

# Net Energy from Wastewater



ARPA-E Potential FOA

Mark A. Shannon

January 27, 2010

## Technology Landscape

Issues and Metrics

Program Scope and Metrics

ARPA-E EWW from Wastewater Program

## Existing Landscape for Water-Energy

- There is white space for ARPA-E to develop a program that complements existing federal research directions.
- Currently, there is not a water mission in DOE. There is work on energy generation from biomass w.r.t. water, but not on wastewater water/energy + nutrients recovery. No other agency (as far as we know) has goal of clean water with net energy generation from wastewater. Unique objective.
- ARPA-E can have an innovative and significant impact:
  - Higher risk, cross-cutting research
  - Encourage teaming to harness complementary skills, ranging from academia to industry
  - Partnering with EPA, associations and NDA's, and other governmental groups to enable insertion into practice



# White Space for ARPA-E, EPA, National Labs (NREL), EIA, etc.



Incinerators

Pyrolysis-

Gasification

Anaerobic digestors

Thermal Oxidation

Plasma arc

Microbial Fuel Cell

Algae-Novel Biology

Novel Material  
Enhanced MBR  
and Disinfection



New microbes for energy conversion  
Methods for low cost enzyme hydrolysis

Novel Architectures  
and Combined Systems

Completely New  
Concepts like FO

**Note: What we are looking for is technology or suite of technologies will achieve the metrics and objectives of the program. No technology type is favored or excluded. Science that revolutionary advances technology is desired.**

Technology Landscape

**Issues and Metrics**

Program Scope and Metrics

ARPA-E EWW from Wastewater Program

# Issues with Energy from Wastewater Program

- U.S. lags far behind Europe, Israel, and Singapore
- Expertise sparse here in U.S. in traditional systems
- Potential lack of performers in most exciting technologies
- Almost impossible to innovate in U.S. in water sector
  - Regulations, litigation, codes, financing new products
  - Consultants control all interactions between vendors and customers (municipalities, wastewater companies)
  - Customers need to see substantial past practice before accepting new products, with predictable results that systems can be specified from.
- Need association participation (WERF, WEF, WRF, etc.)
- But if successful, huge number of adopters, from industries to municipalities. Overseas market huge.

## Energy from Wastewater Program

- Demonstrate net energy output for municipal wastewater systems with organic composition at X ? ppm that must be reached.
  - Energy balance must include *all* inputs, including electrical, chemical, and thermal energy. Output must be in total converted energy output, not in energy content as measured (i.e. computed higher heating value).
  - Quality of product water needs to be pathogen free and meet non-potable industrial use standards (less than Y ? ppm total dissolved solids).
  - Full cycle analysis is needed including periodic cleaning cycles, cost of materials, and discharge.
  - Cost to treat water, including energy, capital amortization, and operating costs (including any pre- or post-treatment) needs to be  $< \$?/m^3$  of product water. Trade offs of size to energy, or capital to energy need to be incorporated.
  - More to be included from workshop input.

Technology Landscape

Issues and Metrics

**Program Scope and Metrics**

ARPA-E EWW from Wastewater Program

## Energy Clean Water from Wastewater Program

- Three 18 month phases are envisioned.
  - Phase I: Component demonstration with individual balances for systems that will be applicable for flows of *less than* 1 liter/second (23,000 gal/day) and flows *that equal or greatly exceed* 1 m<sup>3</sup>/second (23 MGD). Different solutions needed.
  - Phase II: System integration for the different flow targets with full cycle analysis.
  - Phase III: Pilot plant demonstration of 2-3 maybe more full system with real water. Multiple approaches expected for targeted size of system.
- Funding for Phases I and II now, with Phase III to come if additional funding from Congress is provided.
  - Phase I aggressive, with substantial downselects expected. Successful teaming agreements expected to get to Phase II, with downselects to Phase III.
  - Co-funding by EPA, solution providers, and community/State expected for Phase III.

Technology Landscape

Issues and Metrics

Program Scope and Metrics

**ARPA-E EWW from Wastewater Program**



# Program Outline Cost/Phase/Risk



- 5-10 component investigations at ~\$0.5-2.5 M ~\$ 10 M
  - Demonstrate key enablers (E.G. non-fouling membrane) (Phase I-II)
- 3-5 technology platforms at ~\$5-7 M ~ \$20 M
  - System level platforms that will exploit (Phase I, II, III)
- 2-3 industrial pilots at \$6-10 M (ARPA-E share) ~ \$15 M
  - Head to head testing of system in pilot to gain data (Phase III)
- Totals ~ \$35 M
- Phase I and II will involve down selects, with only successful component investigations being carried forward with successful technology platforms, so savings from initial committed \$ are expected.
- Phase III pilots from future ARPA-E rounds with buy-in from EPA, State, and local stakeholders
- Risk profile is high, since enabling technologies are needed to create breakthrough changes in state-of-the-art. If demonstrated in Phase I, risk profile reduces to medium, as a well-established industry exists, and the pull if successful is very strong.

# ARPA-E Program Criteria

- What is the global landscape of the field – science, technology, markets, players?
- What are the major gaps and “white spaces”? Have you coordinated with rest of DOE?
- What’s new & why is it a potential game-changer?
- Is there room for left-field ideas?
- Can your goal be reframed to achieve a better outcome?
- If successful, what potential impact can it make in terms of quantitative metrics?
  - *Energy independence & security*
  - *Reduction of GHG emissions*
  - *Technological lead for US*
- Will it scale in cost and volume? Why?
- Who will adopt this technology? Who are the customers?
- Are there non-technical barriers (policy, markets)?
- Who are the potential teams and players?
- What is your potential risk profile and time horizon – low, medium, high, short/long-term?
- How much will it cost and why?