

# Extension, Engagement, and Technology Transfer

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A report for  
The Waste to Fuels Technology Partnership  
2017-2019 Biennium: Advancing Organics Management in Washington State



*Center for*

**Sustaining Agriculture  
& Natural Resources**

WASHINGTON STATE UNIVERSITY



DEPARTMENT OF  
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## **Abstract**

This chapter describes the extension and engagement efforts related to research conducted under the auspices of the Waste to Fuels Technology (WTFT) partnership. This work was led by Embrey Bronstad, Georgine Yorgey, and Karen Hills, but includes contributions from members across the WSU Waste to Fuels Technology team. Outreach efforts provided in-person engagement opportunities for an estimated 754 stakeholders, and access to online resources and publications that were viewed over 18,000 times. In addition, current and past work under the partnership led to \$357,658 of additional leveraged funds in this biennium.

Bronstad presented at, and led discussions with, a number of solid waste advisory committees (SWACs) across the state and participated in organics management workshops. These efforts increased awareness of next-generation solutions, supported the adoption of technologies for recovering value from waste, and developed insight related to current priorities and constraints for organics management. Extension work promoted bi-directional communication and collaborative understanding between the Waste to Fuels Technology team and the organics management sector in Washington State. Stakeholders were educated in the concept of biorefineries; various component waste processing technologies including composting, anaerobic digestion, and pyrolysis; and opportunities for implementing these technologies in order to promote the efficient valorization of various waste streams. In addition, the team continued to work to understand the priorities and constraints in the current organics management sector in Washington State, in order to identify opportunities for contribution to relevant solutions.

## **Technology transfer and engagement with regional organics management stakeholders and the organics value chain**

The goal of the Waste to Fuels Technology partnership is to promote more efficient conversion of waste into energy, nutrients, and other saleable products. This process reduces or offsets overall energy inputs from the production of these components, therefore reducing the need for other carbon-intensive sources. The application of these technologies and processes depends on adoption by industry and municipal partners, and purchase and use of the generated products (compost, biochar, etc.). Outreach efforts therefore targeted both organics management stakeholders like existing composters and solid waste advisory committees, and also those stakeholders related to product use (agricultural users, e.g.). Outreach and extension deliverables are outlined below and include presentations and technical support to stakeholders.

### **Building relationships across the organics management and value chain**

Bronstad, Yorgey, and colleagues made numerous presentations during the biennium related to the Waste to Fuels Technology partnership. These presentations included discussions of the biorefinery concept, composting, anaerobic digestion, pyrolysis, and nutrient recovery. These targeted in-person presentations and interactions comprised approximately 754 contacts with key stakeholders who work on sustainable organics management in the region, including those who work in the organics management industry, purchasers and users of organic residuals, graduate and undergraduate students of engineering and other disciplines who are likely to work on areas related to sustainable organics management:

- Bronstad, E. (2019) Organics Management Options in the Context of a Biorefinery, Pierce County Solid Waste Advisory Council, May 2019; approximately 15 participants.
- Yorgey, G. G. (2019) Waste to Fuels Technology End-of-Biennium Progress Update. Conference call with Department of Ecology Solid Waste Planners Organics Job-Alike Group (OJAG) (5/21/19), May 2019; approximately six participants.
- Yorgey, G.G. 2019. Carbon sequestration in working lands. Guest lecturer for Civil Environmental Engineering 412: Sustainability seminar. Portland State University, May 2019; approximately 40 participants.
- Bronstad, E. (2019) Introductory call with Pierce County Solid Waste Planners for presentation ideas to the Pierce County Solid Waste Advisory Council, April 2019; approximately four participants.
- Bronstad, E. (2019) Garbage Can! Evolution of a Biorefinery, BioCycle West, April 2019; approximately 35 participants.
- Yorgey, G.G., S.A. Hall, C. Kruger, C. Stockle, K.M. Hills, M. Donnay. (2019) Carbon sequestration potential in cropland soils in the inland Pacific Northwest: A summary of knowledge and gaps. Poster and lightning presentation at Healthy Soils, Healthy Region Workshop, Pendleton, Oregon, March 2019; approximately 40 attendees of poster session.

- Stacey, N., Collins, D.P., Seefeldt, S., Gang, D., Flury, M., Hoashi-Erhardt, W. (2019). Biochar and Co-composted Biochar as Soil Amendments in the Pacific Northwest. Poster presentation at Healthy Soils, Healthy Region Workshop, Pendleton, Oregon, March 2019; approximately 40 attendees of poster session.
- Bronstad, E. (2018). Introduction to Waste to Fuels Technology Partnership, the Biorefinery Concept, and Organics Management Options, presentation to the San Juan County Solid Waste Advisory Council, December 2018; approximately six participants.
- Yorgey, G. G., T. Jobson, D. Gang, D. Collins and S. Seefeldt. (2018). Waste to Fuels Technology Partnership: Biochar Co-Composting Update. Department of Ecology Solid Waste Division, Program Management Team. Olympia, WA, December 2018; approximately 10 participants.
- Collins, D.P., and Stacey, N. (2018). Soil Quality Improvements with Biochar and Compost, presentation to the Washington Organics Recycling Council Annual Conference. Tacoma, WA, November 2018; estimated 80 participants.
- Bronstad, E. (2018). Introduction to Waste to Fuels Technology Partnership, conversation with King County Solid Waste staff, October 2018; two participants.
- Bronstad, E. (2018). Options for Organics Management, presentation to the Washington Organics Recycling Council Board, October 2018; approximately 20 participants.
- Bronstad, E. (2018). Waste to Fuels Technology Partnership and What it Can Do for You, conference call with Department of Ecology Solid Waste Planners Organics Job-Alike Group (OJAG), September 2018; approximately six participants.
- Enns, T., Collins, D.P., Stacey, N., Seefeldt, S., Gang, D., Dubois, N. (2018). Soil Quality Improvements with Biochar and Compost, poster presentation for Research and Extension Experience for Undergraduates (REEU) at Summer Undergraduate Research Symposium. Pullman, WA, August 2018; estimated 150 participants.
- Yorgey, G.G. (2018). Resource Recovery. Presentation to Au Sable Institute. Mount Vernon, WA, July 2018; Estimated 15 participants.
- Seefeldt, S. (2018). Compost, Biochar, and Co-composted Biochar as Soil Amendments to Potatoes. Field day at the WSU Mount Vernon Research and Extension Center, Mount Vernon, WA., July 2018; approximately 100 attendees.
- Garcia-Perez, M., J. Amonette, D Paige-Dumrose, and G. Yorgey. (2018). Biochar Education Day (full day education and discussion for Washington Department of Natural Resources). Ellensburg, WA, March 2018; approximately 15 participants.
- Yorgey, G.G. (2018). Climate and Resource Recovery Update. Presentation to CSANR internal and external advisory committees. Ellensburg, WA, February 2018; estimated 30 participants.

- Amonette, JE. (2018). “Biochar: An Overview.” Presentation to Working Session, Washington Senate Agriculture, Water, Natural Resources & Parks Committee, Olympia, WA, January 2018. PNNL-SA-131938. Estimated audience of 60, plus was available on legislative CCTV (both during and after the event).
- Yorgey, G.G., and K. Hills. (2017). The Waste to Fuels Technology Partnership: Advancing Organics Management in Washington State. Olympia, WA, December 2017; approximately 10 participants.
- Ewing, T., G. Yorgey, and M. Fuchs. (2017). Odor Reduction in Compost: An Introduction to Biochar. Washington Organics Recycling Council, Tacoma, WA, August 2017; approximately 25 participants.
- Yorgey, G.G. (2017). Science in Action to Improve the Sustainability of Agriculture, Natural Resources and Food Systems. Washington State University Extension Agriculture and Natural Resources Division Meeting. Spokane, WA, July 2017; estimated 45 attendees.

### **Providing technical support**

Bronstad provided technical support to solid waste industry and municipal stakeholders, as well as non-biased information and resources to specific individuals and assisted them in their decision-making around biorefinery-related issues. This support manifested as calls or emails with the below participants, and reached approximately 60 people:

- Suggested options for Sustainable Connections/Whatcom County Solid Waste Advisory Committee on cannabis waste management.
- Continued workshop planning and discussions with King County and Zero Waste Vashon to support King County’s organic waste goals.
- Continued to provide scientific and technical support to NW Natural, a natural gas utility in Portland, with respect to how regional educational institutions might be able to help understand the potential of individual biogas and biomass resources. NW Natural is working with a couple of dairies and wastewater treatment plants in our region that are beginning to explore production of renewable natural gas for pipeline injection.
- Continued to provide scientific and technical support to Stevens County Conservation District regarding their plans for supporting organics diversion and composting.

Yorgey also provided technical support to several ongoing efforts in Washington State relating to sustainable management of organics:

- Provided interview and further referrals to Ecology and WSU contacts relating to the development of a 2040 Sustainable Materials Management (SMM) pathway for the Pacific Northwest, an in-depth research report led by the Center for Sustainable Infrastructure.
- Provided input to the Whatcom County Community Research Project on Climate, relating to organics.

- Provided input relating to organic amendments and other agricultural strategies for carbon sequestration to a climate action plan for the Methow Valley, an effort led by the Methow Valley Citizen's Council.

In addition to these specific examples, Bronstad and Yorgey were invited participants to the King County Organics Recycling Two-Day Summit in Tukwila (3/6/19 and 4/17/19) focused on organics recycling in the Puget Sound region and collecting stakeholder input to identify and prioritize organics recycling. The workshops each had approximately 50 participants (with overlapping participation). Ongoing Waste to Fuels Technology partnership work was discussed during the workshops, with the work relating to compost valuation and biochar co-composting being of particular interest.

Subsequent to the workshop, Bronstad was contacted by King County to provide comments and suggestions for a request for proposal (RFP) that the County is issuing to consultants for a composting feasibility study. In addition to asking for help on the RFP, King County asked if Bronstad could continue to act in an on-going advisory role throughout the project. This request represents an opportunity to provide a different, more structured type of technical "consulting" support to help municipalities and solid waste managers ask questions of their for-profit consultants and make more informed decisions about their organics management options. This is also an opportunity for the expertise and knowledge encompassed in the Waste to Fuels Technology partnership to be used to provide input and/or more formal recommendations for counties or municipalities engaged in specific organics management projects.

## **On-demand extension resources**

Written extension resources that are continuously available and provide on-demand information are an important complement to in-person presentations and individual conversations. They also provide a variety of products to meet a range of information needs. In many cases, the information has been peer-reviewed, an attribute that non-academic stakeholders throughout the region have indicated as important to them (Kantor et al. 2012).

This biennium's efforts included work to update a white paper on carbon sequestration in agricultural systems to include information about municipally-derived organics. The original white paper was developed by Yorgey and colleagues in response to questions raised by the Washington non-profit community related to the potential for agricultural systems to help in climate change mitigation efforts. Topics included in the white paper included strategies such as tillage and perennial plants but had not included amendment with organics. The work funded by the Waste to Fuels Technology partnership therefore included a review of the literature related to climate change mitigation opportunities provided by municipally-generated organics (biosolids, compost, and biochar). The white paper was also submitted to the Washington State University Extension system, where it will undergo peer review and then be available to stakeholders throughout Washington.

- Yorgey, G., S.A. Hall, C. Kruger, C. Stockle, K.M. Hills, M. Donnay. Carbon sequestration potential in cropland soils in the inland Pacific Northwest: A summary of knowledge and gaps. WSU Extension Publication submitted June 2019.

In addition, during this biennium, Yorgey and collaborators Sonia Hall and Hills provided, recruited, and coordinated blog content to both the Center for Sustaining Agriculture & Natural Resources and agclimate.net (a regional PNW website related to climate and food systems/agriculture/natural resources issues). Content described past and ongoing Waste to Fuels Technology partnership findings, as well as other regional work on topics relevant to sustainable organics management. Related content included the following posts:

- Hills, K. [The Devil is in the Process: Co-composting Biochar Could Benefit Crop Growth and the Environment](#). Agclimate.net and CSANR Blog. February 19, 2019.
- Hall, S. [How to Spread Biochar in Forests](#). November 2, 2018
- Hills, K. [Turning Urban Wood Waste into Biochar](#). Agclimate.net and CSANR Blog. June 8, 2018.
- Houston, L. [Forest to Farm Biochar – What will it take?](#) Agclimate.net. May 17, 2018.
- Schnepf, C. and McAvoy, D. [Biochar and Forestry](#). Agclimate.net. May 3, 2018.
- Trippe, K. [Biochar: What can it do for your Soil?](#) Agclimate.net. April 26, 2018.

In addition to these current efforts, resources previously completed via the Waste to Fuels Technology partnership and a wealth of other information related to organic resource recovery is being maintained on the [waste management topic pages](#) of the Center for Sustaining Agriculture and Natural Resources website, which includes subtopic pages for compost, pyrolysis (biochar), anaerobic digestion, and nutrient recovery. In total, on-demand products relevant to Waste to Fuels Technology (those produced this biennium, and those produced in previous biennia) were viewed a total of 18,020 times in the 2017-2019 biennium.

Meanwhile, other portions of our work (carried out with separate funding) continue to integrate an assessment of the potential benefits from municipally-generated, carbon-rich amendments – including compost, biochar, and biosolids – to soil health in the region, as well as the barriers. Notable contributions and activities in this regard that were presented or published in this biennium include:

- Yorgey, G.G., W.L. Pan, R. Awale, S. Machado, and A. Bary. (2017). [Soil Amendments](#) (includes discussion of biosolids, compost, and biochar). In Yorgey, G. and C. Kruger, eds. [Advances in Dryland Farming in the Inland Pacific Northwest](#), Washington State University Extension, Pullman, WA.
- Pan, W., W. Schillinger, F. Young, E. Kirby, G. Yorgey, K. Borrelli, E. Brooks, V. McCracken, T. Maaz, S. Machado, I. Madsen, J. Johnson-Maynard, L. Port, K. Painter, D. Huggins, A. Esser, H. Collins, C. Stockle, and S. Eigenbrode. (2017). [Integrating historic agronomic and policy lessons with new technologies to drive farmer decisions for farm and climate: The case of Inland Pacific Northwestern U.S.](#) *Frontiers in Environmental Science*. 5:76. doi: 10.3389/fenvs.2017.00076

- Yorgey, G., S.A. Hall, E. Allen, E.M. Whitefield, N. Embertson, V.P. Jones, B.R. Saari, K. Rajagopalan, G. Roesch-McNally, B. Van Horne, J. Abatzoglou, H.P. Collins, L. Houston, T. Ewing, and C. Kruger. (2017). [Northwest U.S. Agriculture in a Changing Climate: Collaboratively Defined Research and Extension Priorities](#). *Frontiers in Environmental Science*. 5: 121-141. doi:10.3389/fenvs.2017.00052.
- Yorgey, G.G., K. Borrelli, K.M. Painter, and H. Davis. (2018). [Conservation tillage in a winter wheat – fallow system: Ron Jirava \(Farmer to Farmer Case Study Series\)](#). (covers biosolids use) Pacific Northwest Extension Publication PNW 706, Pullman, WA.
- L. Michels, B. Saari, K. Hills, G. Yorgey, J. Moore Kucera, G. Roesch-McNally, D. Finkelnburg, D. Wysocki, and S. Cappellazzi. (2019). [Healthy Soils, Healthy Region Workshop](#) (2 ½ day workshop). March 13-15, Pendleton, OR. Approximately 150 participants.

Additional relevant work, carried out with complementary funding, focuses on the opportunities for pre-consumer organic wastes to be managed via co-digestion with livestock manure.

Relevant new publications from the current biennium include:

- Yorgey, G., C. Frear, N. Kennedy, and C. Kruger. (2019). [The dairy manure biorefinery](#). Washington State University Extension Publication FS316E, Pullman, WA.
- Hall, S., Benedict, C., Harrison, J., and Yorgey, G.G. (2018). [Nutrient Recovery Products from Dairy Manure](#). Washington State University Extension Publication FS305E, Pullman, WA.
- Frear, C.S., Ma, J., and G.G. Yorgey. (2018). [Approaches to nutrient recovery from dairy manure](#). Washington State University Extension Publication EM112E, Pullman, WA.
- Jensen, J., C.S. Frear, C.E. Kruger, and G.G. Yorgey. (2018). [Completing a successful feasibility study for an anaerobic digestion project](#). Washington State University Extension Publication FS292E, Pullman, WA.
- Hall, S., and G.G. Yorgey. (2017). [Video: Recovering Nutrients from Manure – New Tools for Maintaining Air and Water Quality](#). Produced by CAHNRS Communications. Extension Publication PRV03. Washington State University, Pullman, WA.

## **Leveraging Waste to Fuels Technology funds to increase impact**

The Waste to Fuels Technology partnership plays an important role in engaging faculty in next-generation waste processing issues. Many partners use their work within the partnership to leverage additional funding that enhances their work and impact in the region. During the 2017-2019 biennium, research and extension personnel were able to leverage the Waste to Fuels Technology partnership work to successfully obtain \$357,658 in additional funds:

- Garcia-Perez M, Moller G, Strawn M. (2019) Engineered Biochars to Enhance the Profitability of Distributed Energy Systems to Reduce the Environmental Impact of Anaerobic Digesters. \$246,000
- Yorgey, G.G., Gang, D., Collins, D.P. and Seefeldt, S. (2019) Integrating Municipal Compost and Biochar for Production of High-Value Crops. United States Department of Agriculture, McIntire Stennis Capacity Funding. \$50,000.
- Collins, D.P., Siegner, A., Stacey, N. (2019) Investigating the Elasticity of Biochar: Manure Handling, Compost Feedstock, Soil Amendment and Carbon Storage. United States Department of Agriculture, Western SARE, Professional + Producer Grant. \$49,988.
- Amonette, J. (2019) Impact of Process Emissions on Climate Offsets by Different Biochar Production Methods, Washington State University BIOAg. \$11,670.

## **National and international reach**

Research findings from the Waste to Fuels Technology partnership were also shared with academic audiences throughout the region, nation, and beyond through both presentations and publications.

Presentations included:

- Stacey, N.E., Collins, D.P., Seefeldt, S., Gang, D., Flury, M. and Hoashi-Erhardt, W. (2019) Biochar Amendment in Agricultural Soils: Feast, Famine, or Moderation in Soil Carbon, Nitrogen, and Water. Soil Science Society of America International Soils Meeting. San Diego, CA. (1/6/19-1/9/19)

Relevant peer-reviewed journal publications that were published during this biennium include:

- Ayiania M, Carbajal-Gamarra FM, Garcia-Perez T, Frear C, Suliman W, Garcia-Perez M: Production and characterization of H<sub>2</sub>S and PO<sub>4</sub><sup>3-</sup> carbonaceous adsorbents from anaerobic digested fibers. *Biomass and Bioenergy*, January 2019, 339-349.
- Ayiania M, Terrell E, Dunsmoor A, Carbajal-Gamarra F, Garcia-Perez M: Characterization of solid and vapor products from thermochemical conversion of municipal solid waste woody fractions. *Waste Management*, 84, 2019, 277-285. (2015-2017 biennium work).
- Ayiania M, Hensley AJR, Garcia-Perez M, McEwen JS: Thermodynamic Stability of Nitrogen Defects in Carbonaceous Materials from First Principles. Paper Submitted to *Carbon*, 2019
- Ayiania M, Hensley AJR, Smith M, Scudero L, McEwen J-S, Garcia-Perez M: Core Level Binding energy for Nitrogen Doped Char: XPS Deconvolution Analysis through Computational Calculations from first Principles. Paper to be submitted to *Carbon*, 2019.
- Haghghi-Mood S, Ayiania M, Jefferson-Milan Y, Garcia-Perez M: Nitrogen Doped Char or Anaerobic Digested Fiber for Phosphate Removal in Aqueous Solutions, Paper submitted to *Science of the Total Environment*, 2019.

## **Impacts of technology transfer, outreach and extension activities**

In total, extension efforts resulted in an estimated 754 in-person contacts with key stakeholders who work either primarily on organics management in the region, or whose work touches on sustainable organics management in various ways. Our efforts also resulted in 18,020 views of Waste to Fuels Technology reports, publications, blog posts, and other extension resources relating to Waste to Fuels Technology concepts. Work carried out in the previous and current biennium was used to leverage an additional \$357,658 awarded during this biennium to support work in areas related to Waste to Fuels Technology priorities.

While the ultimate outcome of these interactions and activities is likely to be realized in the long-term, there are short-term indications that stakeholders have found them useful. Bronstad heard numerous times from many municipal and industry stakeholders in Washington state that they were very excited to hear that Ecology was involved in this type of work, and that WSU was engaged in this type of research.

Specific quotes included:

- “It sounds like WSU is up to a lot of awesome things in the areas of biogas and biorefineries.” -NW Natural email
- “[ ] and I were both intrigued by your presentation and how our agencies can work together. We’re considering how we might incorporate research assistance and/or a forward-looking project into our solid waste system, and who here at King County should see another presentation.” King County email

Only a few were aware of the ongoing partnership prior to interactions with our team, therefore we have successfully introduced the effort to many new stakeholders across the region. Additionally, some Department of Ecology solid waste staff learned more about the research being conducted by the Waste to Fuels Technology partnership and can, in turn, advocate for next-generation organics management strategies in communities around the state when appropriate.

## **References**

Kantor, S.I., G.G. Yorgey, and C.E. Kruger. 2012. REACCH stakeholder advisory committee interests in climate change information needs. REACCH Project Report. Center for Sustaining Agriculture and Natural Resources, Wenatchee, WA.