STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47775 • Olympia, Washington 98504-7775 • (360) 407-6300

July 15, 2011

Commissioner Jeffery Goltz
Utilities and Transportation Commission
P.O Box 47250
Olympia, WA 98504-7250

RE: Study of the Potential for Distributed Energy in Washington State, Docket UE-110667

Dear Commissioner Goltz:

Since 2001, the Department of Ecology Waste 2 Resources Program (W2R) has conducted numerous studies of the municipal organic or 'biomass' waste stream and plans for recovering organic waste for use. W2R has documented that significant volumes of organic wastes are collected in centralized facilities. Data about the composition, chemical and biological characteristics, and annual quantity of waste generated are provided within a set of enclosed references. These are annually renewable and sustainable resources. Some of the organic rich materials are recovered through waste stream recycling, diversion, and composting programs. However, over half of the organics collected in central waste handling locations continues to be disposed.

These organic waste materials represent an opportunity to recover energy, fuels and fertilizers, as well as stable carbon and amendments that improve soil productivity and numerous by-products. The costs for disposal of these materials represent not only a loss of potential energy and fuel, but also loss of a significant opportunity to provide green commerce (also called 'bio-economy').

Our research institutions at the University of Washington and Washington State University as well as Battelle Pacific Northwest Laboratories have completed, and continue, with work on compelling studies demonstrating the real value of our organic resources for recovering methane, and potential for creating ethanol, biodiesel, green fuels (gasoline and diesel), and process heat and electrical power. This can be achieved while limiting the release of greenhouse gasses, storing stable carbon in amendments for improving agricultural soils, and capturing nitrogen and phosphorous nutrients that pollute surface and ground water, and overburden our agricultural soils with nitrogen and phosphorous fertilizers.

Please find enclosed some general comments and specific feedback on the organic resources available in solid waste for development of distributed energy. Our main points are as follows:

- Organic materials, such as food, yard debris, wood waste, soiled paper and cardboard, represent approximately 55 percent of all material disposed in Washington State. Disposal equals wasted resources.
- The Waste 2 Resources program has invested millions of dollars to develop new technologies to turn wasted organic materials into renewable fuel, electricity, and products.
- The Waste 2 Resources program would like UTC to recognize that biomass represents a distributed energy opportunity.

We believe we can no longer afford to throw away sustainable and renewable biomass.

Sincerely,

Peter Y. Lyon for
Laurie G. Davies

Laurie G. Davies
Program Manager
Waste 2 Resources Program

Enclosure

A. General - Cross Cutting Issues:

The Department of Ecology, Waste 2 Resources Program (W2R) mission is "to reduce the amount and the effects of solid wastes generated in Washington." In 2009 W2R funded an update of Washington Statewide Characterization Study. Results show that Washington citizens generate over 4.2 M tons of organic "biomass" solid waste annually. This includes food waste, green and yard clippings, land clearing, construction and demolition woody debris, paper and smaller quantities of other materials. Composting, recycling and diversion for energy recovery reduce this amount of organic waste and account for about 2.2 M tons of diverted organic resources. Here are salient highlights.

- Organic 'biomass' solid wastes comprise over 55 percent of the refuse stream in Washington (Appendix E, 2009 Washington Statewide Waste Characterization Study, ECY pub. No. 10-07-023).
- The organics include: food waste which is 17 percent and paper, paper packaging, and cardboard which is 21 percent, of the total waste stream, respectively.
- Green waste primarily from lawn clippings and food waste are very biologically reactive and cause capacity challenges for the compost industry.
- Wood wastes from multiple sources (construction, demolition, land clearing, right of way and land management, etc) are significantly about 10 percent of the waste generated.

Organics in waste are a renewable resource. Review of population growth in the state compared to waste generation shows that for every one percent increase in population, organics in waste increases by three percent.

There are many options for recovering the embodied energy, nutrients and products in waste organics. W2R partnered with Washington State University and the University of Washington to support advances in technology to improve production of methane through anaerobic digestion, recover of nutrients from digestate, produce ethanol, and build a technology base to support biochar and bio-oil production.

Anaerobic digestion shows great promise, creating fuel and fertilizer from organic waste while limiting production of greenhouse gasses and air pollutants. Food waste and lawn clippings represent the highest and best premium quality anaerobic digester feedstocks. These feedstocks generate the highest volume of methane, and create recoverable nitrogen and phosphorous fertilizers. And, the carbon dioxide generated can be recovered for further industrial and agricultural purposes.

Similarly, food wastes and paper and wood wastes can be used for production of ethanol, while woody wastes can also be processed to produce green gasoline and diesel.

- In a 2009 the University of Washington estimated 110 gal/ton, 90 gal/ton and 40 gal/ton ethanol production from food waste, paper and yard trimmings, respectively (ECY pub. No. 09-07-060).
- Also in 2009, Washington State University reported that recovery of fuel precursors to green gasoline, and diesel, as well as sugars that can be fermented to ethanol as outcomes of thermochemical pyrolysis of woody organic materials (ECY pub. No. 09-07-061).

Organic waste provides a renewable and sustainable source for soil productivity improvements enhancing the environmental attributes. These materials effectively sequester organic carbon improving soil productivity across a range of conditions.

- Compost and biosolids amendments applied to a variety of soil types across the state in single event or repeat amendments increased soil organic matter and nutrients which remained stable over the period (10-15 years). Some soils where amendments were applied also were shown to have improvements in soil moisture holding capacity and soil tilth (ECY pub. No. 09-07-059).
- Biochar from the thermochemical pyrolysis of wood and straw has been shown to be stable in soils over long periods. This effectively creates a sink for pulling down atmospheric carbon, and storing it in a form that supports soil productivity (Woolfe, et al., 2010, Sustainable Biochar to Mitigate Global Climate Change).

Organic wastes are well distributed across the state, because while population centers form the largest quantity of these materials, food processors and other sources are distributed in the agricultural sectors. This can be seen in the 2005 Biomass Inventory.

With all of this potential from the abundant feedstocks and demonstrated technologies for producing renewable fuels and energy, projects that have been proposed have run into challenges. Barr-Tech is a current example in Lincoln County. The facility has been selected to receive American Reinvestment and Recovery Act funds. However, the facility is not eligible for renewable energy credits, because of limitations in the definition of renewable resource in Chapter 19.285 RCW (I-937). Inclusion of food and green waste as a renewable resource would provide incentives for recovery of energy and other valuable products from these wastes in ecologically sound processes.

Question 7. Biomass generated within solid waste systems is collected year around. Some peaks in generation occur throughout the year, such as green waste from lawn clippings increases in the spring and fall. Most of the biomass could serve baseload capacity in anaerobic digester, and thermochemical processes.

Question 16. Biomass fits with a complex set of technologies ranging from gasification and pyrolysis for heat and power to anaerobic digestion. The technology must match feedstocks. Readily decomposable food and green waste are most applicable for digesters. High lingo-cellulosic waste such as wood and straw are not good feedstock for digesters, but can be excellent sources for pyrolysis projects. Recovered paper can be a great source for ethanol projects. Several documents supporting these statements are referenced in the attached list of reports funded by W2R since 2003. The reports provide further specific information on organics in waste, technologies for recovering energy and fuels, in combination with stable carbon and nutrients. These reports are available on the W2R Publications page: http://www.ecy.wa.gov/biblio/swfa.html. Detailed energy and fuel recovery reports are also available from the Washington State University Energy Extension (WSUEE) program library at: http://www.pacificbiomass.org/Library.aspx.

- Anaerobic digestion of readily decomposable waste is already adopted technology across Europe. A digester for municipal decomposable waste is under construction in British Columbia. Several facilities are in stages of planning in Washington.
- Dairy manure digesters are being built in greater numbers across Washington. WSUEE and others maintain a comprehensive list of current and planned digesters.
- Gasification plants are also being built. A new plant has been complete in Vancouver, BC. The feedstock for this plant is wood waste. Another plant has been completed at the University of South Carolina.
- Fast Pyrolysis plants and test facilities have been built in Canada, and the US Midwest. The plants operate on wood and agricultural resources.

B. <u>Technology-Specific Issues</u>:

Distributed Energy from Biogas and Biomass

Question 11. What is the Generation Capacity for biomass in Washington?

Attached reference reports provide source information for some of the estimates below. The source for the straw and wood estimates is from the Washington State University (WSU) Biological Systems Engineering Department in an updated estimate of wood and straw sources in a recent Appendix A report to the Washington Department of Agriculture.

Applicable process technologies are matched to the organic characteristics in the Table Below.

Estimated biogas and biomass from organics by resource category.

Process Technology	Organic Resource	MMTon annual wet wt	Power	Fuel	Other Attributes
			MW	MGGE	
Anaerobic Digestion	Food and Green	1.3[1]	45[2]	nc[3]	N & P fertilizer, soil amendment, GHG reduction, zero waste
	135 Dairies w/ co-digestion	2.9[2]	40[2]	nc	N & P fertilizer, soil amendment, GHG reduction, zero waste
	Food Processing	3.5[2]	32[2]	nc	N & P fertilizer, soil amendment, GHG reduction, zero waste

Process Technology	Organic Resource	MMTon annual wet wt	Power	Fuel	Other Attributes
			MW	MGGE	
Thermochemical: straw	Pyrolysis: Slow[4]	2.5[2]	198[2]		30% wt. stable biochar carbon soil amend. , zero waste
	Pyrolysis: Fast[4]			174[2]	15% wt. stable biochar C, zero waste
Thermochemical: wood	Pyrolysis: Slow[4]	5.9[2]	463[2]		30% wt. stable biochar, carbon negative soil amend., zero waste
	Pyrolysis: Fast[4]			407[2]	15% wt. stable biochar, carbon negative soil amend., zero waste

[1] 2009 Waste Characterization Study, Table 8, food (both categories), leaves and grass and animal manure, wet weight basis.

[2] Dr. Craig Frear, WSU Biological Systems Engineering Department.

[3] not calculated.

[4] Calculated as if all biomass in the category were processed either as power, or as fuel.

Question 14. Municipal green stream digesters are common place in Europe. However, municipal digesters have not yet been built in Washington. These projects are not eligible for energy credits under Chapter 19.285 RCW.

Biomass is significant for Washington. Given our physiographic conditions defined by onshore moist air, mountain ranges, and plateaus, Washington's biomass is abundant. A Biomass Inventory completed by Washington State University under funding from Ecology identified 16.4 M dry tons of organics in forest, agriculture and municipal sectors. Department of Natural Resources is conducting new and more comprehensive assessments to further define forestry resources.

The attributes and characteristics of these organic resources will require a suite of technologies. Digesters are the logical outcome for recovering energy from readily decomposable wet organics. Several thermochemical process modes may include slow and fast pyrolysis. The technology will be dependent on end uses of the energy and products. A goal of Ecology is that organics will be recovered and used in processes without creating an endpoint waste for long term management. Thus, boilers and gasifier methods which create an ash requiring long term landfilling and monitoring are much less desirable than pyrolysis which creates energy or fuel and stable carbon for amending soils.

C. References:

Annual solid waste reports:

Washington Department of Ecology (Ecology), Waste 2 Resources Program (W2R) completes an annual report on solid waste in Washington. The most recent of these annual reports is listed here. All reports are available on the Waste 2 Resources publications page: http://www.ecy.wa.gov/biblio/swfa.html. Click on the year (top bar) and a browse list will come up.

1. **Solid Waste in Washington State, 19th Annual Status Report,** 2010. http://www.ecy.wa.gov/biblio/1007031.html

This annual solid waste report reflects conditions and activities in solid waste in Washington State. The chapters of the annual report discuss some specific activities underway as we continue to implement Beyond Waste and our partnering for the environment through grants to local governments. The 2009 data is provided for solid waste infrastructure in the state, litter collection efforts, the statewide recycling and diversion survey results, information on waste disposal and moderate risk waste.

Waste characterization:

In 2009, Ecology commissioned Cascadia Consulting Group (Cascadia) to conduct a four-season municipal solid waste (MSW) characterization study during 2009–10. Waste collected from tipping floors was catalogued into 130 types and the mass of the materials obtained.

1. **2009 Washington Statewide Waste Characterization Study,** 2010. http://www.ecy.wa.gov/biblio/1007023.html

The purpose of this study was to conduct an in-depth examination of materials and resources currently disposed throughout the state. This study incorporated three specific tasks:

- A packaging versus product analysis which separated each of the 130 materials with an emphasis on paper, plastic, glass, and metal into either packaging or product classes, or one of six other material categories when the packaging and product designations do not apply.
- Detailed composition results for each of the state's six waste generation areas (WGAs) Central, East, Northwest, Puget Sound, Southwest, and West.
- A supplementary analysis which combines the 10 county statewide results with prior waste composition studies carried out in three additional Puget Sound Counties.

Biomass recovery for energy, ecology and economy:

W2R has also supported numerous studies of biomass recovery and use for energy through Washington State University, Biological Systems Engineering Department, Agricultural Economics Departments and currently the Center for Sustaining Agriculture and Natural Resources. Biomass to fuels projects including a life cycle assessment for recovery for fuel versus landfilling have also been completed within the College of Forest Resources at the University of Washington. The reports below have been completed as a part of W2R's ongoing efforts in recovery organics for energy, and fertilizers, and soil amendments for carbon sequestration.

1. **Bioenergy Inventory and Assessment for Eastern Washington**, Shulin Chen, Craig Frear, BingCheng Zhao, and Guobin Fu. October 2003. http://www.ecy.wa.gov/biblio/0307021.html

   This Phase 1 project assessed Eastern Washington's twenty counties for available biomass and calculated the potential energy production from twenty four organic resource types. Annual production of 4.3 million tons of underutilized dry biomass was found.

2. **Biomass Inventory and Bioenergy Assessment: An Evaluation of Organic Material Resources for Bioenergy Production in Washington State**, Craig Frear, Bingcheng Zhao, Guobin Fu, Michael Richardson, Shulin Chen, and Mark Fuchs, December 2005. http://www.ecy.wa.gov/biblio/0507047.html

   A biomass inventory and bioenergy assessment of forty five organic resource types across Washington was completed, producing this report and a database with GIS maps (http://www.pacificbiomass.org). Annual production of over 16.4 million tons of underutilized bone dry biomass was found, capable of producing (by combustion or anaerobic digestion) over 15.5 billion kilo-watt hours of electrical energy.

3. **Producing Energy and Fertilizer From Organic Municipal Solid Waste -- Project Deliverable #1,** Usama Zaher, Dae-Yeol Cheong, Binxin Wu, and Shulin Chen, June 2007. http://www.ecy.wa.gov/biblio/0707024.html

   A literature review of current digester technologies formed the framework for designing a bench scale study of a high solids anaerobic digestion (HSAD) system. The study shows that significant improvements in methane production can be attained while decreasing capital costs for facilities. A new digester design is proposed that will optimize methane from organic food and green waste digestion, while recovering nutrients from the digestate.

4. **Biomass Inventory Technology and Economics Assessment -- Report 1. Characteristics of Biomass,** Wei Liao, Craig Frear and Shulin Chen, June 2007. http://www.ecy.wa.gov/biblio/0707025.html

   This project compiled a literature search for biomass chemical characterization and conducted supplemental laboratory study of forty two feedstocks for 33 parameters such as dry matter, chemical oxygen demand, carbohydrates, lipids, elemental and mineral matter, and standard properties such as protein, fiber, pH, etc. A follow-on report will group similar feedstocks, assess potential energy conversion technologies and conduct an economic analysis of feedstock collection and energy production.

5. **The Formation of Polyaromatic Hydrocarbons and Dioxins During Pyrolysis: A Review of the Literature with Descriptions of Biomass Composition, Fast Pyrolysis Technologies and Thermochemical Reactions**, Manuel Garcia-Perez, June 2008.

http://www.pacificbiomass.org/documents/TheFormationOfPolyaromaticHydrocarbonsAndDioxinsDuringPyrolysis.pdf

It is clear that any new thermochemical processing technologies must represent clean processes. To examine whether the production of bio-oils and biochar could generate polyaromatic hydrocarbons (PAH) and dioxins during pyrolysis processes, a global literature review was conducted. The processing method for recovering energy, fuel and products from organic waste can have detrimental impacts such as odors and emissions from compost yards. This report also contains laboratory data on PAH and dioxins within biochar and bio-oil produced at the laboratory.

6. **Organic Waste to Resources Research and Pilot Project Report: Waste to Fuels Technology: Evaluating Three Technology Options and the Economics for Converting Biomass to Fuels**, Hayk Khachatryan, Ken Casavant, and Eric Jessup, Jie Chen, Shulin Chen, and Craig Frear, September 2009. http://www.ecy.wa.gov/biblio/0907058.html

   This study further investigated biomass from the 2005 biomass inventory by comparing three fuel technologies: cellulosic biomass conversion by fermentation for ethanol, or gasification for mixed-alcohols, and anaerobic digestion of high volatile solids biomass for methane production. The study then integrated the major cost factors: biomass availability, feedstock prices, transportation costs, processing costs, and geographic distribution into a comprehensive model framework using Geographic Information System and MATLAB-SIMULINK models, to assess final delivered fuel cost.

7. **Organic Waste to Resources Research and Pilot Project Report: Land Application-a true path to zero waste?** Kate Kurtz, Sally Brown, Craig Cogger and Andy Bary, March 2010. http://www.ecy.wa.gov/biblio/0907059.html

   This study tested the benefits of recycling organic residuals to soils. Sites having previously received one or more biosolids and compost applications were sampled. Soil carbon and nitrogen were found to be higher, while soil density (compaction) decreased with the organic amendments. Soil water holding capacity was improved in over half the sites. Amendments turned into the soil rather than left on the surface further boosted the benefits. The amendments also increased crop yields over conventional fertilizer.

8. **Organic Waste to Resources Research and Pilot Project Report: Converting Washington Lignocellulosic Rich Urban Waste to Ethanol**, Rick Gustafson, Renata Bura, Joyce Cooper, Ryan McMahon, Elliott Schmitt, and Azra Vajzovic, Septmber2009. http://www.ecy.wa.gov/biblio/0907060.html

   This study investigated the potential of producing ethanol from three primary sources: mixed waste paper, yard trimmings, and a laboratory prepared mixture (50/50 food & paper) representing municipal solid waste (MSW). Pretreatment consisted of dilute acid hydrolysis (mixed paper and MSW), and steam explosion (yard waste). Ethanol yields of 105, 90 and 55 gal/ton were found for the MSW, mixed paper, and yard waste. A preliminary Life Cycle Assessment showed that overall environmental impacts of ethanol production from MSW are highly beneficial compared to landfill. Conversion of the MSW mixture to ethanol was found to be economically viable.

9. **Organic Waste to Resources Research and Pilot Project Report: New Bio-refinery Concept to Convert Softwood Bark to Transportation Fuels Final Report to the Washington State Department of Ecology**, Manuel Garcia-Perez, Shulin Chen, Shuai Zhou,Zhouhong Wang, Jieni Lian, Robert Lee Johnson, Shi-Shen Liaw and Oisik Das, September 2009. http://www.ecy.wa.gov/biblio/0907061.html

   This project tested a new pretreatment concept to enhance the production of sugars from the fast pyrolysis of wood and straw. It proved that sugars recovered from pyrolysis can be easily converted into ethanol. These two results are important because they show that fast pyrolysis of wood or straw followed by bio-oil hydro-treatment can create green gasoline and diesel (from lignin), as well as ethanol (from cellulose).

10. **Organic Waste to Resources Research and Pilot Project Report: Use of Biochar from the Pyrolysis of Waste Organic Material as a Soil Amendment**, David Granatstein, Chad Kruger, Hal Collins, Manuel Garcia-Perez, and Jonathan Yoder, September 2009. http://www.ecy.wa.gov/biblio/0907062.html

    Biochars from different feedstocks were tested on five soils. Biochars on all soil types increased soil carbon. Biochar carbon was stable in soil with mean residence times estimated in the hundreds of years. Soil nitrate levels were reduced with increasing biochar rate perhaps due to ammonium adsorption. Biochar did not accelerate loss of indigenous organic matter through the 'priming effect.' Biochars raised soil pH, but did not lead to consistent plant growth improvements.

11. **Organic Waste to Resources Research and Pilot Project Report: Producing Energy and Fertilizer from Organic Municipal Solid Waste: Enhancing Hydrolysis and Bacterial Populations and Mixing and Thermodynamic Modeling of New Solid Waste Treatment Technology**, Usama Zaher, Shulin Chen, Chenlin Li, Liang Yu, and Timothy Ewing, June 2009. http://www.ecy.wa.gov/biblio/0907064.html

    This project developed, tested and modeled a high solids anaerobic digester consisting of a solids reactor and a leached liquids up-flow anaerobic sludge blanket for reacting volatile fatty acids. At near neutral pH the system improves methane production 50% over existing digesters, while return flow reseeds the solids digester with high titer micro-organisms that improved biological kinetics. The dual reactors system provides for control of digester limiting acid and ammonia processes, while allowing for nutrient recovery, and significantly improves performance for capital outlay.

12. **Organic Waste to Resources Research and Pilot Project Report: Biodiesel and Biohydrogen Co-Production with Treatment of High Solid Food Waste**, Yubin Zheng, Jingwei Ma, Zhanyou Chi, and Shulin Chen, September 2009. http://www.ecy.wa.gov/biblio/0907065.html

    A two-step process was developed as a potential technology to produce hydrogen and biodiesel from food waste. The first process use fermentative bacteria to breakdown glucose from food waste to produce hydrogen and volatile fatty acids (VFA). The VFA are then fed to yeast for simultaneous carbon sequestration resulting in production of biodiesel from the oil-producing microbial biomass.

13. **Methods for Producing Biochar and Advanced Biofuels in Washington State Part 1: Literature Review of Pyrolysis Reactors**, Manuel Garcia-Perez, T. Lewis, C. E. Kruger, April 2011. http://www.ecy.wa.gov/pubs/1107017.pdf

    This is the first of a series of reports exploring the use of biomass thermochemical conversion technologies to produce energy, fuels and industrial chemicals and sequester carbon in biochar. The report conducts a comprehensive review of historical pyrolysis reactors and technologies including criteria to select a reactor type, reviews of historical kilns, retorts, converters and current fast pyrolysis designs, vehicle gassifiers, and a brief introduction on environmental and safety concerns for woody biomass pyrolysis.

14. **Organic Waste to Resources Research and Pilot Project Report: The Next Step for Biomass Energy Development in Clallam County**, Northwest Sustainable Energy for Economic Development, Institute for Washington's Future, and Northwest Cooperative Development Center, September 2009. http://www.ecy.wa.gov/biblio/0907067.html

    New technologies allow us to harness the energy in animal and plant biomass to generate electricity and fuel vehicles. The energy derived from biomass resources that are produced and harvested sustainably is considered renewable. This report is a primer on biomass power for Clallam County and funding opportunities.

Washington State University Energy Extension Program References Library:

We encourage you to also see the Washington State University Energy Extension Program which is an excellent source of Washington and regional biomass reports and data. The library can be accessed at: www.pacificbiomass.org and click on the Library link on the left tool bar or go directly to http://www.pacificbiomass.org/Library.aspx. This library has an extensive set of reports on biomass and bioenergy potential. In addition, the extension librarian provides an outstanding capacity for compiling resource reports and information.