

*Bri Colon:*

Hello, and welcome everyone. We'll get started in just about a minute or so, and we'll let some others trickle in. Thanks for being here. All right, well, let's go ahead and get started. Have the top of the hour. Again, thank you for being here today. Welcome to our waste reduction network, Coming Full Circle - An Introduction to Circular Economy Principles webinar.

We're thrilled to have you all here and I want to start off first with just a few housekeeping notes. Today's webinar will be recorded and archived on the Better Building Solution Center. We'll follow up after today when those recording and slides are made available. Next attendees are in listen only mode, which means that your microphones are muted.

But if you experience any audio or visual issues throughout the webinar, please go ahead and send a message in the Q&A box located at the bottom of your Zoom panel. You can also utilize that box to submit questions throughout the webinar, and we'll field them at the end. Feel free to direct them to a particular speaker.

Or if they're applicable to multiple then we'll be able to pose it to others throughout when we get to the Q&A portion. Go the next slide. All right, next step, me, hello. Welcome everyone, my name is Bri Colon and I serve as a fellow in the Building Technologies Office at the US Department of Energy. Within the Better Buildings family and the waste production network I serve as a building's lead.

I'm joined by many others who also support in this effort, who will showcase in a future slide coming up here soon. Next slide. We want to start off first with just a few programmatic updates on our end. First off, just to share for folks to mark their calendars, save the date, come one come all to our Better Buildings Better Plant Summit, which is going to be occurring this upcoming year, April 11th through the 13th.

It'll be happening in the heart of the Washington, DC area. We're really excited to be able to convene folks, partners, trade organizations, leading experts to engage on a variety of different areas of everything buildings and plants. Please stay tuned to that URL listed there for ongoing updates in regards to registration, hotel reservations and the like. All the information will be continuously updated at that forum.

We'll also be within the summit engaging more on the topic of waste. If you'd like to learn more and connect with folks in person,

will be a great opportunity to convene and learn more and connect with network partners. Next slide. Dovetailing nicely from the summit update, we are also open currently for our Better Project and Better Practice Awards opportunities.

These applications are currently open, they're due by January 23rd, 2023. They're great opportunities to recognize active Better Buildings, Better Plants partners for efforts made to improve performance in decarbonization, energy efficiency, water savings and waste reduction. Please go ahead and look into that website for those brief applications.

We're looking forward to honoring and highlighting partners proven, and real-world successes in these different categories. For projects we'll recognize efforts to demonstrate what's possible in individual facilities and for practices we'll recognize those efforts to drive organizational and cultural changes. The winners of these awards will be highlighted at our Better Buildings Better Plant Summits, and throughout the year 2023 through a variety of different avenues.

Be it speaking opportunities, social media highlights because we're hip here at the DOE, so a variety of different ways that we'll be looking to showcase those winners. If you have any follow up questions regarding this opportunity, please don't hesitate to reach out. Next slide. We have a great new couple of resources coming out of the waste reduction network. First off being our waste glossary.

This is a really great opportunity to read up on relevant industry definitions, to support partners throughout our network. These terminologies were compiled utilizing a lot of existing resources and authorities out there from partner organizations, the DOE and additional sources. It's great one stop shop to look into a variety of different terminologies and then next up, we have our waste stream energy content calculator.

This is intended to really quickly estimate the energy recovery potential of waste streams based on the values of waste generated annually. The calculator considers two main pathways for energy recovery, direct combustion and aerobic digestion. This resource can be found on our solution center and downloaded. If you have any questions as you're navigating it, we'd be happy to follow up and support in this. Next slide.

Alright, a brief agenda here for today's webinar. I have a few more just informational slides here to share, I have a couple interactive polls, and then I'll turn it over to our colleagues over at the National Renewable Energy Lab. We're also joined by Brent Trenga, from Kingspan, who'll talk about their construction waste practices. Then we'll offer space for Q&A for our speakers and closing.

Go the next slide. Without further ado, I'm happy to embark on our first couple polls here, we can watch those, they should be showing up on your screen. If folks want to take a minute or so I'll pause here to first off, enter information on what sector folks are coming to us from and best describes your organization.

This is helpful information for us to have just in general, and for our speakers to get a better understanding of who's in the room and get the lay of the land there. You want to take a minute or so to respond to that, and then our second question listed there as well is do you have a circularity goal at your organization? We recognize that many are in different phases in their waste reduction journey.

If you do have a more formal goal, if you could describe that goal at a high level, that's helpful, just interesting information for us to have as well. I'll pause here and let folks type those responses in. Okay, maybe just a few more seconds or so, sure folks are typing like the wind right now, and thank you all for engaging in these polls. Really appreciate it.

As we wrap up these polls, we'll be able to showcase the responses and the results here on our screen in just a couple moments. Okay, let's wrap up those polls and showcase the results here on the screen if that works, perfect. If you see attendees, I see a good representation of folks from the industrial sector, commercial real estate great showing, others to classify as the category for others and contractors and nonprofits.

This is really helpful information, thank you for sharing everybody. For the second poll question, I think we're not able to see those responses live. We'll be able to look into that post webinars. At least I'm not seeing anything come up for the second question responses. But thank you for filling out those answers for folks, and we'll look into some of those responses after the fact.

We can go to the next slide. Okay, just a few more updates from our end. I mentioned, I'm one of many here on our waste reduction network team. I won't read through everyone's names, but wanted

to showcase we have great folks from the industrial and building side of things. Were supported by others, experts in our national lab, and our wonderful contractors who specialize in this topic.

Thank you to all of our team. If you do have any questions, you have a great array of folks to reach out to. You can go to the next slide. Within the waste reduction network, we're continuously enriched by folks joining to really get to represent the market economy in diverse facets. We're really lucky to have a diverse array of folks here representing the market economy.

If you don't see your name here listed and you'd like to learn more and be a part of our network, please go ahead and get in touch with us. Again, our network is continuously bolstered by folks joining with this diverse holistic representation I should say. Next slide. When folks join onto the waste reduction network, they can join and embark on a variety of different tracks.

One being our solutions track, where data recording is not a requirement, you're not required to set a formal goal. But we're happy to have more partners in this avenue. Participants are then encouraged to contribute in ways such as publishing a case study, which we call solutions, and on our Better Building Solution Center, sharing out best practices, lessons learned through more informal peer exchanges within and across sectors.

Documenting potentially the ways that waste management impacts other priority areas, such as energy reduction, greenhouse gas emissions, embodied carbon equity and circular economy for example. The other way partners can commit and engages with our data track where they can set formal waste goals, and report progress utilizing the following options as a variety of different goal opportunities.

We recognize that there's no one size fits all for waste goals. Given a variety of different ways in which folks can set those goals, and receive support from our data team in these efforts and tracking the data by submitting them to a third party, non-bias entity. Go the next slide. Then finally, the types of activities we like to engage in, we send in regular newsletters with updates to our network with a variety of different resources.

Tips and tricks coming out from the DOE as well as other partner organizations, resources and any recent case studies that are being published from partners in the network. Webinars like the one you're a part of right now, peer exchanges and working groups to

embark more deeply in topics such as previous ones, which have really engaged in things like data and measurement, employee outreach, and then for the industrial side of things on the topic of plastics, for example.

Next slide. Without further ado, I'm going to go ahead and transition it over to our first speakers. We're joined by a great team from the National Renewable Energy Lab. I'll just introduce them here. First off, we have Dr. Heather Goetsch, Dr. Goetsch joined NREL in 2020 as a member of the Building Energy science group within the Building Technologies and Science Center.

Her research focuses on decarbonization and applying circular economy principles to the building sector. She is particularly interested in applying these principles to building design, innovative low impact material use and reuse, waste reduction and management and offsite construction. Her research also includes determining and overcoming industry barriers to decarbonization.

Next up we're also joined by Swaroop Atnoorkar. Swaroop is a researcher in the resources and sustainability group in the Strategic Energy Analysis Center. Her current research focuses on sustainable building construction, utilizing mass timber, biofuels research, resource modeling, transportation systems and the material flow through industry tool which she'll demo here shortly.

She's also interested in decarbonization policy analysis. Then finally, we're joined by Julia Sullivan. Julia brings a decade of solar energy industry experience and mastery of sustainable architecture, and years of experience from the New York's bustling film ministration NREL solutions and scaling group, within NREL's Building Technologies in Science Center.

Central to her interest is improving the ways that designers, architects, engineers, construction professionals and developers interact and overcome barriers to streamline the design and construction of more energy efficient, lower carbon buildings. She's interested in expanding research into building materials and their impact on areas such as equity, carbon emissions, occupant health and building longevity.

Thank you all for being here with us today. I will turn it over to the NREL team, and take it away.

*Julia Sullivan:*

Thank you, Bree. I'm Julia Sullivan, a sustainable buildings researcher here at NREL. I'm joined today by Heather Goetsch and

Swaroop Atnoorkar, and we would like to give a special shout out to Michael Deru who is one of the group manager's here at the Building and Thermal Sciences Center at NREL. Today we will be talking with you about reducing waste through circularity.

We'll start off by looking at the status of waste and circularity today. To get started, I know I've heard from Bri and Hannah that many of you have outstanding waste reduction goals. I know that a lot of that waste might actually contribute to the municipal solid waste stream. We've started by looking at the municipal solid waste stream from 1960 to 2018, as indicated in blue on this chart.

You'll see that it's been steadily climbing year over year. If you click, you'll see we're approaching 300 million tons of municipal solid waste a year. In orange, you can see per capita generation, and this is not just attributable to population growth, we're actually producing close to five pounds of waste per person per day, which indicates that we really have a long ways to go in terms of reducing our waste.

If you wouldn't mind going to the next slide. Even though municipal solid waste is a significant portion of the waste that we need to consider, a much bigger part of the picture, is our construction and demolition waste, which is above 600 million tons as of 2018 in that year. If you wouldn't mind clicking, so 95% of that is actually coming from demolition alone.

Which indicates that this is an area that we might want to investigate further in terms of really attacking our waste systematically in this country. Next slide, please. We started off by looking at our municipal solid waste and what's actually ending up in the landfill. You can see if you wouldn't mind clicking, if you start to consider it from the perspective of the built environment, which is what I work on here at NREL.

The majority of these materials, 64% of them are materials that are commonly used in the built environment. Things like wood, metals, paper, paperboard, glass, all of these things are commonly used in buildings every day, which raises the question of why more of these things aren't being reused in our built environment. Next slide, please.

Then when we look at construction and demolition waste, the overall landscape is a little bit better in terms of only 24% of our waste is actually ending up in landfills. But when you start breaking it down by material, the landfill waste is indicated on

both of these charts in light blue. You'll see that the majority of these columns are highest in the front, in the landfilled row, the light blue.

Then they're really dominated by these much larger bar charts under the concrete categories. Part of that is because concrete simply is so much heavier than things like wood, if you've ever held a comparable piece of each concrete is considerably heavier. Even though concrete products are being reused as aggregates and manufactured products, the rest of these materials still pose a huge part of the challenge that we face.

On the next slide, we've isolated this group and excluded concrete products to really look at these other materials. For example, and once again, the portions of these materials that are ending up in the landfill is shown in light blue. As you can see for all of them except for metal, they're predominantly ending up there. Wood, around 30 million tons of wood every year are being sent to the landfill.

Wood is 50% carbon and as it decays that becomes carbon dioxide, which enters our atmosphere. It's really critical that we start thinking about ways that we can reuse these, and keep them in the built environment so that doesn't happen. What is such a common material, I bet everyone on this call has driven by a construction site where wood frame is going up. Next slide, please.

When we juxtapose where the problem with how these materials are being used at end of life, with our raw material sourcing from the very beginning and we start thinking circularly, we see that this problem is much larger and systemic. In light pink, here, you can see all of the raw materials that are going towards construction materials, since 1900 through 2018.

We can see that the materials going to construction are more than double all of the other materials combined, so this is really such a large systematic problem. That's part of why I'm here today urging you to consider ways that perhaps some of your waste streams might be able to contribute to some of our sourcing problems in the built environment.

With that, we'd like to take a brief break for question. I will pass things off to my colleague Heather Goetsch.

*Heather Goetsch:* All right, great. Thanks, Julia. Alright, if we go to the next slide. Most modern economies are primarily linear in nature, including

the construction materials that Julia was just discussing. This figure really depicts a strictly linear process with what Julia was sharing, all of that stuff ends up at the end of this process here in the arrow, that head of the arrow there. If you go to the next slide.

Alternatively, circular economies are characterized by activities such as reuse and recycling that avoid waste and keep materials in use. Some of the key elements of a circular economy if you click again, are listed here. A circular economy really aims to eliminate waste through better design and materials, products, systems, business models, with the intention of maintaining value of products and resources for as long as possible.

It's really restorative and regenerative by design, and we're really trying to replace this idea of end of life with restoration. You go on to the next slide, we're going to ask you another quick question. We want you to think about what are your biggest challenges for implementing more circular processes into your operations? I think with this one, we'll be able to see the results here.

We'll give another few seconds. All right, can we see those? Awesome, perfect, great. It seems that majority of folks say the cost is the biggest challenge, with technical solutions is the close seconds. Again, all of these things are important challenges to be thinking about. Thank you, again, for providing that feedback. If you go to the next slide, probably the one after that.

Similar to what you all have noted, in our research we've also determined similar challenges that need to be overcome before a circular economy can really fully be realized. First of all, circular design requires a new way of thinking, it really does require a paradigm shift which may result in low adoption rates at first. There's also a lack of infrastructure that is required to support a circular economy and its strategies.

Things like segregation facilities, or other logistical infrastructure that will support the pathways of recycling or reuse or upcycling. There's also a lack of local markets, we need to be able to sell these materials and for folks to feel comfortable buying refurbished materials, and then might require also different — structures. Salvage materials will also need to be recertified for similar quality to virgin materials.

Finally, we need better data and information for making circular choices, because currently, it might not be available or it might be inaccessible. If we go to the next slide, despite all of these



challenges there are current efforts to implementing circular economy that we wanted to highlight. It's not something that was still a pie in the sky there, there are folks that are actually implementing this.

It's really exciting and we hope to maybe provide some inspiration to you all. Just to note though, that these examples are primarily focused on the building industry, because that's what our research really does focus on. If you go to the next slide, we can first think about applying circular economy at the micro level. This is at the building material level. We go to the next slide.

Materials in existing buildings can be recovered and recycled for new material source. In this example, companies can recover and recycle flooring such as carpet, vinyl tile, rubber flooring, and also ceiling tiles from their customers, resulting in future use in other buildings. On the next slide, circularity can also be applied as a service, so purchasing a service instead of the equipment for the service.

An example of lighting, the customer buys the service where the company owns and manages the lighting equipment. The company then has the incentive to reuse and refurbish the equipment, and recycle the rest of those materials. They have the know-how of how to do that because they're familiar with those materials. We go to the next slide. Circularity can also be applied to new business models.

In this case, a company would retrieve HVAC systems that are at the end of their life in large commercial retail buildings. They recover used refrigerants, recycle most of the HVAC components, and this really does help large commercial retail building owners avoid landfill use by recycling HVAC systems. Alright, we got to the next slide. What we were talking about was at the micro level before.

If we zoom out a little bit to what we're calling the Meso level here, where really we're talking about the whole building holistically. In this infographic, we showed the different layers of the building on the left. Starting with the base of the frame, the enclosures, the partitioning that's on the interior and the services that a building provides in operation.

These blue dots represent different touch points in the building, which are really opportunities to implement circularity at the whole building level. On the next slide, we're providing an

example of doing full building deconstruction. Instead of demolishing and building, one can be very thoughtful of how to deconstruct it, it will take more time, more labor and therefore more cost.

But in this example, it is still viable to sell those reclaimed materials, if proper care is taken during deconstruction, resulting in this viable business. Actually, this case study is something here in the Denver Metro area. Then if we go to the next slide, those refurbished and reclaimed materials can be used in new construction. In this example, the combined housing and office space project called Upcycle Studios in Copenhagen, Denmark, they relied on upcycling materials.

About 1000 tons of concrete were upcycled, windows were recycled from a public housing renovation. It resulted in 45% lifetime carbon savings, and about 1000 tons of waste reduction, which is pretty significant. Then if we go to the next slide, if we zoom out even further, it's worth noting that the circular economy can be applied at a macro level.

Looking at the source of say one commodity, not just in buildings. In this example, if we look at the circular economy of flat glass, it could look something like this. Where in that red circle, you see the sources of flat glass in this particular instance are residential, commercial buildings and vehicles. Then through different processing, such as the glazing and other repurposing, you can have different materials at the end.

That glass can be used in containers, bottles, fiberglass, in construction or as fillers. Okay, if we go to the next slide, that was a quick introduction of what circular economy can look like. We'd like to get some feedback from you all. If you have any operations that are moving towards a part of a circular framework, or if not, what opportunities you might envision for your organization to implement more circularity.

We should have a poll coming up shortly that can provide some of this information. Again, I mean these answers can be pretty quick if you'd like. This does help us have a better sense of what folks are doing in this space already. Maybe we'll take a few more seconds. All right, well, thank you for filling that out. I think we'll head on to the next part of the presentation.

There are some tools out there that can help organizations think about circularity, we're going to highlight two that are from NREL.

The first that we'll talk about on the next slide is CELAVI. Forgive the acronym, but it's actually a fun acronym. We think about when we're transitioning to a circular economy, we expect to have lots of different benefits.

But we need to better understand what those impacts are, which can lead to more informed decisions about how to implement those circular strategies. That's where CELAVI comes in, or it stands for the Circular Economy, Lifecycle Assessment and Visualization modeling framework. It's really used to assess the type, quantity, the spatial temporal distribution of impacts.

What might occur from when we transition or supply chain might transition from a linear to a circular economy. This framework is publicly available and you can find full documentation of this framework on our website along with a case study that focused on wind blade, that supply chain. If you go to the next slide, we do have another tool that Swaroop will help us understand a bit more.

The material flow through analysis or flow through industry tool is also publicly available. Again, Swaroop Atnoorkar is here to help demonstrate it and see how you might all be able to benefit from it. With that, I pass it off to Swaroop.

*Swaroop Atnoorkar:* Hello, hi everybody. I am Swaroop Atnoorkar and today I'm going to be demonstrating the use of the material floater industry tool. Next slide, please. The MFI tool is a linear network model of the US industrial sector. What it does is it models about 900 Industrial commodities, using about 2000 recipe to analyze the energy use and emissions impact of the product producing these commodities.

Each recipe is basically information about how a product is produced. It includes information about the material energy and utility inputs to producing that commodity. The tool framework then analyzes the impacts of producing that commodity by analyzing the entire supply chain, 10 steps are analyzed as a default in the supply chain.

This tool was primarily created to analyze impacts of producing these commodities, it wasn't meant to be used as a tool to analyze the use phase or the end of life. Next slide, please. Please click through the slides to that, thank you. Having said that, this tool does have the capability to be used to analyze the end of life effects of commodities.

For example, this tool has recently been used to analyze the upcycling impact of PET, which is poly ethylene terephthalate. Since you can model any recipe in the tool if the material and energy inputs are known, it is very possible to analyze the end of life impacts using this tool. The study which has been referenced here analyzed the impact of producing glass fiber reinforced plastic, either through its conventional production or by using recycled or upcycled PET.

Now I'm going to be showing a demo of the tool, to give an idea of how this can be used. This is the homepage of the MFI tool. There are details tutorials here about how this tool can be explored, how you can request a login, how you can explore recipes, build a new scenario, or use existing scenario for the analysis. My main goal over here is to walk you all through how you can use the functionalities of this tool.

Going to the product recipes. I already have here input polyurethane foam board, which is a common insulator. There are about 900 products in this tool which can be searched through this search box here. When you search for a particular product, it shows all the recipes through which that product can be produced.

It also shows the baseline weights, which are the default weights which NREL has assigned to these production processes. Here we see that the aggregated process has a baseline weight of one, and that is this test case which I created which has a baseline weight of zero. Now how do you use this tool if you want the test case to have a baseline weight of one. That can be done through modeling a scenario.

Again, I have created an example scenario here, but we will be creating a new one to see how it is done. When you click on new scenario, you can define how you want to analyze a particular process. You can give a scenario name, you can select a sector to choose what your primary product you are looking to analyze is, let's say it's a polyethylene terephthalate with just fiber, you can specify how much quantity you want to analyze.

You also can specify the baseline weight for a product, you can change it over here as a custom weight. If you want the entire production to be through a particular recipe, which is not the default in the tool already. One can also define the electric grid which is to be used in producing a particular product. We have electricity grids for multiple years, multiple locations and also just

using either renewables or entirely fossil fuels to power electricity production.

Then when you create, you can click on submit and then create the scenario. Once a scenario is created, one can go and just click on run scenario in Excel. Then this functionality gives you all the results you would need to analyze the scenario. I'm going to quickly share an example scenario which I created to show how the results are displayed. I still sharing my screen?

*Bri Colon:* Yes, you are.

*Swaroop Atnoorkar:* Okay. Do you see the Excel sheet?

*Bri Colon:* Yes.

*Swaroop Atnoorkar:* Okay, great. In this Excel sheet, you can see all the inputs you have given to create that particular scenario on the first tab. Here we have about 1000 kgs of polyurethane foam used on good stock production. We have the main processes, the aggregated process, and then we are using the electricity grid for the US in 2022. The next steps give information about the results of the scenario.

We can see in this tab, all the top 10 inputs to this particular scenario, it's brine crude oil you can see how much amount of these inputs were used up to 10 steps in the supply chain of producing the boat stock. Similarly, one can see results for energy, what were the top 10 energy consumers? What were the top 10 emissions from producing the board stock? How much electricity was used in the production?

Where was it coming from? The total fuel used, the sources of these materials, as well as the emission from each of these fuel combustion processes. You can also see transportation emissions and you can also see the electric grid mix which was used in the analysis of this scenario. Having said that, we do have a few limitations for this tool as well. As of now, only NREL can enter recipes into the tool to be modeled.

But we have are open for collaborations or agreements where we can enter recipes for you, and you'd be able to analyze those recipes in the context of whatever scenarios you want to define. For that I would like to be open for any questions or pass on to the next presenter.

*Bri Colon:* Thank you Swaroop, this is a great demo and a really valuable tool, which folks might have some additional questions on for the end. We will now transition back to the slide deck if that works, and then we'll transition to our next speaker. Perfect, and thank you all from the NREL team, looking forward to any particular questions from attendees related to that information shared.

Next, we'll transition to Brent Trenga who is joining us from Kingspan Insulated Panels North America. Brent is a director of sustainability for Kingspan. His background consists of him being an architect, construction manager, developer and project owner, which give him a unique perspective on a lot of different facets of the construction industry.

Trenga leads Kingspan's North America has material health and transparency program, and their planet passionate sustainability program while collaborating with the company's global healthy buildings team. Kingspan has set a goal of zero waste to landfill by 2030, and Brent will be presenting on how Kingspan Insulated Panels North America addresses waste in its processes. Thank you for being here with us today, Brent. I will turn it over to you.

*Brent Trenga:* All right, thank you so much. Thanks for the intro. Yeah, if you go the next slide actually, that's just a interesting photo, we'll go on past there to this. As you mentioned, our planet passionate program is a global program for Kingspan. All of the divisions in all the regions are applying this to their global business. As you mentioned circularity, actually the buckets for planet passionate in our energy, carbon, circularity and water.

For today, I want to focus on the circularity target for us. Zero waste to landfill is a really big lift, we have 221 manufacturing sites in 70 countries. Specifically, here in North America, my team has been focused on that target. Waste to landfill is difficult, it's very cheap to put things in a landfill in the US so it was something that wasn't really prioritized and now we've put an awful lot of effort into it.

As part of that also, and some other presenters have talked about this. Utilizing raw materials and reusing and repurposing raw materials, we set a target for a billion PET bottles to be recycled into raw materials, ultimately to a hybrid polyol that we can use in our installation. That was a 2025 goal, we've already done over 800,000 bottles in just the first year. Then part of that is going into our products.

If you go to the next slide, this puts out the framework of what we look at as lifecycle product circularity. From really cradle to grave, how lean and circular design is critical, that bespoke component of how our product and what the industry needs. Input materials, obviously a common part of where we start this journey is what we're making materials of.

Interesting enough is we've done a huge amount of LCA work on this, it's not always better to repurpose and reuse and recycle material, it's very specific on the product and how you're using it. The embodied carbon and energy used to use a recycled material versus a virgin material, it doesn't always end up better so it's a very specific piece to look at.

Factory process, that's something we can absolutely control, the waste and the pollution side of our factories and running every one of those is clean as optimized as we possibly can. End of life models, what happens to the products, deconstruction, repurposing, reusing, chemical recycling, mechanical recycling, all things that we're looking at. Of course, then cycling that material back into other materials.

If you get on that slide, and again we'll because skip over that one right into the next one. We looked at really on the factory level, so DeLand, Florida is our headquarters in the US. We immediately rolled out a waste to landfill program as a pilot down there. What we realized was we have to separate everything into nine waste streams, every single material that comes on site we separated, broke that down into those nine waste streams.

Then really started to tackle how can we recycle and divert all of that material from landfill. This was extremely successful project and just simply is you go even to the next page on the next slide, breaking out every waste stream into a bin, labeling it clearly and putting those all over the factory with signage. Became very easy for us to start to weigh, attribute where the waste is coming from streamline and account for it and measure it.

Exciting that we went from probably sub 10% to now 98% waste diversion. It was easy to recycle water, things like that, almost everything coming out of our plant now is diverted from landfill. Now if you go to the next slide, one of the things that we were challenged with was the foam product. There is absolutely foam that comes as a byproduct of panel waste and generated that doesn't meet our criteria to be sent out to a customer.

How do we deal with this? Again, I mentioned chemical recycling and that is absolutely something we can do, I'll talk about that a second. But we partnered with a company called Belter Tech out of Atlanta, and we stripped the steel, 100% of the steel comes off the base of the panel. That gets recycled, goes to scrap and ultimately ends back up into our steel manufacturers.

But the foam is collected, we're optimizing how we're now shipping that foam to Atlanta, so we get as much volume in the tractor trailers as we can. Insulation is by nature made primarily with air, so it's very light or takes a lot of volume. We get it to Belter Tech, they're grinding that material, go to the next slide, and they're processing that and using it into a product they've come up with which is called Belter Therm.

It's a lightweight, insulated concrete mix, it's an additive. They're also they're also re-using it for ceiling tiles, they're using it for wall applications and it's great. As the previous presenters mentioned, it really creates alternative supply chain and alternative business opportunities to support and grow in this circular economy. It's critical for us as we need someone to take some of these byproducts if we can't and maybe bring it right back into our process.

That was a very successful project and something we're scaling across other parts of our business now. Next slide, something we also make is mineral fiber, insulated metal panels made with mineral fiber. Again, the process there is a significant amount of waste that comes off of some of that process. Our plant realized that the dust and the cut offs in those things was in collaborating and working with our supplier, with Rockwool could be taken back.

Now have a program that we've stood up to recycle 100%, once we get fully optimized 100% of that mineral fiber is able to be sent back to Rockwool. That takes about 800 tons or 680 tons of mineral fiber waste that was going to landfill, back to the supplier which ends up back in their raw material and then being made into new materials from their side. Again, a nice success.

Next slide, is you talking about designed for deconstruction, what happens to these materials. If you go to the next slide, we can talk a little bit about and these are, the theory of deconstruction is been out for a while, as mentioned a recovering architect if you will. But finding ways, products have a long lifecycle and just they can be in in use for a very short time, we've been partnering and talking with



companies like Microsoft and Skanska that are very much diving into this.

How we build the building, how we design the building, how manufacturers design the products. Mechanical fastening is a big part of this, we can't glue products down, we can't glue products together, mechanical recycling optimizes the way that we can deconstruct that product or that building apart. That's been a really interesting piece, and we're actively looking for some pilot projects at scale to do this, really across the globe not just here in North America.

But really exciting what that could come and do, is we build a building, it stays there for three or four years, 10 years maybe. The whole building comes apart, revealing the envelope where we have the most impact. Then that's transported, reused and collect parts put back together another building. Cost savings, carbon savings are tremendous value to this, but we really have to optimize how it's done.

There are some stumbling blocks there. I'll just mention if you think about this is a very disruptive component, how do you insure a building that has now a different set of parts that doesn't come maybe with manufacturer warranties and testing and things like that. I'll say that one of the big hurdles to this from what we're hearing is really the financing and insurance side of the building that it's going on.

But again, ripe for disruption and something we can surely overcome. Next slide, I talked a little bit about, go past one more, PET the recycled PET that goes into our products and high recycled steel. This is a great piece moving away from blast oxygen furnace to mini mills or electric arc furnaces have a huge difference recycle content, roughly 22% for blast oxygen furnace and up to 89% on average recycled content for electric arc furnace mills.

Then putting anywhere from about eight to 12% of that PET back into a high-grade poly all that goes back into our proprietary installation. We're really trying to optimize both recycled content recyclability, but also in institute driving down the embodied carbon of those products. The last slide, if you want to change over, is back to those input materials.

There's a lot of work from our side and across the industry about biomass, and biomass balanced portfolios including this in the

larger portfolio of materials. The bio-based materials alone, there has been huge innovations where we've asked our suppliers a number of years ago, they said it was a decade away of what those raw materials could be converted over to non-petroleum based to bio-based.

They're now back to us to two years, and now we're piloting biomass and bio-based materials, raw input materials. We have a lot of plastic over in the economy enough that we can probably continue to recycle and repurpose, sustainable packaging and overall brain chemistry we feel has tremendous opportunities, we grow and look for the future of what this could be. With that, I'll hand it back over and look for questions and answers and appreciate the opportunity.

*Bri Colon:*

Thank you so much for sharing, Brent. That's really exciting stuff going on at Kingspan, and love the visuals there. Perfect, if we can go to the next slide. Now we'll transition to our Q&A space here and want to give again, a thank you and shout out to our presenters, the folks from NREL and Brent from Kingspan.

If folks want to be able to turn on their cameras and others attendees if you'd like to input any questions that you might have had arise throughout this information that was shared, feel free to input that in the Q&A function. We can pause here, and as we're waiting if folks from NREL have questions for Brent, we can have an interchange as well as if attendees are currently typing.

All right, I see a question coming in from Heidi, asking is anyone able to find an outlet for particle board besides waste to energy? I'll let panelist if anybody wants to unmute, and if they have a particular answer for that.

*Julia Sullivan:*

I mean, I can say that particle board is typically made with petrol chemically derived glues so using it for waste energy, probably long term isn't the best solution. I know that there is ongoing research into new forms of engineered wood that might use existing wood products. But I don't actively know of any current commercial uses.

*Brent Trenga:*

Yeah, I can't add much to that. I know on the waste energy stuff, it is a short-term solution for sure. There is obviously lots of regulations on how that incineration is cleaned and scrubbed, both carbon capture and chemicals. They're not releasing a lot of toxic stuff into the atmosphere as they can, but you're still incinerating and it's not the best case for the material.

But yeah, I would think maybe another wood supplier or maybe a paper mill or things like that locally, may be interested in raw material source, especially as raw material prices continue to go up. I think it's going to be a nice catalyst for some of these conversations. I don't know, I think there was a question came in from Ed, are you looking for alternative waste materials such as textiles and other plastics for integrating into your installation panels?

Not so much textiles, because actually a lot of textiles are still petroleum-based, there's still a lot of plastic in the textiles. We are very focused on the mechanical or the chemical recycling side, but in a good way. Anything that we can capture back, any installation that PIR type installation has been made that we can recover, we actually have a company called Stasia, based out of Barcelona that developed the technology.

We can, at a high-grade level capture a lot of that raw material back which has been up until a few years ago, not even more of a concept than anything was proven. But that again, is a lot of short-term components I think as we transition over to bio-based materials if we can, and not make forgettable sacrifices or performance sacrifices or embodied carbon sacrifices, they tend to be easier to recycle.

There is no golden or shiny golden ticket on this one. It's something we're actively pursuing doing a whole lot, I mean we probably have 30 or 40 different types of research projects on different types of installation and ingredients that go into the installation. It's an ongoing piece for our R&D team.

*Bri Colon:*

Yeah, thanks for sharing Brent, helpful insights there. It looks like Tom also had more of a comment, I think in connection to one of the first questions there saying that, they currently sent wood pallets for waste to energy. They're also looking for an alternate solution there on that with pallets being European dimension, so no US companies have interest in those particular sizes.

*Brent Trenga:*

There's a little ringer there, I'm assuming because the European sizes that are coming over from Europe, but we worked with our suppliers on that same problem, we were actually chopping it up and using it for shipping, as boxing and structures for shipping. But talk to the supplier and see if they're willing to take back the pallets from where you're getting them.

There again, with costs of everything going up. As you're shipping things over, if they're not shipping back you may be able to send all the material back to them and just keep it in that shipping cycle.

*Bri Colon:*

Yeah, that's a great point, and great examples of that, that circularity coming into play. I see Heidi too also mentioning that what is the challenge for them in their organization for end of life, and also mentioned that wood augers can be used and then it can be composted. Thank you too Heidi, for sharing that insight. I did have a question as we're pausing it for others to come in from the audience.

This might be something that that Heather and Julia were touching at the beginning with some of those emerging, kind of like, service models arising. I'm curious if you all have seen particular examples of that coming into play, or is it still on the new end of things in terms of some of those circular ideas fitting into those as a service models?

*Heather Goetsch:*

Well, I mean, the example that we gave the lighting as a service that is a viable company, I mean they are providing that. I don't know Julie, if you have other thoughts on other types of services that you've been finding out.

*Julia Sullivan:*

I mean, there are certainly other companies that have similar models. For example, there are solar manufacturers that guarantee they'll take your solar panels at end of life and reuse what they can, dispose of what can't be reused in safe ways. I think that some of that is coming from the energy industry towards the building industry. We're starting to see more of these service-based models.

I even know of an example of a school or actually several schools, where they don't actually own the school, they're renting it for 12 years with the condition that they can buy it out after that time period. They're not responsible for maintaining any of the building systems or any of the building components beyond regular maintenance, like if a doorknob is loose.

There certainly is a shift in how these models are being applied to buildings, and building components and maybe even in other industries that you work in.

*Brent Trenga:*

That's interesting. Yeah, I know in the Netherlands a couple of our teams have piloted and working with the industry to pilot leasing products and leasing facades and materials and things like that. Again, there's a bit of a disconnect between the financing of

buildings and doing some of that, and the insurance pieces like oh, wait, you don't own.

In the industry for cars that makes total sense, but financing a \$50 million building where suddenly you don't own the building or parts of the building. If we can totally get over it, again, disruption and just getting out of what we know and what we're comfortable with. I know there are a number of companies, there's a company called Ripley, that's been gaining a lot of traction.

They're a database of use materials, a lot of interior finishes and a lot of office furniture, things like that, that they can bring in big scale and go to big developers and land building owners and take out all the material and hold it. The challenge or really the opportunity is, and this goes across all building products is it's logistically expensive to move material around.

It becomes a very regional conversation, like for me to take a building down in California and ship it to Texas, it's just unbelievably expensive at a cost where those business models start to fall apart so they become regional conversations. I know Eden Brockman from San Francisco, there are a lot of cities are piloting takeback programs where they can aggregate materials.

They have the warehousing or the footprint to take materials and store it until the next person comes to find it, comes to use it, that's the big disconnect. Is taking it down and finding the building that it goes to, but where does it live in the middle and where does it store, getting it to one place and taking it to the next. We can sort out but physically, it's big volumes of stuff.

The cities tend to have these on appealing and under bridges and under highways and under overpasses where no one's going to lease that space, where if something becomes giant storage units for building products, it's very interesting model to work out.

*Julia Sullivan:*

Another thing on, just to piggyback off that is if these things can be transported via rail instead of trucks, and then you have a quarter of the transportation carbon footprint. One interesting thing that we see here in Colorado on long front ranges, we have all these old coal plants that have been shut down. They say those really long trains, it's about an hour of coal for a coal plant.

They have these tracks around the old coal plants that now are just leased out as storage. There are interesting ways that you can consider it when you start considering rail.

*Brent Trenga:* Well, that's cool, yeah.

*Bri Colon:* Definitely. Thank you for sharing Brent and Julia, I think it just showcases that the future is innovation and people getting really creative in the ways that they're able to really re-envision these processes. Brent, I like your terminology to the disruption there and how to really be seeing that in a positive light, and really way to move forward. Thank you all for sharing.

I know we're at time, so we'll close here. I don't know if there's maybe a final slide. Yes, contact information, very important. If you'd like to touch base with these folks, post webinar, the information here on this slide. But also, just to share the additional Better Buildings handles here on the left to learn more information coming out of the program here.

Again, big thank you to the folks from NREL and Kingspan for being here with us, our speakers on this webinar. Really appreciate you taking the time and sharing your expertise and organizational practices with our waste reduction network folks. Hope everybody has a great rest of your day, and we will talk to you all later. Take care.

*[End of Audio]*