Bruce Lung: Well hello and welcome to the 2021 Better Buildings Summer Webinar Series. In this series we are profiling the best practices of the Better Building Challenge and Better Plants Program partners and other organizations, working to improve energy efficiency in buildings and plants.

My name is Bruce Lung and I'll be your moderator for today. Just a quick introduction. I've been working in industrial energy efficiency since the late 1990s and more recently supporting the Advanced Manufacturing Office at the US Department of Energy, particularly Technical Partnerships Energy Management CHP and Better Plants.

Today is a second part of our two-part series on combining power this summer. If you missed our first webinar on CHP and decarbonization, resiliency, and efficiency for industrial commercial sectors, you can see it's recording on the Better Building Solutions Center. It's either been posted or will be posted soon.

Our webinar organizers will send out a link through the Chat box for you to check it out. Today is more qualitative and our speakers will go through some sample analyses of combining power systems.

I'm going to introduce them in a just a minute, but first I'd like to go through some instructions on Slido. Are we ready for that slide? Yes, okay.

We are excited to announce that we'll be using this interactive platform called "Slido" for Q&A. Those of you who have been on our webinars before or through the summit you've probably seen us use these before, so hopefully it will be easy to use. Basically, all you have to do is just go into www.slido.com using your mobile device or by opening a new window in your internet browser. Today's event code is #DOE in capital letters.

If you'd like to ask any of our panelists any questions please submit them anytime throughout the presentation. We will be answering your questions near the end of the session. You can select the Thumbs-Up icon for questions that you like and this will result in the most popular questions going to the top of the queue and that means we'll get to them you know faster and, and better.

Please reach out to our webinar or webinar organizers through Go To Webinar Chat Box if you run into any issues.

And I think we'll go ahead and do a poll so far? Yes. We're going to start off with a few polls so we can learn about our audience. As you can join us over at Slido to respond to the polls. Go ahead and the first one here.

The first poll that we have for you today is: What manufacturing sector do you represent? And we're going to leave this up for about 30 seconds for you all to, to chime in, so… It looks like we've got some food processing and okay good, some engineering, government, utilities, excellent.

Keep on voting.

The multifamily, okay, universities, consultants, okay, good, excellent. You still have plenty of time left so go ahead and keep entering your sector. Some pharmaceuticals, electrical equipment, cosmetics, very good, okay, keep on coming now. Water and wastewater treatment, excellent, okay. Trucking. I actually have one who's looking for work, so hopefully we can help him out today as well. Avionics, okay, good, we like to have an aerospace sector, automotive.

Okay, we'll leave it up for just a few more seconds for everyone to chime in.

I know we've got a pretty big audience today, about a hundred people, so want to make sure you all have enough time. Research, okay.

Excellent, okay we've got 41 so far so I we'll go ahead and, and close it off right there, but thank you for joining. It looks like we have a pretty broad swath of industrial and commercial sector.

Our next question here is: What is your organization's experience with Combed Heat and Power? Either you own or operate a system, you're evaluating it, you're not evaluating it, evaluated recently, okay more than five years ago. Okay so you all are – a lot of you already have some CHP systems, good. It looks like a lot of folks are now evaluating it for the future. Good, good, okay. So it looks as though this webinar will be pretty informational for those of you that are going to be looking at for possibly in the future.

We'll give you a few more seconds.

Okay, excellent. I think we've got a decent number right there and we can move onto the next poll real quick.

We want to know: What are the primary drivers or reasons for you exploring CHP at your facility? I believe this is going to be a word cloud. Okay, cost savings, heat recovery, yep, resilience. Okay good energy efficiency is a big driver, biogas utilization, okay. Okay so far it looks as though energy efficiency is the big reason for a lot of folks. Also come compliance drivers, interesting, power generation, definitely, okay.

We'll give folks a few more seconds here.

See if we can get up to 40. All right 36, grid independence, okay, excellent, very good, excellent okay.

Yeah these are really good reasons. I think our speakers will definitely you know look through these and work them into their, their presentations a little later on.

It looks as though we've kind of reached perhaps a maximal here, so I think we'll go ahead and, and close this one off, but thank you for responding.

I, I think our last one here is: Are you familiar with the Department of Energy's CHP Technical Assistance Program and the technical assistance services that they offer? Oh okay, go ahead.

For those of you who are unsure I will say that the, the CHP TAP Program has gone through a few name changes, so you may have known them when they were I think the Regional Application Centers. Okay, good we're getting up to almost 40 so far. It looks as though a lot of you are not familiar with the TAP, so I think this will be a good webinar for you to understand all the things that they can do and how they can help you.

Okay there's a few more seconds and I think we're pretty much almost there. Okay. Well I think this probably gives us a good idea right there. I don't know if anyone else wants to jump in one more time. No, okay. I think we can probably close it off there. Thank you very much for, for participating in these polls.

So basically what I'm going to do now is introduce both of our speakers and then they'll, they'll take it from there.

Our one speaker who is the Technical Assistance Partnership as part of the University of Illinois Chicago, is Cliff Haefke. Cliff has over 20 years experience in the energy industry. He is the Director of Energy Resources Center at the University of Chicago. The ERC is an interdisciplinary public service, research, and specials projects organization that strives to improve energy efficiency and the environment, providing expertise in the area of energy efficiency, distributive generation, combined heat and power, bioenergy, sustainable transportation, utility data analytics, and sustainable landscapes.

As Director of the ERC Cliff oversees the Center's strategic direction. He is overseeing the securement of over $30 million in new research funds. He serves as the Director of the US DOE's Midwest and Central Combined Heat and Power Technical Assistance Partnership, and he also serves as an Assistant Director in the UIC's DOE Industrial Assessment Center.

Also, with us today is Bruce Hedman. Bruce is the head of Entropy Research and is the Senior Advisor to DOE's Combined Heat and Power Deployment Program and serves as the Coordinator for DOE's Package CHP Accelerator. Bruce Hedman has over 40 years of experience in industrial energy technology research, development, and commercialization, including with combined heat and power and distributed generation, technology in the markets.

As a reminder, please send in your questions through Slido and by going to slido.com and typing in the event code #DOE and we'll get, we'll try to get to them as soon as we can.

The session will be archived and posted to the Better Buildings Solutions Center for your reference.

And with that I'm going to pass things off to Cliff to begin the presentations. Thank you all for joining and we thank you ahead of time for staying through the end of the presentations.

Cliff?

Cliff Haefke: Great, thank you Bruce for the introduction. It's a pleasure to be with you all today. I guess I should have had the name Bruce, right, and we would have had three Bruce's here. So I've never presented with two Bruce's but excited to be here with, on this Better Buildings webinar.

So here's the agenda that Bruce and I, Bruce Hedman and I will, will cover. Give a quick overview of the DOE CHP TAP Program. For those who are not familiar we saw in that survey hopefully there will be insight into our program. A quick overview of the CHP basics and benefits. Then really is what I want to dive into in more depth are those next few bullets. The project development process for, for CHP systems and then showing you if you're going to work with the DOE CHP TAP, the no-cost service is you know what do those, what do our projects look like? The screening analyses, what do those look like and, and how will that interaction occur? We'll show then some of the follow on technology assistance that we do provide, which we call "Advanced Technical Assistance." We'll give some examples there.

Then Bruce Hedman will then end the, the webinar or carryon the webinar with showing how are we calculating emissions savings from CHP and providing some perspectives there.

Next.

So this is what we're going to look at, how do CHP projects fit into your goals. And we know there, they got to be tailored for the different facilities, but you already saw here is what I will be covering.

So next slide.

Here I want to give a brief overview of our CHP Technical Assistance Partnerships or as we call "TAPs." One is here is the three, three objectives that we have. One is working is end users to provide them education, the concepts, the benefits, and opportunities that CHP can provide them.

Next is we work with stakeholders, such as regulators, utilities, policy makers again to provide education for how CHP could be part of the larger energy solution, whether it's at a city level, state level, a regional level and even a national level.

Third is what we'll be diving into today on is the technical assistance services, where our team members of our various CHP TAPs provide one-on-one technical services to evaluate CHP at specific facilities.

Next.

Here is the, the, the map of our nation, right? So we have ten regional centers. You can see them by their color-coded regions. Just for a perspective I am located in the Chicago area at the University of Illinois Chicago. My team does manage the two green centers, the two TAPs there, the, the darker green and light green. And on the different boxes and bubbles you can see their contact information from all the different TAPs.

Following this presentation you'll be receiving a copy where you can get the contact information for each of our TAP directors.

Next.

So on, on this slide what I really want to do is take to that, that graphic in, in the middle there, the Project Flow diagram for CHP projects. I'll start right away that a CHP system is usually not your, your quick replacement, your quick installation. So CHP is comprehensive. There are many facets. You're we're working with a variety of forms of energy, fuels, looking at the electric side, the thermal side. You know several components that are brought in here, different size systems.

So you know CHP projects can take yeah months to even we've seen several years of implementing them due to complexity.

So this is what we want to look at to you know help a, a client work through this process and start from the beginning. Let's screen a facility. Let's do a preliminary analysis before jumping in into a feasibility analysis or investment grade analysis. Let's get some of those basic concepts flushed out. Let's see what kind of, what's, what's, what's happening at your facility. We like to do that at the very beginning before embarking on and putting too many resources of you know both our side and even you know a client side into this too.

So as you can see starting with the screening and preliminary analysis. If that looks like there is an opportunity at that site for CHP we typically recommend a feasibility study. Most often then to at the feasibility study has favorable results and we want to look at securing the financing for the project. Then we're going to go towards an investment grade analysis. If the project looks great at that time then we're putting a project in, we're procuring it, we're operating it, maintaining, and commissioning.

The text boxes in the bottom there show where our DOE CHP TAPs are, integrate within the project development process. Pretty

heavily in the upfront portions and then hopefully by the feasibility study, investment grade analysis you're working with the private sector, but we are also working as, as advisors. We are providing technical reviews. We are helping with calculations or other types of activities. But just being a sounding board and helping a client, hold their hands through a CHP project as it moves on toward development.

Next.

So Combined Heat and Power. If you attended the last session I apologize for this slide, you probably saw this, but just a quick recap. Combined Heat and Power or CHP is a form of distributed generation located at a site or a building, an integrated system; provides at least a portion of the electrical load. The key aspect there is heat recovery. Can we utilize the thermal energy from a CHP prime mover to generate heat, cooling, or even dehumidification?

Next.

Combined heat and power the big advantage here and we saw that from your answers, from the, the survey results from Slido is energy efficiency is one of the key aspects of this. So when you have the high efficiencies that hopefully translated in a lower operating cost, right? Reducing the, the operating costs of your facility is one of the big keys. But also with efficiencies you are hopefully getting reduced emissions as well when you're taking it back to the source energy. So that, that's the aspects with energy efficiency.

Another aspect of CHP that we're seeing more and more traction with is the resiliency that it can provide a facility. If, if the grid goes down we are seeing CHP system maintain operation of their facilities and plants. As an extra level of reliability which is a growing concern of, of many folks, many facilities and the manufacturing sector, critical infrastructure, and others. Also, CHP when you have reliable fuels you can also provide help to the grid in terms of grid congestion and avoiding distribution costs.

Next slide please.

So now this is where I'm trying to get to the, the meat of my presentation. This is where it starts here is when we're looking for a, a CHP project, the candidate site what do we need? What are the conditions? What, what are we as, as CHP TAPs what are we

looking for and, and how, why, and when would it make sense to the facility?

So we've kind of grouped this into four different categories. First is the necessary conditions, one, are you using electricity? But right away at the same time do you also have coincidental thermal loads at your facility? Very important that you're using both electricity and thermal energy at the same time. Do you have high hours of operation? The longer you can run the CHP system the, the better your return on investment usually it can be. So you want to have that system running as, as often as you can.

Second, when should you look for a – or when should you consider CHP at your facility? And here's a few examples. It's when you have, when you have a facility that's looking to replace energy equipment. We'll start with the first one. If you have backup generators, they're aging, you're looking to replace them. Instead of replacing your, your back-up generator with another back-up generator why not look at a, a CHP system that's continuously running, that you know it's going to be up-and-running. It may have a higher incremental cost, but as you are running you are also recouping on your investment, your return on your investment. You're getting your savings and you're not getting your savings on a back-up generator unless there is an outage. So here you can look, look at those opportunities.

With a chiller. Again, if you're looking to replace a chiller, instead replacing the electric chiller for another electric chiller, why not look at a steam converter with the CHP system and then also you'll have an electric generating asset. Again, there would be an incremental cost to that, but what are the long-term benefits and impacts?

And often we see when entities, many manufacturing plants are looking to replace a boiler you're generating hot water or steam and instead of just replacing the one-for-one boiler, again look at the CHP opportunity. There will be an incremental cost, but oftentimes you can cover that thermal needs that are needed at your facility with the CHP system and now you've added the added benefits of generating electricity onsite for additional energy savings, but also beefing up your resiliency aspects at your facility.

That third, the customer motivation, that's, that's, that's kind of the "Why." You know why, what is the, the driver there? What's really driving the facility to look at combined heat and power? And you know to have someone that's going to champion this project at a

facility too. Are utility costs the primary driver? Are they looking at reliability concerns? Do they may have waste heat coming off an industrial process that maybe they can capture and generate electricity with? Or do they have biofuels resources onsite or nearby? Maybe there's an anaerobic digester for treating food wastes. Maybe they have biogas available onsite. Maybe there are nearby facilities that maybe have biomass or other organic substrates that could be used as, as fuels eventually.

Other, sustainability or environmental goals for a facility. That we're seeing that as a, an increased driver and motivator as well. We're seeing that built into the sustainability plans, where we're seeing sometimes CHP has a, a bigger impact than several other projects and not just impacting today, but also the future.

And also expanding, when there's expansions at a facility. Maybe you're adding on another process load at your facility. Another process is coming online. How would those energy needs be met? That's where CHP can, can have a play in there. Instead of putting in another boiler or another chiller why not look at a combined heat and power system? At least take the time to evaluate the cost there and the benefits if you're planning early in, in the stages here.

And finally, the other factors is when we come to a facility and they're looking at CHP we want to make sure there are some other activities in place. Have they already implemented maybe low-hanging fruit, other energy efficiency measures, that we are sizing CHP systems to the right size. And also it's not impossible, but it does help when a facility has a centralized heating and/or cooling system so the project can be easier, more easily tied into the existing cooling and heating system.

So again, when we're looking for ideal conditions at a site for potential CHP opportunities these are the items that we recommend you looking for. These are the recommend or the conditions that we are looking for as also we're trying to qualify CHP projects.

Next.

So once a site is qualified and that's one of our rules as a TAP to help qualify these facilities, hopefully we can be what your, your stop you know when you're looking into this, when you're exploring. Again, the services the DOE CHP TAPs are at no cost.

This is our first step here. It's a quantitative and a qualitative analysis here, where we are taking high-level data, we're having a conversation with the facility, we're trying to understand what the client needs are, what their concerns are. We're trying to piece things together here. We're also going to help identify if there are red flags. We want to minimize the resources put in on both sides. We don't want to client to put in too much time if we can identify maybe some of the red flags early on. But hopefully and hopefully more often than not there are more green flags than red flags and we're recommending you to move onto a feasibility study.

So this would – the really the, the outcome of this is really to advise a client to further pursue the investigation of CHP. We will not giving the investment grade decision at this point, but more so providing guidance to the client sharing the TAP. CHP looks like it can make sense, got to do a more deeper dive after this, but here we have some good numbers and we will walk you through this.

Okay next slide.

So as we're going about the screening process these are the steps that we typically walk through. You can see them there, but I'm going to talk about them slide-by-slide.

So next slide please.

I apologize for all the, the text on the screen here. But this is you know our first step with, when we're looking at a screening analysis is that initial conversation with a client. Our TAP it's usually about an hour conversation or so, could be shorter. But here we're, we're trying to flush out you know an understanding of the facility.

A lot of the questions you're seeing on the screen here I already covered a few slides ago when I was talking about the ideal conditions and what we're looking for. But again, we're trying to understand what is occurring at the facility. What energy projects have they already done? What are the motivations? You know understanding the particulars.

So sometimes we are sending this questionnaire beforehand, we're getting the answers back or it's just part of the discussion. And we're having this discussion with a client and we're walking through these you know questions. And again, trying to understand how does CHP fit into the mix and what are, what are the real drivers from that facility? Why are they looking at CHP?

Next slide.

Next it's the fun part here. Hopefully we're, we're collecting data. Again, the more data we can collect the better solution we can provide. I'll also say too though at times we have limited data and then we're making assumptions, but we are agreeing with the client what those assumptions are to try to get an answer. Yeah maybe we're making projections on what a future load might be that's added onto a facility, maybe it's a, a green site and we're, we just have very minimal ballpark numbers, but we're going to get you an answer somehow.

You can see on the right of what we're looking for. On the electric side we're looking for electric consumption (kWh). We're also looking at that the demand rates. We also might take a look at your utility rates. If CHP is implemented how does that impact some of the costs?

On the thermal side oftentimes we don't have as much information, but we're trying to get what we can there. Are you – is there steam at the facility? Is there hot water? If there's steam what pressure? Are there pressure drops at the site? What are the flow rates? What is the condensate return temperature? We're trying to collect as much information so we can feed you a, a better result. Maybe some of that thermal data is also chilled water. So we're looking at all aspects here.

We're going to look at your natural gas bills. Then also get an idea of your site characteristics, so hours of operations. Where is space available on-site there?

You can see the graphs on the left there, the top is a thermal, the bottom is electrical. You can see there maybe is a little miss match of how the energy loads are during the year and trying to get the same energy loads for a CHP system.

This is a chemical facility, but there are some seasonal demands occurring here. So on the thermal side you can see the winter months have more thermal energy; electric side the summer months have higher energy.

So with our analyses we try to get the best match CHP system for you.

Next slide.

So here once we have the energy data now we're sizing the system. On the top those are load duration curves. So here we're taking the hourly interval data and we're taking on the left-hand side is the electric demand, we're taking the highest electric demands pushing them to the left and the lowest electrical demands to the right. So you can see this facility peaks at about 5 megawatts and it drops down to about 1 megawatt all the way to the right.

That dotted yellow line there we've kind of estimated at 3.2 megawatts CHP system. If you were to take the intersection of those two lines, the blue and the dotted yellow, drop it down you're somewhere around I guess the nine-month rate frame here on the X-axis.

I apologize this should have been hours like the graphic on the right, but we put the wrong, wrong graphic in here.

But you can see that 3.2 megawatts would cover a, a site's energy load for 75 percent of the time and the rest of the 25 percent we'd be over-generating, so that's not too bad of a match there.

On the right-hand side we're doing the same thing for the thermal demand. We've taken these site steam demand. On the left-hand side of the blue there it's almost 40,000 pound-per-hour for 125 Psi. You can see to the right there is a, a plant shutdown there where basically we're not using any steam. The dotted yellow line shows 20,000 pounds-per-hour of steam generation with a turbine that's unfired. If we're firing it this system could provide up to 30,000 pounds-per-hour.

So now we're starting to match-up you know what specific CHP system can we match up for your facility? Again at a high-level estimate.

Next slide.

So once the system is or we're looking at the sizing and the systems. We do at times look at the CHP technology. Sometimes at some levels we don't have to worry too much about the – what CHP technology we're looking at, but yeah if there's a, a high-pressure steam at the facility we're probably going to look at a combustion turbine. But yeah it depends from system to system.

Here you can see a graphic of different size system. If there's a lot of steam at a site we may look at a steam turbine or a backpressure steam turbine.

What I also want to highlight there at the bottom is the Department of Energy has produced the CHP technology fact sheets. And in there all our TAPs are using the same numbers. We're looking at the same specs. We're using average specs that were grabbed from the industry. We're looking at average costs and average O&M costs. So we're trying to use some unified information as we are working between all ten TAPs as we're trying to provide solutions for a number of different clients.

Next slide.

So once the facility or the CHP system is sized then we're starting to look at their results here. What, what are we coming out with here? Now I'm jumping to a, another type of facility, it's a paper mill, a paper facility. A little bit larger. Here on the top you're seeing the CHP system specs. This is a 32-megawatt CHP system, a 31,963 is what our model put out, generating over 130,000 pounds-per-hour at 240 Psi g-steam. So that is the size of our system.

Then when you look at the lower part of this slide here you see the base case versus the CHP case. Right away I'm going to draw your attention to the purchased electricity, that first line. In the base case we're purchasing 280 million-kilowatt hours from the grid. Now when the CHP system is installed we're, we're purchasing a lot less in their grid, about 5-1/2 million-kilowatt hours from the grid, because we're generating over 274 million-kilowatt hours.

You could see maybe five rows down the boiler fuel consumption. So that's drastically reduced. But if you look at the bottom line there is – we are consuming more fuel, okay? But oftentimes we want to compare that to what was the source energy? What was you know being consumed at the grid level?

On the right-hand side you can see the efficiency. So over the 8,760 hours of operation over the year this CHP system would have been operating at a 75 percent efficient. So using the fuel generating electricity, recovering heat, and have an efficiency at 75 percent, so a very high efficiency here when we're comparing it to our separate use of, of energy.

Next slide.

Then we're looking at the economic results. So remember this is a screening analysis. First screening analysis to see if there is potential for a CHP project. Oftentimes that next step is a recommendation towards a feasibility study. There could be something in between there.

Looking at here, again looking at the purchased electricity, we purchased a lot of electricity, we're paying for a lot of electricity in that base case, that left side, $16 million. Where the CHP case now we're spending less than $2 million for purchased electricity, because we're generating so much.

In the boiler case we were using $4.8 million to generate thermal energy. Now the CHP case we're only using $332,000.00 for boiler fuel.

But here's the – I wish I could stop there, but we do have fuel for the CHP system, $8.5 million. We got to make sure we account for O&M, incremental O&M about $2.5 million. But you can see there's still operating savings of nearly $7.5 million for this project.

Now I'll jump into the lower part of this slide, you can see for the size of system like this average cost might be around $47 million. Our CHP TAPs look at grant incentives, utility incentives, investment tax credits. What can we take advantage of to help lower that first install cost? Here we're taking advantage of the ITC, the Investment Tax Credit and we're having a total cost of $42 million. Do the math there, $42 million, $7.5 million in annual operating savings, we have a payback of about 5.7 years, that is not – that's pretty decent for a CHP project of this size. Remember all the benefits that come into play.

Next slide.

So the screening analysis completed. It's delivered to the client. We look at what are the qualifying opportunities? Again, what were the primary drivers of the facility and the site? And we look through that list and we talk with the, the client there. We might massage some of the numbers. We might add in some other scenarios, but we're trying to see if does this qualify.

Then we're looking at the next steps. Sometimes it's a feasibility study or maybe there are some additional activities that we suggest that occur. I'm going to walk through those on the next slide here.

Next slide please.

So here's a list of some of our Advanced Technical Assistance. You can read on the screen there, they're all over the place. It could be a 15-minute performance model. Maybe, maybe a site needs a pro-forma, again at a high level to understand it. Maybe it's a greenhouse gas emissions analysis. Bruce is going to cover some of that. Maybe it's looking at how the standby rates are impacted.

There's so many other aspects that we could be looking at. If we're further down the road and maybe a feasibility study is completed, our CHP TAPs help review studies. We've reviewed bids before. We've helped clients develop an RFP. Again, we're trying to help hold the hand of a CHP project, because these can take quite, quite some time. They can take months, sometimes even years to implement from initial conception to all the way to implementation.

Next slide.

So now I'm going to step through some specific examples and I'll be turning it over to Bruce shortly here. These are just some examples from our Midwest Region. Other TAPs from different regions have other stories. I'm just sharing the, the Midwest flavor here.

This is Benton Harbor – Saint Joseph Wastewater Treatment Plan in Michigan. We met with them a year or two ago. We started with an IAC assessment, another DOE program. Then we did a CHP screening. They wanted to use the biogas at their site for CHP. We helped them with some of the biogas analysis. This year they implemented a CHP project. So a great success story of a, a wastewater treatment plant that worked through various programs of the Department of Energy.

Next slide.

So this is Gundersen Health. They were the first hospital in the United States to reach a 100 percent energy independence. Our CHP TAP had the opportunity to work with them on a couple of projects. The one shown there is a landfill gas fuel CHP project, where they partnered with the county, piped the landfill gas two miles to the hospital and now they're using CHP with absorption chilling there. Our team helped with the landfill gas calculations, helped with RP development, and also helped review the, the applications there. It's a great project there. Another project we

helped there too is with their woody biomass project that was completed a couple of years later.

Next slide.

A recent activity of ours we worked with Illinois Wesleyan University. They, they did it in more detail. So we provided an hourly performance analysis, we helped with the pro-forma and this all helped feed into a feasibility study that they later had implemented that was funded by the natural gas utility. They did put an RFP out for this one this spring and I think they are securing their engineering company to, to do further analysis for them.

So again, there's various ways that we have helped in the past.

Next slide.

Here's just an example of a – we did an hourly performance analysis, but then we also completed a pro-forma. So this has a, a turbine in here. Return on an equity of 19.3 percent; net present value of $6.4 million and simple payback of 4-1/2 years. So this facility, a cereal manufacturer, simple payback wasn't enough, they needed more so this is where we helped tailor that solution for them.

The next and my final slide is kind of segue into Bruce's discussion here, talking about emissions reductions. This, this site, a paper mill in Wisconsin, not only wanted to know what the emissions impact of CHP were today, we're now projecting out 10-, 20-years. Then this is – but we feel we might be doing more analyses like this in the future.

So that – I'm going to take you to that graphic there, that red line is showing if there are no new energy policies and we're staying as is. The blue line is showing if we by 2050 if we have only CO2 emissions from natural gas peaking plants and that green is if we go carbon-free generation on the grid by 2050. So you can see it's all about the carbon emissions impacts, so CO2 emissions impacts of a CHP system.

You can see projected out that no new energy policies, there's still a lot of impact when it's just the marginal generation is natural gas we still have impact. What you can see is, is green, there's less impact. But again this is for a natural gas fired system, but over time these could also be converted over with renewable natural gas and hydrogen and other fuels.

So I'm going to leave the rest of carbon emissions discussion to Bruce. Thank you for your time and looking forward to the Q&A.

Bruce Hedman: That was a great intro into what I'm going to be talking about. I want to spend the last ten minutes really walking through the basics of, of calculating the emissions and energy impacts of, of CHP.

And you know as Cliff, Cliff talked about this is an area where we're getting a lot more inquiries about. What are the emissions impacts of CHP? We're getting it from facilities that exploring or evaluating CHP to be part of their sustainability plans and, and we're getting it from other stakeholders that are wondering if that, that, that fossil fuel CHP that's in their area is, is really saving any energy and emissions at this point and, and is, is it, is it helping?

So what I'm going to do is walk through the process of how we evaluate the emissions and energy savings of CHP at a, at a fairly high level and, and with pointing you to some resources that will walk you through it and help you implement these kind of analysis on your own.

So in this slide here I, I, I'm going to start really with a slide I used in the previous CHP Part 1 webinar where we, we sort of explored the role of CHP on the path to decarbonization. Can CHP be part of a long-term solutions? And, and we do think there is an important role for CHP in decarbonizing the US economy and US industry.

I think first it's, it's really important to note that CHP is fuel flexible. Current CHP systems use renewable fuels, they use low-carbon waste fuels, hydrogen, blends where available. All these systems will be ready to use higher levels of biogas, renewable natural gas, and hydrogen in the future. All the major manufacturers now offer equipment, gas turbines, and recep engines that can run on anywhere from 10 to 40 percent hydrogen mixture and all are working to introduce a 100 percent hydrogen systems in, in the near future, 2030, for, for that market if it develops.

There's long experience on non-fossil fuels. If you look at the industrial CHP capacity that's out there, 15 percent of that capacity is fueled by non-fossil fuels, biogas, wood, other biomass. But in terms of the number of units, installations out there over 40 percent of the current industrial systems operate on non-fossil fuels. So

there's a lot of experience both from the equipment suppliers and end users in using non-fossil fuels on, on CHP and, and it is a very flexible technology.

Second and, and Cliff talked about this too, CHP is the most efficient way to generate power and thermal energy from a combustion point of view. And for the long term renewable and hydrogen fuel CHP we think can be a, a cost-effective path to decarbonizes thermal end-uses in industrial and commercial facilities that are difficult or every expensive to electrify. This could be a more cost-effective path to get those CO2 savings.

And also we, we – there are, we see the need for renewable and hydrogen fueled CHP to support a critical facilities that need to decarbonizes, but also need onsite power, dispatchable on-site power for long duration resilience and operational reliability.

And as the, the natural gas infrastructure converts to renewable hydrogen fuels, if it does that over time, the high efficiency of CHP will be able to extend those resources as they come on. So we think these are all important points for CHP being a part of the solution.

The next slide really gets us into the discussion of, of walking through at a high level how you estimate the fuel and CO2 emission savings for, for CHP. And don't worry I'm not going to go through all these numbers. We'll be able to, to do that when the slides are posted. I'm going to try and walk through the process at a high level.

I'm basing the discussion on this 20-megawatt gas turbine CHP system, natural gas fueled. It's very typical of what you would find in an industrial application. It operates at 90 percent annual load factor, capacity factor it's you know 7,800 hours per year. It has an electric efficiency, net electric proficiency of just over 33 percent, 75 million Btu per hour of steam output. It's a well-designed system so it is using all the steam output, it's not wasting any of its output and that displaces the output from an 80 percent efficient natural gas boiler. So that's sort of the basics of this.

You can see from this, this chart on the, on the right the amount of fuel that, that it takes to supply those thermal needs, electric and thermal needs to this site with separate heat and power you can see the fuel going into the power plant, the fuel going into the onsite boiler and that supplies these energy services at a total 53 percent efficiency.

CHP system on the right supplies these services at a 70 percent of overall efficiency using much less fuel. You can see over 500,000 million Btu per year of less fuel going into the CHP system, resulting in a significant CO2 savings of 70,000 tons per year for this plant. So this is the basic emissions and energy value of, of CHP.

Next slide please.

The, so, so I have the, the you go for the calculations for all this. How, how are these savings calculated? There are two overarching things to remember and I think I put these upside down. But the first is that both electric and thermal outputs of CHP must be considered when you're looking at the you know at the, at the savings of energy and efficiency. And, and, and, key is that the effect of CHP on the grid, the, the fact that you are no longer buying megawatt hours from the grid it's very it's similar to load reductions from an energy efficiency or renewable energy project or, or program.

And it, it, it's essentially it's the marginal generation on that, that grid, that power control area that, that you're in is what you're displacing and I'll go into that a little bit more.

The approach for method, you know for calculating emissions reductions is, is pretty simple. It's basically arithmetic. It's the emissions and energy impacts of CHP are calculated by subtracting emissions and the energy used in the CHP system from the sum of the displaced grid emissions, what you no longer is being used at the grid to energy and emissions to send kilowatt hours to the plant, plus the, the avoided boiler emissions. The emissions reduced and the fuel reduced at the boiler, because you're now supplying steam from the CHP system.

So it is pretty basic. It, it's pretty straightforward, but like most things it's, it's really in the details that can be difficult and what are the correct basic assumptions and you know where can I get the data I need to do this? Those are, are really the key issues.

Next slide please.

And, and just for the easy part you know the CHP emissions, the CHP fuel use, the displaced boiler emissions and fuel leads are very simple, very easy. It's a function of efficiency and fuel of, of these technology, CHP system, and, and the boiler. The efficiency

will vary by, by technology system, size, and fuel type. But all that information is, is readily available. The CHP TAPs have it, we can, can help you out from headquarters as, as well.

And the, and, and if there's one key thing to remember is that for estimating the displaced emissions and fuel for the boiler only the thermal energy that is used can be, can be counted. Sometimes you can recover more thermal energy from a CHP system than you actually use onsite. You got to use what's – you, you got to base the calculation on what's used onsite.

Next slide.

The more complicated part is, is how do you estimate the displaced grid emissions in the energy use from, from the power grid? And the EPA has, has provided guidance for how to do this. They, they did this ten years ago as part of their guidance for, for state implementation plans for energy efficiency, renewable energy, and CHP projects. And their guidance was basically that a, a new project, a new CHP project, a new energy efficiency project or program is really going to displace the marginal emissions on a, on a system. It's not going to displace the average, all-in average emissions, it's, it's sort of displacing what's on the margin at that system.

And, and I put these two curves here just sort of to, to demonstrate in sort of a cartoonish way how that impact is looked at. But these are basically load duration curves, it's typical of a power control area. You got the megawatt demand going up the Y-axis, the hours per year or the number of hours that each resource is operating on the X-axis and that load duration curve is the curve of the demand of the utility or the control area. When you put an energy efficiency project in or a CHP project this is greatly exaggerated on the, on the chart on the right, but it brings that whole curve down particularly if it's a base-load kind of, of system, like a CHP very often is.

And, and you can see that that dropping down a load curve hardly ever gets into cutting back on wind and solar and nuclear and hydro, it's the gas and oil peaks, it's the intermediate gas and oil, and the coal, and combined cycle gas that gets the shed as part of the marginal generation.

If you go to the next slide.

So, so I have you estimate what the displaced emissions are from that mix of marginal generation. And, and EPA has, has helped us out there. They've developed several tools to do that.

But if you look at the chart on the right there are, there are, there's a continuum on how you do it, but the most correct way and, and, ah, most accurate way is to do energy modeling, dispatch modeling of the, of the area you're in and what the impact would be of that project. But that's expensive, it takes a lot of time and, and no, and no one is going to do that.

So EPA has developed two estimates of, of marginal emissions by region in the US. One is very basic and, and was introduced first and that's the Emissions & Generations Resource Integrated Database or eGRID. Then there's a, a new one that came, it's you know it's 10 years old now, but it came out after eGRID, called AVERT, the AVoided Emissions and geneRation Tool, which uses a little bit more of a sophisticated approach to estimate what the or regional – what the marginal emissions are on a, on a regional basis. And, and I'll talk very briefly about the two of those, but you can see on the table on the right a little bit about comparison of eGRID and AVERT. AVERT has less regions, eGRID has a little bit more granularity on, on the regions. It also includes Alaska, Hawaii, and Puerto Rico. AVERT is only limited to the continental US.

But if, if we go to the next slide.

This is looking at more closely at AVERT. Right now you'll see this in a second, but EPA has, has a methodology report that it talks about how to calculate emissions and fuel savings for CHP. A new version is just out. In that version they are recommending first AVERT as the first resource to go to. I think they, they view the marginal emissions estimate in AVERT, it can be a little bit more sophisticated than, than in the eGRID one. But there are some limitations as I talked about. The regional granularity is only for mainland US. It only has 14 regions compared to 27 for eGRID.

As an example an eGRID in New York is split into three regions, Upstate, West Chester and New York City, and Long Island and they have very different emissions profiles for marginal generations. So there are some cases where you might want to use eGRID over, over AVERT.

Next slide please.

So I'm going to try and get through this pretty quickly. I ate up some of my time by not being able to talk.

But going back to our original look of this, of this system. Again, I'm not going to go through the numbers, but now you can see some of the assumptions that were used to come up with these numbers. Natural gas fuel is for the CHP and the boiler, produces 16.9 pounds of CO2 for a million Btu. You multiply that number times the Btu's going into both the boiler and the combined heat and power box here and you come up with the tons of CO2 that you see in the chart.

The marginal grid emissions for nationally for, for AVERT or what we're talking about for CHP is 1,550 pounds CO2 per megawatt hour, multiple that by the megawatt hours produced by the power plant and you get the you know 122,000 tons per year of CO2 emitted by, by the power plant up above.

So again you'll be able to look at – walk through this when you do get the slides after this.

And the next slide, next slide please is the good news.

I talked about this EPA does have a very detailed discussion of the methodology and assumptions, default assumptions to use to, to do this calculation. There is a website and the download for, for the report itself.

And on the next slide even better news is that EPA also has a fuel and emissions calculator tool. It has recently been up, updated. It will walk you through the process of inputting the data that, that's required to do this. Picking the assumptions that makes sense for your project and it will present the results as, as you see on the right here. And the numbers are very close to what I did by hand in the, in the other two slides, they're sort of off due to rounding and things like that, but this is a very useful tool and it will walk you through the process.

Again, if a, if you want any assistance in understanding this calculation process, these tools, or the resources I talked about, my contact information will be at the end of this of the deck and the CHP TAPs are also very familiar with this and use this on a daily basis and, and can help you out on each of the regions.

Very quickly a final slide. And, and again I'll just applying this methodology to a 20-megawatt natural gas CHP system as you see

here results in you know 70,815 annual tons of CO2 savings. That's the, the calculation that is sort of in what I went before. If that was a biomass, biogas CHP system displacing a natural gas boiler that, that savings increases to 165,000 tons.

I put down 20 megawatts of utility solar PV and utility wind in comparison. Not to say CHP is better, because just to show that CHP can provide about the same order of magnitude of CO2 savings as these renewable technologies. It's not because it's creating the same kind of savings per megawatt hour, but because it runs at an annual capacity factor of 90 percent versus 24 percent on an average, a national average for a utility, solar, and 34 for wind. You can get a lot more bang out of that 20 megawatt of, of capacity in, in natural gas or biomass CHP at this point.

So there is a role for high-efficiency CHP in reducing CO2 emissions and reducing energy and with renewable and hydrogen fuels in the future I think that, that a, that role will continue and will be more important.

With that we can go into questions and, and answers if we have any time left. I apologize.

Bruce Lung: Thanks a lot Bruce. That was very insightful. I think because of the technical difficulties we'll probably you know extend the time of the presentation a little bit.

At this time we would like to start taking your questions. So let's transition over to Slido.

So if natural gas is my fuel, is any portion of the power output, heat reused, or efficiency gained considered carbon free? Either Cliff or Bruce Hedman feel – take that one.

Cliff Haefke: Bruce do you want to go first?

Bruce Hedman: Yeah. I don't know if you would call it "carbon free." I mean, I mean I think hopefully the numbers demonstrated that you, you do, you know you do provide carbon savings, CO2 savings. You are not a carbon free technology, that's, that's certainly not, but over time as we move to a completely decarbonized grid and if you assume that part of that way of getting there is also a decarbonization of the two-and-a-half million mile pipeline infrastructure. Those fuels that CHP system are using are low-to-zero carbon. Yeah, then, then you know you, you won't have any

carbon coming out of it you know basically or what carbon is coming out of it is renewable and is part of the cycle.

Cliff Haefke: Yeah and I'm going to add to that too. I mean I agree with Bruce there. Maybe looking at some of the state nuances of how they qualify renewable energy technology. Sometimes we've seen where recovered heat is, is the qualifying you know what is it I guess technology or concept. It could be some, some loopholes. I don't want to say "loopholes," but some nuances there to explore in some states where looking where recovered heat is eligible as a renewable fuel and sometimes that can qualify if you really did into it. But again, state-to-state and just an additional thought there.

Bruce Lung: Very good, thank you. The nest question that has the highest number of likes. I'm not sure how we can really answer this but: Can you describe if the CHP system can replace chillers?

Cliff Haefke: Yeah, I'll take a stab that, maybe that's how I, I presented it. You know when you're looking at your facility and you have electric chillers there and you're looking to upgrade those or update them with new chillers. The concept there is you know you could just replace one-for-one, an electric chiller with an electric chiller or you could explore a CHP system where the recovered heat from our system is not going for actual heating loads, but you're taking that either recovered heat, your generating hot water, or you're generating steam and then you're putting that steam or hot water through a steam-fired, steam-fired chiller or a hot water absorption chiller or some kind of absorption chillers.

So it's you know taking another way of generating electricity versus just with an electric generating chiller. So you, you do that and then you'll also have an opportunity to have you know electricity being generated on your site too with the CHP system.

Bruce Lung: Okay, thanks a lot Cliff.

The next one I think is actually a really good one. Do you have any resources for supporting a combined heat and power after an installation? This speaker said that they found the first year of success was good, but then enthusiasm slips after that. That is an ongoing kind of question about you know how do you maintain a CHP system when there's advances and computerized technology, control systems, electronics and that kind of thing.

Cliff Haefke: Yeah, I'll, I'll take a shot at that and then Bruce maybe if you want to add onto there. Yeah I would say you know contact one of the

CHP TAPs. The CHP TAPs are plugged into the community there. So, um, or you can bounce some ideas, thoughts you know off the CHP TAP representatives. But there's also trade organizations out there too and associations where there are a number of folks that you know do the maintenance of these systems. So I would say your first stop is work with the TAP and they might be able to direct you in a certain direction. But then there's also a larger CHP community that can help with this.

You know staying plugged into resources like this, the Better Buildings Webinars and, and other webinars such as those from the, the eCatalog that can provide some updates on there too.

Bruce, I don't know if you have anything else to add on you know the systems after they're installed who to plug into.

Bruce Hedman: No, I think, I mean I think you covered it, but, but you know we have had examples where you know folks have come to the TAPs and, and had some problems with their systems and just wanted to you know have a third party take a look and see if they had any suggestions or, or system they could provide. So it, it, it is part of the part-and-parcel of the, of the job I think.

Bruce Lung: I agree and actually also if you're in the Better Plants Program you can also lean on your technical account manager, as a lot of them have you know experience and understanding of CHP systems and how to maintain combustion technology and stuff like that.

The next question we have is: Do you have examples of small combined heat and power projects? The person says, "As an example I have a facility that generate heats from product testing that is currently wasted." He would like to use it for HVAC or other processes.

Bruce Hedman: This, this example sounds a little bit more like recovering heat and then using it sort of like a waste heat to power or waste heat to chiller or something example. And there are a number of small ORC systems out there that, that he could look at. Heat Is Power, it's a trade organization for waste, you know ORCs and waste heat that you might look at.

But there are a all sorts of examples of small, traditional CHP projects, engines, micro-turbines providing 24-, 15-kilowatts of, of power to a, to a site and, and hot water. And, and one of the resources DOE has put together is a package CHP Electronic Catalog, Package CHP eCatalog. It ranges – it has packaged

systems that have been sort of vetted or, or reviewed by CHP and packagers and solution providers that range right now I think from 24 kilowatts up to 16 megawatts in, in, in this electronic catalog and there are 270 system offerings. And you could get a really good feel for what kind of equipment is available at the lower size range from browsing through that, that eCatalog. I think if you just Google "DOE package CHP eCatalog," it, it should pop up pretty quickly when you do that.

Bruce Lung: Thanks a lot Bruce.

Cliff Haefke: Yeah I was going to –

Bruce Lung: Go ahead Cliff.

Cliff Haefke: Yeah I was going to say the same thing about the eCatalog. It's a great resource looking at technologies. And if, if any of you are interested in looking at what is already out, installed there, the Department of Energy has also created a nice database where they try to keep track of all known CHP systems around the country. You can navigate by state, downloadable spreadsheets, you can see what system sizes, fuel types, year installed, site name, et cetera, et cetera, a number of installations out there. That one if you Google "DOE CHP installation database," you'll be able to get the thousands of CHP systems there. So great resource as well.

Bruce Lung: Thanks Cliff. I think we're going to take one last question and the question here is: Does the TAP cover hydrogen fuel cells? But my sense is that you know it might be better to redirect the question a little bit and say: Can a TAP help with hydrogen as a fuel for CHP? But feel free Bruce or Cliff to address that.

Cliff Haefke: Sure. Contact the TAPs. We are, we are working on this. You know it is a, a new piece of the energy puzzle. You know when you do… I guess the pun is intended, when you tap into one of the TAPs we're a network of ten TAPs. We also work with a number of the DOE consultants like Bruce and other program managers. So we will get the solutions to you. So the TAPs can you know are looking into hydrogen and you know fuel cells already CHP technology too. So I would say just contact one of our TAPs and we will get the resources to you.

Bruce Lung: Right, okay. Well thank you very much Cliff. I think we're going to wrap it up now. Unfortunately, we've got to cut it off there. But if you have any further questions you know feel free to e-mail us at

Better Buildings and we'll try to direct your, your questions to the appropriate speaker.

Just a quick you know update and reminder that this webinar is part of the 2021 Summer Webinar Series. We have a great lineup of presentations throughout the month of August. We encourage you to visit the Better Buildings Solutions Center to register for them.

The next webinar that we'll have will be on Energy Service Provider Companies in the Express Lane. The ESPC in the Express Lane on July 13th. This will officially launch DOE's eProject eXpress, a new easy-to-use energy project tool tailored to states, local governments, and public institutions.

With that I'd like to thank our panelists for taking the time to be with us today and thank the audience for staying with us. Feel free to contact the presenters directly with additional questions that we couldn't get to during the Q&A period.

I also encourage you to follow their plants on Twitter and on LinkedIn to see all the latest news and updates about partners and we'll see you all in about two weeks.

Cliff Haefke: Thanks everyone, appreciate your time.

Bruce Hedman: Thank you.

Bruce Lung: Thank you.

Additional Speaker Q&A:

Better Buildings does not endorse or recommend any product or technology provider. The answers in this document are solely the opinions of the speakers based on their professional knowledge and experience.

Additional Questions

Audience member: How can we justify CHP projects at large industrial manufacturing sites located in low-cost areas (Midwest primarily)?

Response 1: CHP systems can be an important part of a facility's resilience strategy. In the event of a natural or man-made disaster that takes down the grid for an extended period, a CHP system can keep critical processes operating until the power connection can be re-established.

Response 2: If a manufacturing facility is already looking at replacing boiler or chiller equipment, it might be worthwhile to look at the incremental cost of a CHP system and the economic analysis. Some utilities offer production incentives to help offset the capital cost, for example, ComEd in northern Illinois offers up to $0.12 per kWh generated.

Audience member: How much power can you get from gas derived from a wastewater treatment plant?

Response 1: This depends on the volume and density of organic material in the wastewater.

Response 2: From EPA study: A typical WWTF processes 100 gallons per day of wastewater for every person served, and approximately 1.0 cubic foot (ft3) of digester gas can be produced by an anaerobic digester per person per day.

One million gallons per day (MGD) of wastewater flow can typically produce enough biogas in an anaerobic digester to produce 26 kilowatts (kW) of electric capacity and 2.4 million Btu per day (MMBtu/day) of thermal energy in a CHP system.

Audience member: Can you please comment on the technical feasibility of converting existing natural gas CHP systems to Hydrogen (if and when it becomes broadly available)?

Response 1: In terms of combustion impacts, hydrogen has one third the energy density of natural gas, a higher flame speed and a higher flame temperature. However, modifying engines and turbines to run

efficiently and safely on hydrogen with low criteria pollutant emissions is a matter of engineering design and all major manufacturers are well underway in developing hydrogen versions of their prime movers. Other considerations that will need to be addressed include upgrading the infrastructure for hydrogen production, transmission, distribution and storage.

Response 2: Most of today's commercially available CHP systems can operate on hydrogen mixtures from 5% to 40%. All major engine and combustion turbine manufacturers are developing 100% hydrogen capable models for availability by 2030 – some have 100% hydrogen systems in operation today. As an example, 2G Energy's packaged CHP engine systems currently can operate on hydrogen mixtures up to 40%. They have several 100% hydrogen prototype engines operating in the field now and are developing a field modification kit that would convert their current engines to 100% hydrogen at the site.

Audience member: CHP is not a new idea. Many industrial and institutional energy users have already considered or employed CHP systems. Where do you see the growth for CHP? Are there industries or market segments that are now worthy candidates?

Response: CHP capacity continues to be installed in industrial applications with significant and coincidental electric and thermal loads and long hours of operation, but we've seen growing activity in recent years in in non-traditional CHP markets such as light industrial, commercial, institutional, and multi-family - the top CHP applications in terms of units added from 2015 to 2019 were multi-family buildings, hospitals, wastewater treatment facilities, colleges/universities, schools, hotels, office buildings, food processing and nursing homes. Many of these projects were driven by energy reliability and resilience needs in addition to operating savings.

Audience member: Does CHP make sense for a new single-family dwelling?

Response: There are several micro-CHP systems under development in the U.S. and commercial systems do exist in Europe and Japan for residential applications. However, single family dwellings could be a hard market to penetrate in the U.S. Typically the hours of operation will not be sufficient because of the nature of domestic electric and thermal loads and the cost of the system will initially be high on a $ per kW installed basis. Initial markets for these small (<5 - 10 kW) systems will most likely be light commercial applications such as gas stations and convenience stores.

Audience member: Do you work with technology providers?

Response: DOE works with technology providers through the CHP Packaged Systems eCatalog: https://chp.ecatalog.lbl.gov/

Audience member: Would CHP systems that cannot use renewable fuels like biogas or hydrogen become stranded assets in a decarbonized grid?

Response: All existing natural gas CHP systems can operate on renewable natural gas (RNG) - biogas and landfill gas that has been cleaned up to meet pipeline standards), so these systems would not be stranded assets to the extent that RNG can be phased into the natural gas infrastructure. All major engine and combustion turbine manufacturers are developing hydrogen capable models. Upgrading an existing CHP system to hydrogen capability in the future could be a matter of field modifications for newer systems or engine/turbine swap outs for older systems.

Audience member: Does DOE follow up several years later with facilities that have implemented CHP to see how they are doing?

Response: DOE maintains the national CHP installation database. As part of maintaining the database, inquiries to existing CHP installations are made to confirm operation. The DOE CHP TAPs also coordinate with existing CHP installations for project profiles (case studies), presentations, etc.

Audience member: What emission factor should be used for wwtp biogas?

Response: Unfortunately, there is not a single value for biogas – it depends on the feedstock and production process. Biogas from some feedstocks such as anaerobic digestion of animal manure or food and green wastes can achieve negative carbon footprints by reducing methane emissions through avoiding "business-as-usual" disposal pathways, while biogas sourced from a landfill or waste water treatment facility where business-as-usual practices collect and destroy methane cannot account for any climate emissions benefit from that methane destruction. Additional information can be found at An Overview of Renewable Natural Gas from Biogas and here.