Anaerobic Digester Economics

In recent years, a variety of solid waste agencies have been approached by developers offering dry AD systems to process and treat organics. BY MARC ROGOFF

Zero Waste Energy

This article provides a general overview of several economic feasibility studies conducted by SCS Engineers. In these, the agency's organic wastestream will be processed, and a biogas will be converted to revenue producing product (combined heat or power, compressed natural gas, and high-quality compost). SCS has collected available data and information on operating anaerobic digestion (AD) facilities with a similar design technology proposed for application at these agencies with the objective of strategic planning of AD facility.

Anaerobic Digestion Technology

There are nearly 240 AD facilities around the world with operating capacities greater than 2,500 tons per year. These plants process not only the organic fraction of the municipal solid waste (MSW) wastestream, but also organic waste from food industries and animal manure. Europe leads in the number of AD plants and total installed capacity principally due to the European Union Directive that requires member states to reduce the amount of landfilled organics by 65% by 2020. As shown in Exhibit 1, there are more than 120 plants processing the organic

Exhibit 1. European Countries With AD Facilities

Country	No. of Plants	Country Capacity (tons per year)
Germany	55	1,250,000
Spain	23	1,800,000
Switzerland	13	130,000
France	6	400,000
Netherlands	5	300,000
Belgium	5	200,000
Italy	5	160,000
Austria	4	70,000
Sweden	3	35,000
Portugal	3	100,000
United Kingdom	2	1,000,000
Denmark	2	40,000
Poland	1	20,000
Total	127	5,505,000

Levis, J. W., et al. "Assessment of the State of Food Waste Treatment in the US and Canada." *Waste Management*, 2010 August/September 30 (8–9). 1486–94.

Jeff Lindenthal, Monterey Regional Waste Management District 2013

Exhibit 2. Last of four digesters installed in place

fraction of MSW in Europe of about 4.6 million tons per year. The principal technologies used around the world are provided by BTA, Cites, Dranco, Kompogas, Linde, RosRoca, Valorga, and Viesmann.

Currently, there are only three commercially operating AD facilities in North America, with two being in the US. The first is on the campus of the University of Wisconsin-Oshkosh, and the second adjacent to the landfill operated by the Monterey Regional Waste Management District in Marina, CA. The Oshkosh facility currently processes about 6,000 tons of yard and food wastes per year; the Monterey AD facility is currently sized to process about 3,000 tons per year.

In Canada, there is an AD facility digesting source-separated organics, which has been commercially operating in Toronto for a number of years, processing about 90,000 tons per year. A second AD facility is currently under construction by the city and should be operating within a year. Similar AD facilities have been authorized by Quebec City and Montreal, with additional facilities funded in the Province of Quebec.

Smartferm Anaerobic Digesting System

A number of clients wanted to assess the economic feasibility of the dry anaerobic digestion technology. Zero Waste Energy LLC is a San Jose, CA-based company that

Exhibit 3. General Assumptions for Pro Forma Model

Variable	Value	Comments
Base year	2014	Costs estimates were made in current 2013 dollars and escalated based on the inflation factor identified below.
Inflation Rate–Annual Escalation (for energy, labor, and waste collection)	3%	Based on recent Federal Reserve Board guidance
Waste Received (tons per year)	5,000	Approximately 3,500 TPY per year are available from Tribe facilities; an additional 1,500 TPY of similar organic materials were assumed to be attracted from the Albuquerque market region
Retail Rate of Tribe Electric Power	$0.085/kWh	Billing records provided by the Tribe
Electric Production	270 kWh/ton	Estimated from information provided by AD developers
Financing Cost	Interest Rate: 3.35% Term (Years): 40	US Department of Agriculture
Tipping Fess	$30/ton	1,500 tons per year based on SCS preliminary market survey
Sale of Digestate	$0.00	Regional markets to be developed with maturation of project
Annual Operating Costs ($)	5% of Capital	Estimated from information provided by AD developers
Annual Capital Repair and Replacement	1% of Initial Capital	Estimated from information provided by AD developers

holds the exclusive US license to construct and operate the German "SmartFerm" AD technology developed by Eggersmann Group of Germany. This "proprietary" SmartFerm technology is widely utilized in Europe and is currently being used in a pilot AD facility in Marina, and one under construction for the city of San Jose.

The unique characteristic of the SmartFerm system is that it is modular (Exhibit 2). Individual digester units are linked together above an underground "percolate tank," which recirculates liquid from the digesters above. The AD process inside the modules creates methane gas, which is trapped inside a chamber that inflates above the digester. An engine generator consumes the methane gas as fuel to produce electricity.

The Marina AD facility became operational officially on March 8, 2014, when the first bay of the digester was filled. Since that time, all of the digesters have been filled, emptied, and refilled. During the AD process, biogas has been released filling the storage reservoir, which is located above the digesters. On April 2, 2014, the engine generator became fully operational, producing the full 100 kW of electricity. According to district officials, work continues to optimize the raw material mix and loading and unloading of the digesters to minimize odors, to achieve the best operational mix for the pilot facility.

Exhibit 4. Pro Forma Model Summary

Items	2014	2033	2053
Revenues:			
• Electrical Production	114,750	201,215	363,416
• Avoided Solid Waste Collection and Disposal	131,440	230,481	416,274
• Digestate/Compost	0	0	0
• Tipping Fees	52,500	92,059	166,269
Total Operating Revenues	298,690	523,755	945,959
Operating Expenses:			
• Operating Costs	132,000	232,340	419,631
• Digestate Disposal	0	0	0
• Repair and Replacement	26,500	46,468	83,926
Total Operating Costs	159,000	278,807	503,557
Financing Expenses:			
• AD Facility Loan Interest	88,775	60,539	3,929
Net Cash Flow	**$50,915**	**$184,408**	**$438,473**

Pro Forma Model General Pro Forma Model Assumptions

In order of the proposed project revenues, costs savings, and expenses, a number of assumptions were made, shown in Exhibit 3.

Exhibit 5. NPV and IRR Values, Proposed AD Project

Scenario	NPV	IRR
Base Case	$986,995	5%
Reduced Energy Output	($11,871)	3%
Increased Facility Size (10,000 tons per year)	$1,660,387	5%

Economic Analysis Results

Revenues and expenses were projected over a 40-year operating period, and the net cash flow was calculated. The projected revenues and expenses for the 1st, 20th, and 40th (final year of the loan) years are shown in Exhibit 4.

A series of additional Pro Forma Model scenarios were constructed to assist in comparing the possible changes in NPV and IRR values (Exhibit 5). As shown, the Base Case and two additional Pro Forma Model scenarios provide positive NPV and a IRR greater than the cost of borrowing (3.35%); cash flows are predicted to be positive during the entire length of the proposed project.

Briefly, the internal rate of return on an investment or project is the "annualized effective compounded return rate" or discount rate that makes the net present value of all cash flows (both positive and negative) from a particular investment equal to zero. In more specific terms, the IRR of an investment is the interest rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment.

Internal rates of return are commonly used by communities and companies to evaluate the desirability of investments or projects. The higher a project's internal rate of return, the more desirable it is to undertake the project. Assuming all other factors are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first. These data provide important financial metrics to gauge this proposed project against others being considered. MSW

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