Hannah Debelius: Hello, and welcome to the 2021 Better Buildings Summer Webinar Series. In this series, we are profiling the best practices of Better Buildings Challenge and Alliance partners and other organizations working to improve energy efficiency in building. And today, we're gonna be discussing "Waste Reduction: Lessons Learned and What Comes Next." And I'll be sharing a little bit more about the ongoing Better Buildings, Better Plants Waste Reduction Pilot. And then we'll hear from two experts about tools to help you in waste management. So with that, my name's Hannah Debelius, and I'll be your moderator for today. I'm in the building technologies office at the US Department of Energy. And I've also partnered with our advanced manufacturing office for the Better Buildings Waste Reduction Pilot.

So next, speaking of the pilot, more than 40 commercial and industrial partners have joined us for a two-year waste reduction pilot that'll wrap up later this year. Partners committed to tracking progress towards waste goals, including reduction, diversion, and the elimination of specific products or waste streams. You can find results from the first year of the pilot in the 2020 Better Buildings Progress Report. We've also captured some of those here for you.

Next. I'd like to really thank our more than 40 partners for their continued dedication to waste management and participating in the pilot with us. Partners worked across sectors and across industry and participated in a series of working groups and peer exchanges, attending webinars, and sharing ideas in order to really get to the bottom of sharing both challenges and successes in waste management. And from a series of these conversations over the last year and a half or so, we do know that one of the greatest challenges to getting – to achieving those waste goals is actually getting just accurate and complete waste data, as well as identifying specific cost-effective and efficient solutions. So that's one reason why we've invited two experts today to speak about specific tools that can help tackle some of those challenges that have really risen to the top through the waste pilot.

Next. I'd also like to highlight our new resources page. So if you maybe checked out our waste pilot page at the beginning, we have now updated it with an incredible number of resources from these participating partners throughout the pilot. So this page highlights key solutions and case studies from commercial and industrial partners. And you can find – additionally find recordings from our quarterly calls and webinars, all related to waste, that highlight key findings from our partners overcoming their challenges, and also some of the working groups that we've held. Speaking of working

groups, next, to date, the pilot has held three working groups on plastic waste reduction, outreach and engagement, and data and measurement. So pilot partners as well as all Better Buildings and Better Plants partners will be able to engage with us in the future on topics at the waste-energy nexus, including topics such as circularity, which we also have heard is front-of-mind for a lot of our partners.

But speaking of what's front-of-mind from you all, we are looking to hear from our audience today to learn a little bit more about you before we speak with our panelists. So today, we'll be using a tool called Slido, which is an interactive platform that does both polling and also is where we collect Q&A throughout the whole session today. So right now, if you could go to slido.com, either on another browser or if you open up your mobile device, slido.com. And then you can enter the event code DOE. And that's where you'll be able to engage with us both through polling and also submit questions for our panelists today. So I'm giving you a moment to again, go ahead and open up a new browser, go to slido.com, and enter the event code DOE so you can engage with us.

As you're doing that, I'll also just mention that when we do have Q&A on that platform, you can also use a feature that has a little "thumbs up" button – oh, great. I'm seeing lots – first poll was great. But on the Q&A, there's a little "thumbs up" button that allows you to vote for your favorite questions. So thank you all for those of you that have already gone in and are answering our first question. We're just looking to know what sector you're from. A lot of state and local leaders from government, which is great, industrial manufacturing, which is wonderful. No surprise considering our waste pilot. Government, contractors, multifamily, and higher ed.

Could you scroll down? I'm curious to see what other representation we have here. All right, retail, food service, and grocery, data centers, K-12. Excellent. Well, we have almost all of these sectors represented somewhere else, within the waste pilot, that have contributed to those things. So glad to have you on board with us.

With that, I'd like to launch the second poll, which is a little bit closer to the topic today, which is that I'm curious what tools you currently use to track and manage your waste. So regardless of what sector you're coming from, we just wanna know the tools that you're using to track and manage waste. "Spreadsheet" and "Excel." Yeah, the classic. We certainly have a lot of partners that

are relying on that, and there are certainly reasons to. Lots of "spreadsheet"s. And "none."

And I will reiterate that one of the biggest challenges we know that partners have faced is actually just collecting and making sure that data is accurate. 'Cause we know it can be really tough for a variety of reasons. All right, "Energy Star Portfolio Manager," I'm seeing. "Fairy dust." That's good. It's rare that a poll can really make me laugh.

"Yardi." We know that's a common one. "Reports from recycling companies," "data management software." I know a lot of partners also utilize a software that might be provided by a waste hauler. "Gensuite." I'm not familiar with that one. "Cr360."

All right. Excellent. Well, thank you all so much for answering those poll questions. I think it was interesting to see. And hopefully our panelists are also taking a look at this because they're speaking about other tools today. We can go ahead and close that poll and move back over.

We have some wonderful panelists today, Jarrod Bridge from the Office of Resource Conservation Recovery EPA, and also Scott Nicholson from Grid Planning and Analysis Center at the National Renewable Energy Lab. So again, each of these presenters are gonna have some time to talk more about the resources that they work with. But anytime throughout this session, you can go on slido.com with the event code DOE and submit your questions. Or if you see another question that you like, go ahead and hit that "thumbs up" button because that'll let us know at the end, when we get to questions, that that's an important one to prioritize. So with that, I would like to introduce Jarrod Bridge, who's a physical scientist in EPA's Office of Resource Conservation Recovery, where he works on projects related to lifecycle analytics, systems thinking, and international SF – SMM topics. He co-led the development and design of EPA's sustainable materials management prioritization tool and serves as the main point of contact for EPA's Waste Reduction Model, WARM, which he'll be telling us more about today. So with that, Jarrod, would you like to join me on video and we can get going?

Jarrod Bridge: Great. I think I'm all loaded up. Thanks, Hannah, for the introduction, and that's for having me.

Hannah Debelius: You are, and we can hear you. So take it away.

Jarrod Bridge: Perfect. Thank you. So as mentioned, I'll be talking about WARM today, which it looks like in the poll, some of you might be aware of. And I know it's especially popular with some of our state and local waste management folks. So hopefully that may be some of you. And so you may have some familiarity with WARM already. And hopefully, you might be able to learn something new, as well.

So we can hop over to the next slide. So before jumping into WARM, I just wanna talk a little bit of background on EPA's sustainable materials management program, which WARM sits under. So going back to the early 2000s, after 20-plus years of waste management under the Resource Conservation and Recovery Act, better known as RCRA, EPA started to recognize that the waste program would likely need to evolve a bit to meet some of the challenges and opportunities of the future. And so it was clear we needed to start shifting away from thinking about waste to a more holistic systems approach around materials management. And EPA's 2009 report "Sustainable Materials Management: The Road Ahead" really laid out that concept of SMM for the first time and described it as a systemic approach to using and reusing materials more productively and sustainably over their entire lifecycles. And so "The Road Ahead" provided really strong recommendations to government, specifically, for fulfilling its role in achieving sustainable materials management, but it also created an analytical framework to help identify where some environmental impacts might be occurring within the materials that we use in the United States.

And so this analysis really helped solidify some of EPA's priorities for SMM and set the tone for the work undertaken – that has been undertaken over the last decade or so by the Office of Resource Conservation and Recovery. And some of these priorities have included food waste, electronics, plastics, the built environment, and many more. And so part of that sorta strategy was also working to build and improve a base of information, data, and tools that could help us support lifecycle-oriented work under sustainable materials management. And this is where WARM comes in.

So we can go to the next slide. So we – talking about the Waste Reduction Model, better known as WARM, which I said, many of you are probably familiar with. WARM is one of EPA's most useful tools for helping municipalities, states, researchers, industry groups, a wide range of stakeholders, really start thinking about waste from a lifecycle perspective. And so for over 20 years, WARM has been helping users calculate the greenhouse gas

emission implications of different waste management scenarios, and has more recently added energy use and economic impacts to that picture, as well. WARM includes around 60 different material types that are commonly found in municipal solid waste and construction and demolition debris streams. And so in WARM, users can model the impacts of managing those materials through several different waste management pathways. These include source reduction, recycling, combustion, composting, anaerobic digestion, and landfilling.

And WARM is most commonly used in its Excel spreadsheet form. And that's kinda what you'll be seeing in the screenshots throughout this presentation, come from the Excel version. But there's also a version available for the openLCA software program for those of you who are familiar with that. And so we can go to the next slide. And this slide really just gives a brief sense for the wide range of stakeholders that have been using WARM since 1998 and what we've heard that they've used it for. And so WARM has helped varying levels of government plan and make decisions about their solid waste management programs. It's also been used in academic research, school projects, and analyses by all number of – or a wide number of industry groups and waste management organizations.

Next slide. And so the main analysis that WARM helps with is a comparison between baseline and alternative waste management scenarios that the user defines. So I'll show a few slides to demonstrate this, kinda like what you're seeing on screen here. And so the idea is that you can create a baseline scenario on the left-hand side of the screen, sorta that – if you can see the number 1 on there sort of under that side, which typically corresponds to the business as usual or current practice at the municipality or whatever organization you're looking to study with WARM. And so that baseline scenario and then the GHG emission, energy use, and economic impacts that go along with it are compared to the alternative scenario and all of its impacts, which you enter on the right-hand side, sort of under the number 2 on the screen here, if you can see that.

And so this alternative scenario could correspond to a goal that your organization has, maybe, for example, to compost some percentage of food waste or reduce the amount of plastic waste that needs to be managed. Or it could potentially correspond to certain infrastructure changes that might be on the horizon that could impact your organization's waste management scenario. So for instance, maybe a new composting facility is being built nearby,

which might allow you to do more composting in a more cost-effective way. And so these are some sort of examples of what might lead someone to want to use WARM a bit more.

Next slide, please. And so to go through this analysis that I sorta just previewed, you'd begin by putting the tonnages of the various material types being managed in your scenarios into the corresponding boxes that best describe how those materials are being or will be managed. And so you can see the list of material types down the left-hand side. It's just sort of a snippet 'cause I couldn't fit it all on one screen unless I was gonna give you all magnifying glasses. And then you can see the various materials management pathways listed across the top. And so we can think through a really simple example just for the purposes of this presentation.

So let's say you're a municipality and your current waste management scenario includes 100 tons of newspaper going to landfill. And so you would input that in the corresponding blue cell as you see it on the left-hand side of the screen here. But let's say your municipality has a goal to recycle all of the – all 100 of those tons of newspaper next year. So by inputting that into the corresponding cell on the left side, WARM will calculate the GHG, energy, and economic benefits of making that change. And so we can go to the next slide. And so WARM runs these calculations using factors like the ones you see on the screen here. This table shows the GHG emission factors per ton of each material that gets managed through each pathway. So for instance, looking at corrugated containers right at the top, you can sorta scan across the row and see that recycling 1 ton of this material results in a savings of about 3.14 metric tons of CO2 equivalence, but landfilling that same ton would result in the generation of 0.18 metric tons of CO2 equivalence, and so on and so forth, for all of the materials and pathways.

And so you can see that some pathways result in net GHG savings, whereas others result in net GHG emissions. And that's because WARM takes into account the various sources and sinks of emissions throughout the lifecycle of these materials. And so this includes the production of the materials in the first place. And the only lifecycle stage not included in the WARM calculation is the use phase of those materials. So the takeaway here is really that these factors and others like these which have been modeled and improved over the last 20-plus years are really at the heart of the WARM analysis and the outputs for GHGs, energy use, and economic impacts. And so the calculations and modeling

assumptions baked into these factors, more information about them can be found in our extensive documentation chapters on EPA's website.

Next slide, please. But now getting back to our example, just a quick reminder that we are hoping to use WARM to find out what might happen if our organization recycled 100 tons of newspaper next year instead of landfilling it like we did this year. And so now that you have an idea of what's going on under the hood of WARM, we can start to look at some results. Next slide, please. So making that change that we've laid out would result in a savings of about 186 metric tons of CO2 equivalents' worth of greenhouse gas emissions, which is roughly about the same as taking 40 cars off the road for a year. And it would also save about 1,650 million BTUs' worth of energy.

Next slide. And it would also create just under 600 hours of labor, increase the output of wages by about $17,000, and increase tax revenue by almost $5,000. Next slide. And WARM also displays these impacts and benefits as a production versus end-of-life split, meaning that we can get a sense for how much our interventions at the end of life compare to impacts related to the production of these materials in both scenarios that we laid out. And so you can see the results here for greenhouse gas emissions. In both scenarios, the blue part of the bars are responsible for the lion's share of the greenhouse gas emissions. And this corresponds to the production of the newspapers, in this case, in the first place.

So the emissions from landfilling and recycling the newspapers are comparatively smaller. And we can see that even though recycling the newspapers does reduce the GHG emissions compared to landfilling, there are still potentially significant net emissions resulting from the production of the materials in the first place. And so this is really where the lifecycle-based aspects of WARM shine. WARM helps put our efforts at the end of life into perspective. So maybe making this change to recycling all 100 of these tons of newspapers is beneficial enough for us right now, but maybe information like this can inspire us to think about these materials in the context of their entire lifecycles. Maybe there's an initiative we could undertake to source reduce these materials to avoid their production altogether while still meeting the need for the material in a different way.

And so WARM provides this information for all the impact areas shown on the previous slides, not just greenhouse gases. And so it's important to consider these lifecycle-based impacts across all of

these dimensions so as to avoid unintended negative consequences or tradeoffs between, say, greenhouse gas emissions and energy use. So obviously, these results that we just went through are for an extremely simple scenario. We just looked at one material type, just the newspapers. But you can assess an entire diverse waste stream across literally dozens of material types and several different management pathways all in the same analysis and get much more sort of complex, nuanced results. And so this could be useful for future planning of waste management programs and can potentially help decide which materials might provide the most environmental bang for your buck, so to speak, by including in your waste management program.

And we can go to the next slide. So just talking a little bit about the future of WARM going forward, every year, we try to work really hard to improve the model itself as well as the interfaces that people use to access the model and the documentation material behind the scenes just to make sure it's as relevant and accurate as possible. And so this year, we're in the process of making a few particular improvements, including the management of wood flooring and food waste material categories, as well as looking at the way we handle soil carbon storage in the composting pathway. We're also in – updating the economic impacts in WARM as they're tied very closely to EPA's Recycling Economic Information report or REI report, which some of you may be familiar with. And since EPA just released a new version of that report last year, we're updating the economic modeling in WARM to make sure we match that report.

And then these last two items here have a bit longer of a time horizon. We're hoping to recreate a web-based user interface for WARM, where basically, it would just be a website on EPA's – or a page on EPA's website so people don't have to worry about downloading Excel files if they don't want to or the open LCA tool, so we can just have one central place. We're hoping to have that within about a year or two. And then alongside that, we're hoping to include more lifecycle environmental impact categories. So we're always looking to sort of have a wide array of different metrics and indicators that we could look at to make more informed decisions with where we go in the environmental sustainability realm. And so these could potentially include things like water use or toxicity impacts, among many other possibilities.

And so you can find more information about – you can find WARM and more information about it at the URL on screen here.

And I think that's it for me. So yeah, happy to take any questions later on. And feel free to reach out to me anytime.

Hannah Debelius: Awesome. Great. Thank you so much, Jarrod. I really appreciate that. And I –

Jarrod Bridge: Course.

Hannah Debelius: We already have some questions coming in, which is –

Jarrod Bridge: Great.

Hannah Debelius: – which is great. So people are clearly interested. And for everybody else, again, you can also give a "thumbs up" to those questions that have risen to the top.

Jarrod Bridge: Perfect.

Hannah Debelius: Thanks, Jarrod. We'll bring you back for Q&A.

Jarrod Bridge: Great.

Hannah Debelius: And I am going to switch over to Scott. Scott Nicholson is a member of the economics and forecasting group in the Grid Planning and Analysis Center. He works on the materials flows – 'scuse me. He works on the materials flow through industry supply chain modeling tools that identifies energy and carbon impacts within the U.S. manufacturing sector. So thanks so much. And Scott, you can go ahead and take it away.

Scott Nicholson: Okay. Thanks, Hannah. Hopefully you can hear me all right. I just wanna echo how really insightful that last presentation was from Jarrod. I mean, it's – the WARM model is something that we've been looking at at NREL as a really useful way of tracking these kinds of waste flows from an LCA perspective. And I think there's a lot of potential synergies between that tool that's very well-established now, of course, and these relatively newer tools, such as the one I'm gonna describe in this presentation. So I'll leave it to the webinar viewer to put those connections together, but certainly the opportunity is there.

So we can jump to the next slide here. But basically, the idea of this – where I wanted to take this part of the presentation is describing some ways that we've been using, yeah, various waste utilization techniques to model impacts from doing that – from doing – essentially, instead of landfilling or linear supply chain

roots to certain products, figuring out ways of recycling these, whether it be closed loop, open loop, all different manners of treating this waste so it's no longer really a waste treatment. It's now a usable feedstock that can go into something else. And there's a lot of work going on in this space at NREL, in particular the plastic space. I know my colleague Bertie Carpenter was on, I think, one of the previous webinars going through some of the plastic work that we're doing. This will be sort of an update of that, with some new projects that have just come out through the pipeline, and just sort of a quick refresher on what this Materials Flows through Industry tool is.

But basically, what we have in our analysis toolbox, so to speak, at NREL, anyway, is sort of a three-pronged approach to dealing with these sorts of systems. And we typically start with a technoeconomic analysis to look at what these processes are that could either take waste plastic and sort it or take waste plastic, convert it into something useful, just essentially what the plant would look like. And tools like Aspen+ are really useful for modeling that kind of system. If we go sort of up a scale to the broader – what you might call the supply chain scale, this is the tool that I work on, this MFI tool, Material Flows through Industry tool.

And that's looking at essentially a – what you might call a cradle-to-gate lifecycle, where we're not distinctly treating the waste and end-of-life phase or the use phase, but we're looking at – essentially, in a pretty detailed way, at a product level, what goes into making those materials? What goes – what are the energy inputs? What are the material, chemical upstream inputs that go into it? For polymers, it's pretty cut and dry. It's the upstream monomers and that kinda thing. So that is really the purview of the MFI tool.

And if we go up an even further step to the broadest scope that we have in-house at NREL, it's this relatively new BEIOM model, which is a Bio-based Environmentally-extended Input-Output model. And unlike the MFI tool, it's more of a top-down approach to looking at broader economic impacts, from introducing some of these new processes and potentially waste management processes into the broader economy and seeing what the potential impacts are across a number of different impact categories, even just beyond environmental. So those are sort of our three scopes of analysis that we look at. And as I mentioned earlier, the target for this has really been plastics recently. It seems like it's all I work on these days, for better or worse. But the two technologies that I'll be

looking at for the rest of presentation are essentially two different ways of depolymerizing PET plastic, so polyethylene terephthalate. And so there's some cutting-edge research that's hot-off-the-press here at NREL that I'm happy to share. So we can jump to the next slide to start going through those.

Actually, I'll just run through quick little background on the MFI tool first before we get to those, just to give folks a quick refresher if they haven't seen the previous presentation. I mentioned this is a – essentially a process-based supply chain modeling tool that draws in a lot of different elements from LCA, lifecycle assessment. And we're looking at many different types of products, a lot of basic chemicals, your polymers, your upstream platform chemicals, intermediates, and also metals and paper products, some ag products, but not too much. So I noticed that in the earlier poll, we had a lot of industry and manufacturing folks on the webinar, which is awesome. I think this tool fits right in that wheelhouse. We have plenty of coverage there.

And so essentially, what we're doing is building out these network diagrams and models of what goes into making a final product. And that's represented on the right here, where you have – essentially working backward from your final product, you figure out what goes into making it and then what goes into making those inputs, and so on and so on, build out these network diagrams. So you can really capture where these flows are occurring and track essentially impact hotspots through the supply chain. And we have a – sort of a compilation database that goes through a lotta these different unit processes that link these materials together, from both proprietary and public sources. I mentioned this is basically a cradle-to-gate scope by default, but that doesn't mean we can't add on things like the use phase or the end-of-life impacts that we have. Especially for this sort of waste-focused webinar, the end of life is obviously really important. So that's sort of a – an add-on feature you could have for this sort of analysis.

And then last but not least, I will plug that we actually do have a web app. And just a quick question to Jarrod, if you do start to set up a web app, it's – it can be a little tricky. But I strongly encourage people to check out this MFI tool, web app. You can run your own sort of very bare-bones supply chain scenarios through the MFI tool and get some interesting results. And with that, we can jump to the next slide to actually go through some of these most recent results.

So this first one, we literally just published it a few weeks ago in

Joule, looking at enzymatic depolymerization of PET. Next slide, please. So as far as the system boundary for this model in MFI, we've typically focused on a pretty simple linear supply chain for conventional PET, where you've got your fossil feedstock extraction and end up with your ethylene. There's additional refining that goes into that. You – your monomers and other precursors are developed. And the finally, polymerization yields your polymer. And – but we didn't really consider anything from the end-of-life phase or the use phase.

If we go to the next slide, you see the – sorta the flipside of this, which is the novel addition from this analysis, where we've added on this closed loop process to that system boundary, where instead of just saying the commodity polymer just goes out into the world and never to be seen again, we say, "No, it's gonna be collected after its use and depolymerized with this enzyme." Some really cool chemistry there. I'm not gonna get into that. The biology is really exciting. It's not my area of expertise by any means. But once you get to that closed loop process, you can start to track exactly what those impacts would be from keeping that plastic in your system. And that's what we attempted to do with this analysis.

Next slide. So here is really just a – sort of a high-level rundown of what our results were from this analysis. And it's actually pretty promising as far as the impacts that we look at from our MFI tool typically, which are – and this is similar to WARM. It'd be energy use and GHG emissions are the two main impacts that we're looking at for these supply chains. And in the case of comparing sort of a linear, virgin PET production process versus this closed loop recycling process from the enzymatic route, we're seeing pretty big reductions in energy use from what we got outta the MFI tool. And so that's a really promising supporting case for why this sort of technology is looking pretty good.

So same thing for the GHGs. Essentially a pretty substantial reduction, not quite as big as the energy. And that's – usually what we find is that's due to the use of feedstock energy. And if you're counting the feed stocks from – literally the contained energy from the crude oil that's being used in the system carried through to the final product, you're not really reducing that as much 'cause it stays and the plastic is not being emitted at any point – it's not being combusted. And so you don't see a corresponding reduction in GHG emissions from that type of use of material. But generally, these results look really promising.

So again, this has now been published in *Joule*. Encourage

everyone to take a look at it. Please provide feedback. And we look forward to using this same sort of analysis on other – potentially projects way outside of the plastics space. It'd be great to see some sectors that we haven't really covered yet for this type of analysis. But for now, it's mostly plastics.

Okay, next slide, please. This is a similar process here, this VolCat process. And this is actually still in development. And we can jump right away to the next slide. But similar situation, where we're looking at using a waste feedstock, in this case, again, waste PET plastic, although it could come from multiple sources now. We could – instead of just looking at bottles, we could be looking at carpets and textiles and all sorts of things that could be fed as this blended mixed waste feedstock. And your output is this really nice, pure, BHET monomer that you can use for all sorts of things, including repolymerization back to PET.

So that is the really exciting feature of this process that's been developed by IBM, and it's still in development, that NREL's looking at. So they've tasked us with doing some of the really interesting analysis for this, and can share some – essentially what are preliminary results from that on the next slide. And actually – the results on the next slide. But for now, the goals here are looking at trying to identify what the key drivers are for this depolymerization.

There's plenty of different process variables. I don't wanna get too into the details and the weeds on this, one because I don't really know exactly what's going on in this process to any high degree. I just work on the outputs. But also, it's really best deferred to the experts on that. But what I can tell you is that they're really interested in getting both the energy sort of case for this as well as the GHG case for really selling this kinda process.

And it really goes a long way to telling the complete story of why you would even bother doing this, right? Why would you try to take this, all this weird waste like PET and try to convert it into something else more useful? So that's really the main driver here. And again, this is still a work in progress, so this whole process diagram could potentially change in the future.

Next slide, please. What we do have are some preliminary MFI estimates of energy requirements and GHG emissions, which will be on the next slide. But for now, we're seeing, again, really beneficial reduction in energy use compared to virgin PET production from this process. The process itself, even though it's

chemical recycling, just doesn't seem to be using that much energy, which is really a big selling point for this. The catalyst is relatively easy to produce. There aren't a whole lot of steps. The purification process is relatively simple. And all that ends up leading to a really nice benefit on the energy side. And we'll see a similar picture on the feedstock side – or, sorry, the GHG side.

So we can jump to the next slide for that. On the GHG side, we're seeing about 60 to 65 percent lower GHG emissions compared to virgin PET production, which we've estimated at about 3.2 kilograms as sort of a baseline in MFI. So the figures at the right are only showing different cases of this VolCat process, but I don't wanna get bogged down in the nitty-gritty of the results themselves. The idea here is just to showcase what this tool can do. Although I will point out that one of the benefits of the MFI tool is that we can get pretty detailed on how things are being either emitted or consumed as energy. And in this case, the GHG emissions, we can see what the breakdown is between process fuel use and electricity use and transportation of inputs around the supply chain and where those GHGs are occurring and sorta their relative ratios, which can also give some clues on where you might look for abilities to improve the process.

And then we can jump to the next slide, which might be my final slide here, which is just to sum up and say that I think there's a lot of synergies between this MFI model and the WARM model, which, to be quite honest, I wasn't entirely familiar with until this presentation, so I'm learning a lot, too, from this webinar. And I think there are a lot of opportunities to say – you could essentially combine results from these models. I think there's enough overlap in what they're tackling that you can paint a really nice picture of what's going on here. If you want sorta more product– very specific details on the intricacies of where energy use is occurring and where the GHG savings might be occurring, then maybe the NFI tool could help with that, and then the broader picture from looking at these categories of impacts as a whole from WARM.

But really, the idea here is that we're utilizing waste as a feedstock. That's what it all comes back to with these analyses that we're using the MFI tool for. I've showed two different examples of that that are very narrowly focused. They're both on PET plastic, which is just a small, tiny fraction. No matter how much PET we reproduce, there's always gonna be plenty of other things we could look at as far as waste reduction. So this is just one piece of the pie.

And there's, of course, plenty of other opportunities for this. And that's really what I wanna hear from in the Q&A, at least, or comments or e-mails to me later, is, what other areas could we use this methodology for? 'Cause I think there's a lot of opportunity. With that, I think I'll wrap up here. And we can start the Q&A unless there's anything else that needs to be covered, Hannah. Thanks.

Hannah Debelius: That's great. Thanks so much, Scott. And actually, the question you just posed the audience, I think I've seen reflected in a couple of questions of the audience back to you.

Scott Nicholson: Awesome.

Hannah Debelius: So you're certainly on the same page with that. Jarrod, would you join us again and we can move into Q&A? For our audience, we do have some great questions in Q&A that have some upvoting, to I guess borrow a term from Reddit, but it's not too late to click the "thumbs up" to send something to the top of the list or still add a question to the bottom. 'Cause we do have at least 20 minutes here for questions, which is great. So we will start here with our most popular question, which Jarrod, will be to you, because it's, "How are WARM users collecting data? Waste invoices can have several units, which may be difficult to decipher or measure. How is the waste weighed?"

Jarrod Bridge: That is a great question. And to be honest, I don't know. I'm sure it's different with every organization. We – usually when we're dealing with stakeholders using WARM, they've already got their data sort of sorted out, so to speak. And so we don't have a lot of insight into – at least that I know of, into how they're exactly measuring it. So I'm afraid I don't have a lot of insights on that one.

Hannah Debelius: So – and I – just from the pilot perspective, I will say that we – I don't know how it integrates with WARM, or it sounds like you mentioned that WARM uses – can use an Excel spreadsheet, which is the most common way that people are interacting with it. And from our poll at the beginning of today, we know that people are mostly using Excel spreadsheets – or not mostly, but a lotta partners are using those to collect their waste data. And I'll say, at least for our commercial partners, where I see them collecting data is usually a spreadsheet provided by the hauler or tickets at weigh stations when it goes to the recycling center or landfill or compost or whatever it may be. But as I've said multiple times already, we do know that getting that accurate data is a really big challenge for partners. Great. So the next question here, Jarrod, will also be to

you, which is, "Does the greenhouse gas emission data output of WARM integrate with any other tracking or recording platforms for greenhouse gas emissions?"

Jarrod Bridge: So I should also note that I'm relatively new to WARM. I've been the main point of contact for about four months now. So there's probably a large historical context that I'm not always privy to. But as far as I know, WARM was sort of created independently of these tracking and reporting platforms for GHGs. But I know that there have been cases of folks using WARM in some of those other platforms. And I don't know that it's always an easy one-to-one kinda thing to do, but I know that it has been done and that some platforms do sort of allow for that sort of input from folks using WARM data. So I think there's some precedent there. How widespread or sort of automatic it is is probably maybe not always there.

Hannah Debelius: Yeah, understood. And I will also say that Jarrod, you have provided us your contact information at the end of the slide, so –

Jarrod Bridge: Yep. Yep.

Hannah Debelius: – I trust that also, some people might follow up with you, which is great. And a – so a reminder to our audience, that'll – his e-mail will be at the end. And also, all of the slides that were showed today will be available to you. All right. Well, the next question is pretty straightforward, which is to both of you, which is, "Are both of these tools free to access?" So maybe Jarrod, since we were just chatting with you, if you wanna answer, and then I'll pop over to Scott?

Jarrod Bridge: Yep. WARM is totally free, both the Excel and openLCA versions. You don't need any sort of external – I mean, as long as you can run Excel, you can use either tool totally free.

Hannah Debelius: Great. Thanks, Jarrod. Scott?

Scott Nicholson: Awesome. Yeah, as far as MFI, we do have this – I mentioned this web app that we have available, which is free to use. It's sort of a streamlined, simplified version of it. You should end up essentially getting the same results. It's just not as customizable as what we use for our in-house version.

And I should also caveat that by saying that we do have some proprietary data limitations that – as far as what we can share publicly for this since they are a lotta paid sources. So that's a little

bit of a roadblock as far as being completely transparent with how this is going. But we share, essentially, as much data as we can.

Hannah Debelius: Great. Thanks. And I will shamelessly plug that all the solutions coming outta the waste pilot are also free and open access on the Better Buildings Solutions Center. Okay. Moving on to our next question, which is to you, Jarrod, which is, "Can you combine alternative scenarios in the WARM tool, such as composting and material, reducing and material – "

Jarrod Bridge: Yep.

Hannah Debelius: Yeah, " – combusting and material?"

Jarrod Bridge: Yeah. You could theoretically have a scenario where you use all 60 materials and all, what is it, 6 or 7 management pathways in the same sort of calculation if it was appropriate to do so for your scenario. So the only limitation is that the way WARM works is the total tonnage for – let's say we're – we looked at newspapers in our example. The total tonnage for newspapers on both the baseline and alternative need to match. So where those tonnages go, those different pathways, that can change. But the total has to sorta match up on both sides or else the calculation won't run. So – but other than that, you can use as many materials and pathways as you – as you need to.

Hannah Debelius: Great. Thanks. For the next question here, I – I'll see if Scott can weigh in on this, but I'll also mention to our audience that we do have a robust audience today, and we know that a lot of you are also in industrial manufacturing. So just in case someone else has a resource that might be able to speak to this, on Slido in Q&A, anyone in the audience can directly reply to a question. So you could drop a resource or an insight there. And also for my colleagues in AMO, I've got the chat open if there's something you'd like to add to this one. So Scott, I know this isn't exactly the wheelhouse you spoke on, but you might know, "If you have a particular plastic, is there a place we can go to figure out what industry might need that material?"

Scott Nicholson: Yeah, that's a good question. And I think maybe the easiest way to answer this is to – you can sorta start by saying, yeah, of course there's market research reports that you could pay for to identify where these things are going at a very rather precise level of detail, but of course those are not free. Maybe a simpler approach would be to just look at the different forms of the plastic that are being produced. So films are gonna have a much different end use from

more rigid materials. So you can maybe start to get a sense of where the – where the demand is in that case. And we do have some published data on where the end use demand, or really, end-use production of commodity polymers – I can point – whoever's interested in that question, I can point them to that. Happy to do so. So we do have some data out there for it, but maybe not quite the level of detail that they're looking for.

Hannah Debelius: Yeah. I agree. This is a creative question now. And Scott, if – I think you're probably not also on Slido. So as a reminder to our audience members, Scott's information and e-mail will also be at the end of this if you'd like to follow-up on that.

Excellent. So then we'll go to the next question. We are moving right through, which is great. 'Cause these questions are – I can tell people are interested because they're specific, actionable questions. "Can WARM be used estimate or calculate energy recovery?"

Jarrod Bridge: So energy recovery is sort of baked into some of the calculations depending on the scenarios you're building out. But the outputs from the tool itself don't – it won't give you an output of this much energy recovered. But there are – if someone's adventurous enough and wants to dive into our documentation, there are usually very detailed layouts of the calculations behind the scenes that are going on. And so someone may be able to use those sort of beyond the confines of the tools themselves to do a sort of custom calculation, where they could get an estimate of that as sort of a midpoint outcome. So it's possible to do that from WARM's sort of infrastructure, but not necessarily in the user interface itself.

Hannah Debelius: All right. Great. Thanks, Jarrod. And actually, I think we had a similar question later in the list, so if that one comes up, we'll circle back. Moving right along, "Can WARM use either weight or volume metrics for waste, and if not, is there a conversion built in?" This is kinda similar to, I think, the second question we asked you, so we can – feel free to pass if it's too similar to that one.

Jarrod Bridge: No, I think there's enough of a nuance there. So WARM is built to work off of short tons. So you input data for waste in short tons. I think there is – there's not a conversion built into the tool itself, but there may be some in our documentation. I would have to double check on that. But I know that it's not built into the interface itself. So short tons is the metric you're going – is the – yeah, is the metric you're going for when inputting data into the tool.

Hannah Debelius: All right. Great. Thanks. Scott, this one'll be back to you because the question is – oh, wait, they just switched. So this one maybe, then, is still a Jarrod, which is, "Can you include information on production of recycled paper versus virgin paper production?"

Jarrod Bridge: So you can – there's a setting in WARM where you can change the percent – or – yeah, sorta the percent recycled content sort of assumed in the calculations. So for instance, the – it's really just two – it's mainly just two settings. There's current mix, which is sort of the current assumed normal amount of recycled content being used in the production processes. Or you can choose a 100 percent virgin assumption, which obviously assumes there is no recycled content being involved in the calculation. So it's not a super granular – exactly a certain percentage, but there is that sort of switch where you could choose either the current case or 100 percent virgin.

Hannah Debelius: Great. Thank you. All right, Scott, and now I'll go back over to the question for you, which is, "Are there any application for the tool from NREL for commercial buildings? Maybe in procurement?"

Scott Nicholson: I would say absolutely. And it might not be the case that it's very specific types of materials that are used only in commercial buildings and nowhere else. But as far as more of the generic, major inputs – and I don't know exactly what goes into that, so whoever asked the question, apologies for not knowing the nuances of commercial buildings. But if there are any sorta basic materials, the concrete or wood production or any sort of chemical treatment that's going into that process, you could certainly derive impacts from NREL's tool, the MFI tool, for each of those, and sort of piece together what the overall impact would be from using those materials, and maybe run some sort of comparative scenario where you're using more of one material versus another or some alternative there to just derive some comparisons. And that doesn't directly have anything to do with waste, I don't think, but it's not to say you couldn't use some sort of waste-derived secondary material for that commercial building, and then do the same sort of comparison, essentially.

Hannah Debelius: Great. Thanks, Scott. This question –

Scott Nicholson: Looks like this one's for me, too.

Hannah Debelius: Yeah, it is. Yeah. We had a couple in a row for Jarrod, and now it's – you're in the hotseat. "Does VolCat work on other things besides PETs?"

Scott Nicholson: This one, I'm not sure about. And I'm inclined to say it's specifically PET right now. I don't know enough about the very specific chemistry involved to know if it could work for other polymers. I can ask.

Hannah Debelius: Great. Thank you. The next question is directed to both of you. So the question is, "Do either of these tools play into the circular economy or making decisions for circularity?" So because this is either of you and this is not exactly specifically about the tool, whoever's ready or wants to jump in, you're welcome to.

Jarrod Bridge: Sure. I can take a stab.

Scott Nicholson: Go for it, Jarrod.

Jarrod Bridge: Yeah. So a big part of the way circular economy's usually talked about, it's those sort of loops of getting materials and resources staying in the economy or back into production. And some of WARM's management pathways do sort of play a role in the – in those pictures, especially things like recycling and composting and things like that. So it plays a role in that way. And we're also looking towards, in – the potential for adding a reuse pathway in WARM as well, as sort of a – an in-between from source reduction and recycling to get – as reuse is a – seems to be a big part of the circular economy discussion, as well. So hopefully in the future, WARM might have even more to say in that discussion.

Hannah Debelius: For sure. Thank you. Scott, anything to add on that?

Scott Nicholson: Yeah. I mean, as far as MFI's concerned, I think that really is the ultimate goal, is to be able to analyze these circular economy supply chains compared to linear, conventional supply chains. That's our end goal. How close we are to getting there is another question. But we're still sorta figuring out exactly what that looks like. And I think eventually, once we get maybe a more robust suite of secondary processes for dealing with all these different wastes, we can make a better claim that we do capture these sort of secondary, closed loop, open loop, different types of recycling, supply chains that are essentially alternatives to conventional routes. So work in progress.

Hannah Debelius: Great. Thanks. And I also see ties back to the last response you gave, about looking at building materials, as well, on the commercial side of things. Because we of course know that reuse is a – could be a big factor in that, and in embodied carbon, as

well.

Great. So this question, I think, actually, Jarrod, was the one I was thinking of that you maybe touched on a little bit earlier, about being able to kind of dig in and see the factors that go into the information. So the question, "is information cited concerning what factors are used to calculate the GHG emissions?" Maybe Jarrod, I'll start with you, but then that might also be applicable to you, Scott, since they don't determine that.

Jarrod Bridge: Sure. And I think I've mentioned a couple of times our extensive, voluminous documentation chapters on our website. And they are so extensive and voluminous because we try to be as transparent as possible with every calculation. As you saw in the presentation, each of the 60 materials has a different emissions factor associated with each materials management pathway. So you can just imagine how many calculations are going on behind the scenes there. So we try to be as transparent as possible, lay out the different components of each emissions factor, what sources they come from, what sort of mathematical manipulations are going on to get to those final emissions factors, and just try to be as transparent and up-to-date as possible.

Hannah Debelius: Thanks, Jarrod. Scott?

Scott Nicholson: Yeah. Just to echo the up-to-date aspect of this, it is super important. And we've, in the past, lagged a little bit on keeping up-to-date with these 'cause it can get out of hand. And all the sudden, you're five years out of date on something that's been updated. So yeah, we try to keep the global warming potential factors that we use for GHG calculations pretty current. I think we've used the latest IPCC numbers for that, so pretty standard there.

But as far as what we actually use for those calculations, we're focusing on combustion GHG emissions, which is a little bit simpler and narrower scope than full lifecycle GHG emissions. So we're really only looking at actual combustion of fuels in the supply chain. So we have those emission factors all up-to-date and current and documented, which is important, too. So that's really the scope of MFI's use of emissions factors. Yeah.

Hannah Debelius: Great. Thanks so much, Scott. And actually, that puts us at five till the top of the hour. So even though we have – we have lots more wonderful questions left, I wanna go – we gotta cover a couple of programmatic slides before we close out here. But to all of our audience members, if your questions were not answered, I'll also

remind you that the contact information'll be at the end of this slideshow. Whew. And so you can reach out. And you can also reach out directly to me if you'd like to be connected with someone.

So with that – let's see. As I mentioned in the beginning, this webinar part of the 2021 Summer Webinar Series. And you can visit the Better Buildings Solutions Center to register for these. And actually, pretty soon, we'll also be announcing our series for the year. In fact, I hope that you will join us on August 10th for our final webinar in the series, which is entitled "Visualize Your Energy Future with the State and Local Planning for Energy performance – " or "Platform, SLOPE."

This webinar will share New Mexico's experience using DOE's SLOPE platform to inform its grid modernization roadmap project and how SLOPE's new transportation data can help your jurisdiction. And I know we have a lotta state and local folks on the line, so I hope you'll join us for that one in particular. To watch recordings from the Better Buildings virtual summit, the previous Better Buildings Webinar Series, or technical presentations from our national labs, you can visit the on-demand webinars library, where all previously-recorded presentations are archived, including some others from the – others from the waste pilot.

So with that, I would like to thank again our panelists so much for your time today, for sharing these tools. I really hope that our partners and audience members check those out. And I know that you'll also probably get a couple questions in your inbox since we weren't able to get to all of them today. But yeah, thank you all so much. And for anyone who's interested in being more involved in waste through Better Buildings, you're welcome to reach out to me, and we will get you to the right person. So thank you so much. Oh, and also, a recording of this and all of the slides will be available to our panelists and also all of our audience members in about a week. We'll e-mail it out to you.

Scott Nicholson: Awesome. Thanks, Hannah.

Hannah Debelius: Thank you all so much.

Jarrod Bridge: Thanks, everybody.

Scott Nicholson: Bye.