



Muck to Money: Unraveling Anaerobic Digesters on Dairy Farms

Featuring Lauren Ray

Agricultural Sustainability and Energy Engineer, Cornell CALS PRO-DAIRY

DJ May 00:02

Welcome to the Decode 6 Podcast where we take your questions about carbon and ecosystem services and match them to the experts with the answers. I'm your host, DJ May. Today we are talking about a tried-and-true way to turn the newer into liquid gold. Well, not quite gold, but renewable natural gas. Yep, we're talking about anaerobic digesters. Here to walk us through it is Lauren Ray, a member of the pro dairy team at Cornell. Lauren is an expert in energy system economic analysis, energy efficiency and greenhouse gas quantification of dairy manure management systems. In her work with pro dairy, Lauren conducts Applied Research and Education to help New York State dairies become more sustainable. Lauren has a bachelor's from Cornell University and a master's degree from Georgia Tech, both in mechanical engineering. Lauren, welcome. It's great to have you on the show.

Lauren Ray 00:57

Great to be here, DJ, thank you.

DJ May 00:59

Getting right to it. What is an anaerobic digester?

Lauren Ray 01:04

Yeah, so an anaerobic digester creates an environment without oxygen, in which naturally occurring microorganisms are able to thrive and through that break down organic materials, and then that creates biogas. And really digestate are the effluent coming out of the digester.

DJ May 01:25

Okay, so walk me through that what goes in and what exactly is coming out if I have an anaerobic digester?

Lauren Ray 01:30

Sure. So so what you have is organic material. So it can be dairy manure, or other types of animal livestock manure, it could also be food processing waste, or food scraps, or otherwise. And that organic feedstock is fed into a digester. The digester can often be thought of as a vessel. So it might be seen as a tank, kind of a tank style design that we see often in the region I'm in which is New York state, as well as the northeastern United States and upper midwest where it's cooler. So generally, we have the vessel type anaerobic digesters, that can be maintained at about 100 degrees Fahrenheit. And that really creates an ideal environment with the absence of oxygen. So these are sealed vessels that then prevent oxygen from occurring. And that anaerobic environment is ideal for the microorganisms to break down organic material. So okay, yeah. And then once they break down that organic material, so you have food scraps, waste going in, and you talked about gas, and something else comes out what else comes out, right, so we can kind of take it a little deeper. So anaerobic digestion really involves a series of processes, again, kind of naturally occurring where the culmination of those results in methanogenesis. And that is really what produces that biogas. Biogas is composed of about 60% methane and 40% carbon dioxide on average, generally. And that's really what can be used for energy generation from the digester. So we can talk more about that. But then, in addition, the digester has liquid effluent sometimes called digestate. And that's really primarily, it's very similar in volume to what came into the digester. So you don't have a lot of reduction in the in the overall volume. But that comes out and needs to be

then stored and managed for the nutrient value that it has. So the digestate is really where the nutrients lie. And that can be used to fertilize crops, for example. Perfect. Okay. So I guess to get a little bit technical, what does the installation process look like if you're putting one of these on your farm? Sure. So while there are some very small containerized vessels that can that you know, are on the market, and can be used for anaerobic digestion, those are typically, you know, very, quite small, maybe designed for a campus food waste program, for example. And so the majority of what we've seen to date, especially on dairy farms, or other livestock farms have been that a more economically feasible for those types of applications have been the constructed tank or set of tanks on site that are again going to be set up for that anaerobic environment, and either constructed of concrete or metal or, you know, combination of that and insulated. Sometimes they're buried to help with the installation quality or level. And so, again, that's what we'll see in cooler climates. I guess I want to also explain that in certain parts of the US, for example, where we have warmer temperatures year-round, many livestock facilities. So, this might be in California or Texas, or the southeastern United States, we'll see livestock manure systems that are considered lagoons, anaerobic lagoons, and these are quite large treatment systems for manure that can actually be covered with an impermeable plastic cover that allows for capture of biogas. And that's generated through again, the anaerobic environment in those lagoons. And so those can be referred to as digesters. So I do want to distinguish the difference between kind of the systems that you'll see covered lagoons in the warmer climates versus in the cooler climates where we have the more vessel type designs. So that gives you an idea of installation of the digester itself. And then really with that, we need to consider how that digester is fed. So we might have scraped or flushed manure from the barns, for example, if we're talking dairy, and we could have other organic material, as I mentioned, it's not necessary. But if the, if the facility was taking in food waste, they'll need to have a way of accepting that food waste often from a truck into a reception pit. So we'll have the organic material kind of collected for a short term in a in a pit before it's fed steadily to the digester. And then we'll need, you know, pumps and things to manage through that. Sometimes there's preprocessing equipment. So we might have, for example, sand removal, if the dairy is sand bedded, we don't want inorganic material in the digester. So really, preprocessing is about taking out in organics, if there might be packaged food waste, for example, removing packaging, and then also breaking it down into smaller pieces when needed. So for example, a head of lettuce that needs to be chopped up. And then I guess the other components of installation with the digester system include the biogas recovery. So you'll have biogas piping from the digesters, headspace where it's collecting in the digester. And that, that is then piped to generally a cleaning system, which would sit outdoors, mainly vessel kind of filtration type of equipment. So we'll have the systems in place to remove hydrogen sulfide and water. Those are the two common components in the biogas that you do generally remove to before using it for energy generation. And then from there ideal, you would have various energy generation options.

DJ May 07:48

Perfect. So just to make sure I'm following, if you're using manure, you know, you get it into the digester, make sure there's no sand or any inorganic material. If you have food waste, you have to make sure it's small enough that it can be broken down and then eventually you get gas out of that headspace. So the area above whatever's digesting I, that's probably not the right way to say that, but whatever's digesting in there.

Lauren Ray 08:12

Yeah, yeah, yep.

DJ May 08:14

And then you have the filtration process at the end so that you have renewable natural gas you can use for energy. Is that kind of the short, the short version?

Lauren Ray 08:22

That is the short version? Yes.

DJ May 08:25

The very short version? Yes, yes.

Lauren Ray 08:26

And I think the other important thing that I always emphasize in my work is that you do need to consider the digestate as well as the biogas that are coming out of the digester. So the digested again, being that liquid effluent and does contain the nutrients that were in those organic feeds feedstocks, so that's really, that's really a plus, but it has to be managed appropriately for the site and the applications and you need to account for storing it for then land applying and so there there is components to the installation and design that have to go into that piece as well.

DJ May 09:03

Okay. So, what does it cost to install a system kind of like what you described a covered digester with a vessel.

Lauren Ray 09:12

So the cap the the capital costs or installation costs for this system. So we definitely have variation in that based on the type so we have the vessel type I described that's that often needs heating, you know heating, hot water piping, for example, to maintain that 100 degrees Fahrenheit temperature, which is most common in at least US anaerobic digester systems is to to stay around that or maintain that temperature within the vessel or covered lagoon for example. And so, we can have a lot of variation in sort of how that set up and and the vessel itself, whether it has mixing or not. And so, you know, I know, we had some examples in a recent article of some costs, the digester would generally be the largest portion of the cost. So constructing that vessel, and that might be, you know, half the cost or even two thirds. And then you'll have additionally to that, you know, the energy generation or the biogas to energy system that can vary based on the sophistication of it. So for example, renewable natural gas, which I think you mentioned, and that's, that's really using that biogas cleaning it, like I mentioned, needs to be done in really all cases, and then upgrading it by taking out the carbon dioxide. So that it becomes in composition very close or similar to to natural gas that we have in the pipeline, hence the renewable natural gas term. And then that in that case, it can be injected into the pipeline. And so that actually requires an additional, you know, additional equipment to get that removal of carbon dioxide. And that would have more cost than, for example, using biogas more on site for electricity generation, which is another option. So I didn't directly give you costs, but I know that we've seen you know, ranges on kind of the small side from about 2 million for a total project two to 3 million, and then really upwards with farms that are maybe 3000 cows, or more seeing costs for a total installed system, that would be more like the eight to 10 million, you know, possibly you'd have slightly less than that, or even more based on the sophistication and kind of overall site requirements.

DJ May 11:38

Okay. And then long term, how much does it cost to maintain the system? And is there a possibility of like breaking even in terms of your energy production? Or how can you kind of recoup some of those costs? What's the benefit?

Lauren Ray 11:52

Yeah, that's a that's a really good question. Obviously, we would want these to be economically feasible and viable. The good news is they are long term or long lifespan systems. So they're designed to last 20 to 30

years with proper maintenance, you know, keeping up different components, the actual digester vessel themselves definitely can last quite a long time. And so then we want to think about, obviously, that's a long term investment. But we, a lot of people are financing entities or investors to this would be still looking for something, you know, 10 years. And under payback, that's always ideal, even with these long lifespans. So you know, on the operating cost side, you generally think of it in three primary parts, the actual operation and maintenance of the equipment. So the digester and the gas biogas energy system, for example, some of the other equipment might be pre processing or manure handling on the effluent side or the influent. And so, so that has a cost, as well as electricity usage for the system for the digesters, mixers, if they have if it has mixer mixers, it's not required, but many of the vessel type do pumping biogas upgrading systems, or the cleaning systems more, so the upgrading can use quite a bit of electricity. And so that ends up being a cost that needs to be considered on the operation side. And then finally, you know, kind of the other third bucket would be the digestate management, which mainly involves like land application costs. Or if you're looking for a sophisticated, maybe separation of that digestate into more solid liquid components, then that would have a cost for that process. So I know, in a case study that we did recently, we ended up with a situation where the farm had about even costs between those three buckets. So it was similar cost for each. And then as far as the payback, we definitely have variable conditions on both electricity costs, maybe to power the system in parts of you know, the US or otherwise, as well as the revenue that you can get based on the location you're in. So you do need to consider that for kind of right where you are. But I mean, there's opportunities for the revenue to be maybe two to three times the operating cost or even more, talking about food waste, that can bring in another source of revenue in addition to the energy, which is from tipping fees or, you know, accepting that waste and getting paid to take it and you know, and so I, I would say the larger systems, we're seeing that they're paybacks can be under five years. So larger being maybe 3000. Cows are more, or systems taking in a good amount of food waste and manure combined. So larger kind of design systems could have those shorter paybacks and then really, the smaller anaerobic digester systems of which we've seen less of, you know, might have a much longer payback 10 to 15 years, and may even struggle to make that break even on the operation costs if they're quite small. And so that needs to be looked at really carefully.

DJ May 15:15

Okay, no, that's really helpful. I guess just to kind of put a nice bow on this. What are some things that you would maybe tell a dairy operator to think about before looking into a digester?

Lauren Ray 15:29

Yeah, that's really an important question. And we do have, I know, Cornell PRO-DAIRY program, we've developed a few fact sheets that really lay out a set of questions that dairy farmers is kind of the focus, but could ask a developer, for example, or a partner that they're discussing the opportunity for anaerobic digestion with. But you know, starting really, with the manure, side of things, they need to consider how they're managing it today, what type of bedding is used, I mentioned the inorganic material not being a good fit for digestion. And that's really because we have that enclosed sealed vessel. And so we do not want to build up of inorganic material in there. So sand bedded dairies need to really consider whether this is a good fit for them. And it can be an option to sand separate, to have a sand separation system, those would come at a higher, certainly significant costs. So you have to weigh that against, you know, consider that in the overall economics. And then really the so other than the bedding type and kind of thinking through your options, maybe you want to move toward a different type of bedding when you put in anaerobic digestion, if you're using sand, maybe you can consider moving and shifting to separated solids or otherwise separated manure solids. So some of those are important to discuss and plan and weigh the costs for if you will need to change the way you're transporting or hauling manure, you know, make sure you consider consider that. Often what we see is the anaerobic digestion system would fit between where the manure is collected from the Barns now and then where it

ultimately is stored at the farm for field application later. So think of it as the effluent from the digester is now what can go into that manure storage that may be existing on the farm and can often be used still. And so your your manure application to the fields, for example, or the way that you handle the nutrient management aspects of your farm can be similar, but do need to be carefully discussed with your nutrient management planner. And understanding maybe impacts from anaerobic digestion, certainly adding food waste, or other different ways would change that nutrient composition. Farms should, you know, ask questions of partners I mentioned, often you have a developer that can provide a lot of the capital investment and then actually own and operate the system. And with that type of model, you want to do your vetting of that company, understand their experience, have they installed systems in your region before or in similar regions? You know, climate is a factor. So you want to understand kind of their experience level based on maybe similar dairy farm operations. And if they've got that or not, and kind of how they've set up systems before how they've compensated farms for the manure feedstock. What does that look like? Thinking of some of the kind of top questions first, but certainly consider long term this is a system designed for, as I said, typically 20 to 30 years. So is this something that can fit with the farms overall growth plan, you should certainly consider if there is plans to grow that the anaerobic digester would would actually accommodate the overall volumes of of manure going forward. These systems really do perform better when they are sized correctly. So you want to consider that growth. I'll leave it at that unless you have another question. No, I think that's a great a great rundown.

DJ May 19:27

So just to kind of like recap, it sounds like you really need to think about basically your your operation in terms of bedding, manure storage, nutrient management, and then your growth like where you're going in the future. If you plan to have a lot more cows or maybe change any of those things. I bet that's a factor to think about too.

Lauren Ray 19:49

Perfect, certainly, and do your due diligence when you're evaluating these capital intensive projects because they can certainly have strong economics, but it's important to really go through each and every aspect to verify the the estimated costs and benefits to the farm.

DJ May 20:08

Excellent. Thank you so much, Lauren. That was a really great overview. I appreciate your time.

Lauren Ray 20:12

Yeah, thanks, DJ. It was great to talk with you more about this.

DJ May 20:17

That's our show. If you want more information about anaerobic digesters, check out the show notes. And if you liked this episode, make sure you subscribe or better yet, share it with a friend. And if you want to learn more ways to improve your or your client's dairy sustainability, come visit us at decode6.org We'll see you there