RFI DE-FOA-0000933, *WASTE: Waste Applications for Sustainable Technologies for Energy*, Responses to Category 1 Questions

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The National Association of Clean Water Agencies (NACWA) appreciates the opportunity to respond to the Request For Information Number DE-FOA-0000933. NACWA's responses to the questions in the RFI Category 1, ***State of WTE Industry, Technology Development and Technology Readiness,*** are submitted in conjunction with the Water Environment Federation (WEF) and the Water Environment Research Foundation (WERF). WEF and WERF have submitted responses to the Category 2 and 3 questions, respectively. NACWA, WEF, and WERF jointly published the *Water Resources Utility of the Future. . . Blueprint for Action*, which provides information and initiatives related to the work of POTWs in the energy sphere.

NACWA represents the interests of nearly 300 public wastewater treatment agencies, which treat and reclaim a majority of the wastewater generated nationwide. Treating municipal wastewater has traditionally been the primary function of publicly owned treatment works (POTWs), but POTWs are evolving into resource recovery facilities that reuse water, extract nutrients, and produce energy.

The 15,000 POTWs in the U.S. treat over 40 billion gallons of wastewater each day, generating over 8 million dry tons of biosolids annually. Since biosolids contain approximately 8,000 Btu/lb (2.3 kWh/lb) on a dry weight basis, the biosolids produced nationally each year contain more energy than 1 million gallons of gasoline. A variety of technologies may be used to recover this energy, including anaerobic digestion, incineration, gasification, and pyrolysis. In addition to the energy contained in biosolids, POTWs can produce energy through various other methods, such as using the kinetic energy of flowing wastewater, recovering the heat in wastewater, and using microbial fuel cells to generate electricity from the organics in wastewater. All of these technologies are in various stages of research and implementation.

Although wastewater utilities are increasingly implementing energy recovery methods at their facilities, economic and regulatory barriers remain to fully utilizing these renewable energy sources. For the more established technologies, like using biogas from anaerobic digestion to produce electricity, these barriers include the initial cost of equipment, which is often difficult to justify given the payback time for the project, and limitations on the use of tax-exempt bonds for energy projects. In addition, air emission regulations have increased costs of energy recovery methods associated with biosolids incineration. Electrical utilities sometimes create barriers when POTWs produce electricity by removing the lower rates and rebates provided to POTWs. For newer, less-tested technologies, POTWs are reluctant to put the public ratepayer funding they have been entrusted with at risk to try something new and unproven. More specific information about energy recovery at POTWs is provided below.

1) How do you define waste-to-energy? What is the state of the technology for WTE?

Waste-to-energy (WTE) for POTWs is defined as using any aspect of the influent wastewater, or the products resulting from the treatment of this wastewater, to produce heat, fuel, or electricity. Using this waste for energy reduces the dependence on fossil fuels or other energy sources for

the POTW and, in some cases, outside entities. Some methods of WTE used by POTWs are well-established technologies that have been used successfully for many years, such as anaerobic digestion of biosolids to produce biogas. However, other promising technologies are still being investigated, and if they are proven effective in practice at more POTWs, WTE production may be significantly increased at these facilities. (More details about technologies are contained in the response to Question 4 below.)

2) What are the most promising new areas in the field of WTE R&D that U.S. DOE should consider? Is there any current federal assistance in these areas? Are there any existing policies that present barriers to this technology and prevent its expansion?

There is currently little or no federal assistance for research related to energy production from wastewater. While any of the technologies discussed in Question 4 should be considered for a WTE R&D program, research into increasing the energy produced from anaerobic digestion of biosolids may have the most immediate benefits, since this technology is already in use at a large number of POTWs. Pyrolysis, microbial fuel cells, heat recovery, and kinetic energy recovery are also promising technologies that may achieve good results with more R&D. Information about barriers to these technologies is provided below.

3) What waste feedstocks should be considered eligible for funding within a RDD&D effort?

Wastewater, and the sludge, biosolids and biogas produced from treating it, should be considered eligible feedstocks. Additional organic waste materials that can be combined with wastewater or biosolids to increase biogas production during anaerobic digestion should also be considered eligible feedstocks. Since wastewater and these other organic wastes must be managed/treated appropriately to protect public health and the environment, energy production at POTWs reduces the consumption of non-renewable fuels and provides additional environmental benefits.

4) What technology options can be applied to convert waste biomass feedstocks into fuels, products, or power? What are the potential benefits or impacts of these technologies? What barriers must RRR&D activities overcome in order for these options to be competitive?

Anaerobic digestion of biosolids is the most commonly used technology to produce energy at POTWs. Over 1,400 POTWs use anaerobic digesters to process their biosolids, generating biogas that consists primarily of methane (60-65%) and carbon dioxide (30-40%). Biogas can be used in place of natural gas in boilers and engines to produce heat and electricity. Over 800 POTWs use biogas for energy, and nearly 300 of these produce electricity from biogas. While anaerobic digestion of biosolids is a successful energy generation method, additional deployment of energy generation equipment to all POTWs using anaerobic digesters would increase production. In addition, energy production associated with anaerobic digestion may be increased with technologies that are not yet well-established in the U.S. that could benefit from additional R&D:

- **Co-digestion of organic wastes** increases biogas production by co-digesting organic materials with the biosolids. These organic materials include food processing wastes, airplane de-icing fluid, and animal products such as blood or manure.
- **Pretreatment of solids** can increase biogas production by 30 to 60 percent. Before anaerobic digestion, by breaking open the bacterial cells of the biosolids with thermal hydrolysis, mechanical disintegration, or electrical pulse treatment. These pretreatment technologies have not been used in Europe but not in the U.S.
- **Improved primary treatment** increases the volatile solids content of the biosolids, increasing the yield of biogas. Technologies for treatment include chemically enhanced

primary treatment, ballasted flocculation, and fine screens. Current EPA policies on wastewater treatment prevent many POTWs from investing in these treatment options.

- **Conversion of biogas methane to methanol** using microbes is currently in the exploratory research phase.

A barrier for biogas use that could benefit from more R&D is contamination by siloxanes, compounds used in a variety of consumer products. During biogas combustion, siloxanes are converted to silicon dioxide, an abrasive solid similar to fine sand, causing damage to equipment and loss of efficiency. Siloxane removal with current methods is expensive, significantly adding to the cost of WTE projects.

Incineration of biosolids produces combustion gases that pass through a heat recovery system to produce steam, and then a steam turbine generates power. This underutilized WTE method is hindered by the emissions standards set by EPA in 2011 that make it significantly more expensive for POTWs to invest in innovative biosolids incineration/energy production technologies.

Gasification of biosolids involves the chemical reaction of the organic fraction of dried biosolids at elevated temperatures, producing heat and gas that can be used to generate power. Gasification has only been used at a few POTWs, and a barrier to increased implementation is the cost and energy required to dry the biosolids.

Pyrolysis uses high pressure and temperature in the absence of oxygen to decompose the organic material in biosolids into a combustible gas, a bio-oil, and a solid residue called char, which all have energy value. This process is only being used at one facility in the U.S.

Steam reformation is a chemical process that converts hydrogen-containing fuels into hydrogen gas at high temperatures. This process has not yet been used extensively for biomass.

Ammonia from wastewater can be burned in internal combustion engines or used in fuel cells.

Heat recovery uses the latent heat in wastewater to heat buildings or water. This type of system was used at the athlete's village for the 2010 Vancouver Winter Olympics.

Hydraulic energy recovery can be achieved by installing micro-hydro water turbines or hydrokinetic devises in channels and conduits prior to discharge.

Anaerobic treatment of wastewater allows direct conversion of the chemical energy in wastewater to biogas. It is a well-established technology for high-strength, high-temperature wastewaters, but more research is needed before it can be used on the lower temperature municipal wastewaters in the U.S.

Microbial fuel cells generate electricity from the organics present in wastewater and have been tested at the bench-scale level.

5) What characteristics do you think are desirable in using waste as a feedstock? What characteristics would be undesirable and why?

The most important characteristic of a waste used as a feedstock is that its use does not have negative environmental impacts. Wastewater must be treated to protect the environment and public health, and POTWs are treating wastewater by using the same processes that would occur in nature. Wastewater is a continuously produced renewable fuel source that does not result in land use changes. Maximizing the energy produced at select POTWs has shown that these facilities can produce all of the energy they need to operate and even generate excess energy for other purposes.