52,372 cubic feet of natural gas, 70 barrels of liquified petroleum gas, and 47 barrels of fuel oil per home.

The national average carbon dioxide output rate for generated electricity in 2010 was 1,232 lbs CO_2 per megawatt-hour (EPA 2014), which translates to about 1,328.0 lbs CO_2 per megawatt-hour for delivered electricity (assuming transmission and distribution losses at 7.2%) (EIA 2013a, 2013b; EPA 2014).

The average carbon dioxide coefficient of natural gas is 0.0544 kg CO_2 per cubic foot (EPA 2013c). The fraction oxidized to CO_2 is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of distillate fuel oil is 429.61 kg CO_2 per 42-gallon barrel (EPA 2013b). The fraction oxidized to CO_2 is 100 percent (IPCC 2006).

The average carbon dioxide coefficient of liquefied petroleum gases is 219.3 kg CO_2 per 42-gallon barrel (EPA 2011b). The fraction oxidized is 100 percent (IPCC 2006).

Total single-family home electricity, natural gas, distillate fuel oil, and liquefied petroleum gas consumption figures were converted from their various units to metric tons of CO_2 and added together to obtain total CO_2 emissions per home.

Calculation

Note: Due to rounding, performing the calculations given in the equations below may not return the exact results shown.

1. Electricity: 12,069 kWh per home × 1,232 lbs CO_2 per megawatt-hour generated × (1/(1-0.072)) MWh generated/MWh delivered × 1 MWh/1,000 kWh × 1 metric ton/2,204.6 lb = 7.270 metric tons CO_2/home.

2. Natural gas: 52,372 cubic feet per home × 0.0544 kg CO_2/cubic foot × 1/1,000 kg/metric ton = 2.85 metric tons CO_2/home

3. Liquid petroleum gas: 70.4 gallons per home × 1/42 barrels/gallon × 219.3 kg CO_2/barrel × 1/1,000 kg/metric ton = 0.37 metric tons CO_2/home

4. Fuel oil: 47 gallons per home × 1/42 barrels/gallon × 429.61 kg CO_2/barrel × 1/1,000 kg/metric ton = 0.48 metric tons CO_2/home

Total CO_2 emissions for energy use per home: 7.270 metric tons CO_2 for electricity + 2.85 metric tons CO_2 for natural gas + 0.37 metric tons CO_2 for liquid petroleum gas + 0.48 metric tons CO_2 for fuel oil = **10.97 metric tons CO_2 per home per year**.

Sources

- EIA (2013a).2014 Annual Energy Outlook Early Release. Table A4 (PDF) (2 pp, 234K About PDF)
- EIA (2013b). 2014 Annual Energy Outlook Early Release, Table A8 (Total generation,

2012 Average Monthly Bill- Residential

(Data from forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U)

State	Number of Customers	Average Monthly Consumption (kWh)	Average Price (cents/kWh)	Average Monthly Bill (Dollar and cents)
New England	**6,203,726**	**634**	**15.71**	**99.64**
Connecticut	1,454,651	731	17.34	126.75
Maine	703,770	531	14.66	77.77
Massachusetts	2,699,141	627	14.91	93.53
New Hampshire	601,697	615	16.07	98.80
Rhode Island	435,448	597	14.40	86.04
Vermont	309,019	565	17.01	96.09
Middle Atlantic	**15,727,423**	**701**	**15.27**	**107.01**
New Jersey	3,455,302	691	15.78	109.10
New York	7,010,740	603	17.62	106.14
Pennsylvania	5,261,381	837	12.75	106.78
East North Central	**19,583,335**	**803**	**12.05**	**96.72**
Illinois	5,098,647	767	11.38	87.20
Indiana	2,755,595	997	10.53	104.93
Michigan	4,250,620	676	14.13	95.50
Ohio	4,869,305	895	11.76	105.23
Wisconsin	2,609,168	703	13.19	92.79
West North Central	**9,096,181**	**942**	**10.59**	**99.75**
Iowa	1,334,596	873	10.82	94.50
Kansas	1,217,256	945	11.24	106.19
Minnesota	2,317,336	793	11.35	90.06
Missouri	2,699,287	1,060	10.17	107.80
Nebraska	806,524	1,000	10.04	100.46
North Dakota	342,549	1,091	9.06	98.85
South Dakota	378,633	980	10.07	98.68
South Atlantic	**26,018,443**	**1,079**	**11.38**	**122.71**
Delaware	399,998	942	13.58	127.92
District of Columbia	231,550	721	12.28	88.51
Florida	8,645,207	1,081	11.42	123.45
Georgia	4,071,478	1,098	11.17	122.73
Maryland	2,212,287	1,005	12.84	129.00
North Carolina	4,230,588	1,077	10.91	117.45
South Carolina	2,113,144	1,119	11.77	131.64
Virginia	3,248,518	1,117	11.08	123.72
West Virginia	865,673	1,078	9.85	106.15
East South Central	**8,053,112**	**1,185**	**10.32**	**122.25**
Alabama	2,150,977	1,187	11.40	135.26
Kentucky	1,924,644	1,130	9.43	106.54
Mississippi	1,256,392	1,193	10.26	122.49
Tennessee	2,721,099	1,217	10.10	122.98
West South Central	**14,809,221**	**1,171**	**10.30**	**120.62**
Arkansas	1,332,154	1,120	9.30	104.14
Louisiana	1,995,661	1,254	8.37	104.99
Oklahoma	1,679,296	1,132	9.51	107.60
Texas	9,802,110	1,168	10.98	128.27
Mountain	**9,048,794**	**874**	**10.94**	**95.58**
Arizona	2,585,638	1,061	11.29	119.84
Colorado	2,149,637	706	11.46	80.94
Idaho	673,368	1,010	8.67	87.52

2012 Average Monthly Bill- Residential

(Data from forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U)

State	Number of Customers	Average Monthly Consumption (kWh)	Average Price (cents/kWh)	Average Monthly Bill (Dollar and cents)
Montana	473,033	842	10.08	84.88
Nevada	1,080,583	935	11.83	110.58
New Mexico	859,281	656	11.37	74.62
Utah	966,063	793	9.93	78.70
Wyoming	261,191	867	9.85	85.35
Pacific Contiguous	**17,597,091**	**684**	**12.94**	**88.55**
California	13,101,887	573	15.34	87.91
Oregon	1,642,444	957	9.80	93.80
Washington	2,852,760	1,037	8.53	88.46
Pacific Noncontiguous	**695,017**	**587**	**28.76**	**168.97**
Alaska	275,405	654	17.88	116.89
Hawaii	419,612	544	37.34	203.15
U.S. Total	**126,832,343**	**903**	**11.88**	**107.28**

WILLAMETTE VALLEY BIOGAS PLANT CONVERTS FOOD WASTE TO ENERGY

JC-BIOMETHANE FIRST IN PACIFIC NORTHWEST TO TRANSFORM COMMERCIAL FOOD WASTE INTO RENEWABLE BIOGAS

JC-Biomethane, LLC, in Junction City, near Eugene, is the first biogas plant in the Pacific Northwest to produce energy from the digestion of post-consumer commercial food waste. Through anaerobic digestion, the plant transforms a mix of organic waste into methane-rich biogas, which is then used to generate electricity.

Anaerobic digestion is the process by which bacteria in an oxygen-free tank convert heated organic wastes into biogas, along with byproducts such as liquid fertilizer and fiber compost. While most biogas facilities process a single feedstock, often municipal wastewater solids or dairy manure, JC-Biomethane co-digests post-consumer commercial food waste, as well as smaller volumes of dairy waste and fats, oils and greases from food processing plants and other sources.

The biogas fuels a 16-cylinder reciprocating engine, similar to a locomotive engine, that generates electricity. With a 1.55 megawatt capacity, the co-generation engine is expected to produce 12,250 megawatt hours of electricity annually, energy equivalent to what would be needed to power about half the homes in Junction City for a year. The renewable power is sold to Portland General Electric through a wheeling arrangement with the Blachly-Lane County Cooperative Electric Association and Bonneville Power Administration.

Construction of the biogas plant started in late 2011. It began producing renewable gas and generating electricity in fall 2013. Designed and managed by Dean Foor of Essential Consulting Oregon, LLC, the facility is a clean and nearly odorless renewable energy plant.

Foor said he and his team recognized a distinct opportunity to develop a biogas plant that would convert food waste within their own community. He had recently developed an agriculture-based biogas plant, Stahlbush Island Farms near Corvallis, and knew financial and technical support was available from Energy Trust of Oregon and the Oregon Department of Energy.

"We were exceptionally fortunate to have backing from Energy Trust," Foor said. Energy Trust contributed $2 million toward the project's $16 million total cost.

The biogas project also qualified for approximately $4.7 million in federal grants and a $1 million Oregon Business Energy Tax Credit pass-through payment.

EnergyTrust of Oregon

Dean Foor, managing member in Essential Consulting Oregon, LLC, and plant designer/operator.

The continuously stirred tank reactor, CSTR, where heated waste digests in an oxygen-free environment, takes shape on left. Smaller crane on right hoists inflatable top for the biogas storage tank.

Food waste from post-consumer commercial sources is processed to remove contaminants such as metals and plastic as an initial step in producing biogas.

Foor explained that JC-Biomethane is a product of a passionate team driven to make a difference in their community. "The field of waste management seemed reluctant to embrace the technology of processing food wastes into biogas," Foor said. "The technology needed a push to make it happen and show its potential. That's what Essential Consulting Oregon did with the JC-Biomethane facility."

Methane, comprising about 60 percent of the biogas, is a greenhouse gas approximately 20 times more potent than carbon dioxide. Burning the biogas to generate renewable energy prevents methane from being released to the atmosphere while also offsetting electric power generation from fossil fuels.

The organic materials feeding the biogas plant typically are landfilled. Without JC-Biomethane, 25,000 tons of organic materials per year would be shipped to traditional landfills. Diverting these materials to the biogas plant prevents the release of methane. Nutrients found in the organic materials, including inorganic nitrogen and phosphorus, are recovered and sold as agricultural fertilizer.

> "We are anaerobically fermenting organic material to create methane-rich biogas, which we consume in an engine to turn a turbine to create electricity."
>
> Dean Foor, managing member
> Essential Consulting Oregon

HOW IT WORKS

1 **Truck waste:** Trucks bring up to 80 tons of organic waste daily into a receiving warehouse. Most is post-consumer commercial food waste from the Willamette Valley and Portland. The plant is located adjacent to Lane Forest Products, which produces compost from organic material. Trucks transport Lane products north and are filled with food waste for the return trip south.

2 **Receiving building:** A large receiving building with translucent fabric walls and roof accepts the food waste. The facility excels at odor control, exceeding state and federal regulations. It is the first U.S. biogas plant to employ ozone for odor control.

3 **Bioseparator:** Inside the receiving building, a Swiss-made Hybag Bioseparator breaks down the waste and removes hard contaminants like metal and plastic from the organic waste. It is the first known application of this technology in the U.S.

4 **Liquid waste tanks:** Separate tanks receive limited amounts of liquid fats, oils and greases that are added to the digester in moderate volumes because of their high energy content.

5 **Homogenization tank:** With contaminants removed, the waste is pumped into a homogenization tank, where it sits for several days.

6 **Digester tank:** From the homogenization tank the material is pumped into a large, continuously stirred oxygen-free tank reactor, CSTR, for 30 days of anaerobic digestion. The tank is insulated to maintain a constant 105 degree Fahrenheit temperature. "This is where the magic happens," according to Foor. As the material circulates through the oxygen-free tank, bacteria convert the organic waste to biogas, which rises to the top of the tank.

7 **Post-digester tank:** From the CSTR the processed material, now called "digestate," is pumped into a post-digester tank. A distinctive inflatable top collects the biogas. From there the biogas is piped into a cleaning tower, where bacteria remove gas contaminants. Solids move through a screw press to extract excess liquid and create clean-smelling fiber, one of the plant's commercial byproducts.

8 **Liquid digestate tank:** Odor-free liquid digestate is pumped from the post-digester into the largest tank on the site, capable of holding up to six months of the product. It is sold as liquid fertilizer for replacement of 2,000 acres of conventional fertilizer.

9 **Co-generation unit:** From the post-digester, the biogas travels through underground pipes to remove water content and through three small tanks adjacent to the co-generation unit for final cleaning. It is now ready to fuel the 2G-CENERGY combined heat and power unit—a 16-cylinder, 2,000 horsepower MWM co-generation engine. Combustion of the biogas turns a generator, converting mechanical energy into electricity and completing the JC-Biomethane operation.

10 **Engine heat:** Heat created in the engine during combustion is directed back into the CSTR as needed to maintain a constant temperature. Excess heat may someday be sold to nearby businesses.

11 **Power interconnection (not pictured):** Electricity from the generator is interconnected via Blachly-Lane County Cooperative Electric Association distribution lines and then wheeled to Bonneville Power Administration transmission lines for purchase by PGE.

A look at the engine inside the co-generation unit and some of its 16 cylinders. The engine turns a generator to create electricity.

PROJECT-AT-A-GLANCE

Project team

- Essential Consulting Oregon, LLC
- Energy Trust
- Oregon Department of Energy
- Portland General Electric
- Blachly-Lane County Cooperative Electric Association
- Bonneville Power Administration
- Lane Forest Products
- FormTec GMBH

Project benefits

- Generates approximately 12,250 megawatt hours of electricity annually from a clean, renewable biogas fuel
- Reduces emissions of methane and nitrous oxides
- Produces odorless liquid fertilizer and dry fiber for compost
- Retains four jobs in biomass logistics, and creates eight permanent jobs and 60,000 person-hours of construction work
- Potential to use excess heat from co-generation in nearby commercial operations

Financial analysis

- $16 million total project cost
- $2 million Energy Trust cash incentive
- Approximately $3 million federal grant in lieu of an Investment Tax Credit
- $1.7 million in federal funding through the American Recovery and Reinvestment Act of 2009
- $1 million Oregon Business Energy Tax Credit (third party pass-through amount)

Estimated annual earnings

- About $1 million in power sales
- About $1 million from waste processors and sales of byproducts

+

Learn more about Energy Trust assistance and incentives for biopower projects, visit **www.energytrust.org** or call **1.866.368.7878**.

Energy Trust of Oregon 421 SW Oak St., Suite 300, Portland, OR 97204 1.866.368.7878 503.546.6862 *fax* **energytrust.org**