To Get Energy From Wastewater

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Think Energy Latent Organics

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Not Sewage Sludge

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White Paper

To Get Energy From Wastewater — Think Energy Latent Organics — Not Sewage Sludge

By
Melvin W. Cook, Founder/CTO
Filtration Dynamics, Inc.

This White Paper will bring to the attention of the reader, a unique Concept; that could transform energy consuming municipal wastewater treatment plants into energy producing Resource Recovery Plants — with a carbon negative footprint — designed to reduce electricity consumption on the grid infrastructure; deliver eco-friendly water; and sell excess electricity to local grids.

First, a brief review of the ever-increasing wastewater, energy, and sustainability challenges that cash strapped municipalities must overcome, as mandated by the Environmental Protection Agency (EPA).

SEWAGE SLUDGE IN WASTEWATER TREATMENT

The treatment and production of sewage sludge is the most energy intensive component in Wastewater Treatment (WWT), consuming more than 60 % of the total energy requirements of a municipal WWT plant. In the United States, this equates to greater than 12.6 billion kilowatt hours of electricity, annually, while simultaneously producing more than 10 million tons of sewage sludge. Conspicuously, the production of this sewage sludge has created a massive waste disposal, environmental, and sustainability problem.

Prior to the mid-1940's sewage sludge was neither a consideration nor an environmental problem because untreated wastewater was simply discharged directly into local waterways, carrying a heavy load of bacteria and other unwanted organisms along with it. After the mid-1940's, the WWT plants that were constructed had the ability to process, treat, and separate the sludge from raw sewage. Thus, began the era of the energy intensive production of sewage sludge and its inherent disposal, environmental, and sustainability issues.

Subsequently, rather than address the disposal problems associated with sewage sludge, municipalities began constructing new WWT systems that employed the same old technology, rather than encourage the development of new techniques. This shortsightedness was primarily due to the availability of massive federal funding, promulgated by the 1972 Water Pollution Control Act, whose treatment infrastructure lessened the need to search for the most cost-effective solution.

Recent advances have introduced newer treatment techniques: such as large-scale activated sludge systems, advanced anaerobic digestion processes that significantly enhance the breakdown of organic materials, and single-stage and multi-stage anaerobic digestion (AD) with biogas utilization for the production of combined heat and power (CHP). In spite of the incremental advances that have been made with these similar sludge treatment processes, the production of sewage sludge continues to remain energy intensive; and the massive disposal, environmental, and sustainability problems are still with us today.

The energy potential for CHP at WWT plants represents an important sustainability decision. The Water Environment Research Foundation (WERF) has stated that sewage contains 10 times the energy needed to treat it. Dr. Mark Shannon, University of Illinois at Urbana-Champaign, addressing Chicago's WWT issues, has stated that harvesting methane from Chicago's sludge could yield a potential 5 mega-joules of energy from each cubic meter of WW treated (5,385 kilowatt hours per million gallons treated). This sludge potential has more than 12 times the energy produced with current AD processes. Accepting these authoritative energy potentials, and aware of the inherent limitations; it is unlikely that the current AD technologies will ever approach these projections, without the achievement of a major breakthrough.

Filtration Dynamics, Inc. (FDI) has postulated that the inherent limitations with the current AD technologies are the inability to isolate the organics — from which the energy (methane to electricity) is generated — from the conventional production of sewage sludge. FDI has the breakthrough Centrifugal Wastewater Filtration/Anaerobic Digestion Technology that is designed to overcome these limitations.

FDI's unique Technological Concept could transform energy consuming municipal Wastewater Treatment Plants into energy producing Resource Recovery Plants; significantly reduce electricity consumption on the power grid infrastructure; filter and deliver eco-friendly water; sell electricity to local grids; and attain a minimum net-energy advantage of 3,150 kilowatt hours of electricity per million gallons of WW processed.

FDI predicts that this transformation could prove to be so fundamental that the 15,610 municipal WWT facilities whose flow rates are 5 million gallons a day or less — EPA's established lower economical limit for CHP — could soon have the option to mitigate their wastewater, energy, and sustainability problems; by upgrading to energy producing Resource Recovery Plants. Considering a 1 MGD average, for the 15,610 facilities, the annualized reduction on the power grid could equate to 14.2 billion kWh of electricity; the electricity sold to local grids, to 3.7 billion kWh; with a net-energy advantage of 17.9 billion kWh. This represents a free, recurrent source of energy that is readily available, 24/7; without adding to the electricity power grid or building new fossil fueled power plants, saving untold billions of dollars.

ENERGY LATENT ORGANICS

The Anaerobic Digestion questions that FDI was compelled to ask are:

1) What are, and where are, the Energy Latent Organics in WW; and can they be defined by size?

2) Can the Energy Latent Organics be isolated, concentrated, and recovered from WW influent?

3) Can the Energy Latent Organics be digested, without interference, in their own unique environment?

4) Can the AD mitigate the massive waste disposal, environmental, and sustainability problems?

5) Will the AD process be capable of approaching the WERF/Shannon energy projections?

FDI's research has revealed that the answer to all five questions is Yes. To the best of FDI's knowledge, no company has created a patented or patents pending Conceptual Model; that can approach the energy potential in municipal WW, as define by WERF/Shannon.

1) What are, and where are, the Energy Latent Organics in WW; and can they be defined by size? This question is answered in **Figure 1.**

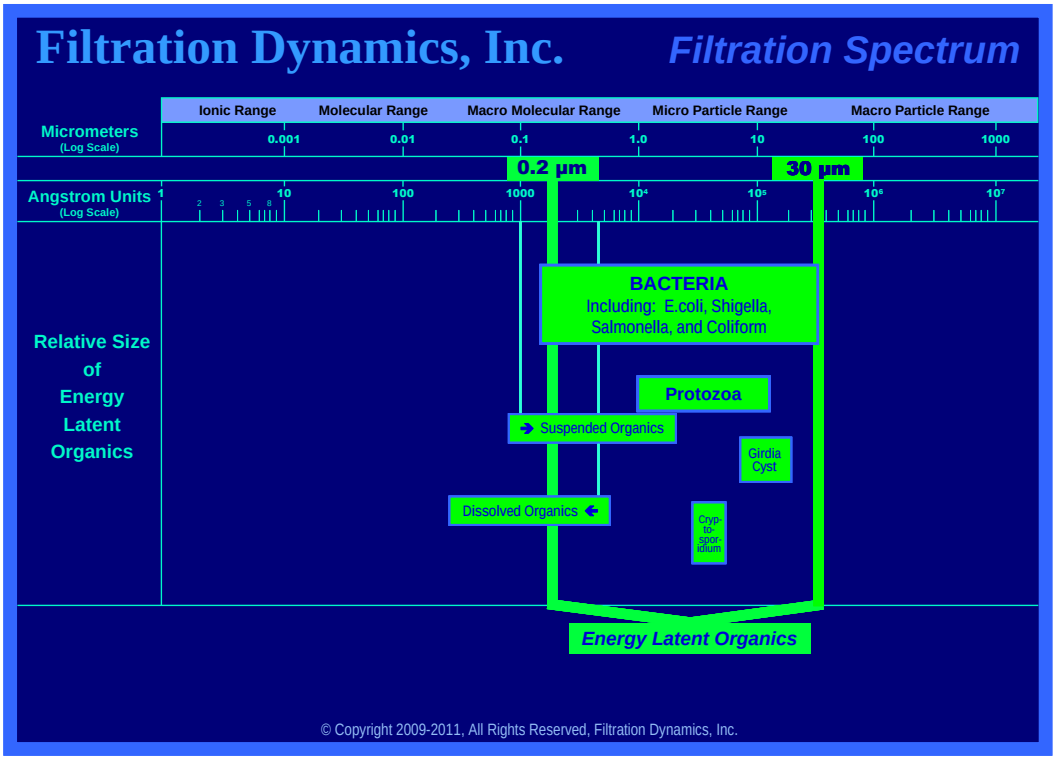


Figure 1. Size Range of Energy Latent Organics

2) Can the Energy Latent Organics be isolated, concentrated, and recovered from WW influent? The answer to this question is Yes.

The filter industry has evolved to the point where sintered filters are now available that can withstand the radial forces generated in FDI's Centrifugal Wastewater Filtration System (CWFS). Therein, the Energy Latent Organics can be concentrated and quantitatively recovered from the WW influent stream and immediately transferred into FDI's innovative 4-Stage Anaerobic Digester.

3) Can the Energy Latent Organics be digested, without interference, in their own unique environment? The answer to this question is Yes, as illustrated in **Figure 2.**

The Anaerobic Digestion of organic matter in WW occurs in four sequential stages. Each stage of the AD process has its own optimum environment, i.e. concentration, temperature, and pH. For that reason, in order for each stage to attain maximum conversion in the shortest time frame (which can occur in minutes instead of days or weeks); it is essential that the stages are separated from one another. Even though recent advances have been made in AD technology, the current sewage sludge AD techniques will be unable to approach FDI's breakthrough 4-Stage AD energy recovery process, because of the inability of the technologies to isolate, concentrate, and recover the unadulterated Energy Latent Organics from sewage sludge.

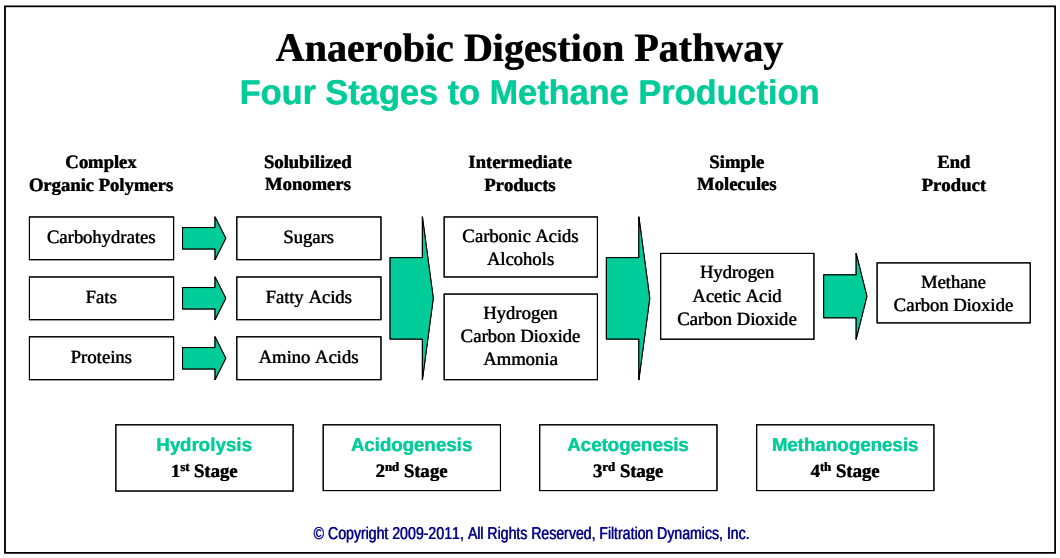


Figure 2. Anaerobic Digestion Pathway

4) Can the AD mitigate the massive waste disposal, environmental, and sustainability problems? The answer to this question is Yes.

Because the CWFS is designed to recover unadulterated Energy Latent Organics from the WW influent stream (approximately 1,700 pounds of Organics per million gallons) and immediately transfer those concentrated Organics into the 4-Stage AD; the Resource Recovery Plant will avoid sewage sludge.

FDI projects, that the 4-Stage AD will ultimately convert a minimum 80% of the Energy Latent Organic mass into methane and carbon dioxide. FDI further projects that the remaining environment friendly 340 pounds of Digestate will be designated Class A by the EPA; thus mitigating the ever-occurring waste disposal, environmental, and sustainability problems, currently associated with sewage sludge.

5) Will the AD process be capable of approaching the WERF/Shannon energy projections? The answer to this question is Yes.

From the Shannon data, 5 mega-joules of energy potential per cubic meter of WW treated equates to an energy level of 5,385 kWh/MG (based upon an average Biological Oxygen Demand concentration of 200 mg/L).

A recent Electric Power Research Institute (EPRI) study has shown that current AD processes can produce about 350 kWh/MG of WW treated, whereas a recent EPA–CHP Partnership estimates up to 525 kWh/MG can be produced. Although both figures are noteworthy, the current energy production is still 10–15 times less than the WERF/Shannon projections.

FDI's Conceptual 4-Stage AD is projected to produce a minimum 1,400 kWh/MG of WW processed. This projection represents a considerable improvement over the cited EPRI/EPA–CHP energy estimates. Although it is less than the WERF/Shannon projections, FDI believes that 1,400 kWh/MG (26% of the available energy) is a good energy recovery starting point, for this state-of-the-art Concept.

Recognizing the fact that the Conceptual 4-Stage AD is in its early stages of development, and accepting the certainty of scientific improvements; it can be stated with confidence that further energy advances will be inevitable within FDI's 4-Stage AD. This realization will make the Resource Recovery Plant Concept the breakthrough technology that will be capable of approaching the WERF/Shannon energy projections.

ENERGY ADVANTAGE

FDI's Centrifugal Wastewater Filtration System and Anaerobic Digester technology represents a breakthrough Resource Recovery Plant Concept that could mitigate the ever-increasing challenges that cash strapped municipalities must overcome; in order to comply with EPA's stringent wastewater mandates. FDI's energy producing Resource Recovery Plant is projected to:

1 Reduce by more than 50% the cost to upgrade and the cost to build new WWT facilities.
2 Reduce the operational footprint by 80% (50' x 50' per MGD), and recover unused land.
3 Operate 24/7/365 indoors; and provide redundancy, with modular scalability for the future.
4 Avoid sewage sludge and related costs.
5 Reduce operation and maintenance costs by 25%.
6 Eliminate electricity consumption: 2,500 kWh/MG. (kilowatt-hours per million gallons processed)
7 Produce electricity @: 1,400 kWh/MG.
8 Consume electricity @: – 750 kWh/MG.
9 Sell excess electricity to local grid: 650 kWh/MG.
10 Attain a net energy advantage: 3,150 kWh/MG (3.15 megawatt hours/MG).

Example: Any City, U.S.A, (~ 1,000 population) processing 0.1 MGD, could realize a net energy advantage of 115,000 kWh annually (115 megawatt hours).

Any City, U.S.A, (~ 10,000 population) processing 1 MGD, could realize a net energy advantage of 1.15 million kWh annually (1,150 megawatt hours).

Any City, U.S.A, (~ 50,000 population) processing 5 MGD, could realize a net energy advantage of 5.75 million kWh annually (5,750 megawatt hours).

11 Give 15,610 WWT facilities, with flow rates of 5 MGD or less, the option to become energy positive.
12 Achieve EPA's recognition as Best Available Technology Economically Achievable (BAT).
13 Qualify for EPA's ENERGY STAR label for Superior Energy Efficiency.
14 Qualify for State and Federal renewable energy incentives, grants, rebates, and carbon credits.

CONCLUSION

FDI's extensive research has revealed that no company has created a Conceptual Resource Recovery Plant technology designed to: 1) Mitigate the municipal WW, environment, and sustainability challenges. 2) Reduce electricity consumption on the power grid. 3) Filter and deliver eco-friendly water. 4) Recover unadulterated Energy Latent Organics from WW. 5) Produce and sell excess electricity to local grids. 6) Avoid sewage sludge. 7) Reduce the WWT footprint by 80%. 8) Provide scalability for population growth and urban expansion. 9) Provide indoor capability. 10) And sell for less than 50% of current systems.

CALIFORNIA ENERGY ADVANTAGE

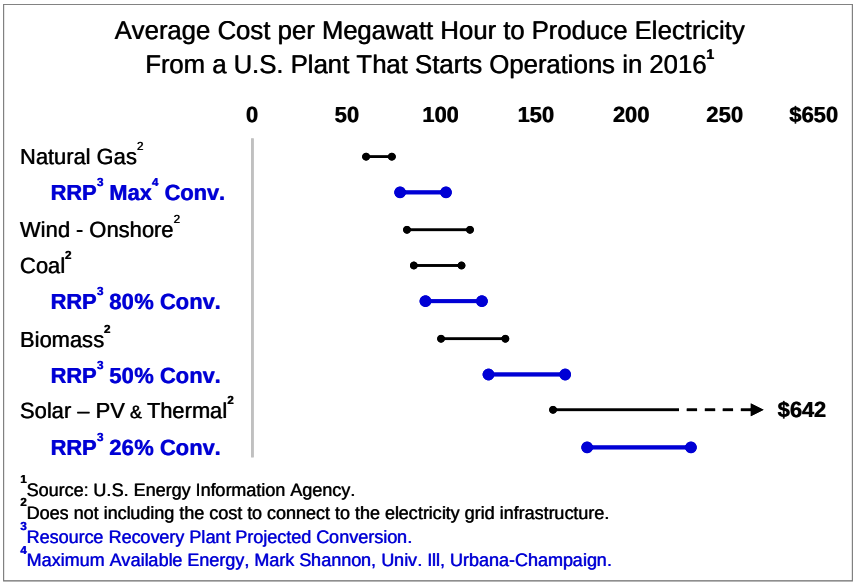
In California, there are 293 cities and towns with WW flow rates in the range of 0.1 to 5 MGD. The EPA has evaluated current AD technologies; and has established that flow rates of 5 MGD or less to be the lower economical limit for co-generation, also known as Combined Heat and Power. By transforming the energy consuming wastewater treatment plants into energy producing Resource Recovery Plants, in these small cities and towns, the annualized excess electricity production could be greater than 133,000 megawatt hours (MWh), whereas, the annualized net-energy advantage could exceed 646,000 MWh of electricity. Most importantly, this excess electricity production would be fed directly into local grids, contributing to Governor Brown's goal of deploying 12,000 MW of localized renewable energy by 2020.

By way of comparison, it would take more than 1,024,000 homes — with four large 120-watt Solar Panels, per home — to produce the same 646,000 MWh of electricity, over a one-year period. Additionally, the annualized net-energy advantage of 646,000 MWh would be equivalent to removing more than 87,000 passenger vehicles off California roads.

For another comparison — while profoundly encroaching on our fragile environment — it would take one-hundred-ninety-seven 1.5 MW wind turbines to produce the same 646,000 MWh of electricity, over the same one-year period; requiring a land mass of 35 square miles; above and beyond the construction cost of connecting to the power grid. Likewise, the annualized net-energy advantage of 646,000 MWh would be equivalent to removing more than 464,000 metric tons of carbon dioxide from the atmosphere.

This same 646,000 MWh of electricity equates to 80% of the U.S. 2009 net-electricity generation from Solar (PV & Thermal), without incurring the cost of connecting to the power grid infrastructure.

Cost Comparison to Produce One MWh of Electricity



United States Energy Potential from Wastewater

Environmental Sustainability and Societal Impact

"By many measures, the world's energy system" — including electricity — "is not keeping pace with the goals of sustainable development." In an attempt to meet these demands, ". . . the established system generates harmful particulate and chemical pollutants that threaten the health and the environment of the world's people."[1]

In the United States, our current power system is burdened with an increasing demand for more electricity. Moreover, the Electric Power Research Institute has projected in their 2003 Electricity Technology Roadmap[2] that 7,000 GW of additional electric generation will be needed by the year 2050. The U.S. is also confronted with the ongoing conundrum of how to produce additional electricity without increasing the demand for more water, and without further contributing to greenhouse gas emissions.

In April 2005, a Lawrence Berkeley National Laboratory Study[3] estimated the electricity potential from methane produced by the anaerobic digestion of wastewater biosolids (using current methodologies) from Industrial, Agriculture, and Municipal facilities. In ***Table 1*** a segment of their Summary of Electricity Production and Emissions Reductions are shown; if the electricity were generated from fossil fueled power plants on the electricity grid infrastructure. From the facilities in this segment, the Study calculated a total annual production potential of 8,900 GWH of electricity; more than the 2005 production of Hoover Dam, Glen Canyon Dam, and Shasta Dam, combined; with 3,233, 3,209, and 1,806 GWH respectively. Most importantly, this free, recurrent source of energy is readily available, 24/7; without building new fossil fueled power plants or adding to the electricity grid infrastructure; saving untold billions of dollars.

Table 1 Summary of Clean Energy Technologies Potential (*NOTE: **CO_2** @ million metric tons*)

Technology	Electricity Production	Emissions Reduction (metric ton)			
	(GWH/year)	CO_2	NO_x	SO_x	Hg
Industrial Wastewater	300	0.16	199	695	0.00
Agriculture Wastewater	1,400	0.82	993	3,478	0.02
Municipal Wastewater	7,200	4.20	5,091	17,835	0.09
TOTAL:	**8,900**	**5.18**	**6,283**	**22,008**	**0.11**

Over a 10-year period, the above Clean Energy Technologies Potential is equivalent to removing 51.8 million metric ton of CO_2 from the environment with a reduction of 1,632 million barrels of imported oil, equivalent to reducing foreign payments by $163 B — @ $100 per barrel.

Filtration Dynamics, Inc. owns the patented and patents pending Resource Recovery Plant Concept; that is designed to make this happen.

[1] The Program on Energy and Sustainable Development *at Stanford University*, January 2006.

[2] 2003 Electricity Technology Roadmap, Electric Power Research Institute.

[3] E.O. Lawrence Berkeley National Laboratory Study, April 2005, LBNL-57451.

Filtration Dynamics, Inc.
P.O. Box 1807
Los Gatos, CA 95031-1807
408.391.6550

Direct Inquiries
to
Info@FiltrationDynamics.com

Visit FDI's Website
at
www.FiltrationDynamics.com