White Paper

For Wastewater Treatment — Think Energy Latent Organics — Not Sewage Sludge

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SEWAGE SLUDGE IN WASTEWATER TREATMENT

The treatment and production of sewage sludge is the most energy intensive component in Wastewater Treatment (WWT), consuming up to 60% of the total energy requirements of a municipal WWT plant. In the United States, this equates to an annual consumption of 12.6 billion kilowatt hours of electricity, 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, many 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 still remains energy intensive and the massive disposal, environmental, and sustainability problems still persists.

The CHP recovery potential at WWT plants can represent an important policy lever for sustainability. 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 wastewater 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 will transform outdated, energy intensive Wastewater Treatment Plants into energy producing Resource Recovery Plants—with a carbon-negative footprint—attaining a net energy advantage of 3,150 kilowatt hours of electricity per million gallons of wastewater processed.

FDI predicts that this transformation will 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—will soon have the option to mitigate their wastewater, energy, and sustainability problems; by upgrading to energy producing Resource Recovery Plants. Assuming a 1 MGD average for the 15,610 facilities, the annualized net energy advantage will equate to 1.80 billion kWh. Most importantly, this recurrent source of energy from wastewater is readily available, without building new coal fired power plants or adding to the electricity grid infrastructure; 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 determined 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 wastewater, as define by WERF/Shannon.

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

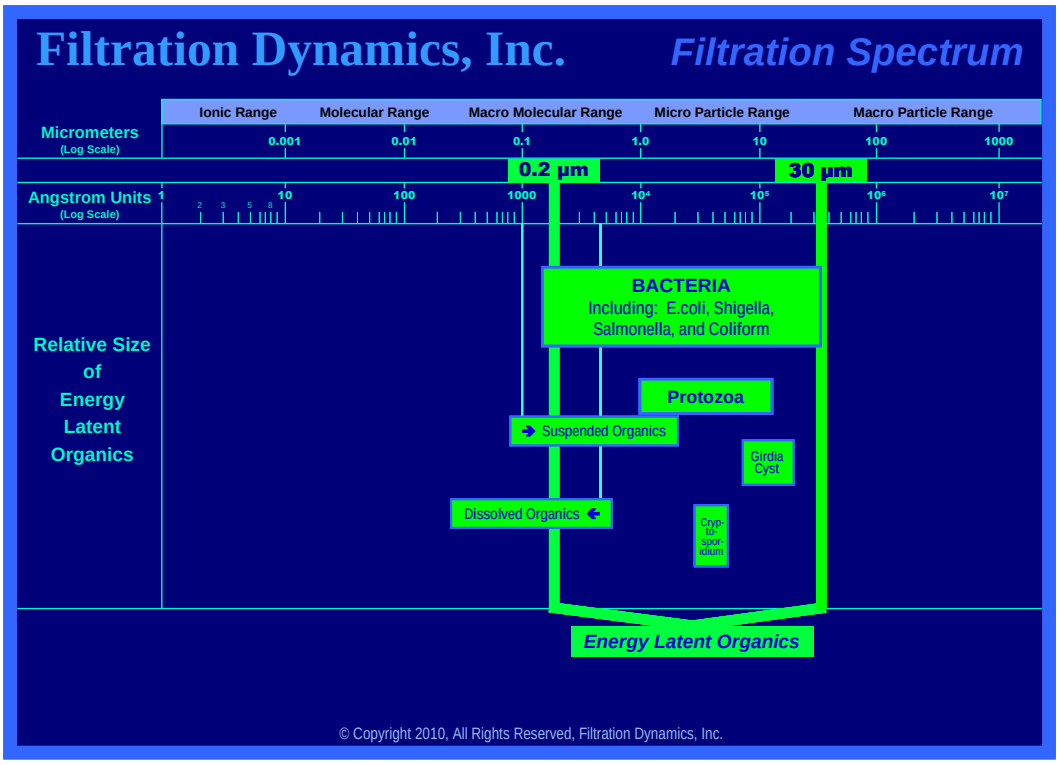

Figure 1. Size Range of Energy Latent Organics

2) Can the Energy Latent Organics be isolated, concentrated, and recovered from WW influent? The answer to that 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 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 that question is Yes, as illustrated in **Figure 2.**

The Anaerobic Digestion of organic matter in wastewater 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 to isolate, concentrate, and recover the Energy Latent Organics from sewage sludge.

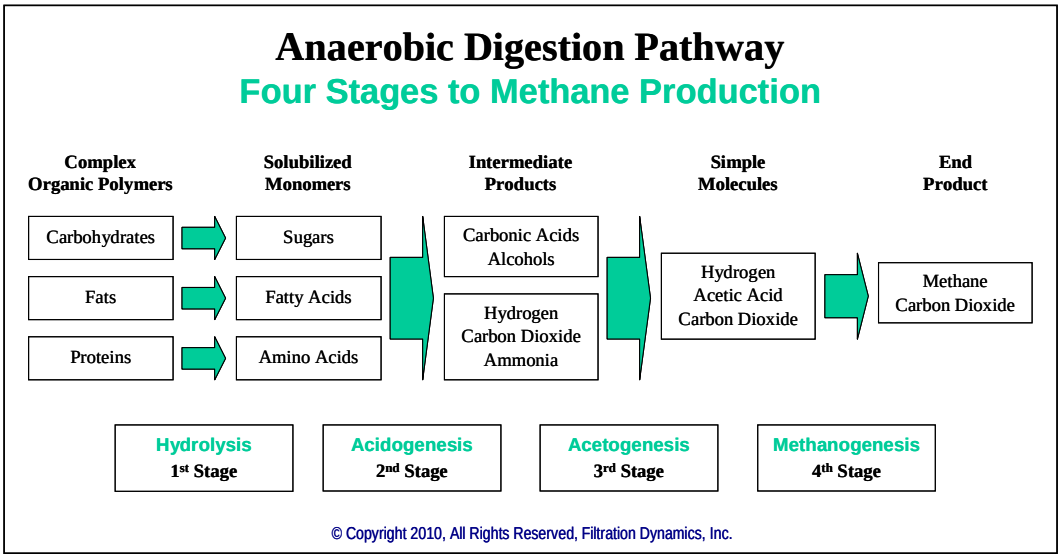

Figure 2. Anaerobic Digestion Pathway

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

Because the CWFS is designed to recover the Energy Latent Organics from the WW influent stream (approximately 1,700 pounds of BOD per million gallons) and immediately transfer those concentrated Energy Latent Organics into the 4-Stage AD, the Resource Recovery Plant will not have sewage sludge.

The 4-Stage AD is projected to convert 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.

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

From the Shannon data, 5 mega-joules of energy potential per cubic meter of wastewater treated equates to 5,385 kWh/MG (based upon an average BOD 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 wastewater treated, whereas a recent EPA–CHP Partnership estimates up to 525 kWh/MG can be produced. Although both figures are noteworthy, the energy production is 10–15 times less than the WERF/Shannon projections.

FDI's Conceptual 4-Stage AD will produce a minimum 1,400 kWh/MG of wastewater processed. This projection represents a considerable improvement over the cited EPRI/EPA energy production. Although this energy production is 3.9 times less than the WERF/Shannon energy projections, FDI believes that 1,400 kWh/MG is a good energy recovery starting point, for this state-of-the-art Concept.

Recognizing the fact that the 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 in FDI's 4-Stage AD; making the Resource Recovery Plant Concept the breakthrough technology capable of approaching the WERF/Shannon energy projections.

ADVANTAGE

FDI's Centrifugal Wastewater Filtration System and Anaerobic Digester technology represents a breakthrough Resource Recovery Plant Concept that can provide numerous advantages over current energy intensive WWT systems. The FDI technology will filter the wastewater and produce effluent to EPA standards; while simultaneously producing methane from its 4-Stage Anaerobic Digester to achieve net electrical energy—with a carbon-negative footprint. FDI's energy producing Resource Recovery Plant will:

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 Eliminate sewage sludge and related costs.
5 Reduce operation and maintenance costs by 25%.
6 Eliminate current electricity costs: 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 the grid: 650 kWh/MG.
10 Attain a net energy advantage: 3,150 kWh/MG.

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

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

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

11 Give 15,610 WWT facilities, with flow rates of 5 MGD or less, the option to become energy positive.
12 Qualify for EPA's ENERGY STAR label for Superior Energy Efficiency.
13 Qualify for State and Federal rebates and carbon and energy credits.

FDI's research has determined that no company has created a synergistic Resource Recovery Plant technology that is designed to: 1) Filter wastewater to EPA standards. 2) Quantitatively recover the energy latent organics from the wastewater. 3) Transfer those organics to a 4-Stage Anaerobic Digester. 4) Produce and generate a maximum amount of methane and electricity—all occurring within minutes, instead of days. 5) Eliminate sewage sludge; 6) Reduce the operational footprint by 80%.

ADDENDUM, United States

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 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. 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 recurrent source of energy is readily available, without building new coal fired 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 $114 B — @ $70 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.

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