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ARPA-E Energy from Wastewater

Breakout Group #3 - Net Energy from Wastewater: Science and Technology Needed, with Associated Metrics

Group 1: Science and technological challenges to obtaining energy from wastewater with more than an order of magnitude better performance than current technologies

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Studies have shown that there is ~10x as much energy in wastewater as what is required to treat it. How far can we realistically expect science/technology to take us along that that gap?

- It would be good to have a metric of net Joule/1000 gallons (J/kgCOD is only organic loading + thermal content (J/differential temperature)) to match $ / 1000 gallon concept ➔ we need a good BENCHMARK on what we are at today for energy recovery for existing WWTPs with today's technology
- How does the value of X scale across facility?
- Zero X is no net energy recovery; most facilities today have a NEGATIVE X (what is
- The "best X" is probably the facility in Switzerland from WERF talk – find out what the X value is for that facility
- A metric should be P in wastewater versus P "embedded" in per capita P consumption. Would removing even 100% of P from wastewater make a difference?
- PKN is important for fertilizers (phosphorous, potassium, nitrogen = PKN) and may be important metric to compare against conventional fertilizers
- Is wastewater available for "water-splitting" technologies to produce hydrogen

- Biosolids, solid fuels, water splitting to generate hydrogen all forms of energy you could extract,
- An ongoing approach is to mix agricultural waste with municipal ww biosolids to see how much energy can be extracted (Michigan state)
- Anaerobic biogas -> electricity (established process, efficiency varies – Lincoln Nebraska, 40MGD plant that can support 70% of it's power on site)
- Benchmark system: Swiss system at net energy neutral. ARPA-E should baseline off that and try to develop technologies beyond that
- If you start with new technologies only after the secondary treatment step, you won't reach the energy goals. Analysis and innovation needs to start at the pipe.
- Some plants can make use of natural resources to make up for some of its energy use (like around lakes where algae can be used)

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What are the roadblocks that are preventing current systems from maximizing the energy extracted from the biomass produced from wastewater treatment?

- Nutrient recovery is important to meet demands of keeping nutrients out of receiving waters; nutrients also have an economic value
- Take a systems approach to capture energy at different points in a system and don't rely upon only one approach/technology – LCA approach is critical
- Use high capacity digester (MBR) to reduce volume of reactor which increases the ease of heating, etc. (reduced capital)

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- Question to answer: How much COD do you have to convert to biogas to sustain your plant?

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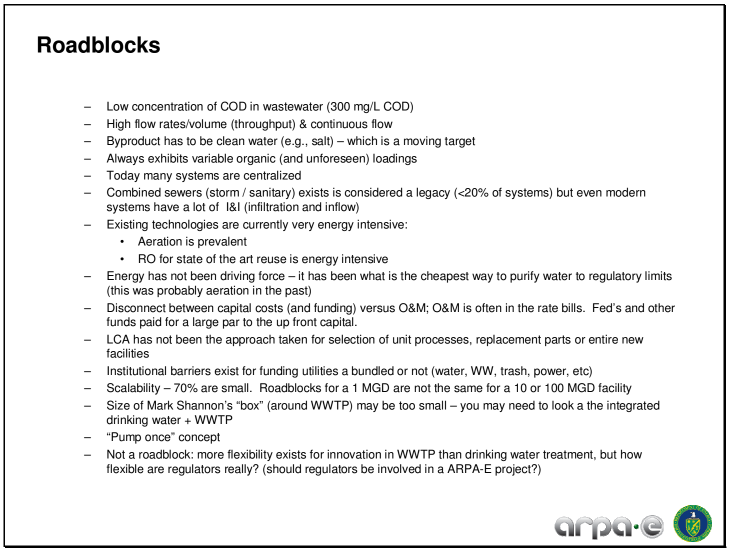

- Challenge – seasonality, availability of certain organics
- Expertise is required by operators in wastewater treatment plants that are efficient, as the operator needs to know how to maneuver around the normal process to optimize it.
- If digesters go sour, they are out of operation for long stretches of time (months)
- Challenge is how to grab COD out of the water without using thermal energy
- Overall challenges: dilute wastewater, high flowrates/throughput and byproduct, variability of wastewater – needs to be resistant to loading changes. The concept of "clean water" is a moving target. Centralization of our current systems. Combined collection systems are a problem - stormwater is being mixed with regular municipal water. Salting. Old pipes leading to either leaking, or intrusion. Aeration required and is very energy intensive – infrastructure inadequacy.
- Policy wise, electricity and sewage have to be decoupled. Mayors cannot be allowed to hike up electricity to pay off sewer to keep the cost of that down, since price hikes in elec are more socially acceptable. Must make America realize the importance of WW as a resource
- Processes don't necessarily scale for different types of source WW
- A lot of energy gets wasted in the transport – so many pumps always running, and many different lift stations. Perhaps the WW should be dealt with at the point of flush, and should go to benefiting the house or origin for energy/cost efficiency

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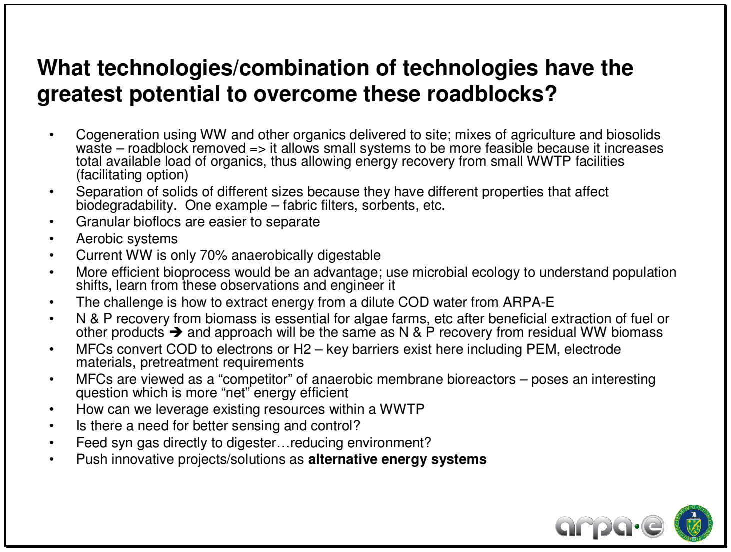

- Renewable biodegradable biowaste adsorbent – adsorbs organics and not water then it goes into digester
- An innovation that is out there is very efficient fabric filters, rather than membranes to efficiently separate out larger constituents and put into anaerobic digester. They have surface properties like membranes, but short lives. Does/can the fabric have embedded energy? Perhaps it can be developed such that its can be energy extracted after it can no longer be used to extract COD
- Membrane bioreactors with nanofiltration. Can we have granular type of biosystems, rather than (floc?) which are more prone to fouling
- Use natural microbial ecologies to identify population shifts to get stronger and most efficient populations. Allows for selection of more ideal strains.
- Systems approach required. Should try to capture energy from all components of WW: biogas, sludge, and remaining CODs.
- Microbial fuel cells about "10 years" out. The benefit of MBFC is the efficiency jump because of direct electrical conversion of COD. One major challenge is that a concentrated energy source is required.
- Synthetic biology going on, trying to get systems to do things biology doesn't do
- Fuel cells research is declining since operation is difficult enough with hydrogen. Would be significantly more challenging with wastewater.
- Regarding variability – perhaps develop technologies to sense and control variability
- If you increase H2 concentration or produce syngas... maybe feed it to the digester? Keep it in a completely reduced state. Use sludge to form syngas, feed the syngas right back to the digester. Biological water shift reaction

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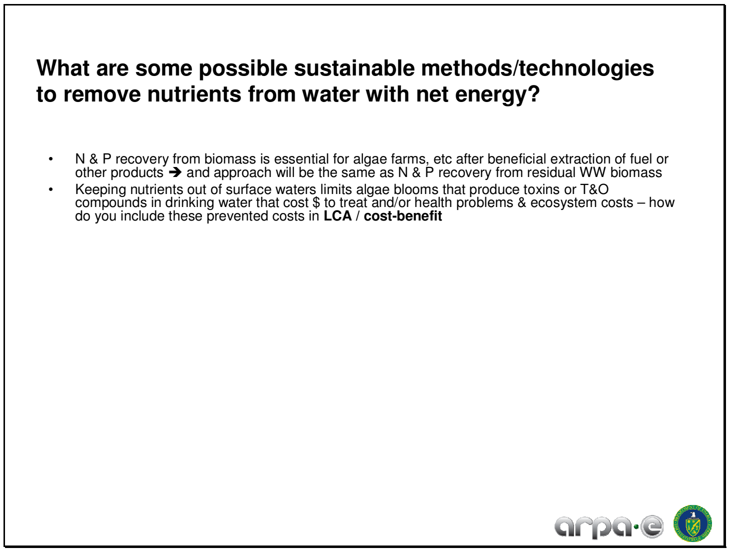

- If all P was extracted from wastewater, would have significant impact on P balance
- Nutrient recovery = N and P
- PKN value in the wastewater – the question is, what is the value of recovering these nutrients compared to the cost/energy to produce. Perhaps an area to go after if balance is favorable
- To breed algae P and N are needed, so really P and N must be recovered from waste for system to be realized. P and N requirement is the biggest economic roadblock
- It is a hard challenge to separate algae from affluent and it needs to be done. Algae has to be collected in order to be processed