

Economics of Digesters

Phil Lusk

I'm going to focus more on the economics of digesters. I'd like for you to become acquainted with some of the economic terms used to evaluate digestion opportunities because obviously there's a lot of technical potential out there, but it comes down to what makes economic sense—can you get this project financed and what do you have to consider.

I'd like to say that economics is like religion—you've got to believe it even if you don't understand it.

Of course I'm working on the great book of jokes about economists—I mean here's some of the best tag lines: You know economists have forecast four of the nine past recessions. My favorite one right now is there are three kinds of economists in the world: those who can count and those who can't. Sounds like Yogi Berra. But you see numbers like this all the time and you have to say, "Is this a good project or is this a bad project?" You've got things like simple payback period, internal rate of return, net present value, income, cash flow, asset test ratios, and then if you get down to it—net generation benefit or cost, is this a value added to your project?

So let's get some common definitions. This is that area of economics that's called capital budgeting. Some assumptions—it's a competitive market. Well, that's obviously not true. Rational behavior in the market—well, that's obviously not true. Consistency in measurement—well, maybe that's one thing we can control. But in general the goal is to maximize profit because we just don't have enough money to buy everything in the world that we want. This is about providing decision tools. It's not ultimate solutions.

As an introduction, the first type of economics under capital budgeting is what I call the economics of liquidity where basically you have a cash flow—you have income sources and you have expenses. Do you have a negative or positive cash flow? From that kind of information, you can pretty quickly calculate what is called a simple payback period which is your net investment divided by the net annual cash flow. That's just a quick and dirty number. The problem with the economics of liquidity is that it does not really account for project life. A digester, if it lasted just one year, would be one thing, but a well-maintained digester can almost have an indefinite life, and that does not account for the time value of money. So here's Einstein discovering that time is actually money.

That gets to the economics of profitability where we try to establish the time value and use current dollars, because they're more valuable; a dollar that's in my pocket today is more valuable than a dollar that I may be getting in the future. Present value is determined by the discount rate, so is a beer today better than three beers tomorrow? We often hear life cycle costing. And here we get into the economics of profitability which is governed by two statistics—net present value and internal rate of return. If you really are interested, I'll send you a copy of this presentation.

We have some decision rules. When you work through the numbers, you decide whether to accept or reject a particular investment. Like everything else, there is a tradeoff. There are some problems associated with life cycle costing. Net present value and internal rate of return are used every day but you have to accept what the tradeoffs and the liabilities of these decision rules are. The important thing you might hear about is the discount rate and, when you're doing life cycle costing, that choice is critical to the outcome. It comes down to what kind of risk is involved. A risk-free investment is commonly described as a treasury bond and you have a higher discount rate as risk profile increases.

How to lie with numbers—this is my favorite part. It depends on whether you're buying or selling. One common way to fudge the numbers is to use a project life that is too long or short. Who benefits if you say that a particular project has a 30-year life? Fuel escalation rate fudging—who benefits if you assume a constant 10% increase in electric rate? Is that a valid assumption? These are some ways that analyses can be changed and you have to be aware of the nuances involved and always question the assumptions that are behind any model.

Discount rate fudging—if you set a discount rate too low but don't account for risk, have you done anybody a favor? When you have a potential project, you need a sources and uses of funds statement. Sources of funds are equity out of your pocket, debt, and state, federal and local resources. Uses of funds—how are you going to spend the money?

And then, what a lot of people neglect is the owner's budget. When you start a project up and it's called a turnkey price, that's just for the construction budget. Commonly you have issues like working capital, financing cost, construction interest as a part of your overall financial analyses. You have income statements, owner's equity, balance sheets, and cash flow statements. If you want to take a project to the bank, they want to be able to look at things like income

statements and balance sheets to make sure that, given your assumptions, this project will return the investment and allow them to recapture the loan they have made to you.

I have this table of animal species and minimum size to consider a digester. You have to consider the electric rate. Obviously the higher the electric rate, if you're manufacturing electricity from the biogas, the better the project is. But in general you can say if I have more than 400 head of dairy cows, maybe digestion is something I should be looking at.

I think this is the key to any digestion project—methane generation—and I talked earlier about total solids and volatile solids. That's what gives you the methane; the degradation/destruction of the volatile solids is going to determine how much methane you'll get. It depends on the feed, temperature, solids retention time and a number of other factors. What's the factory concentration of total volatile solids? With dairy manure, maybe you'll get 8.3 cubic feet of methane per pound of DSD; I've seen numbers in the literature all over the place. The digester types, plug-flow, stir tank, fixed film, all have different rates with which volatile solids are destroyed.

What do systems cost? This is something that is probably now about 18 months old, but I went to the EPA AgStar website and looked it up and did the math. Dairy Plug-Flow Digesters with electricity cost range—\$150 to \$630 per animal unit. Weighted average cost—\$292; likely cost—probably more in the \$400 range. This is based on a fairly good sample size at the time—14 systems, 12 animal units per KW was what they averaged. Boilers are less expensive, but there are fewer systems installed. Stir tank digesters—more expensive than plug-flow, weighted average cost \$455 per animal unit. A small sample size but 16 AU/KW was the average. Dairy two-stage stir tank with electric—\$357 to \$655, \$420/AU. Dairy fixed-film—\$250 to \$350 per animal unit, weighted cost \$300 per AU. Also a fairly small sample size, but this might get you more in the ballpark of what's it going to cost.

Things that you should consider. Boilers are generally about 85% efficient. Engines are 25 to 37% efficiency, which basically means a heat rate of 9200 to 13,600 BTUs per kilowatt hour. Micro-turbines have a spotty track record on the technology. The only turbine that I might be interested in looking at today would be an Ingersoll Rand. You also get thermal energy off your engine generator, so at a 32% thermal efficiency and 75% total heat recovery, you might get about 4500 to 4600 BTUs of recoverable energy per kilowatt hour generated. This is going to be roughly 160° hot water.

Fiber sales—highly dependent on location, with \$5 to \$10 per ton, 2 cubic yards per ton. So a 1000-head dairy generates about 3400 tons of fiber per year, assuming some evaporation and, if fiber sold for \$7.50 per ton, that could be \$19,000 in revenue. That's another ballpark figure.

Filtrate—do nutrients have a saleable value today? I don't know. You tell me. We talked during the panel session about greenhouse gas credits but assuming \$1.25 per ton of CO₂, we all know that's way low but 1000-head dairy would generate about 1580 metric tons per year of carbon equivalent methane emissions. So maybe that's worth \$8,000 in income.

System operation and maintenance—this could be actually as low as 1% to 2.25% but for, say, a \$200,000 digester, roughly \$4,000 per year at the 2% capital cost. Now it's not that you're going to spend \$4,000 every year, but eventually what you're going to do is you're going to put this money into a Happy Sack and you're going to get \$15,000, \$20,000, \$30,000, some comfort zone so that you know you have a pot of money to cover any expected operation and maintenance expenses.

Engines—at 1.25 to 1.5 cents per kilowatt hour, a 1000-head dairy might cost \$15,000 per year. The one thing that I like about the Ingersoll Rand Microturbine is that they do offer a contract to do the maintenance and that's averaging 1.5 to 2.5 cents, depending on the size range. That means that it's their problem and not your problem when you have a service contract. You have to account for things like parasitic electricity because there are pumps and motors associated with the digestion system, so not every kilowatt hour that you generate goes into your pocket. This might be 2 to maybe 6 kilowatt hours per ton of feedstock processed. A 1000-head dairy that scrapes produces around 18,000 tons of manure per year. Assuming 5 kilowatt hours per ton means roughly 94,000 KW or roughly 7.5% of the electricity that you're going to produce is actually consumed on site as a parasitic loss. That's money that's not going into your pocket. If you have a heated digester (anything except a covered lagoon is heated), as a rule of thumb, figure you will have a 30° delta T. You have to increase the temperature of the incoming manure to that of the digester. That means that roughly 20% of the engine's recoverable thermal energy is going for parasitic heating.

Labor requirements—you have to account for labor. Farmers report 15 to 30 minutes a day is what they spend feeding the digester, checking the engine oil, and the like. Over the long haul, this probably equals a .25 FTE (full time equivalent) to run a project.

How long does a digester last? For covered lagoons it depends on the cover type. It could be 3 to 4 years, it could be as long as 10 to 15 years. Everything else should last 15 to 20 years if it's well designed, built of decent materials and is properly maintained. And actually it should have an indefinite life.

I've been working on another project in the State of Michigan where I had the opportunity to work with five livestock producers to determine the best digester technology. The first thing you do is characterize available waste. I did on-site interviews with the producers to learn their goals. I combined that with data commonly used to characterize manures, and then I toenailed that back into each producer's comprehensive nutrient management plan.

Three of these farms were dairies. For the first farm, goals were to add to farm profitability and to control odors. If odors could be effectively controlled, then herd size could be expanded.

The second farm was a little bit smaller, a little bit different process. Goals were to supply power and control odors.

The third farm was a caged layer operation—two of the more successful digesters in the U.S. did operate on caged layer manure—basically it has to be diluted significantly to avoid ammonia inhibition and also to allow the grit contained in the feed to precipitate out. If odor could be controlled, flock size could be expanded. Here the producer said, "I want a 15 to 20% return on equity," so at least he was thinking about that.

Number 4 was a fairly large hog farm. They could expand the herd if they could control odors. He wanted a simple payback of 10 years or less.

And my last client, if odors could be controlled, he could expand the herd but he wanted less than a 5-year simple payback.

You pay money to get rid of the manure now. These guys all had contracts with second parties to produce feed, remove manure, and apply it at agronomic rates and the net expense of that manure management portion of their agreements roughly averaged \$60 to \$75 per head per year. And the question was, if I put a digester in, is it profitable, can I reduce my manure management expenses? You start by estimating manure production. You have to know whether they use hydraulic flushing (three of these did) to determine the digester types. In Michigan, covered lagoons really were not an energy option. That left plug-flow, attached growth, and stir tank. What I tried to do is estimate the solids destruction, come up with total VS per day, cubic

feet of methane per pound of VS per day, and estimate how much methane each one of these farms is capable of producing.

Then I developed a system cost comparison. This uses the funds statement. Figuring out the animal units, the range was anywhere from \$282 per head for a plug-flow digester (cheapest thing on the block), the \$300 per head range was for attached growth, and this last one which came in at \$1.1 million was for a stir tank digester which was way out of position in terms of the cost structure. Some cost assumptions that I made: I assumed a project life of 20 years but prepared a balance sheet and income statement for only the first 10 years. I used a 10% discount rate, basically prime plus 5 or 6 points. I overestimated the operator expenses, half-time position involved in the digester, wages, benefits; engine O&M; plant O&M; revenue. There electricity is pretty expensive, 9.5 cents per kilowatt hour, wholesale electric rate 5 cents, propane which would be offset because we recover hot water from the engine; fiber at \$6 per ton; carbon credits at \$1.25 per ton CO₂; and even though everybody said they wanted odor control, nobody wanted to pay for it. Go figure. It's a free good. So does it cash flow?

This is my economic performance comparison. When I worked with industrial programs, they generally wanted a 2-year simple payback or less or they weren't interested. I don't believe you're going to find a 2-year simple payback on a digester project unless you have really some special circumstances. I think anything in the 4- to 5-year range is an excellent opportunity. But you have to balance that against the farm. If you're a last generation farm, the kids have run off to the big city, nobody is there, don't put in a digester. If you're going to be retiring in, say, 5 years, it doesn't make sense. But if you're a multi-generation farm and somebody is going to be involved on that farm for the next 10, 15 or 20 years, 5 years payback is excellent. And that's as good as you're going to find. More than that, 6 years, that's still not a bad project. Seven, eight, that's stretching it on out, and when we get out to the last one, a 10-year simple payback, well, it's still not bad. An anaerobic digester is the only odor control technology that can pay for itself. Everything else costs you money every month.

When you are evaluating this type of technology, you have to put these issues in the big box, push the pieces of the puzzle around and see what makes sense to you. With these Michigan farms, even the worst project from an economic basis instead of being a cost to the farm actually made money. It had a 10-year simple payback but produced revenue over the life cycle. This was

based on a 10-year proforma, even though I know that the technology will be there for 15 or 20 years if it's well maintained.

I appreciate your time. If you have any questions, I'd be glad to answer them.

Response to question:

A lot of this is on the EPA AgStar website, especially the first part of the information. My only criticism is that it's dated information and the field changes constantly. The point was to give you an idea of the general concepts associated with this type of evaluation process, how to get your arms around the economic potential. This was not a specific cost analysis of your specific project.

The last thing is, of those five digesters I was in Michigan last week, three of the five farms say they're interested in going forward. They saw economic value, even though they weren't willing to pay for odor control.