Executive Summary

To accelerate the commercial production of drop-in hydrocarbon fuels from wet waste biomass, the Bioenergy Technologies Office (BETO) in the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) held a workshop on November 5, 2014, in Arlington, VA. A broad spectrum of experts from industry, academia, national laboratories, and government participated in the workshop, contributing their ideas, insights, and perspectives. The wealth of information gathered at the workshop will enrich BETO's strategic planning and prioritization efforts.

As summarized and grouped thematically in Table ES.1, the participants discussed activities and technologies that could facilitate the commercial conversion of wet waste feedstocks into drop-in hydrocarbon fuels and products. Working in four parallel technical breakout sessions, the participants identified 17 advancement activities as high in priority. Some of these activities apply broadly to wet waste conversion, while others apply to specific technologies. Across these priority activities, four areas of focus emerge:

- **Pre-Processing:** Better understanding and modifying feedstocks to improve downstream processing efforts. Activities include limiting feedstock variability, optimizing pre-processing and conversion systems for use with available feedstocks, and enabling product flexibility.
- **Process Research:** Applying research concepts to conversion processes to achieve breakthroughs in operations. Focus areas include enhanced understanding of microbial and biological processes and of thermochemical reaction kinetics to improve process efficiency, product quality, product flexibility, and by-product utilization.
- **Process Engineering:** Applying engineering concepts to known processes to reduce operational or capital costs and make liquid fuels more cost-competitive. Activities focus on improving processes to accommodate highly variable feedstocks and contaminants, improving product quality and yield, and enabling the scale-up of technologies.
- **Analysis:** Conducting broad, computationally based efforts that will increase understanding of and help to improve WTE efforts. Analysis efforts focus largely on directing WTE research along promising pathways, validating the techno-economic feasibility of projects, and quantifying environmental impacts.

Identified activities that could potentially accelerate progress and help realize the commercial potential of drop-in hydrocarbon biofuels from wet waste feedstocks are summarized below in Table ES.1.

Table ES.1. Activities To Accelerate the Commercialization of WTE Technologies

Activity	Description	Group*
Pre-Processing		
Characterize feedstocks and co-digestion	Prepare guidance on the relationship of organic feedstock characteristics to digester performance and to biogas production	AD 1
Manage moisture by blending with dry biomass	Explore blending solutions to economically manage the variability and uncertainty of wet waste for hydrothermal liquefaction (HTL)	HTL
Demonstrate and deploy preprocessing and pretreatment technologies	Develop pretreatment to enhance methane production in anaerobic digestion; incorporate other waste streams into AD	Other

Activity	Description	Group
Process Research		
Improve understanding and real-time monitoring of microbial anaerobic processes	Increase the scientific understanding of microbial systems through the development of real-time biosensors for anaerobic processes	AD 1
Enable direct conversion to high-value products including fuel intermediates	Control and modify microbial processes to improve profitability and flexibility of the products and product types	AD 2
Produce AD end products beyond methane, methanol, and ethanol	Develop technologies that are able to produce end products beyond CH_4, methanol, and ethanol through anaerobic digestion	AD 2
Develop economic usage of non-oil HTL effluent streams	Identify and develop an economically viable process/technology to utilize the nutrient-rich, non-HTL crude oil streams produced during the HTL process	HTL
Conduct R&D on biological and thermo-catalytic conversion technologies for pre-processed waste biomass	Develop higher-value, targeted profiles for storable/transportable products/intermediates that can be produced faster and under less severe conditions than anaerobic digestion (AD)	Other
Process Engineering		
Configure new bioreactor for enhanced AD and higher process efficiency	Improve environmental and technical performance via shorter retention times; improve gas quality, energy yield, and digestion rates to make AD cheaper, smaller, better, and faster	AD 1
Develop cheaper gas cleanup technology that works on smaller scale	Develop biogas cleanup technology that costs less than $2/MMBtu, produces 50-500 standard cubic feet per minute (SCFM), yields greater than 95% biomethane, and provides long-term reliability.	AD 2
Design robust digester to handle wide variability of feedstock	Design robust digester system to handle various feedstocks and high-solids waste streams	AD 2
Improve process monitoring and control to handle highly variable feed streams	Develop robust process controls to optimize novel waste-to-energy processes that use highly variable, non-homogeneous input streams	Other
Support scale-up of technologies	Demonstrate conversion of manure and organic substrates (waste) to middle distillate fuels (diesel); enable multiple value streams; prove beneficial use that avoids environmental runoff	Other
Analysis		
Design a lifecycle systems approach that includes feedstocks and biosolids, conversion technologies, and end use products	Quantify biogas production, energy balance, and carbon sequestration from wastewater sludge; reduce greenhouse gas (GHG) emissions from co-digestion diverted from landfills; calculate the economic, GHG, and resource conservation benefits of biosolids as fertilizers	AD 1
Optimize macro process improvements	Enable technology developers to co-optimize/optimize cost, environmental performance, and fuel yield ; Analyze HTL of wet-waste/biomass: integrated analysis of all HTL process unit operations (everything from sludge to fuel and resource recovery)	HTL
Conduct techno-economic analyses	Evolve conceptual process design and modeling to define process variables, technical barriers, and key drivers for economical technologies	Other
Other		
Identify and reduce regulatory barriers to improve technical acceptance by the marketplace	Enable technology implementation and early adoption; develop technical basis for regulatory concerns	HTL

***AD 1**- Anaerobic Digestion of Wastewater Residuals and Biosolids
AD 2- Anaerobic Digestion of Foodstuffs and Other Municipal Solid Waste
HTL- Hydrothermal Liquefaction of Wet Waste
Other- Other Conversion Processes of Wet Waste