D I A L O G U E

FOOD SCRAP RECYCLING: OPPORTUNITIES AND REALITIES

SUMMARY

When food waste decomposes, it releases methane, a greenhouse gas with at least 25 times the warming potential of carbon dioxide. Municipalities and organizations are beginning to prioritize diverting food waste from landfills by preventing waste, rerouting edible food to food-insecure households, or recycling waste through composting, animal feeding operations, or anaerobic digestion (AD), a process in which microorganisms break down organic material and create biogas and digestate. On April 8, 2021, the Environmental Law Institute, BioCycle, and the American Biogas Council hosted a panel of experts that explored the opportunities and challenges of developing AD projects to divert food waste and recycle it to create valuable products. Below, we present a transcript of that discussion, which has been edited for style, clarity, and space considerations.

Carol A. Jones (moderator) is a Visiting Scholar at the Environmental Law Institute (ELI), and Co-lead of ELI's Food Waste Initiative.

Melissa Pennington is a Sustainability Coordinator at the U.S. Environmental Protection Agency.

Julia Levin is the Executive Director of the Bioenergy Association of California.

Mark McDannel is the Manager of Energy Recovery Engineering, Los Angeles County Sanitation Districts.

John Hanselman is the Chief Executive Officer of Vanguard Renewables.

Carol Jones: I am pleased to be moderating this webinar with this outstanding slate of speakers. I'd like to take a minute to highlight some recent Environmental Law Institute (ELI) publications related to our topic today.[1]

In 2019, ELI published a report focusing on wastewater utilities and their business strategies for adopting co-digestion. The report includes lessons learned from both policy and utility perspectives, various case studies, and a diagnostic framework for utilities to use and tailor a co-digestion strategy to their individual utility market and policy context. And we have recently published updated and expanded versions of six of the case studies.

We started with the utilities that have had success co-digesting food scraps, which is less common than co-digesting other food wastes such as fats, oils, and grease (FOG), and food processing residuals. This is because municipal solid waste agencies traditionally have not collected food scraps separately and, further, the scraps need additional processing to be suitable as an anaerobic digestion (AD) feedstock. I highlighted the utilities' innovations and sourcing strategies in an ELI blog post and also in a pair of recent BioCycle articles.[2]

Most likely you are familiar with the statistics that highlight why food waste is such an important issue. An outstanding share of food that is produced is uneaten, with waste occurring along the supply chain from farms to consumers. Much of it ends up in landfills or incinerators. Producing uneaten food wastes the resources used to produce it and further is responsible for roughly 4% of U.S. greenhouse gas emissions.[3] To address this problem, the United States has made a commitment to reduce food waste by 50% by 2030, which aligns with the target set out in United Nations Sustainable Development Goal 12.3.[4]

The top priorities to address the problem are first, preventing food wastes, and second, recovering food that is edible in order to feed hungry people. But for the food waste that inevitably remains, the goal is to divert it from landfill disposal where it becomes a major source of greenhouse gas emissions, and to recycle it through composting, animal feeding operations, or AD.

However, a major challenge is the lack of recycling facilities. This is the second of two webinars we're doing focusing on strategies to increase recycling capacity. Our

1. ELI, *Publications From ELI's Food Waste Initiative*, https://www.eli.org/food-waste-initiative/publications (last visited May 14, 2021).

2. Carol A. Jones, *Co-Digestion of Food Waste: A Triple Greenhouse Gas Solution*, Vibrant Env't Blog (Apr. 1, 2021), https://www.eli.org/vibrant-environment-blog/co-digestion-food-waste-triple-greenhouse-gas-solution; Carol A. Jones, *Innovations in Sourcing Food Scraps for Codigestion*, BioCycle, Mar. 22, 2021, https://www.biocycle.net/innovations-in-sourcing-food-scraps-for-codigestion/; Carol A. Jones, *Solid Waste Partners Drive WRRF Food Scrap Sourcing*, BioCycle, Mar. 30, 2021, https://www.biocycle.net/solid-waste-partners-drive-wrrf-food-scrap-sourcing/.

3. ReFED, *Roadmap to 2030: Reducing US Food Waste by 50%* and the ReFED Insights Engine at-a-Glance 1 (2021), https://insights.refed.com/uploads/refed_roadmap2030-FINAL.pdf?_cchid=a013dff6534d1409dcf3fe652a4691fc.

4. U.S. Environmental Protection Agency (EPA), *United States 2030 Food Loss and Waste Reduction Goal*, https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal (last updated Jan. 13, 2021.)

previous webinar focused on recycling mandates and landfill bans as policies to induce the supply of feedstocks for the facilities—kind of a reverse "build it and they will come" approach.[5] One takeaway was that these policies are helpful, but other complementary policies are also needed to stimulate sufficient development of facilities to meet our goals for food waste reduction, recovery, and recycling.

Today, we are focusing on the opportunities and realities in developing a specific type of organics recycling project: AD. What is that? AD is where bacteria break down organic material in the absence of oxygen and create biogas and liquid and solid digestate.

Digestion of food waste can occur in three different types of digesters. It can be co-digested in farm digesters along with livestock manure or in wastewater digesters along with biosolids from wastewater treatment. Or it can be the primary feedstock in merchant or standalone digesters.

The process occurs in an enclosed environment and yields biogas—a mixture of methane, natural gas, and carbon dioxide (CO2), which can be used to create valuable renewable energy products—and digestate, which can be used to create a range of products including nutrients and soil amendments. These digestion products contribute cost savings or revenue to the project, plus tipping fees are earned from accepting food waste.

Also, digestion of food waste is a triple greenhouse gas win. It reduces landfill methane emissions. It enables generation of renewable energy from the biogas. It can promote carbon sequestration in soils through land application of digestate-based soil nutrients and amendments. But various impediments to AD co-digestion products are cited for slow adoption rates, including the project economics not penciling out, regulatory uncertainties, stakeholder concerns, and, for farm and wastewater digesters, the fact that co-digestion is outside the primary mission of the organization.

Today, we have four outstanding panelists to explore the opportunities and challenges of developing AD projects for food scrap recycling. Two are providing perspective on the issue and two are presenting case studies of successes.

Melissa Pennington, from the U.S. Environmental Protection Agency (EPA), is presenting new data on where food waste goes, how much is recycled and how much goes to landfill or incineration, and a new profile of the AD sector.

Julia Levin of the Bioenergy Association of California is providing information on the benefits of bioenergy, including the important role it plays in meeting the goals of the California climate plan, and on California policies to support development.

For the case studies, Mark McDannel from Los Angeles (L.A.) County Sanitation Districts is speaking from a joint wastewater and solid waste utility perspective. And John Hanselman from Vanguard Renewables is speaking on some major private developer farm-based co-digestion projects.

Melissa Pennington has served as sustainability coordinator in the materials management branch of EPA since 2011. Her overall focus is to build capacity for organics recycling in Region 3 and at the national level through collaboration with strategic partners, with a focus on voluntary programs. She was responsible for the development of EPA's report series on AD facilities processing food wastes in the United States.

Julia Levin helped found and is the executive director of the Bioenergy Association of California, which represents more than 75 public agencies, private companies, utilities, and nongovernmental organizations working on sustainable bioenergy development. Previously, she served as deputy secretary for climate change and energy at the California Natural Resources Agency, and as a commissioner on the California Energy Commission, where she led the Commission's work on renewable energy and energy efficiency.

Mark McDannel is manager of the Solid Waste Management Department's Energy Recovery Section at the L.A. County Sanitation Districts. His section is the in-house developer for the districts' food waste recycling program. It also operates two landfill gas-to-energy plants that generate more than 30 megawatts of electricity, and it buys and sells energy and related attributes for the agency.

Finally, John Hanselman is co-founder, chair, and chief executive officer of Vanguard Renewables, one of the largest recyclers of food waste in the United States. In December 2020, Vanguard Renewables, alongside Starbucks, Unilever, and Dairy Farmers of America, founded the Farm Powered Strategic Alliance as a call to the food industry to commit to a circular solution to food waste reduction, repurposing, and decarbonization. And they have announced plans for major new co-digestion projects.

Melissa Pennington: It's crazy to say out loud, but I've been at EPA for more than 30 years at this point. I lead the Sustainable Management of Food team in the Philadelphia Regional Office and focus on development of building capacity for organics recycling in the mid-Atlantic region.

EPA is very invested in AD as a technology for processing food waste. We awarded $3 million in grant funding for AD in 2020.[6] That's a lot of money. EPA does not usually put out that much money for grants. And we are most likely going to make a similar announcement for available funds in mid-June.

I want to start by talking about the Sustainable Management of Food program. I could talk all day about this program and how much I enjoy this work. But I will say, rather than talk about how much food waste there is and how bad it is and what we should be doing

5. ELI, Webinar: Food Life Cycle: Effectiveness of Food Scrap Recycling Mandates & Landfill Bans (Feb. 10, 2021), https://www.eli.org/events/food-life-cycle-effectiveness-food-scrap-recycling-mandates-landfill-bans.

6. Press Release, U.S. EPA, EPA Announces the Selection of 12 Organizations to Receive $3 Million in Funding to Support Anaerobic Digestion in Communities (Oct. 1, 2020), https://www.epa.gov/newsreleases/epa-announces-selection-12-organizations-receive-3-million-funding-support-anaerobic.

about it, that my program works to prevent disposal of food waste in landfills.

We'll move on to the meat of the presentation to talk about information on the current status of food waste diversion from landfills. I'm going to talk about the EPA report series and a couple of things that you should know upfront.[7]

First, the report is focused on AD facilities that process food wastes. So, the data that I'm going to talk about does not include digesters that process just manure, like farm digesters or digesters at water resource recovery facilities (WRRFs) that process just wastewater solids. WRRFs are sometimes still called wastewater treatment facilities, but I will be referring to them as WRRFs for clarity.

I also want to mention that this was a voluntary survey, so we do not have a 100% response rate for the survey. The information is based on the data that we received from the survey, so not the entire universe of food waste digesters out there.

To generate these reports, we collected data annually for three years from the three different types of digesters that Carol already mentioned: the stand-alone food digesters or, as she also referred to them, merchant digesters; on-farm digesters that co-digest food waste; and WRRF digesters that co-digest food waste.

What do we learn from collecting this data? We learn all kinds of things, and I will hit on the highlights. Our first objective is to identify how many AD facilities there are processing food wastes in the country and also where they are located. Digesters of food wastes are concentrated on both coasts, and also in New England, and essentially the northeast part of the country. In New England's case, it's not that each state has the most amount of digesters. But consistently more states have digesters in that region than in any other region in the country. I think it's important to note that at least 30 states have at least one digester. So, they are kind of evenly distributed.

California, not surprisingly, has the most number of digesters with 23, followed by Wisconsin with 10, and Ohio and New York both have nine. But it's interesting to note that none of the latter three states are either in New England or on the West Coast, yet they have the second and third highest number of digesters by state. So yes, right down the center of the country, from top to bottom, there are states with no digesters in them. But after that, the distribution of facilities gets a little more even. The next two highest are Massachusetts with eight and Pennsylvania with six. The rest of the states have five or fewer digesters.

EPA collected data in three surveys conducted in 2017, 2018, and 2019. The data that I'm going to discuss are from the most recent survey, which was in 2019. During the survey, we collected data on three key data points. If you want a more detailed look at the data over time, all three reports are on the website.[8]

The three key questions that we are trying to answer are (1) how much capacity is there to process food wastes in the country; (2) how much food waste is being processed; and (3) how much biogas is being produced? We have four years' worth of processing data and three years' worth of capacity data (see Table 1).

Table 1. AD Report: Key Data Points (2019 Survey)*

Total of three digester types	2017	2018
Amount of Food Waste Processed	9.6 million tons	9.8 million tons
Amount of Biogas Produced	25,274 SCFM	27,193 SCFM
Food Waste Processing Capacity	24.3 million tons per year	

* SCFM is standard cubic feet per minute.

Source: U.S. EPA, Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 & 2018): Survey Results tbl.33 (2021).

That's because we collected data in three rounds. The capacity data is really a snapshot in time for the time that the data was collected. The processing data is for a specific operating year. We collected two years' worth of processing data in 2019, which gives us a total of four years.

Table 1 also shows the processing data for 2017 and 2018. Both of these years were collected in the 2019 survey. So, what the table is showing is the critical data for the 2019 survey. There are some variations over time, and that is all explained in detail in the reports. The processing capacity for the 2019 survey shows just over 24 million tons per year processing capacity. The amount of food waste processed in 2017 was 9.6 million tons and then 9.8 million tons in 2018. So, there was a slight increase from 2017 to 2018 in the amount of biogas produced. It was just over 25,000 standard cubic feet per minute in 2017 and then just over 27,000 standard cubic feet per minute in 2018. These numbers represent the totals across all digesters. Table 2 on the next page shows the critical data points by digester type.

When you look at AD capacity and the amount of food waste processed by digester type, you're going to see that the greatest amount of capacity by far is in stand-alone digesters, at 20.6 million tons per year. And then, likewise, the greatest amount of food waste being processed is also at stand-alone digesters. In 2017, it was 8.1 million tons. In 2018, it was 8.2 million tons.

7. U.S. EPA, Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 & 2018): Survey Results (2021), https://www.epa.gov/sites/production/files/2021-02/documents/2021_final_ad_report_feb_2_with_links.pdf.

8. *Id.*

Table 2. AD Report: Key Data Points by Digester Type

Digester Type	Reported Capcity in 2019 (tons per year)	Reported Amount of Food Waste Processed in 2017 (tons)	Reported Amount of Food Waste Processed in 2018 (tons)
Stand-alone Digesters	20.6 million	8.1 million	8.2 million
On-farm co-digesters	162,716	100,685	119,300
Co-digestion systems at WRRFs	3.5 milllion	1.5 million	1.6 million

Source: U.S. EPA, Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 & 2018): Survey Results tbls.6, 7, 8 (2021).

Our survey also shows that there is a significant amount of capacity to process food wastes at WRRFs. That capacity is 3.5 million tons per year. But there's also a significant amount of food wastes being processed at WRRFs at 1.5 million tons in 2017 and 1.6 million tons in 2018.

For farm digesters, it represents only the farms that we collected data from, just like the rest of the data. We believe that there are a lot more farms that are actually processing food wastes, but we have a difficult time gathering this data. Across the three years of data that we collected, we had a poor response from the farm digesters. In 2019, it was just 17% of the surveys that went out. And my answer to this poor response is typically that farmers are busy farming. They're not sitting at their desks and answering electronic surveys. So, there's a lot more food waste being processed at farm digesters than what we've presented here.

Carol asked me to break down the data on the amounts of food waste processed by feedstock type. We collected data on the types of feedstocks that were processed, but we did not collect data on how much of each feedstock each facility processed. This is because we're walking a fine line between the data that we wanted to have and convincing facility operators to respond to the survey.

Anyone who's done work with surveys will tell you that it's very difficult to get people to respond to them. If the questions were too difficult or time-consuming for people to answer, we were afraid that we wouldn't get enough data. So we don't have volume data for each type of food waste feedstock.

We did ask the respondents what types of feedstocks were processed at their facilities. We found that multiple choice questions were much better than open-ended questions. We're getting responses. We collected data on both food and nonfood waste feedstocks.

The top five feedstocks processed by AD according to our survey results were FOG, food processing industry waste, beverage processing industry waste, fruit and vegetable waste, and pre- and post-consumer food service waste.

Not surprisingly, the feedstock processed at the most number of facilities is FOG, with the most being at WRRFs. This isn't particularly surprising because this feedstock is known for boosting biogas production levels. That is one of the main reasons that people add food wastes to their waste streams to begin with.

The next two most common feedstocks are food processing industry waste and beverage processing industry waste. Again, these feedstock types tend to be more uniform and homogenous and it makes them ideal for use in AD. The last two most common feedstocks are fruit and vegetable waste—that may be surprising to some people—and also food service waste from pre- and post-consumer waste streams.

The last two of the most commonly processed feedstocks if we did top seven were, first, source-separated commercial, institutional, and residential organic wastes. Thirty facilities processed this feedstock, which is just about one-third compared to how many process FOG. Then, second, is retail food waste, which covers supermarkets, grocery stores, and so on. Twenty-five facilities process this feedstock. That's also just under one-third of the ones that process FOG.

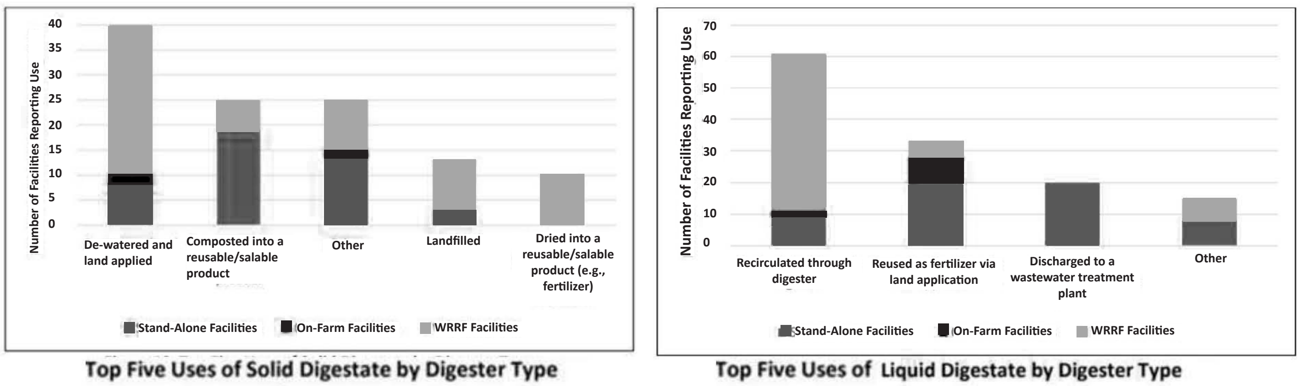
Carol asked me to add some data on how digestates are managed based on EPA survey data. But before I do that, I want to talk about digestate. Digestate is anything solid or liquid that's coming out of the anaerobic digester, so essentially the non-gas byproducts of digestion. But digestate is not necessarily a biosolid. EPA defines "biosolid" as a product of the wastewater treatment process, which is a very specific process. Biosolids and sewage sludge are often used interchangeably. Biosolids are specifically regulated by 40 C.F.R. Part 503, which is part of the Clean Water Act (CWA).[9] If the digestate in question does not contain biosolids, then it is not regulated by Part 503.

What does that even mean? If biosolids equal sewage sludge, and sewage sludge is a feedstock in any digester, then the digestate that comes out at the end is a biosolid. If anybody has any questions about this, we could talk about it all day. EPA regulates biosolids under Part 503, but the states regulate non-biosolid digestates, not EPA. That is an important distinction.

What happens to the digestate? In addition to the critical data points that we collected data on, EPA was very interested in learning about where digestate coming from AD was actually going. This was because at the time that we started this project, there was the perception even within EPA that all of the digestate coming from AD was being landfilled or incinerated. It was kind of a dark cloud hanging over AD at that point. People thought composting is good and AD is bad. And we clearly wanted to dispel that notion. Thus, in our survey, we asked operators how they were managing their solid and liquid digestates. Figure 1 on the next page shows the top five uses of solid and liquid digestates.

9. 33 U.S.C. §§1251-1387, ELR Stat. FWPCA §§101-607.

Figure 1. What Happens to the Digestate?



Source: U.S. EPA, Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 & 2018): Survey Results figs.10, 11 (2021).

It's a little different for the solid and liquid digestates, which makes sense. There's different uses for different materials. We're going to talk about solids first. The top use is land application. This is great. It's what should be happening. This data allowed us to document that which we weren't able to prior to collecting this data.

The next highest use does include composting into a saleable product and then the "other" category includes a lot of interesting things that show how the digestate is being beneficially reused. The next highest use is landfilling, which is what I wanted to talk about here. Certainly, fourth is better than first. It allowed us to show that way more digestate is being beneficially used than landfilled, which is really helpful when we're promoting the use of AD for processing food waste.

Moving on to liquid digestate, most of it is being recirculated back through the digester or, in the case of a stand-alone digester, it is being discharged to a separate WRRF. A little over 30 facilities indicated that they were land-applying liquid digestate as a fertilizer, which is also good to know.

Moving on to the Wasted Food Report.[10] Please note that I'm going to talk about a lot of different documents. For more details, you can take a look at the documents specifically. EPA released the 2018 Wasted Food Report in November 2020. We used a new methodology with this report.

EPA had been reporting on the generation and management of municipal solid waste for more than 30 years in the Facts and Figures Report, which used to be known as the Municipal Solid Waste Characterization Report.[11] The methodology that we used to calculate the wasted food generation estimates was updated in 2020. The new methodology was used for the first time in the 2018 Facts and Figures Report and also the 2018 Wasted Food Report. The new methodology has a much broader scope in a couple of different areas, both of which changed the landscape a little bit, which is why the data I'm about to present might look a little different than you're used to seeing.

First, the generation estimates now include the industrial sector when it didn't before. It also includes additional sources in the commercial and institutional sectors. Second, there are additional management pathways that are considered. The new pathways include food wastes that are going to animal feed and land application, just to name a couple. Two additional points of interest about this report are that we identified just under 103 million tons of wasted food generated in 2018, and then 10.7 million tons of that was processed by AD.

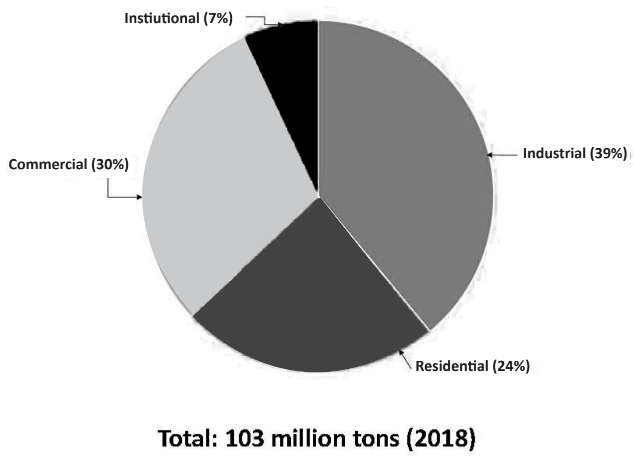
Figure 2 (next page) shows the wasted food generation estimates. I broke this down by sector. The biggest slice of the pie certainly is the industrial sector at just under 40%. Then, the next highest is commercial at 30%, followed by residential at 24%, and institutional at 7%. I like to show this figure because it gives a sense of where to focus attention when you're trying to reduce wasted food. My strategy is always to work with the sectors that have the most waste to identify where the most reductions can be made.

Table 3 on the next page identifies the management pathways from the 2018 Wasted Food Report. As I mentioned, the data are a bit different than the previous Facts and Figures Reports. This is because it includes the industrial sector, which is made up mostly of food and beverage processing. The food and beverage processing sector is good at keeping food waste out of landfills because the more food they throw away, the less money they make. So they do a better job than some of the other sectors.

The amount of wasted food going to landfills is 36%. It's smaller than we're used to seeing. If you take the industrial sector out of the wasted food estimates, then the number goes up to about 56%, which might be closer to what you're used to seeing. The other thing that I want to mention is

10. U.S. EPA, 2018 Wasted Food Report (2020) (EPA 530-R-20-004), https://www.epa.gov/sites/production/files/2020-11/documents/2018_wasted_food_report-11-9-20_final_.pdf.
11. U.S. EPA, *Advancing Sustainable Materials Management: Facts and Figures Report*, https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management (last updated Jan. 28, 2021).

Figure 2. Wasted Food Generation Estimates by Sector (2018)



Source: U.S. EPA, 2018 Wasted Food Report tbl.4, fig.1 (2020) (EPA 530-R-20-004).

Table 3. Management Pathway Estimates (2018)

MANAGEMENT PATHWAY	QUANTITY MANAGED (TONS)	PERCENTAGE MANAGED
Animal Feed	21,978,346	21
Codigestion/ Anaerobic Digestion	10,691,756	10
Composting/ Aerobic Processes	3,455,273	3
Bio-based Materials/Biochem-ical Processing	2,186,873	2
Donation	7,394,096	7
Land Application	9,144,093	9
Sewer/Wastewater treatment	3,743,229	4
Landfill	36,612,263	36
Controlled Combustion	7,747,441	8
TOTAL	102,953,370	100%

Source: U.S. EPA, 2018 Wasted Food Report tbl.5 (2020) (EPA 530-R-20-004).

the amount of wasted food that's going to AD. That's rated about 10% of the total amount of food waste generated. That relates to the 10,691,756 tons that comes from the 2016 data set in the Wasted Food Report.

Julia Levin: I'm going to take this in a rather different direction than Melissa, but will come back to some of the themes that she raised and that Carol raised as well.

The Bioenergy Association of California has more than 80 members at this point. In fact, Mark McDannel with L.A. County Sanitation Districts is one of our original members, and one of my former board members. We represent a lot of public agencies, private companies, utilities, investors, research institutions, and others that are working to convert organic waste, including food waste, to energy. But "organic waste" also includes green waste, agricultural waste, dairy waste, and forest and other vegetative waste, which we have a lot of in the West, and a lot that has to be removed for wildfire mitigation.

As Carol mentioned, I got involved in bioenergy in my previous role as the deputy secretary for climate change and energy at the California Natural Resources Agency. I still think the single most important reason why we need to very quickly accelerate bioenergy development all over the United States is climate change. There are a lot of other benefits from bioenergy, but climate change is by far the most urgent reason why we really need to scale up this industry at a much faster pace than we have over the past decade.

There are a lot of other benefits to bioenergy done correctly—meaning, not direct incineration. That includes advanced technologies like AD for wet waste and gasification for woody waste, drier waste, things like that. There are a lot of air quality benefits of reducing landfills, reducing pile and decay, or reducing open burning of our organic waste. We also need bioenergy from an energy standpoint. I will come back to that.

I'm going to focus first on climate change. Carol touched on this and I really want to underscore it because converting organic waste to energy is probably the single most important thing we can do for the climate right now. That will come as a surprise, I think, to a lot of you. Some people actually resist that argument, which is why I'm going to spend a few minutes on it because I think this is the single biggest environmental crisis of our lifetimes.

About a year-and-a-half ago, the Intergovernmental Panel on Climate Change, the international body of climate scientists under the United Nations, said we have 12 years left to dramatically reduce climate pollution or we face truly catastrophic global climate change.[12] Since that was almost a year-and-a-half ago, for all intents and pur-

12. Intergovernmental Panel on Climate Change, Global Warming of 1.5 °C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty (Valérie Masson-Delmotte et al. eds, 2018), https://www.ipcc.ch/sr15/.

poses, we have 10 years left now. There are only two things that will make any difference to the climate in the next 10 years. That's reducing short-lived climate pollutants and sequestering carbon.

Everything we're doing to reduce fossil fuel use is hugely important in the long run, but it makes no difference to the climate for decades. We don't have decades left when you think about the rapid acceleration of ocean acidification, the loss of forests, and the really catastrophic increases in wildfire in the drier parts of the globe, not just in the western United States, but in Australia and Russia and other countries. We have to focus more on the things that can make a difference right away.

Number one on that list is short-lived climate pollutant reductions. The reason is that they only stay in the atmosphere a few hours to a few weeks. Therefore, the things that we do to reduce short-lived climate pollutants, especially methane and black carbon, benefit the climate right away.

If we want to stop warming at or below 2 degrees centigrade, the only thing that can bend the curve right away is short-lived climate pollutant reductions. CO2 is the main climate pollutant from fossil fuel burning. Even if we stop burning all fossil fuels today, we would see virtually no impact on the climate until 2050 or later. And that's just too late. We can't afford to wait that long. I'm not trying to suggest that we should stop our focus on fossil fuel reduction, but we have to have at least equal if not greater focus on short-lived climate pollutants because they can really benefit the climate right away. I can't emphasize enough how critical that is.

In California, and hopefully other states in the United States as well, our current climate change scoping plan,[13] which is the strategy to reach a 40% reduction in climate pollution by 2030, relies on short-lived climate pollutant reductions for more than one-third of all the carbon reductions we have to achieve over the next decade. That is really appropriate and really critical. I hope other states and EPA will follow.

So, what does that have to do with food waste and other organic waste? You probably all know the largest sources of methane, which is a very potent short-lived climate pollutant, and 72 times more damaging to the climate than CO2 on a 20-year time horizon. Four out of the five largest sources of methane, at least in California, are related to organic waste. That's cows' dairy manure, landfills, and wastewater treatment facilities, as well as methane leakage from the oil and gas sector and methane pipes.

We know now in California and elsewhere that landfills have a lot more methane leakage than previously thought. Landfills are probably number one on the list in California. Some of that is probably unavoidable because of the way that landfills operate. But it is really critical to reduce organic waste going to landfills as a way to reduce methane emissions. I know this is a bit of an aside because we're here to talk about food waste, but it's important in the overall conversation.

Also, we're talking about agricultural waste since that's where a lot of our food comes from. In California, as in a lot of other places around the world, we produce a massive volume of agricultural waste each year. Most of it is actually cellulosic. We leave it in the fields and we open-burn it in California. That is an enormous source of air pollution and climate pollution. A lot of this waste is not compostable. The single most valuable crop in California now is nuts. It's a great replacement for meat, which I think has real benefits to the environment, but not when we pile up the walnut shells and the almond shells and let them decompose, which releases methane.

The one thing that's worse though is open-burning that waste, which releases black carbon, which is 3,200 times more damaging to the climate than CO2. So, I encourage us to think about the whole food production and processing system, as well as food waste disposal, because they're all connected at this point. We can deal with them together. There are a lot of synergies.

One example of putting food and agricultural waste to work is at an organic walnut farm outside of Davis in California's Central Valley. They are gasifying the walnut shells and producing enough heat and power to power the shelling, drying, and packaging of the walnuts. They don't have to import any power from the grid to do that. The walnut shells themselves are powering the entire operation. The only byproduct is an extremely high-value biochar that can be returned to the soil for carbon sequestration, meaning that the project overall is actually carbon-negative.

There is another reason I mention this project and gasification. I know we're here to talk about AD, but one of the big problems with digestate and biosolids and even compost is that they contain per- and polyfluoroalkyl substances (PFAS). These are very dangerous, very toxic chemicals that bioaccumulate. Our food supply is full of them, as is our water supply.

One of the big advantages of gasification or pyrolysis of food and agricultural waste is that those conversion processes operate at very high temperatures and almost certainly break down PFAS chemicals, which unfortunately AD and compost do not.

There's another reason we need to start looking at all of these issues and these residues more holistically, to maximize benefits and minimize impacts of the food waste that can't be reduced or reused. Because of the importance of reducing short-lived climate pollutants, every single one of California's climate plans—our climate change scoping plan, our short-lived climate pollutant strategy, our forest carbon plan, and our natural and working lands plan—calls for a rapid increase in converting organic waste to energy because of all the benefits. We can reduce fossil fuel use. We can reduce emissions from organic waste, decomposition, or burning. And we can provide organic soil amendments.

The other reason that converting organic waste to energy is so, so, so important from a climate standpoint is that it

13. California Air Resources Board, California's 2017 Climate Change Scoping Plan (2017), https://ww2.arb.ca.gov/sites/default/files/classic//cc/scopingplan/scoping_plan_2017.pdf.

is one of the few opportunities we have to provide really significant carbon-negative emissions. Why does that matter? California, like several countries around the world and I think increasingly other states, has set a goal of achieving net carbon neutrality by mid-century. There are a lot of emissions that we're not going to be able to eliminate by mid-century.

So, over the past couple of years several top-notch research institutions—Lawrence Livermore National Laboratory, Princeton University, Stanford University, and others—have looked at what it is really going to take to get to carbon neutrality. They all agree that some emissions are unavoidable—some of them out of leakage, some of them out of human waste, agricultural operations, industrial operations. But we can offset those emissions with carbon-negative emissions.

By far, the largest opportunity for carbon-negative emissions is converting organic waste to energy with carbon capture and storage. In California alone, that bioenergy with carbon capture and storage (BECCS) can provide more than two-thirds of all the carbon-negative emissions we need to get to carbon neutrality. Just how carbon-negative are they? Table 4 looks at the carbon intensity (measured in CO_2 equivalent (CO_2e)) per megajoule (MJ) of energy.

Table 4. Carbon Intensity of Fuels (grams CO_2e/MJ)

Diesel	102
Gasoline	100
Corn ethanol	34-75
Natural Gas	68
Fuel Cell (non-renewable hydrogen)	39
Electric vehicles (CA power grid)	31
Biodiesel	9 to 50
Landfill Biogas	11 to 40
Biogas from forest waste	14
Wastewater Biogas (large Facillities)	8-30
Biogas from Diverted Food and Green Waste	-15 to -180
Dairy Biogas	-276 to -330

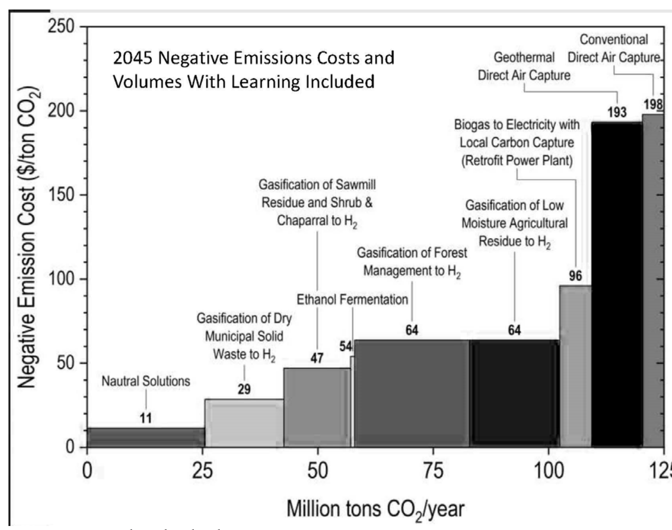
Source: California Air Resources Board, *Low Carbon Fuel Standard*, https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard (last visited June 4, 2021).

This analysis is done under our low-carbon fuel standard, but it's the same analysis whether it's electricity or pipeline biogas because it's based on energy usage, not just whether it's used as a vehicle fuel. So, if you look at the bottom six categories, these are all the organic waste-based fuels. These are the lowest-carbon fuels in existence. All of them can be carbon-negative if you add carbon capture and storage or if you produce biochar as a byproduct.

Actually, the bottom couple categories can be doubly as low-carbon—meaning the California Air Resources Board (CARB) just announced the new pathway for dairy biogas to hydrogen and then to vehicle fuel. That's going to be minus 600-some grams of carbon per MJ of energy. The reason is that hydrogen fuel cell engines and electric vehicles are much more efficient than natural gas vehicles. But these are dramatically important carbon-negative emissions that we can achieve by converting organic waste to energy.

Another reason that's really important is these are incredibly cost-effective carbon reductions. People sometimes complain that bioenergy is expensive. That ignores a lot of things. First, bioenergy is there 24/7 unlike solar and wind. We don't need backup generation. We don't need batteries. Bioenergy also provides some of the most cost-effective carbon reductions. The middle bars in Figure 3 (from "Gasification of Dry Municipal Solid Waste to H2" to "Biogas to Electricity With Local Carbon Capture (Retrofit Power Plant)") are the BECCS categories. Different technologies, different end-uses.

Figure 3. 2045 Negative Emissions Costs and Volumes With Learning Included*



* H_2 is molecular hydrogen.

Source: Roger Aines, Lawrence Livermore National Laboratory, PowerPoint Presentation: Getting to Zero: Technical Options for Removing CO_2 From California's Air (2020).

The average of those BECCS categories are providing carbon reductions at a cost of about $60 per ton. That is less than one-third of the cost of carbon reductions under California's low-carbon fuel standard, where carbon reductions currently cost about $195 to $200 per ton. So in terms of the value of the carbon reductions, bioenergy is extremely cost effective.

The California Legislative Analyst's Office did a similar assessment of the different measures in which California has invested public funding or cap-and-trade revenues over the past five to six years.[14] They found that the investments in organic waste to energy and organic waste to compost are by far the most cost-effective investments the state has made in carbon reductions. They are very high-value and low-cost investments.

14. California Legislative Analyst's Office, Administration's Cap-and-Trade Report Provides New Information, Raises Issues for Consideration (2016), https://lao.ca.gov/handouts/resources/2016/Cap-and-Trade-Report-Provides-New-Information-042016.pdf.

That brings me to the state's organics recycling law.[15] I think Mark will talk about this as well. In 2016, given the emerging body of science around the urgency of short-lived climate pollutants and the benefits of reducing these pollutants, California passed Senate Bill 1383. It requires a number of things related to dairies, renewable gas, and organic landfill waste. It requires that 50% of all organic waste currently going to landfills be diverted by 2022 and 75% by 2025. Seventy-five percent of our organic wastes equates to about 15 million tons per year.

I was listening to Melissa's numbers that across the entire country the processing capacity is just over 24 million tons of organic waste to energy right now through AD. California alone is going to need to add another 15 million tons per year in just the next handful of years. The regulations adopted by CalRecycle only allow three alternatives—bioenergy in different forms, compost, and mulch.

I want to raise a topic that I think may be a bit controversial, but it needs to be said because climate change is hard enough to tackle if we follow the science. If we don't follow the science, we have no chance of succeeding. So, the science is really, really clear that we need to do bioenergy and compost or we need to do bioenergy and biochar if we're using gasification or pyrolysis. We will get far greater climate and other benefits out of projects that do both. I raise this particularly because Melissa just announced the potential for new funding from EPA. It's really critical that public agencies incentivize the projects that are going to provide the greatest benefits.

A couple of years ago, the Oregon Department of Environmental Quality did a literature review of 147 separate studies from across the country looking at the benefits of four different end-uses of food waste.[16] They looked at in-sink disposals in garbage disposals, landfill disposal, compost, and bioenergy. They found unequivocally that bioenergy and composting together will provide 3.5 times the carbon reductions that compost alone can provide. That makes sense because you're getting the upstream reductions. You're getting energy fossil fuel displacement and fossil fuel displacement from fertilizer. So, it's a triple benefit, as Carol said.

All of those studies were looking at bioenergy for electricity generation. If you use the biogas to replace diesel in a heavy-duty truck, then the differential is more like six to 10 times greater carbon reductions because diesel emits black carbon and has a very high carbon intensity. Again, it's really important. I'm not in any way trying to disparage compost. Compost is really valuable to add nutrients to the soil to increase water efficiency and to replace fossil fuel-based fertilizers, but compost is not carbon sequestration.

I know that is not commonly understood. But if you look at the Lawrence Livermore National Laboratory report that I referenced,[17] compost is generally applied at or near the surface of working lands or agricultural and natural lands. It degrades fairly quickly, which is why it's important for providing nutrients to soil, but it is not long-term carbon sequestration.

We really need to maximize its benefits. To the extent we can't minimize food waste or reduce food waste or put edible food back to work as food, we should be using it for both energy and compost or biochar. As I mentioned earlier, the other benefit of energy production, particularly gasification or pyrolysis, is that it likely destroys PFAS chemicals.

Again, bioenergy is also really critical to meet our renewable energy goals overall. California, like Hawaii and a handful of other states, has set a goal of 100% renewable power. We know we can't do that with solar and wind alone because they're not there all the time. Bioenergy is unique among renewable power sources in that it can provide flexible generation power, meaning it can ramp up and down very quickly because it's gas, so it operates the same way that natural gas does.

It also can provide long-duration energy storage, which is critical to back up solar and wind. And it can provide power for backup generators in place of diesel, which sadly California and other western states are increasingly relying on because of the threat of wildfires and our decreasingly reliable energy infrastructure in the West.

The other reason that bioenergy is so beneficial is that every community produces organic waste. Every community can use its own organic waste to produce its own energy supplies. That really boosts local energy security in a world where energy supplies are increasingly vulnerable to climate change impacts and grid outages. California experienced rolling blackouts last summer. We now experience public safety power shutoffs frequently. Texas just had massive blackouts. It is increasingly important for local communities to have their own energy supplies and energy security.

One example is my local wastewater treatment facility, East Bay Municipal Utility District (MUD) in Oakland. They provide my wastewater and my water services. We had a four-day public safety power shutoff last year because of high wind, high temperature, and high wildfire risk. The reason I still had clean water coming out of my tap is because East Bay MUD can power its own facility with the biogas it produces from the wastewater and the food waste that they take in. I think Mark probably can do something similar at L.A. County Sanitation Districts. There are real energy security and public safety reasons why converting organic waste to energy makes sense in addition to climate change and other reasons.

Another example is the Netherlands, which is one of the first countries to adopt a nationwide plan to achieve carbon neutrality. I think only four or five other countries have done that. Every single one of the chapters in the Nether-

15. S.B. 1383, ch. 395 (Cal. 2016).
16. Oregon Department of Environmental Quality, Evaluation of Climate, Energy, and Soils Impacts of Selected Food Discards Management Systems (2014), https://www.oregon.gov/deq/FilterDocs/FoodWasteStudyReport.pdf.
17. Lawrence Livermore National Laboratory, Getting to Neutral: Options for Negative Carbon Emissions in California (2020).

lands' plan refers to organic waste and how local organic waste can provide local energy security. In both the residential and building sectors, local organic waste is being used to provide local power for hard-to-electrify end-uses.

In the residential sector, it's providing combined heat and power or cooling. In the building sector, it's providing fuel for commercial jets and for heavy-duty trucks. I think it's a great example. A previous speaker mentioned the circular economy. That's really what we need to move to as quickly as possible. It is no longer calling organic waste "waste." We should be calling it residues. It's only wasted if it isn't put to use. We can put our organic residues to use for very low-carbon renewable energy.

Mark McDannel: We are a wastewater and solid waste utility. Ten years ago, we started looking at the feasibility of using our wastewater infrastructure to digest solid waste. We have a fully commercial program now that we're still developing. I'll talk about who we are and focus on our business model, our governmental structure, because that really impacts how we operate our program.

The L.A. County Sanitation Districts have 24 separate districts that include 88 cities and the unincorporated area of L.A. County. We are not a county government that oversees everything. We're a special-purpose agency.

On the wastewater side, we're basically like a utility, a public monopoly. You don't choose where you send your wastewater. We charge the cost of service. We have formal rate-setting activities every three years.

On the solid waste side, we are not a monopoly. We actually have to compete largely with private companies in everything we do. We landfill. We operate material recovery facilities, recycling centers, transfer stations, energy facilities, and our food waste recycling program. The economics of this is that our program is driven by our Solid Waste Management Department. We see this as providing a service to our cities and generating revenue to continue to operate our Solid Waste Management Department.

The other point to state is that we do not collect any trash. The Joint Water Pollution Control Plant is our largest treatment plant, and that's where we are digesting the food waste.

We talked about S.B. 1383, and there were several bills that got us started toward reducing methane beforehand. A key point, however, is that this bill was passed in 2016 with a goal of 50% reduction by 2020, but the regulations don't take effect until 2022. So it's a huge effort for our state. There are a lot of stakeholders. The delayed enforcement, for those of us who are trying to develop infrastructure, means that we don't have a food waste stream or an organic waste stream to run our facilities yet to recover our finances.

Why do we want organics out of the landfills? If you put the organic material in the landfill, it stays there for decades. At the best, most compliant landfills, 2% of that methane leaks. A default leakage rate often used in calculating methane leakage rates from landfills is 30%. I'm guessing there's a lot of landfills in the country and certainly in the world that aren't even getting 30% or getting much more than 30% leakage. We operated a landfill. It's been closed since 1961 and it's still generating methane that we have to collect.

The digester doesn't leak. It's a sealed vessel. The material is there for 15 to 30 days. It captures all the methane. They're not leaking and you're done with that solid waste.

We can't put garbage straight into a digester at a wastewater treatment plant. We need to preprocess it. We then digest it. We have gas to recover. The post-treatment—fertilizers and composting—was discussed earlier. I'm not going to talk about that because we already handle all of the biosolids at our wastewater treatment plant. The food waste does not add enough to measure. We haven't seen any impact from food waste.

Again, we can't put garbage in the digester. We have to clean up what comes from the trash haulers. Our business model is that we process some food waste. We have eight other contractors who are processing food waste from various sources. They all use a lot of technologies. Everybody has to meet the same specifications largely for organic content and the maximum on impurities and grit.

We get food waste that consists of a lot of sloppy, smelly stuff, with a lot of bags, and a lot of impurities, and we need to get rid of contaminants so we can pump the material into tanks. The equipment we use to separate the food waste is basically a blender in which we grind it up and squeeze the organics out through holes to the tanks behind. We store that and we take that down to our treatment plant.

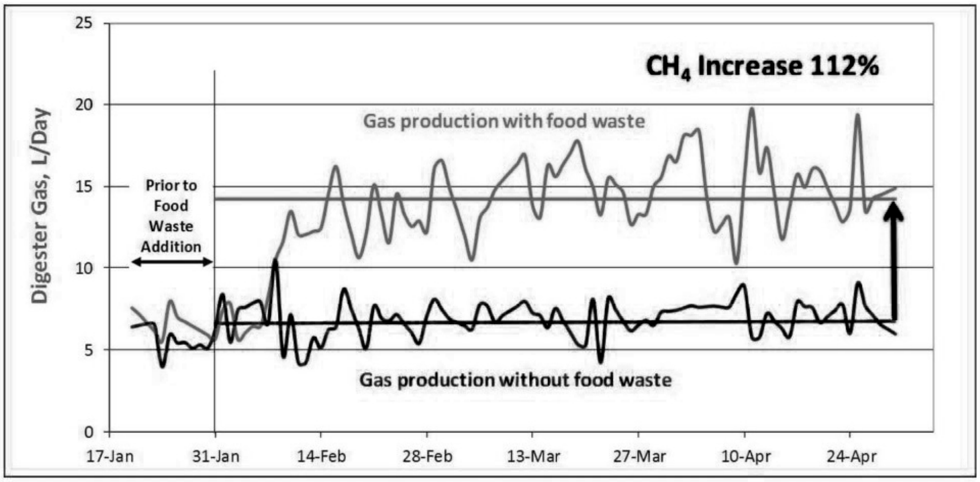
The second step is the digestion. The bottom line in Figure 4 (next page) is how much methane you get from digesting sewage sludge. When adding food waste, we found the optimal rate to be 10% to 12% additional food waste slurry. At this feed rate, there were no adverse impacts on the digestion process and methane production was doubled.

The food waste goes through the sewer. It goes through the whole treatment process. There's not a lot of energy left in that. We get about 60% of the energy out. The raw food waste is like rocket fuel. The extra energy is the key for us in the Solid Waste Management Department to the economics of our program. We're looking to pay for the recycle program and to supplement our solid waste program by energy sales.

We have 24 digesters. Each of these is about four million gallons. The ones at the south end of the plant are where we are putting food waste right now. And we'll be ramping up to feed all five of those digesters. In the middle, we have an existing power plant that produces 20 megawatts. That runs the treatment plant, which, again, is completely self-powered. At the far north, we have an existing natural gas vehicle fueling station that's been there for 10 years. It does about 1,000 to 1,400 gallons per day of business. This is kind of the setup for what we've been doing with our energy and where we're headed.

We talked about the options—electricity, heat, steam, vehicle fuel, biomethane, or renewable natural gas (RNG) to the pipeline. We have to decide what to do. Again, we don't have the advantage of a city that can say we'll just

Figure 4. Biogas Production With and Without Food Waste*



* CH_4 is methane.

Source: Internal research conducted by L.A. County Sanitation Districts' Wastewater Research Section.

raise taxes and everybody will pay for it. We don't even have the advantage of a corporation that says we've got this pot of money and this is going to be our investment. We've got to run like a profit-making company, but we don't have profit to do it. So every project has to pay for itself and it has to have a good return.

These are the options. Power, RNG to put in the pipeline, and vehicle fuel—our key evaluation factors. We run this, again, like a business decision. What does it cost to build it? What does it cost to run it? Sales price—long term and short term—that's key. You can get a long-term electricity contract that's very lucrative. Short-term pricing for RNG is so high that I consider it a gold rush—great prices, but they probably won't last. Longer-term contracts are available at lower prices, but these lower prices are still high enough to justify a project. So there are all these things to consider.

There are emissions. Making RNG is great in the Los Angeles Basin. We have strict air regulations because somebody else is burning it in their tailpipe. They're permitted. They're clean. We don't need an air permit.

As for the technology risk, there are a lot of great technologies out there that haven't been proven. You don't, as they say, want to be the first one to buy the second plant.

There's a developing battle in California. The environmentalists are pushing toward almost a combustion-free state in 2050, which is going to be tough to reach when you still have these bioresources. And the electric utilities, they're not really taking sides. But Southern California Edison has a plan for 2045. They're going to triple electricity usage.[18] So, something is going to shake out in the next few decades. As far as other barriers, again, with any big project like this there are surprises.

Our first system, which uses about one-third of the gas that we expect to have, was almost a no-brainer. We could do electricity. We could put RNG in the pipeline, which costs $5 million for the interconnection. Or we have an existing compressed natural gas (CNG) vehicle station that has 1,000 to 1,400 gallons per day of business. Plus, when you go straight to vehicles, you don't have to connect with the gas company. Just from a chemical engineering standpoint, the pipeline requires 98% to 99% methane. Vehicles only require 88% methane.[19]

We've started up a project. We're completely commissioned. We're waiting on CARB and EPA certification on our renewable credits to essentially completely displace the pipeline natural gas that's being used to feed those vehicles.

Our Phase II energy will use about one-third of the additional gas we will produce from food waste. But Phase II energy, as we ramp up our food waste, is on hold. I mentioned the source of funds. We don't have the power to tax, so we can't invest money unless we really see a return. We have no long-term food waste contracts in place because there's no enforcement until 2022. We're just starting to negotiate that. There are already bills in the legislature to delay that enforcement, so we don't know when we're going to have the food waste. We're not ready to build. This is an $8 to $12 million project.

In California, it is a fear for us because we'll be around for decades. We're not a private developer who builds this fast and gets the $40 million British thermal unit (Btu) landfill gas and pays it off in 14 months. We're going to be around for decades and we're already wondering if there are going to be CNG vehicles to take this gas in 20 or 30 years. That is part of our thinking.

Bioenergy renewable gas is absolutely critical and it's a key part of our solutions. But there's some resistance and

18. Southern California Edison, Pathway 2045: Update to the Clean Power and Electrification Pathway (2019), https://download.newsroom.edison.com/create_memory_file/?f_id=5dc0be0b2cfac24b300fe4ca&content_verified=True.

19. CARB, *Alternative Fuels*, https://ww2.arb.ca.gov/our-work/programs/alternative-fuels (last visited June 4, 2021).

challenges that we find in the marketplace when trying to develop a project. In California today, wholesale brown power is $35 to $40 per megawatt hour. You can enter into long-term solar projects in the $35 to $60 per-megawatt-hour range. These are projects with battery storage. And again, with battery storage, you can keep the lights on from 8:00 a.m. to 10:00 p.m. You're still not going to run your lights overnight. That's a challenge in California because the utilities, the municipal agencies, are so far used to really cheap power. You build a power plant on bioenergy and it costs $0.08 to make the power, you can't sell it. That's a challenge.

On natural gas, again, the wholesale price is $3 per million Btu. You can find buyers for long-term RNG projects, 10 to 15 years, at about $10 per million Btu. It's a huge premium. It's great if you're a seller. But it costs you $5 or $6 to produce it. You have to be sure these prices are going to be there. I call it the RNG spot market. The gold rush is still there with EPA renewable identification numbers (RINs). The California low-carbon fuel standard is $30 to $40 per million Btu, but again, there are no contracts for that that go beyond this year. We've gone through huge swings in administrations as prices stayed up. But again, the EPA RINs are set every year by EPA on a part-technical and part-political decision.

Those are the challenges for us in trying to make sure that we build a plant that's going to be able to recover its cost, serve our cities, and be able to succeed financially.

John Hanselman: We started Vanguard Renewables seven years ago to work with American agriculture and farmers to create a different model for recycling food wastes into RNG and renewable electricity and digestate for regenerative agriculture. We started the company, basically, as renewable energy geeks. We were blown away by the abundance of the feedstock, the overwhelming amount of food waste that was available for recapture in the marketplace.

What we didn't understand is just how incredibly technical the process was and how disruptive it was to a lot of existing industries to actually extract that food waste and process it, as Mark talked about, and to get it out to the farms for recycling. It has been a long adventure, but one that we're really excited to bring to the fore.

Our mission is to take the food waste that is quite unique in the fact that, as Julia said so wonderfully, organic materials are really unique in that the method of disposal and how they're handled really determines whether they become a powerful tool for decarbonization or a really awful greenhouse gas emitter. And our goal is to try to find a way to embrace both the farm community and the food manufacturing community, to combine the power of the two, and create a renewable energy source that is really unparalleled in its decarbonization impact.

We did start early on in New England. Before we started the company, we looked at a lot of predecessor efforts in the United States. We spent a lot of time in Europe looking at what was happening in Germany, Denmark, and the United Kingdom, where they have been doing AD of organic materials for decades. I couldn't understand why it hadn't scaled in the United States. Once we started doing it, we got a very clear understanding of why—because it is disruptive and it requires behavioral change that is just enough to really make it a challenge.

We were set up to do it in a very different way than folks have tried in the past. We used New England as our laboratory to try to figure out how to extract the materials. What we realized early on was that we needed partners, really wonderful partners, to help us accelerate that process and to disseminate the needed education to bring a public commitment to food waste recycling.

To that end, last year, we announced the Farm Powered Strategic Alliance with the founding members—Starbucks, Unilever, and the Dairy Farmers of America—where all of them made the commitment to recycle as much of their food waste as possible to RNG and then to use that RNG as a decarbonization methodology. And then, once the gas has been removed, to take the post-process liquids as regenerative agriculture biofertilizers. I'll talk about that in a minute.

The process, as I said, and as Mark alluded to earlier in his presentation, is an incredibly intricate process where we need to get the right food to the right farm at the right time and in the right manner. And as Mark said, what comes into the front-end of a processing plant is not actually the materials that we can probably put into an anaerobic digester and/or use as fertilizer on the field. So early on, we do quite a lot of preprocessing, I think very similar to what Mark talked about. We take food waste and organic waste in any manner. We take it out to the farm and combine it with the manure on the farm. We then heat that up and process it for the better part of the month, extracting the gas, and then we have the wonderful digestate left over in the tanks that we give to our farmers for that regenerative agriculture piece.

It's been a real learning process to try and balance these systems. You live at the intersection of biology and chemistry. The vagaries of the inbound food waste are not insignificant. It has been wonderful to be able to see that it actually can be done at scale.

This past year, as we started our outreach, we realized that if we took this message of circularity to the large food manufacturers, food distributors, and food retailers across the United States, it would provide a very different model for the way that they see waste. As we said, waste is really a mindset that just needs to be converted. As Julia said, waste is only waste if you don't put it to use.

The circularity here is the thing that is really different from what you've seen traditionally with the way any kind of recycling and/or waste management has been thought of. That would be the ability to go to the farm and take the waste material from the farm, the animal manure, and combine it with other agricultural products to create food. Then, at the food manufacturing plant, take the waste stream, the endemic waste, the stuff that cannot be reused or used for human or animal consumption, and bring that back to the farm. Then, take the retail packaged materials, unsafe materials, and bring that back in a processed manner to the farm. Combine that all in the anaerobic digester, then produce and extract the gas, which would then be sent back to those participants, massively helping them in their decarbonization. Then, take what's left over in the liquid process and return that to the farm. We're actually reintroducing those nutrients back into the soil. That really is the most important thing we can do.

As Julia said so eloquently, we have such a short period of time to make an impact. And making the impact here and reducing the reliance on synthetic fertilizers, reducing this in this entire circular loop here, makes a really huge difference. We are working currently to try to figure out how to create the metrics and measurements to be very clear about how we communicate all these benefits. There's a lot to be done in terms of understanding where all that carbon capture can be, but we are excited.

The thing that was most important is that our friends at Unilever, Starbucks, the Dairy Farmers of America, and now about a half-dozen other entities that are going to be joining the Farm Powered Strategic Alliance in this coming quarter, have all agreed to make a public commitment to recycling their food waste and to utilizing RNG in their manufacturing, distribution, and retail locations.

Almost as importantly, the Farm Powered Strategic Alliance is going to create these use cases, and as we continue to adopt them and utilize them, we're going to have that as part of our education and then distribute that to the industry and to entities across the United States. We're incredibly pleased to have been joined by these remarkable companies. We think this will continue to grow as an organization and be a call to the industry to change that mindset on waste and see if we can take it to a very different place.

What has been incredible, especially with large corporations in the food industry, is how many places food recycling can actually impact and where those touchpoints are—whether it's with the investor community, as in Wall Street environmental, social, and governance drivers; whether it's cost reduction at the plant; or whether it's reintegrating with the regenerative agriculture of their producers. It's all of that. Whether it's Scope 1 or 2 or 3 emissions, every major corporation in the United States that's manufacturing food has made commitments on either science-based goals or other targets. Having an effective tool that really requires a little bit of change at the plant level is something that we couldn't be more excited about.

I think, as Mark and everyone has talked about, RNG is a critical alternative. There is no silver bullet. Having spent more than a decade in the solar world prior to starting AD, we need a layer cake of energy to solve our challenges. If we're going to solve it in a quick fashion, all of these systems need to be put into place. We believe, as Julia said, the value and impact of RNG in the United States is going to be quite a significant part of the plan to take us to our goals.

Carol Jones: Thank you to all the panelists. I only have time for one multipart question, which is open to the whole panel, and that is what and where do you see the greatest opportunities for growth in U.S. food waste co-digestion? We see we have a way to go to achieving both our greenhouse gas and food waste recycling goals. So, what are the greatest opportunities? John, I would love it if you could talk about, in your breathtaking plans for expansion of your co-digestion model, what factors are influencing where you choose to locate your new facilities?

And then the other part is what policy changes do you think we need in order to really ramp up our development of these facilities?

John Hanselman: It's really about education and adoption. We've surveyed most of the United States for the density of food waste in the markets. There are regional and geographic differences in terms of the amount of available food waste in the marketplace. Historically, we used to spend a lot of time looking at the RNG or electric infrastructure. What we're finding more and more is that utilities throughout the United States are working hard to try to embrace RNG. And there are of course regional differences but a much quicker adoption than we saw in, say, the solar world back in 2006 or 2007.

The natural gas utilities are really jumping on board because I think they're looking to see if they can have a carbonization pathway that works. So for us, it's where are the marketplaces where we know there are adopters and there are adopters who are already willing to put forth a good plan.

Carol Jones: When you say adopters, are you talking about the farm sector or are you talking about the energy sector?

John Hanselman: No. It's actually the food manufacturers and/or the municipalities. So, we are seeing the largest segments. We see the commercial, industrial, and the residential sectors as the three primary segments to extract the food waste from. You look for where there are communities of companies that have embraced food waste recycling or where there are states and municipalities that have embraced organic recycling and landfill bans.

Julia Levin: There are probably a number of regulatory changes that need to happen. The lack of long-term certainty has been mentioned. We really need that under the low-carbon fuel standard in California and under the renewable fuel standard federally. Even if credit values are high, it's hard to take those to investors and to the bank if they're not guaranteed for more than a year or two at a time.

But I think the single biggest thing that states and the federal government could do is put a massive amount of money into this area. We have a great example from the federal government in the 1960s and 1970s really transforming our wastewater sector. I think we need that same level of public investment now. As I said, there's nothing more important we can do for the climate. As climate experts would say, this buys us the couple of decades we need until fossil fuel reductions really start to have a beneficial impact on the climate.

Given all of the different reasons why this is so beneficial, I was hoping there would be a few hundred billion or even a trillion dollars in the infrastructure package for this. There are a few bits of money here and there in the proposed infrastructure package, but nowhere near the level that we need to get to. Vice President Al Gore said it really well, that our solutions to climate change have to be commensurate with the risk. I think we're not seeing states or the federal government putting in anywhere near enough money.

Mark explained why for public agencies it takes a long time to get ratepayers to approve rate increases and everything else. We don't have time. What we need to do is put money in. To give a positive example, California has put almost one billion dollars into new dairy digesters. We have 250 new dairy digesters in operation or in active development right now as a result of that funding. We've got to do the same thing for food waste and wastewater treatment facilities and other organic waste diversions.

Mark McDannel: I agree. From a developer standpoint, the market is so illiquid that I've got to decide, I'm a wastewater agency, that's not my purpose. There's a survey that we did in California that says if you can get the food waste to the wastewater treatment plant, we can handle 75% of the food waste in California with existing digesters. But again, there's not funding. We're a special-purpose agency. If a wastewater agency said here's a rule you've got to meet or here's money to help you meet it, that would move things forward.

When I go to sell electricity, nobody is going to pay me $0.08 per kilowatt hour for electricity. There's a feed-in tariff in California of $0.13. That's been in place for what seems like a decade. The utilities are still dragging their feet on signing contracts and implementing it. So, it's tough as kind of a one-facility public agency to get a project actually built and get somebody to buy the project or buy the product.

Melissa Pennington: I want to comment on what Julia said. It has been a long time since that era of construction grants. You haven't seen EPA or any federal agency, maybe aside from the U.S. Department of Energy, put out that kind of money for grants. I wish that weren't the case. We're starting to see a little trickle right now. But $3 million for the whole country, which is what we did last year, which is more than we've ever done in my lifetime at EPA, is still nowhere near what's needed.

I also want to comment on what John said. You mentioned the residential sector. I think that's where the focus needs to go. There's a lot of food waste coming out of the residential sector. What I didn't discuss was how much of each of those sectors is actually being recycled because that's another piece of the puzzle. A very, very small amount of the residential-sector food waste generation is being recycled. That's because of the challenges with managing that material.

But food waste coming from all the different households in the country is a lot more difficult to manage and make sure that it's suitable for composting let alone AD. It's a really big challenge. I also think it's important for additional legislation to come through. Unfortunately, as a federal person, I'm not allowed to say or even encourage the states to pass laws similar to the ones in California that we've talked about, and then certainly in New England and some of the other states that have landfill bans and requirements on what happens with the organic waste. But when that happens, then change occurs. It's going to come, but it's going to come very slowly and probably not in enough time.

Carol Jones: Thank you to all four of you for your excellent presentations.