Anaerobic Digestion Mini-Series

Episode 2 of 4 | October 2019

AUDIO TRANSCRIPT
"How do Anaerobic Digesters Work?"

Lindsay De May: Hello, and welcome back to our discussion about anaerobic digesters. I'm Lindsay De May.

Austin Scarborough: I'm Austin Scarborough.

Abby Bruzas: And I'm Abby Bruzas, and we're a part of Vermont Law School's Farm and Energy Initiative. This is episode 2 of our 4-part series, so you may want to go back and listen to the first part if you missed it.

Lindsay De May: In our first episode, we described how anaerobic digesters are tools for converting different kinds of organic wastes into valuable resources, like energy and fertilizer.

Austin Scarborough: And we focused on how digesters have some incredible potential to help address our environmental goals.

Abby Bruzas: Like reducing greenhouse gas emissions and water pollution, helping divert waste from landfills, increasing our sources of renewable energy… the list goes on and on.

Austin Scarborough: Not to mention they can be a unique business opportunity!

Lindsay De May: But we still don't know how they work!

Abby Bruzas: And that's what we'll be covering in today's episode-- an in depth look at how digesters work and how we get from organic waste back to useful resources.

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Austin Scarborough: We'll cover what digesters look like, how operators select feedstocks and get them to the digester, and the actual digestion process itself.

Abby Bruzas: We'll also look at how you can use the biogas that digesters capture as fuel.

Lindsay De May: Speaking of what it looks like, I think I might've driven by an anaerobic digester before.

Austin Scarborough: Really? It can be pretty hard to tell unless you know what to look for!

Lindsay De May: This one was the size of a building, but shaped like a cylinder with a dome-shaped roof-- and no windows.

Austin Scarborough: Definitely could have been a digester!

Lindsay De May: Oh neat, are they as simple on the inside as they look on the outside?

Austin Scarborough: Ha! If only…

Abby Bruzas: All biodigesters collect biogas and use bacteria to decompose organic waste.

Lindsay De May: But they don't all look the same?

Austin Scarborough: They can look pretty different!

Abby Bruzas: Digesters are designed and work differently depending on the feedstocks they will use and are usually sited near those feedstocks too, so there are also designed to work in a specific location.

Austin Scarborough: Digesters can also be large or small**--** they range from "microdigesters" used to process the organic waste from a single home to industrial scale digesters handling hundreds of tons of material at a time.

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Lindsay De May: But the basic process of anaerobic digestion works the same way in all of them, right?

Abby Bruzas: That's right. Generally, a digester is made up of a series of tanks. Some of these tanks mix organic wastes up, some are just chambers that hold the feedstock as it gets eaten by the bacteria. And others are storage for either the biogas or the digestate.

Austin Scarborough: Biodigesters might only take one feedstock, like cow manure, or might be designed to handle a mix of commercial food waste and other materials. It might be designed to take mostly wet or mostly dry feedstocks.

Lindsay De May: Wet or dry feedstocks?

Austin Scarborough: Yeah. Wet digesters are designed to handle a maximum of 20% dry matter, which is perfect for inputs like a ton of melted ice cream, or wastewater from a brewery. Whereas on the other hand, dry or solid digesters process materials that are up to 45% dry matter.

Abby Bruzas: Exactly. And there are three general categories of feedstocks that digesters will process.

Austin Scarborough: Towards the end of our first episode, we heard from Eric Fitch of Purpose Energy, who told us about these three different categories of wastes: municipal, industrial, and agricultural. What he didn't mention is how those categories typically fall within either a digester for liquid or solid feedstocks.

<<**Eric Fitch:** *Existing digesters, there's really two types. One is something like a stirred tank, and these are really good on a farm. You put your material in there and it's homogenized, and the biology consumes the hydrocarbons and makes methane. The other kind of technology that's out there is called an upflow anaerobic sludge blanket digester. There's a lot of these in operation around the world. The thing about them that they only work with soluble material, so if you're at a soft drink manufacturer for instance, and the effluent just got sugar in it, that system will work pretty good. But if you're in a brewery, we've got solids like hops, grist, trub, yeast, the system will work because the solids will push the biomass right out.*>>

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Abby Bruzas: Here's Bill Crossman from Vermont Technical College, talking about how their digester design was selected, and what ingredients, or feedstocks, they mix together:

*<<**Bill Crossman:** I think they'd pick this digester type because it was fairly sophisticated and could take a wide variety of wastes. Um, versus say like a plug flow digester for a farm is mostly manure based. Um, so we always intended to take a lot of high strength feedstock and produce electricity.*

***Genevieve Byrne**: So what, what feedstocks do you put in?*

***Bill Crossman:** So we take beer waste, um, which is left in the fermenter after the beer from the finished beer is drawn down. We take biodiesel waste was just mostly glycerin and unconverted oil. We take some distillery waste, which is the, what they call potstill or what's left in the still when they distill out the alcohol. We take a small amount of food scraps, and we take about 50% manure from the school farm.>>*

Lindsay De May: Okay, so the type of digester you use depends on the industry you're in and what the primary feedstock for that industry is. Does one type of digester produce more biogas than another?

Austin Scarborough: Well, wet digesters tend to produce more biogas, but that's not necessarily because it's more liquid, but because of the kind of feedstocks that go into a wet digester.

Abby Bruzas: Not all feedstocks are created equal. In fact, feedstocks vary a lot in the volume of biogas that they produce.

Austin Scarborough: Here's Bill Crossman to describe some differences in feedstocks:

*<<**Genevieve Byrne:** We talked about the different feedstocks that you use. Can you tell which one of those feedstocks your digester likes?*

***Bill Crossman:** Yeah, it likes sugar, it likes high energy feedstocks. Mostly like anything with high energy like oil or sugar or the glycerin byproducts from biodiesel. Um, it'll produce quite a bit more gas. Manure does not have a lot of energy or gas*

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production potential in it, but it inoculates the digester every day with fresh bacteria and also provides alkalinity that keeps the entire system buffered.>>

Austin Scarborough: Some materials, like sugars and oils, make the anaerobic bacteria in a digester make A LOT of biogas.

Lindsay De May: Is there any way to predict which kinds of feedstocks produce more biogas?

Abby Bruzas: Yeah, so generally speaking, each feedstock has its own biogas potential-- that means some materials are expected to generate more biogas than others. Finding that perfect combo of feedstocks to make a desirable amount of biogas and digestate can be tricky.

*<<**Chris Cox:** We only have so much space in our digesters and we want to take the stuff that's like rocket fuel for our bugs. Food waste, from what I've done for research, isn't really that great as compared to, like, fats, oils and grease, brewery, waste, dairy waste. Those have very high organic content.>>*

Lindsay De May: From what he just explained, it sounds like brewery waste and ice cream would be a great feed stock.

Abby Bruzas: That's because spent grain and dairy are high in sugar and fat so there's a high biogas potential with that. Later in this episode, we'll talk about a digester at Magic Hat Brewing company that uses those same two ingredients!

Lindsay De May: Then how does poop fit into all of this? Especially since so many digesters are on farms primarily to process livestock manure...

Austin Scarborough: We talked to Dan Bell, the General Manager from Agri-Cycle about that. Agri-Cycle runs a large dairy farm-based digester up in Maine that also accepts foodwaste as a feedstock. They use manure to stabilize their digester and help it run consistently.

*<<**Dan Bell:** So one of the reasons we're a big proponent of farm based anaerobic digestion is because having that stable basis salt important in developing reliable run times. We've developed a 90% run time at the site and we hang our hats on that. And*

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that's mostly due to the fact that the manure is very stable. The cows are, was eating and producing the same materials. So that's our baseline.>>

Austin Scarborough: Remember, consistency is really important because the digester bacteria are very sensitive and can get shocked if there's too much variety in the feedstock.

Abby Bruzas: But at the end of the day, manure isn't giving you great biogas potential. That's why Agri-Cycle has a formula that incorporates mixed food waste collected from households into their digester.

<<***Dan Bell:*** *Manure is basically collected from the dairy cows each day. As I said, we'd make about 30,000 gallons of manure. It's then combined with food waste, whether it be food scraps that we collect in toters or bins or those organic slurries that I mentioned. Basically that manure and off farm waste is combined in a 50-50 ratio. Um, the manure is the stable agent in the process. The food waste is really the kind of boost that helps create the fuel.>>*

Lindsay De May: So Dan Bell --along with Bill Crossman earlier-- mentioned the benefits of using cow manure despite it not being the prime producer of biogas. How about… human manure. Is that...

Austin Scarborough: Works the same!—Chris Cox uses "human manure" in the digesters over in Montpelier.

<<**Chris Cox:***That's the organics. So that's, that's the good stuff. That's pretty fresh. Like they just, someone just flushed that down the toilet- it was a senator. Right to the, it's, I mean-- there hasn't been any digestion of it. So yeah, we want to send that right to our anaerobic digesters.>>*

Abby Bruzas: Right now, the majority of digesters are located on livestock farms or municipal wastewater treatment plants, so it makes sense that both rely on manure because these places typically have consistent access to the necessary feedstocks.

Austin Scarborough: …Which is essential to keeping the bacteria happily producing biogas!

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Lindsay De May: And they may take additional feedstocks, like high-energy food processing waste, to bump up biogas production and maximize the digester's energy output. But, they have to find the right balance of wet and dry materials, and feedstocks with the right biogas potential.

Abby Bruzas: Owners of digesters might need to set up food waste collection from homes or secure contracts with local businesses to ensure they can keep their digester well fed.

Lindsay De May: How does food waste get from my house to these digesters? Is that my responsibility to bring to them there?

Austin Scarborough: It can be, but there are more and more programs popping up to pick up and haul food waste to digesters instead of landfills.

Abby Bruzas: Grow Compost is perfect example of this! Here's the owner, Lisa Ransom, talking about their collection method-- a portion of which gets dropped off to anaerobic digesters. When she says "toters," she is referring to the containers they use to collect food scraps.

*<<**Lisa Ransom:** So the methods of our collection over the past eight years have been that we collect food scraps only. We ask people to source separate their food scraps to, you know, take it off the food fruit labels, to take these onions out of their packaging. And we've been fairly successful with that. The method that we use have used over the past eight or so years has been in box trucks. So we use 48 gallon toters. Um, and we have those toters, we drop those toters off at generators. They fill them, we collect those full totes, we leave clean totes, we take those …back to compost facilities, um, and a lot of our partner farms, chicken farms and anaerobic digesters. And then we wash those totes and then we do it all again. >>*

Abby Bruzas: A lot of food and beverage businesses with on-site digesters, like Magic Hat Brewery, are partnering with local businesses to pick up their waste to feed and capture more energy in their digester. Here's Eric Fitch to tell us more.

*<<**Eric Fitch:** So the uh, the plant that we built actually has more capacity than the wastewater that Magic Hat generates. So we truck in a lot of other substrates from different manufacturers around the state ah, if we could start with breweries, there's probably more than a dozen breweries that separate their high strength waste from*

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the low strength waste. And you have different truckers to go and pick up the high strength waste and bring it to a holding tank that we have at Magic Hat. And then we feed it into our bioreactor. They also get material from a company that hauls chocolate, when they wash off their trucks, they end up with something that's got a cod of around 60,000 milligrams per liter. They bring us tankers of that two times a week. There are I want to say three distilleries that bring us what they call whole slop from the distillery process. Um, we get ice cream from the Ben and Jerry's plants. Uh, so we're, we're kind of a merchant facility there. In South Burlington, we treat about 300,000 gallons a month of materials that comes from off-site.>>

Lindsay De May: Beer, ice cream and chocolate? That's an icky and wet combination.

Austin Scarborough: You're right, and since it's mostly liquid, they'll probably go into a wet digester, which requires mixing together all the ingredients in a mixing tank before the digestion process begins.

Abby Bruzas: The majority of digesters we researched are wet digesters. So, from here on out we'll pretty much exclusively be referring to processing wet feedstocks.

Lindsay De May: Are we really, finally, going to talk about the actual digestion process now?

Abby Bruzas: We sure are! The first step is preparing the feedstock.

Austin Scarborough: Which is basically just chopping up and stirring the ingredients. Here's Bill Crossman with what to do for the prep:

*<<**Bill Crossman:** All of our waste comes into a 15,000 gallon, what we call preparation pit where it's all mixed. Um, there's some chemical ferric chloride added that reduces our hydrogen sulfide level, and then it's all pumped into the first tank, which is a hydrolyser where the larger molecules are broken into smaller molecules by certain types of bacteria.>>*

Lindsay De May: So, mixing all of those feedstocks together provides some level of uniformity at least in the feedstock's texture.

Abby Bruzas: Exactly! And that'll make the digestion process a lot more efficient. But that's not the only part of the process that Bill just described.

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Lindsay De May: Right, he mentioned that after the feedstocks get mixed up, the material is pumped into the first tank-- I think he called it a hydrolyzer?

Abby Bruzas: That's right. And it gets a little tricky. Although anaerobic bacteria needs an oxygen-free environment, we actually have to start with an aerobic process to eat up all of the oxygen in the organic waste we want to digest anaerobically.

Lindsay De May: And that's what happens in this hydrolyzer?

Austin Scarborough: Aerobic bacteria break down large molecules into small organic acids through the process of aerobic fermentation.

Lindsay De May: Hmm sounds like how beer is made!

Abby Bruzas: Yup! And it's why that beer is carbonated-- the process removes oxygen and produces carbon dioxide. And because the hydrolyzer tank is sealed, the aerobic bacteria use up all the oxygen in the feedstock. So after 3 – 6 days, the hydrolyzed feedstock is pumped to the anaerobic digestion tank because all the oxygen has been removed.

Austin Scarborough: Chris Cox over in Montpelier explained how the same process occurs in their digester. He refers to the aerobic bacteria in the hydrolyzer tank as "acid formers" and the anaerobic bacteria in the digestion tank as "methane formers."

*<<**Chris Cox:** There's for real simple terms, there's acid formers and methane formers, so those are the two. So in a mesophilic, you've got organics coming in, and the acid formers actually take the organics and they break it down. And what they produce is, is acid. And then, the methane formers are the ones that are much more, um, impacted by temperature change. They convert the acids in into methane gas, like, their byproduct of them consuming the acid is turning it into methane gas.>>*

Lindsay De May: What did Chris mean when he described the system as mesophillic?

Austin Scarborough: He's talking about the temperature that the bacteria need to live. They need to be between 95 and 105 degrees Fahrenheit, which is basically a

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"medium hot" digester. Mesophilic bacteria is pretty sensitive to changes in temperature, but they're actually the most common type of anaerobic digesters.

Abby Bruzas: Other digesters are kept much hotter. Those use thermophyllic bacteria, which have evolved to survive at scorching temperatures.

Austin Scarborough: So after the hydrolyzer tank, it's the anaerobic methane-forming bacteria's turn to feed on the organic waste. This is called the methanogenic phase, and is the part of the process when biogas is produced. Here's Bill again, with the next steps in the digestion process.

*<<**Bill Crossman:** Once an hour, that first tank pumps a measured amount of liquid over into the digester and then that corresponding amount of liquid overflows out the digester to the solid separator where the digestate is, the solids are separated out. The digestate, which is then used as cow bedding, and the liquid is stored in the tank until it can be field spread. >>*

Lindsay De May: So the digester is constantly spilling out digestate as new feedstocks are added in?

Austin Scarborough: Yes, it pretty much works like our stomachs.

Lindsay De May: How so?

Austin Scarborough: Well, the bacteria is super sensitive to inconsistencies, always needs to be fed, and then, literally, burps out gas from whatever its eating.

Lindsay De May: Wait, so how does that freshly burped biogas actually get captured?

Austin Scarborough: Alright, alright, here's Chris Cox to explain that:

*<<**Chris Cox:** So there's actually three digesters there. And they all have floating covers for gas storage. So it's like a concrete tank and then it actually has a metal tank on top of it. And as, as you get more gas, the tank could actually rise. But what's actually lifting that very heavy cover up its gas is methane gas pressure. So like there's just trillions of bugs in their producing methane gas and the gas that they're producing is actually holding that cover up. Pretty neat.>>*

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Abby Bruzas: And the design can vary for different systems, Bill Crossman's digester uses a balloon on top of the anaerobic digestion tank to collect the biogas.

Lindsay De May: That must be a BIG balloon.

Abby Bruzas: Yup! It's actually a big rubber bladder that can hold up to 93,000 gallons of gas!

Lindsay De May: So now that we know how its captured, how exactly do we turn it into all the different kinds of renewable energy that we talked about in episode 1?

Abby Bruzas: Sure, let's start with heating, since that's one of the more straightforward uses for the biogas.

Austin Scarborough: Yeah, essentially you take the captured biogas and then directly burn it in a furnace to heat buildings on site or nearby. We heard in the first episode from Chris that the Montpelier Facility uses the biogas from their digester to heat both surrounding buildings and the digester itself.

<<***Chris Cox:*** *We're beneficially using the methane gas that we're producing to heat buildings and to heat the digesters. But in the summer when you don't have such a great heating demand, we're having to flare off the methane, which is better than just releasing the methane into the atmosphere.*>>

Lindsay De May: So basically in the summertime, you can't use it... and if you have no way to store it then you have to burn it?

Abby Bruzas: That's right, here's Chris again, telling us more about flaring.

<<***Chris Cox:*** *And even with the new project and we're gonna try to utilize all the methane we can. You still always need to have a flare because right, if the pressure was to build up, you don't want to just off gas it. Right. Methane is 23 times more potent greenhouse gas than carbon dioxide. So it's better to take the methane and burn it because then you actually break it down into carbon dioxide, a few other materials, and water. So it's much better to, to burn methane than to just allow methane to escape directly. That's why you always have that step of flare. Landfills have it, and waste water facilities have it. So we'll still have a flare.* >>

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Lindsay De May: Using biogas for heating sounds like a good option for the winter. But is there any way to *avoid* flaring methane if there's no need for heat?

Austin Scarborough: Well, you can avoid using biogas for heat entirely, but, as Chris said, no matter what the form of energy, you'll always need to have the ability to flare- in case you need to release gas pressure.

Lindsay De May: So it's like a safety mechanism. Do you need to flare when you are using the biogas to generate electricity?

Abby Bruzas: You might…but you're **le**ss likely to flare the gas because you need it to run the generator, and you will probably always be running the generator.

Austin Scarborough: That's one benefit to generating electricity, you can do it pretty much constantly.

Abby Bruzas: For one, it means the biogas can be used year round.

Lindsay De May: That makes sense! Because my fridge needs energy all day, every day..

Austin Scarborough: And when you use biogas to generate electricity that can't be used on site, it can be contributed to the grid and used by other people.

Lindsay De May: You're saying electricity is a source of energy that's easier for more people to use?

Austin Scarborough. Yes. Renewable electricity. We talked to Josh Castenguay , the Vice President and Lead Innovation Officer at Green Mountain Power, which has a quarter of a million customers in Vermont.

Abby Bruzas: Central Vermont Public Service, which merged with GMP back in 2011, started the "cow power" program, which offers their customers the option of purchasing power generated from anaerobic digesters located on dairy farms.

Lindsay De May: Are you saying I could purchase electricity that was generated from cow poop?!

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Austin Scarborough: Yeah pretty much! Josh explained how digesters can contribute to clean electricity- as well as contribute to Green Mountain Power's portfolio of clean energy options.

<<***Josh Castenguay:*** *We're working on a new model where customers can easily go 100% renewable. Our portfolio is um, currently is a little over 60% renewable and 90% carbon free. And for customers who want to be 100% renewable, we're working on a few options where they can, they can do that really easily and, and pick if they want, whether it's solar, hydro, wind, a digester and have that option, um, and likely that will be cheaper than what the cow power is right now.*>>

Austin Scarborough: The fact that anaerobic digesters are always on, make them particularly attractive form of generating electricity.

Lindsay De May: You mean since they're consistently generating energy?

Abby Bruzas: That's right, digesters have the potential to meet our baseload generation needs in a more distributed manner**.**

Lindsay De May: Baseload generation...? You're gonna have to explain that.

Abby Bruzas: Sure, so baseload generation is the electricity required to meet every day demands, it ensures that at any given moment you can plug in your laptop and get a charge or turn on your electric stove and cook pasta.

Lindsay De May: Wait, is electric load different from baseload?

Austin Scarborough: ISH...electric load refers to the demand for electricity at any given point in time. Baseload is the minimum amount of energy we assume we're always gonna need. Josh told us about why digesters are good baseload power.

<< ***Josh Castenguay:*** *Yeah, I mean definitely baseload. They just kind of run. The idea is when you fire them up and you're feeding the manure, it's automatically feeding into the digester. The digester is doing its thing, and it's just a continuous process, other than taking the system down for maintenance a few weeks a year. So it provided a really nice steady base load production amount. They produce the capacity around the clock so they kind of just reduce the, uh, the amount that you need in general. You*

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wouldn't like start and stop on like you do with, uh, with a peaking facility or battery storage that we're doing now. You kind of want it to run and run as often as it reliably can, other than the maintenance period.>>

Abby Bruzas: Baseload generation is important, especially as we start to rely more on intermittent generation sources like solar panels and wind turbines that are only generating for part of the day. Josh talked about how digesters can integrate with intermittent renewables, like wind and solar.

*<<**Josh Castenguay:** The biggest thing when I look at just carbon footprint and power supply in New England, one of the gaps we have is the wintertime. So PV makes up a huge portion of, you know, renewable energy in the spring, summer, fall, but it really tapers off in the winter for obvious reasons between the Lower Sun Angle and snow and that sort of thing. So, resources that fill in the winter, wind is one of them, biogas is another because it's running around the clock, so it provides a great filler from a carbon standpoint. From a pure energy standpoint, it's good to have some local base load generation in general. That's just, that's more energy. That's, that's local, that's renewable and it's running around the clock and doesn't fluctuate as much as like solar might during, during the day. So it has, it has, it definite benefits. Um, but that kind of winter time gap, I'd say that's a really good one.>>*

Lindsay De May: That makes a lot of sense. Digesters work 24 hours a day, 365 days a year. When you're referring to the grid, is that basically just the lines that connect these energy generators?

Abby Bruzas: Actually, the grid refers to the entire electricity system from generation, to transmission, to distribution, to the consumer. In the US, there are three main grid systems, and they're all connected in case there's a failure in one.

Austin Scarborough: That's the Eastern Grid, the Western Grid, and Texas. But those larger grids are also broken up regionally to make management more efficient.

Abby Bruzas: Yeah, for instance, all of New England is managed as one system.

Austin Scarborough: And so is NY state.

Lindsay De May: Do grids generally refer to larger geographical areas?

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Abby Bruzas: We typically talk about them that way, but smaller scale grids, also known as microgrids, can be super localized electric grid systems that more or less operate independently, but they can also still be interconnected to the larger grid system.

Austin Scarborough: Right. When you flip a light switch in Burlington, Vermont the electrons that turn on the bulb *could* be coming from a coal plant in Pennsylvania or a solar panel in Massachusetts.

Abby Bruzas: Digesters are a form of distributed generation, which means using many smaller, local forms of renewable energy to power the grid, instead of larger more centralized power plants.

Lindsay De May: To be honest, I've never thought much about where renewable energy sources come from in relation to me. What's the benefit to staying local if the grids are all connected anyways?

Abby Bruzas: Well there are a few reasons, perhaps the most important is reliability. We want to avoid a blackout. If we rely heavily on a few large plants for our generation and something happens where they stop working, we have a lot of people without electricity if there isn't a similar sized back-up source.

Austin Scarborough: Now, if we diversify our electricity supply to include hundreds of small generators, if one, or even a few are out of operation, we can substitute their generating capacity with other sources.

Abby Bruzas: And decentralized generation keeps the production of electricity close to where it is being used, which is helpful in efficiently managing the grid's overall electric load.

Lindsay De May: So, because digesters run all the time, they can help meet our basic, every day energy needs in a reliable way.

Abby Bruzas: Right, and digesters can reduce congestion on transmission and distribution lines-- when too many people want to flip a light switch on at the same time. We refers to these times of day, when demand for electricity is the highest, as peak load.

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Lindsay De May: Like when everyone comes home from work to watch tv and cook dinner, or on super-hot summer days when everyone turns on the air conditioner at the same time.

Austin Scarborough: Josh told us about how digesters can help reduce peak load when they are set up “behind the meter.”

Lindsay De May: Behind what meter?

Austin Scarborough: Behind the meter means the electricity you generate will be used on-site first. Then, if you have any unused energy, that can go into the electric grid where it, so to say, “becomes metered”.

Abby Bruzas: You may have heard of net-metered solar systems, which work the same way-- they reduce the home electric bill first, and then you can get paid for the extra electricity that goes to the grid. Here’s Josh:

*<<**Josh Castenguay:** They are a, what we call load reducers. So they are able to produce more value for customers, lower costs, reducing peaks...At the scale and the size of these things, There's more value when it's a load reducer or behind the meter.>>*

Lindsay De May: And that extra energy going to the grid… is that going into a micro-grid or into the larger regional grids?

Austin Scarborough: Ideally, it’ll stay local, but can potentially support the larger system. The more distributed power, the better.

Abby Bruzas: If a small town had a solar field and a digester, they can generate solar power during the day, but then will STILL generate electricity with the digesters at night. All of which can help the local energy needs. Nora Goldstein mentions an example of this:

*<<**Nora Goldstein:** In terms of renewable energy development, anaerobic digestion is a really excellent source of distributed energy, especially as a component in a micro grid. Uh, there's a Digester, we toured last fall during our conference in North Carolina where they're developing a micro grid, um, with battery storage and there's some solar panels. They're currently have a diesel engine and then the digester gas and*

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they, um, are, have collaborated with the rural electric cooperative that when either the grid and the main grid goes down, due to storms or whatever, they can supply and when the main grid is operating, but you're at peak demand where power prices are high, you can also pull in from the micro grid and, and that's a very underutilized application.>>'

Lindsay De May: Sounds like digesters are a really flexible tool for generating electricity. But before we run out of time for this episode, could you two touch on the other energy uses for biogas?

Austin Scarborough: Good idea, one of the other uses for biogas is converting it into renewable natural gas.

Lindsay De May: Wait, I thought biogas IS renewable natural gas?

Austin Scarborough: Well, sort of, when it first comes out of the digester, it's often referred to as "raw" biogas, because nothing has been done to it yet.

Lindsay De May: What do you mean nothing's been done to it? Are we supposed to cook it or something?

Abby Bruzas: We don't need to cook it, but we do need to clean it up if we want to make it easier to use by more people in more ways.

Austin Scarborough: That's because a lot contaminants are removed in that cleaning and upgrading process. To make renewable natural gas, any trace chemicals, such as hydrogen sulfide, oxygen, ammonia, volatile organic compounds and siloxanes have to be removed from the biogas.

Abby Bruzas: Chris Cox helped explain why cleaning biogas is necessary, and the kind of investment it requires.

*<<**Chris Cox:** Methane gas is very dirty. The gas that's in there isn't like awesome gas, like propane. You don't want to run your boiler on it or anything. It's very, very wet. It has hydrogen sulfide in it as well, which mixed with water, makes sulfuric acid and it's only, like, the gas that's in there is only really 30 to 60% methane. A lot of it's just carbon dioxide. It's still burnable as long as you're at the higher range, but so to actually use that gas, if someone was to buy it, they would want some kind of*

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treatment to happen to the gas first, before they took it. We just, we take and we burn it in a, in a boiler that's built for it. Which is like the down and dirty way to do it. But if you had like a say a real expensive generator that runs on natural gas, you would have this, it's kind of like pretreatment. You would take the gas, you would remove all the moisture, you move all the hydrogen sulfide gas, siloxanes, you'd really like improve the quality of the gas before you put it into $1 million turbine to make power. So, so that's one thing to think about. So there's a big investment to get that gas to where it's really usable anywhere other than just to burn it and to produce heat in like a boiler.>>

Austin Scarborough: Once biogas is cleaned up to meet specific standards, it's basically indistinguishable from any other natural gas we use-- it can then be mixed together with fossil fuel natural gas and share the same infrastructure.

Abby Bruzas:: We talked to Tom Murray from Vermont Gas Systems, a utility offering their customers renewable natural gas sourced in part from anaerobic digesters.

<<***Tom Murray:*** *we're the first gas utility in the nation that has renewable natural gas, retail offering. So if you're a customer you can buy renewable natural gas. Basically, biomethane is captured at farms and landfills and waste treatment plants, essentially. It is cleaned up. So what's generally happened in this world up until now is that, you know, this was an electric generator. Basically. What's happened is that because renewable solar has become very cheap, renewable wind has become very cheap. ~~T~~he model has shifted to a gas model basically where it's, it's more, ~~uh,~~ lucrative for developers to basically clean it up and inject it in their system.>>*

Lindsay De May: So, why is Vermont Gas Systems one of the few utilities offering renewable natural gas to customers?

Abby Bruzas: They were actually the first! It has to do with how utilities are regulated. Vermont Gas Systems had to set up a special program to offer renewable natural gas to their customers.

<<***Tom Murray:*** *Um, and a lot of gas utilities in many states, by statute you are under this least cost mandate. Basically you've got gotta buy the least costs energy, and, and most electric utilities lived under that rubric as well. It's only been in the last, say decade, that electric utilities are able to pay more for renewables, like the net metering programs and things like that. If you think about that, as a regulated utility, the state's mandate was to keep the prices as low as possible. So you're forcing*

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utilities to buy the cheapest supply. RNG is actually more expensive. So we've got the ability to sell it- we set up the accounting mechanisms.>>

Austin Scarborough: One of the sources of their renewable natural gas is from a landfill in Quebec, that injects cleaned up landfill gas into the Trans Canadian Pipeline System. VT Gas systems purchases the gas, but they aren't providing that exact same gas to their customers.

*<<**Tom Murray:** When we receive the RNG, the molecule essentially gets burned with all the other gas molecules. What we set aside is a renewable attribute, the REC if you will. And then when you purchase gas, we assign that to you, essentially. So you, you get all the renewable credits. >>*

Lindsay De May: I think we need to first explain renewable attributes and RECs.

Abby Bruzas: I can do that. Those are part of the accounting mechanisms that Tom described. Remember, electricity all gets mixed together on the grid- we can't tell who is using which electrons. So, we use a digital ID card, called a REC, to keep track of each megawatt of electricity that is generated by renewable sources. The REC represents the "renewability" or "greenness" of the electricity.

Lindsay De May: So it's like a driver's license for renewable energy, that lists where it came from and how old it is?

Austin Scarborough: Pretty much. But your driver's license is always assigned to just you. And RECs can be bought and sold separately from the electricity that created it. Only the owner of the REC can claim their electricity is renewable.

Abby Bruzas: By buying a REC, the electricity you actually use takes on a new identity- it's now renewable because you own the environmental attribute. Like if buying someone's driver's license made you trade identities.

Lindsay De May: Wait a minute, how did we get back to discussing electricity? I thought Tom was talking about renewable natural gas?

Austin Scarborough: Well, **r**enewable natural gas works the same way for Vermont Gas Systems customers.

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<<***Tom Murray:*** *There's a transaction when the gas comes to us, there's a transaction, like we buy all of our gas. So we know that we got 10,000 MMBTUs of RNG. We inventory that essentially. And then when you sign up for the program, you can sign up for like 10% or something like that. And then we'll assign that equivalent to you.* >>

Abby Bruzas: Tom, or Vermont Gas Systems, buys a certain amount of physical gas from a generator, like an anaerobic digester or a landfill.

Austin Scarborough: Then that gas all mixes together with fossil fuel natural gas. The customer who elected to take part in the renewable natural gas program, receives that mixed up gas but they also receive the renewable attribute, or ID card of the gas from the digester or landfill. Then they can claim that they are using renewable natural gas.

Lindsay De May: The Vermont Gas program works pretty much like the REC system used for electricity to make sure that only one person gets to claim the gas they use is renewable.

<<***Tom Murray:*** *As we sit here today, when you buy RNG, you get all that environmental value. So we have to be very careful about saying, even though we're going to have like probably close to 5% of our system's going to be RNG, we really, that's not, we're just the pipeline. We can't make those claims as Vermont Gas. We're just selling renewable natural gas. All the environmental attributes are accruing to the customer because you're paying for it, essentially.*>>

Lindsay De May: So in episode one we talked about how renewable natural gas can also be used as a transportation fuel.

Austin Scarborough: That’s right. Once it’s in the pipeline, renewable natural gas can be moved to a facility that compresses or liquifies natural gas, which can then go to a fueling station for vehicles that run on natural gas. Tim Taylor told us more about Sacramento, California’s use of digester gas for transportation.

<<***Tim Taylor:*** *Well, the clean cities coalition, the mission is to reduce the use of fossil petroleum in the transportation sector. And the clean cities coalition in Sacramento is largely focused on trying to cause fleet operators, more than private vehicle owners, but fleet operators to reduce the use of fossil petroleum.*>>

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Abby Bruzas: It makes sense that CA is investing in renewable natural gas because of the emissions benefits. A Dept. of Energy study found that RNG eliminates the need for some emission controls, and results in far fewer air pollutants than petroleum-based fuels—things like particulate matter, nitrous oxides, sulfur oxides, and carbon monoxide.

Lindsay De May: That's because of the cleaning process you described, right? We already removed a bunch of contaminants to upgrade to renewable natural gas. So does it have to go into a pipeline before it goes to a natural gas fueling station?

Abby Bruzas: Once it's compressed or liquefied, it can be dispensed at a refueling station built right on the production site, or it can be delivered to a distant fueling station by pipeline or by truck.

Austin Scarborough: Unless local natural gas fueling infrastructure is already in place, fuel delivery will require constructing of a new refueling station. And the cost to transport the gas from the production site to the fueling station will depend on how close they are together.

Lindsay De May: And you need to find trucks that can use the gas right? Since regular cars can't run on renewable natural gas.

Abby Bruzas: Right, and given the higher cost of natural gas vehicles, it's most popular with high-volume fuel users such as medium- and heavy-duty buses and trucks.

Austin Scarborough: In fact, the fuel user is often the same entity as the waste owner/generator, either a large company or a community that both manages wastes and fleets of trucks.

Lindsay De May: Isn't that what happens in Sacramento?

Austin Scarborough: It sure is. The trucks that pick up the waste are also fueled by the waste. We'll talk about that some more in episode 4. They also try to reduce the amount of fuel required for their services by making their routes more efficient.

*<<**Tim Taylor:** If you sort did an analysis of the overall emissions associated with your effort to do recycling, for the same reason you want fewer food miles associated with*

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growing the food and then selling the food. You know, the fewer miles you'd drive the truck, the better. Same thing on the collection routes for that matter. You're making them take a truck and drive it all over hell and gone to get from one place that generates that much to the next place that generates that much next place it generates that much. So one thing associated with just collecting is trying to find a way to make it possible for the waste collection companies to be profitable in the way that they collect the waste and not force them to create routes that will be unprofitable.>>

Lindsay De May: So using renewable natural gas for heavy duty vehicles making short trips, like buses and garbage trucks, that would otherwise be running on diesel, can make a big difference in reducing emissions from those vehicles.

Lindsay De May: There's just so much to….. digest…. In learning about digesters. But I'm pretty amazed at how flexible a tool they seem to already be.

Abby Bruzas: Don't worry, in the next episode, we'll so some more ...digesting… this time of the challenges with developing digester technology, and some of the environmental drawbacks of using them. And then in our last episode, we'll tell you about some projects we think are doing things right.

Lindsay De May: And for more great discussions about climate change, energy, and the environment, you should listen and subscribe to Vermont Law School's more regularly scheduled podcast, Hot House Earth.

Abby Bruzas: The Farm and Energy Initiative is a project of the Institute for Energy and the Environment in collaboration with the Center for Agriculture and Food Systems at Vermont Law School. We are funded by the USDA National Agricultural Library.

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Abby Bruzas: And thanks to you, for listening!

Austin Scarborough: And remember, waste is only waste if it's wasted.

*<<**Bob Spencer:** Boy, You're about as green as it gets!!>>*

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The Farm and Energy Initiative is a project of the Institute for Energy and the Environment in collaboration with the Center for Agriculture and Food Systems at Vermont Law School, and funded by the USDA National Agricultural Library. Laws regarding the development of biogas and anaerobic digesters can change rapidly. The information presented is for educational purposes only and does not constitute legal advice.

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