Bruce Lung: Well good morning and welcome to the 2020-2021 Better Buildings Webinar Series. In this series we are profiling the best practices of Better Buildings and Better Plants Challenge Alliance Partners as well as other organizations that are working to improve energy efficiency in buildings and plants and throughout society. I'll be your moderator today and my name is Bruce Lung. I'm a Senior Technical Advisor at BGS, LLC working with the US DOE's Advanced Manufacturing Office where I support the Better Plants and other AMO, Advanced Manufacturing Office, technical partnerships programs with stakeholder engagement, tool and program development, with an emphasis on ensuring that AMO technical partnerships programs offer value to manufacturers and to industrial scale energy end users.

We are very excited today to announce that we will be using an interactive program called Slido for your Q&A. If everyone can please go to slido.com using your mobile device or computer opening a new window in your internet browser today's event code is D-O-E so if you can find the hashtag just type in the letters D-O-E in all capital letters and it'll allow you to submit questions. If you would like to ask our panelists any questions please submit them anytime throughout the presentation. We will be answering the questions at the end of the session and there will be a mechanism for offline questions if we still have some that are unanswered. You can also select the thumbs up icon for your questions that you like and those will result in the most popular questions moving up to the top of the queue.

So at this point we'd like to start things off with a poll so we can learn more about our audience. Please join us over at Slido to respond to the next 2 polls. So you should be able to go to the Slido screen and see the 2 polls. Have you tried to identify and quantify non-energy benefits of an energy-saving project? We'll give a few more seconds. It looks like a lot of folks are still kind of new at this but it's good to see that some people are actually in progress and working on it. We'll go ahead and give folks a couple more seconds to finish answering. Hopefully we can get up to about 170, 180. Okay, very good, okay.

I think we can then move onto the next one real quick here. Have you ever asked an energy consultant to identify and quantify non-energy benefits from the energy-saving measures they recommended? Interesting, so we do have some folks that have done it, have tried, and you know some of their consultants were able to do it. That's good to see. All right, we'll give folks a couple more seconds. It looks as though it's still something that we haven't really pushed the consulting sector to do yet and you know that could be changing based on today's webinar. So I think we've got a good one right here. I think we'll move onto the next poll.

Female: That's the only other poll you have Bruce so we can go ahead and go back to the slides now.

Bruce Lung: Okay, excellent. Great, well thank you very much everyone for answering these polls. I would like to kind of give a little bit of background introduction to the topic. I think a lot of folks understand what multiple or non-energy benefits are. Research has been going on into the sector since the late 1990s and 1 of the things that's really interesting about non-energy benefits is that the research has always shown that when you're able to quantify non-energy benefits of energy efficiency projects the return on investment metrics whether it's a simple payback or other metric always improves. I just want to point out 1 example that was done in the early 2000s from some researchers, Worrel, Laitner, Finman, & Hodaya, they did a big assessment of the steel sector and found that energy savings projects in that sector of iron and steel without multiple benefits, the average simple payback of projects for energy efficiency was over 4 years and when they included them, those multiple benefits, it fell to 1.9 years.

The problem that we've faced throughout this time is that a lot of these studies, whether they're mass market studies or individual projects, is that we always end up quantifying these benefits after the project is implemented. And so 1 of the things that we've been thinking about is wouldn't it be nice if we could identify and quantify these projects before a project is implemented and thereby improve the return on investment metrics. And I'm very excited to be able to say that you know we are in that position right now with the Multiple Benefits Project that's been going on in Europe. And I'll go to the next slide real quick and introduce our speakers.

We have a really good pair of presenters today. One is the Better Plants Challenge Partner, Lineage Logistics, and the other, who will be speaking first, is Madam Dr. Catherine Cooremans who has a PhD in Economic and Social Sciences Business Management Orientation and an Executive Master's in Business Management. Catherine has been doing research, teaching, and consulting in the field of energy efficiency investments for 15 years with a focus on non-energy benefits of energy efficiency projects. She has conceived and managed during several years a certificate of advanced studies and energy management at the University of Geneva and is working as an expert in the Swiss Public Authorities on Energy Auditing and Energy Management Public Programs. She is now a Senior Researcher at the University of Lausanne so just a little bit to the north of Geneva and is a Co-Leader in the ongoing EU Horizon 2020 Multiple Benefits Project on valuing and communicating multiple benefits of energy efficiency projects. And so now I'll turn it over to Ms. Cooremans.

C. Cooremans: Thank you. Thank you very much Bruce for your introduction and for describing the situation regarding the non-energy benefits. I am very pleased to have the opportunity to present our multiple benefits analysis method in a Better Buildings seminar webinar and I want to say hello to everyone. I am based now in Geneva and it is snowing. It's 5:00 in the evening and I'm very pleased to be with all of you. The outline of my presentation will be first a short introduction to describe the project and the team, then the context in which we developed this method, then the method itself, the multiple benefits method, and the toolkit going with it. I will continue with a description, a very short description of 2 pilot project examples and finally I will conclude.

The method I will describe in this presentation was finalized in the framework of a European research project and as you see on this slide we are 15 partners in 11 countries. It's a nice mix as you can see of academics and practitioners involving 11 countries so we are 15 partners and 11 European countries. And I would like to take the opportunity of this slide to thank the European Commission for selecting our project. It's a 3-years project and it's very interesting and I also would like to thank the Swiss state of Vaud, which supported and promoted this my work for several years as well as the Multiple Benefits Project.

Regarding the context of this work I think I can start with showing the conventional or illustrating the conventional approach to energy efficiency projects. So what we do as energy experts is that we identify energy savings, we translate these savings into monetary savings, and if a project is assessed as profitable we consider that this will entail a positive investment decisions. And unfortunately as many, many of us know and experienced this approach does not work and does not work or does not work well enough.

Why is it so? Why this situation? It's because energy is not a priority for companies, which often wastes energy. And a very important aspect to remember is that there's a very tough internal competition between projects in companies and decision-makers select investment project contributing to core business and benefitting the whole company. They will favor ideas that look fancy and innovative or they will favor a new product development. They look for ways to secure their business and be more competitive. So we need to meet that and I think the quote on the lower part of the slide encapsulates well the issue at stake. "What is important for a CEO is what is important to helping us grow our business and retain our customers." And if you want to have a project selected by the decision-makers you need therefore to go well beyond energy savings. This is what the Multiple Benefits actually helps you do.

So I will now describe what is this method and what it is not. It's basically a decision support tool for investment projects. It includes complimentary analysis in order to take into account the interests of all company departments. It does not, however, provide default values for the non-energy benefits identified. This is an important point and this is because as you certainly know every project and every companies are different so we provide a method to ask the right questions and to collect the right data to answer the questions but we cannot provide default value. This method, this support, decision support tool applies to any type of project so it can be industrial or regarding a tertiary building, any type of activity or again organization, meaning it can apply to a for-profit company or a public administration. And we designed this method to be clear and simple to apply.

So our MBenefits method increases the attractiveness of an investment project and thus its chances of being approved. Here on this chart you see a description of the method. It's not linear and it's done on purpose because decision-making in a company is rarely linear. It's looping, sometimes it goes back, and this is the same with the analysis. But as you see here starting on the left from a project idea you will start with the first step, which is the company analysis just to better know your customer, to set up the stage in a way. Then you go to the next step, which is dedicated to analyzing the energy and operations aspect of your project. Then the third step is dedicated to the strategic impacts of your project. This is where you will also collect figures necessary to assess the financial impacts of your project and the fifth step is dedicated to a synthesis of all results in order to present them to the selection committee. And the idea here is to be in a better position to have your project selected as I said.

So starting with step 1, company's analysis, step 1 wants to answer the question, "What is the energy efficiency project's contribution to the company's business model?" As I said it's a way to better understand what is a company and how you can contribute to this company's activity. It's about the big picture here but you don't need to enter into all the details. And we also try to investigate a little bit what are the decision-making drivers because it is important to assess which types of factors can block or facilitate your project.

The energy analysis for the step 2 is a convectional analysis. Then we go down to the level of the project and we assess what is the impact of the project on energy consumption. It can be energy consumption of an equipment, of a process, or of the whole company; it depends on the scope of your energy efficiency project or renewable project, renewable energy project. The operational analysis is I would say much more innovative and new and is giving an answer to the question what is the project's contribution to operational excellence. Operational excellence is a concept composed of 4 dimensions, which you see on the lower spot here of the slide. You see that you have safety, so it's safety of the people and of the processes; quality of the products, products can be goods or services; the cost, all costs, which can be operational involved in the project; and then time. Time is an elusive concept because it can be delivery time or the time to develop new products so it has different meanings. But what we will assess here is the contribution of the project to these 4 dimensions, safety, quality, cost, and time, because this is what is important to operations in a company.

And I would like to illustrate this approach by – with this slide here. You see that on the – what you see here actually is a description of the conventional energy approach. You see that what an energy expert will do is to assess the machines and the equipment involved in the analysis and to try to decrease energy consumption of these machines and equipment. And energy experts, they basically stop there. On the other side of the – if I can say so of the company you have people involved in operations and they are very much concerned with the process and the process must work smoothly and deliver the products it is supposed to deliver. And so these people, operations people, they very moderately care about energy consumption. But what they need however are the energy services. You see here that you have the heating, hot water, cooling and refrigeration, ventilation and air conditioning, motive power, lighting, automated processing of information and communication technologies, all these services are absolutely key and vital to operations. And operations people, they don't master those services because those services are really controlled and mastered by the energy experts. So this is where we can bridge the gap between energy and non-energy people and between energy analysis and operations analysis.

I'll give you an example. This is an industrial bakery in Switzerland and they emphasize the fact that it's a Swiss precision, a well-known Swiss precision, and it's a well-proven manufacturing process. They assess that every product meets its specifications exactly; millimeter precision is guaranteed. If you want to quality is the priority so if you want to have a top quality all the time and if you have – if you need to reach millimeters of precision you need to have a very, very high level of energy services and especially you need heating quality for your oven. So when you replace baking ovens in an industrial bakery the classical energy approach would be, "Okay, I'll replace the baking oven and I will decrease the consumption of natural gas or heating oil and this is fine." Okay, this is fine for you energy expert but it's not so convincing to operations people and to the decision-makers.

But look, if you change the oven you will improve the quality of the cooking heat and you will also reduce the preheating time of this oven because it's better insulated. This will improve the quality and the stability of the products and it could even increase production because you could have more batches produced in the same day because you save time on preheating. So you see that here we have a really nice way to join energy and the production model analysis to really attract attention by decision-makers, of decision-makers.

The strategic analysis answers the question, "What is the project's contribution to the company's competitive advantage?" Competitive advantage is again a concept made of different dimensions, actually 3 dimensions. It's first the value proposition developed by a company, it's the value of use for customers, and this value of use translates into revenue so you can sell more or you can sell at a higher price. And – but of course to develop this value proposition you have to consider the risks incurred to produce it as well as the costs incurred to produce the value proposition.

So in the strategic analysis, the value cost risk analysis, we want to answer the question, "What is the contribution of this energy efficiency project to our value proposition, to the company's value proposition to risk decrease and cost decrease?" Using again the example of the replacement of the baking ovens in an industrial bakery so we have an oven new, it's better insulated, you have less heating time, you will have less quality problems, less breakdowns, so regarding the value proposition in part you can identify that you will have an increased product quality, an improved product stability, and increased staff satisfaction and loyalty because of better working conditions. On the risk impact side you will have a lower workplace accident risk, lower legal risk associated with the risk of accident, a lower breakdown in production disorganization risks, lower commercial risks, and lower suit risk.

You see that on the – I just forgot to mention that on the left corner here you see that you have the usual energy analysis will emphasize only the fact that the project entails lower energy and carbon costs but you have many other impacts so value proposition impacts, risk impacts, and also other cost impacts such as increased workforce productivity, increased equipment productivity, lower cost of products not conforming to specification, lower maintenance costs, and of course the lower energy and carbon costs. So the question is now of course you need to put figures on these different non-energy benefits. Most of those benefits are quantifiable. This means that you need to ask some company's department and to ask for information and data so this is sometimes a tricky aspect but most of the non-energy benefits are quantifiable except maybe the risk impact.

The financial analysis answers the question – so it's the fourth step, it's the last step of the analysis before communication, "What is the financial attractiveness of the project?" so it consists in a very classical way in assessing the profitability of the project and the payback. I'll give you an example. This is a complete renovation of an office building in Switzerland, it's a large company, and yes Bruce was mentioning that without non-energy benefits the financial figures are often not much attractive. This is the case here so it's a project of – with a CAPEX of 24,000,000 Swiss Francs (CHF) so it's approximately $27,000,000 US dollars. The investment income before taxes is about 380,000 Swiss Francs and you see that the net present value and the internal rate of return are negative and the simple payback is 49 years, which is just – it doesn't even make sense in financial terms.

If we add the non-energy benefits so the CAPEX is the same but the investment income before tax is much higher with 3,390,000 Swiss Francs and you see that the net present value is almost 5,000,000 and the internal rate of return is 11 percent. The simple payback is 8 years. This is with a discounted rate of 8 percent and an investment duration of 15 years but it's involving – it's a long investment duration but it's regarding a heavy renovation of a building so it makes sense.

Where is this investment income before taxes coming from? I'm sure you are wondering where it comes from. I'm sorry I didn't have time to translate this slide so I will translate it orally. You see on the left part of the slide so it's a copied screen from the financial analysis. You have better space use, maintenance cost reduced, CO2 cost reduced because in Switzerland there's a CO2 tax, reduction of wear and tear of machinery and equipment. We made a hypothesis of an impact on the turnover of the company, we made a hypothesis that the turnover would be reduced by a half percent so it's very conservative, right, but this is because of a more comfortable building and because of a better image of the company, which is very important in Switzerland. And we included also reduced costs of complaint management and adjustments. There were a lot of complaints before because the building was very old and this is how with looking at invoices and really assessing very precisely all benefits involved in this project we came to the figure of 3,391,000 Swiss Francs. We just made a hypothesis on the increase in productivity and reduction of the turnover. For the productivity we made a hypothesis of an increase of 1 percent and a quarter so it's a very conservative hypothesis. We made this hypothesis together with people of the company.

Then step 5 is dedicated to communicating to top management the results and to describing why the project is worthwhile. And with this analysis the project is often worthwhile I can tell you. So this method translates into a toolkit. On the right side of the slide you see here this is actually the main menu of the software because the toolkit is composed of first the method itself with the 4 analysis steps I just described in the communication part and then the software is user friendly software. It's easy to navigate between the different steps. It contains an information help section, an energy services description. It also provides a non-energy benefits checklist. We have about 16 on the energy benefits so it's easy to go through the list and see which non-energy benefits apply to your projects. And finally we also provide a template for the result presentation.

To get used to this method and the software we propose training workshops, which include the concepts and outlining the method and a serious game, which is a very fun way to learn and get trained with this approach. And we will soon also provide a learning base, which will include all our pilot projects with results. We have about 25 project results ongoing or completed in 7 countries participating to the project. I have personally – I was personally responsible of 5 projects, 2 in the industry, 3 related to tertiary buildings, and it was for-profit companies or public administration and it was very, very interesting. So if you want to know more about our pilot projects mark your agenda because our final conference, virtual conference, will take place on May 11th and you will have more information on our website.

Some examples, this is really – I will not go into details. It's not because I don't have time, it's just because – although I don't have time I think you can have a look. It's only just here to show that the software captures really the 4 analysis steps and then a summary, a synthesis describing why the project is worthwhile. You can have a look at these slides afterwards. You have 2 projects here, 1 in a tertiary building of a multi-national company and the second one is related to an SME small industrial company.

In conclusion I'd like to emphasize the fact that the classical approach to energy efficiency measures or projects is dedicated at energy savings only I would say and the contacting companies are the technical functions, which is not appropriate because the technical functions are not the functions making decisions so you need to go higher and this is what we want to do with the multiple benefits approach, which not only takes into account technical aspects but also assesses the value proposition improvements, risk reduction, and other cost reductions apart from the energy costs. And this enables us to have contacts in companies with all functions including top management.

In summary I would like to stress again that the multiple benefits approach increases the attractiveness of projects for decision-makers because it takes into account all main corporate interests, operations, logistics, production, marketing, and sales strategy/finance. It goes well beyond energy savings, which is really necessary. It makes energy efficiency strategic, it makes energy efficiency much more profitable, and it bridges the gap between the energy people and the non-energy people. With that I thank you for your attention. I just would like to say that I think you will receive a copy of the slides and I put a reference list at the end of the slides and our site also. I wanted to say that the excellent work of the Barclay Labs so you may have a look at the reference list. Thank you for your attention.

Bruce Lung: Thank you very much Catherine. That was great. I'm going to move really quickly to introduce our second speaker. We have with us today Dr. Alex Zhang from Lineage Logistics, 1 of the Better Plants Challenge partners. Alex is a Senior Systems Engineer on Lineage's Data Science Team. He holds a Bachelor of

Science in Systems Engineering from Washington University in St. Louis. He does a lot of modeling and simulating of physical designs of Lineage's facilities to evaluate and improve warehouse thermodynamics and airflow. He also tests and optimizes refrigeration controls logic to increase energy savings by improving the stability of system responses. So Alex, take it away.

Alex Zhang: Okay, thank you. So yeah, thank you very much for the introduction and thanks Catherine. That was very fascinating information. So today my focus is more on energy benefits specifically in the industry of my company, Lineage Logistics, in cold storage and the main thing I want to portray here is as on the data science team here our goal is to try and quantify as much as we can by looking at a lot of the different data sources and combining them together to get like a whole picture when we do these different projects, including energy efficiency projects beyond just like here's a raw energy efficiency savings number. Oftentimes the benefits go hand-in-hand so next slide please.

So first I'll just explain what Lineage Logistics is and then I'll walk through 2 specific case studies as much as I can. Next slide. So what is Lineage Logistics and what is cold storage warehousing? So basically this picture right here, we keep stuff cold. So how do you get your ribs or your ham for like Thanksgiving or for 4th of July? It's because of us and because of the cold storage network that moves foods and keeps perishable goods safe and cool over time. So what we're really doing is we're moving this pig again through space and time to make sure that it can be delivered to people's doorsteps or to the supermarkets, to restaurants, et cetera. Next slide please.

And so we have – we service a lot of customers so pretty much most of the food you see in restaurants and like Costco for example or in supermarkets have gone through our network at some point and it's because again as soon as the food comes off the production line, examples like strawberries, fruit, or other perishables such as you saw earlier like pork, meat, and stuff like that, it needs to immediately be frozen and that's where we come in. Next slide please.

And so this is what a typical warehouse will look like. This one specifically is the Port of Oakland near San Francisco. You can see the city across the bay. But you can imagine inside this space all of it is temperature-controlled space with a bunch of 0-degree Fahrenheit freezer space to keep stuff cold and you can see the trucks are coming in, coming in and going, dropping off food and picking up food from the facility. Next slide please.

And we have a global network now, still mostly in the United States but expanding in Europe, in Asia, and in Australia and New Zealand as well and so this is just to show the scale of how many facilities our company actually runs and for an idea each facility can use – these are megawatt scale, energy-using buildings and so they consume a significant amount of power. And so you can imagine that and then imagine that times all the facilities you see here so there's a large energy footprint that we have. Next slide please.

This is what the inside of a warehouse looks like, nothing too fancy. It's a bunch of food pallets stored on racking and this entire space is temperature-controlled I mean and that's the hardest part. That's the main constraint we have to deal with is A, we have to obviously keep up the throughput to move all the product that our customers are requiring, but B, we also have to keep this entire space at 0-degrees Fahrenheit or under and that's the main challenge because that's what uses most of the energy. So you can already imagine if at home you're already paying attention to your air conditioning bills and stuff we're doing that but on a much larger scale because we're using giant refrigeration systems to accomplish that. Next slide please.

And so here's an example of what the engine room for this refrigeration system looks like so it's much larger than a typical rooftop unit you would see on a commercial building. We have to use – we're running these 2-stage ammonia compression systems and so we have to use giant compressor motors, which each of these motors for example can be 400 horsepower that you're seeing in this image here and so 400 horsepower motors times like 9 over here you can imagine the power starts adding up a lot and so that's when we start thinking about how can we be more efficient and how do we start saving energy. Next slide please.

So first let's start through the first case study that I want to walk through today, which is blast freezing. Next slide please. And so our approach here is very similar to what Catherine was talking through earlier as well, which is how do we portray this project more than just like raw kWh energy savings? Well in order to convince like capital costs and stuff like that to help sponsor your project you need to look at how much money or how much energy value you can actually generate. And so for us we're looking at 2 metrics here, which is the quantity, that's how much product we're storing and moving and that's the profit for us, minus the power here, which is how much energy we have to spend and consume in order to keep our warehouses running. So our overall goal here is we just want to reduce the power costs as much as we can and so for this particular project step 1 we're going to evaluate what blast flow designs we have and then 2, develop a newer solution that's just better. Next slide please.

So first what exactly is blasting? Blasting is very similar to what we had earlier but instead it's we're taking food that's not been chilled yet and we're hyper-chilling it ourselves inside a room that we call a blast cell, which is either -20 or -40 degrees and it's much colder 0F to bring that food down as quickly as possible within for example 24 hours to a frozen state. That's what blast freezing is. Next slide please.

And so to be efficient and productive blast cells need to satisfy these 2 metrics, which is 1, the refrigeration needs to be enough so you need to have enough cold air and refrigerant going through the cells to remove the thermal load from your product, and 2, the airflow needs to be good. So the analogy here is very similar to a garden hose. You need to have enough water pressure and for the analogy here that's like the amount of refrigeration, and then 2, you need good airflow and that's like the nozzle shape and the water spray that you're getting. So the greatest example is like even if you're getting really good water pressure you don't want to water your flower bed using the jet setting; otherwise you're going to just annihilate your entire flower bed. You want the nice shower setting to distribute the water equally and that's something similar that we are aiming for in a good blast design. Next slide please.

And so we're taking that idea and looking at this evaluation where on the left side you see here this is what we locked into and you see the standard design. There's not much air guiding going on here and so we're seeing a lot of air short cycling and not homogenous, directed, streamlined airflow. And then what we did was we evaluated models, stimulated long engineering steps to reach the refinement that you see on the right, which is a design where the airflow can circulate more effectively. Next slide please.

And so here you can see the – here's the computation of flow dynamics video to illustrate that where you can see on the right side with this improved design the flow is going to be more homogenous as the cold air is coming out and on the left side it takes longer to homogenize, especially these top level pallet positions. They will always cool a little slower because the airflow is not reaching them as effectively as it is the rest of the pallet positions whereas on the right side you can see here we're getting more even airflow throughout so everything is going to freeze at a more homogenous rate. Next slide please.

And so how do we quantify this? Well there's a few ways. Obviously we have a blast calculator where we're projecting based on the food product properties how long it's going to freeze, but ultimately what we do at the end is to baseline and test everything. We just stick temperature probes in to get the direct core temp measurements and this is the example of the improved versus unimproved blast cells that we have and so you see here the improvement is pretty drastic where you see we're having like 80+ hour freeze times on some of these older cells and then in the newer cell we're getting on average down to like 35, 36 hours in some cases. Next slide please.

And so for us here the benefit obviously is you can save energy but another big benefit also is that we can improve throughput here. Because we're cutting down the freeze time we can move more products. So when you remember back to the equation earlier how we're generating profit, if we're freeing up space because we're able to move stuff through faster that means we can take on more business and more product. So in this case here this blast cell that we came up with, it's not only more energy efficient by kilowatt hours per pallet because it's designed better with better airflow, it also moves stuff almost twice as fast so we could exchange those energy saving levels for more product throughput double that to gain more profit. So that's a quick, quick run-through on that project. Next slide please.

This is a bigger project that we ran, which we call the Energy Scheduling and Flywheeling Project, next slide please, and the goal here is to again reduce energy or power cost in the facility by how we're doing that is by scheduling the energy around the grid prices. And so this is actually all grid interaction from our end as well so we're not just like, "Oh, at whatever-o-clock turn off the power," or something. We're going to create an algorithm here that will intelligently schedule our facility power so that it can meet the facility temperature constraints while still minimizing the power based on the fluctuating prices that we see. And so how do we do that? First we need to just update the warehouse itself in both hardware and software so that it can even follow the directions that we're giving it and this is where a lot of these benefits that we didn't even originally anticipate starting coming in. Next slide please.

So first many of you probably have done projects like these but we've installed a lot of VFD. All of the evaporative fans have VFDs on them and then we improve the controls algorithm so that they could actually follow temperature setpoints and be stable so this took some analysis. Next slide please. So first you can see here the black line is what we're telling the room to go to and the green line is what we measure the room to be doing. And so you can see here it's kind of doing all sorts of stuff and ultimately a frozen room is not rocket science so we figured okay, if we improve the controls algorithms a bit we should be able to get much better, finer control. Next slide please.

And so that's what we did. You see here with the newer control algorithms in addition to putting on the VFDs we're getting much more stable temperatures that we can follow along this setpoint, which is perfect. Next slide. Same with the compressors, we put VFDs on these large compressor motors and we also changed the logic on them to be more stable so the comparison here is you can see the blue line, the blue graph line is 1 of the compressors running on the old logic and the orange is running on the new one and the new one you can see is much more stable so we're not getting these wildly gyrating spikes in the capacity, which also spikes the power usage. And so you can imagine if suddenly you're getting like 300 kilowatt swings throughout the day you might be hit with some big demand charges from utility, which we want to avoid. Next slide please.

And the VFDs themselves have inherent benefits as people know because VFD motors are – it's more efficient to control your capacity control using normal frequency drives than it is to use more physical methods such as on compressors like the slide valves. So the comparison here you can see we can directly measure the relationship of slide valves at this capacity versus VFDs at this capacity. There is that raw difference in energy consumption because slide valves are less efficient so you're going to use more. And on the left here you can see we evaluated our projects through a couple of months just to see the comparison between when it was running on VFD and when it was running on slide valve and the power consumption of that and this is like a sting ray plot to show that. So if you look closely you'll see with the VFD we're using overall much less power. Next slide please.

Next we moved onto the condensers, so same thing with the condensers where we're measuring before and after upgrading a condenser. Originally this was just supposed to be a maintenance upgrade but we turned it into an energy and a cost savings upgrade because we were able to identify this instability. So you can see here if we're not able to maintain our high side pressure and refrigeration system we're going to incur a lot higher refrigeration costs and after the upgrade you can see we're almost maintaining a flat line here, which is much more stable. Next slide.

How we're quantifying this is you can see we can just take all the data for the condenser that we're looking at in question and then compare that to how much energy our compressors are using so now we're doing some relationship analysis. And you see here the power goes up as the pressure goes up and so we can use this graph to quantify our savings benefits from before you saw because we're getting rid of those really high spikes of pressure and lowering the pressure down, which directly correlates here as you see to lower power consumption in addition to stability. Next slide please.

The next thing we did was we looked at upgrading the vessels. So refrigeration systems have giant tanks that store their refrigeration refrigerant inside of them. Usually they're hand-cranked valves but we started looking into again automated valves that can control the amount automatically by logic of how much liquid they're feeding into the vessels. Next slide please. And the reason we looked at that is because of this analysis that we did here where we're looking at how is the existing system working. And so the quick explanation here is all these shaded regions are when the manual hand-crank valve, the solenoid is opening for that so you see it opens and shoots in spurts. And the thing is in the refrigeration system when you shoot in cold refrigerant into a vessel you spike – you cause spikes and flash casts in the pressure and so that actually ends up spiking the compressor power usage on the bottom here. So you can see this relationship analysis where liquid is going in, the pressure is going up, and then because the pressure is going up the motor speed is also going up. And so this is like an artificial, not real load. It's just we're trying to get refrigerant and so if there's a more stable way to do that then we can get rid of these spikes. Next slide.

And so that's what we accomplished using these motorized valves where you can now see we're able to maintain a much more stable liquid level. There's no more of this intermittent feeding in and instead you can see there's – the valve percentage is lively hunting on the bottom graph here in order to maintain a pretty stable motor speed in our motor and so this cuts out the spikes in the energy usage and it also – it's more stable and so there's maintenance benefits here as well. Thanks Bruce. Now after that – next slide please – we'll finish off by seeing how we can tie that into our project we call Flywheeling. And so quick, quick explanation for flywheeling is we're just trying to schedule energy around the peak hours and so the main idea is the warehouse is kind of like a battery. If we overcool our warehouse and bring the temperature down a lot we can give ourselves a buffer so that we can turn off or turn down our energy usage during these peak hours and then let our temperature coast back up but still maintain much under the temperatures that we're required to. Next slide.

And so the example I'll talk about is in Mira Loma, California, a giant, 4-megawatt facility with a $2.2 million annual power bill and it runs on both time of use and demand charges for the utility. Next slide please. So here's what the demand charges look like. Let's fly through this one because we're running out of time. Next slide please. So what I really want to show here is we're looking at the energy prices and then we're also modeling our warehouse temperature using thermal models and then together we project out a resulting power draw that minimizes the energy usage with those 2 constraints. And so you can see here the different colors on the bottom graph are the different rooms in our warehouse and so what we're doing is it's almost like a pie. We're divvying out different amounts of cooling to each room but still maintaining under a maximum threshold, which is the dotted line to not incur a high demand charge and together this makes it so that we can stay under 0-degrees while also minimizing our power based on changing power prices. Next slide please.

And so you can see this is enacted in real life and obviously it's not going to look as pretty as the projections but we can still measure it using the sources that we have. Next slide. And when we moved over to direct access pricing, which is just live changing rates – next slide – and we give it a similar approach here where we give the same algorithm but with the input now of live changing rates and you can see here how it's still divvying out the cooling to each room in order to minimize the power price and to minimize the power usage by these compressors. Next slide.

So to wrap up amongst all these different initiatives we're able to evaluate the energy impact by that and so you can see here we're looking at both how much energy we saved through the different projects and the controls, all the different hardware, the change even in the utility pricing that we went through and rate changes, and we can compare that to the increase in volume, which is more product per story, which corresponds to more energy as well as the increase in annual power price and to do that we can build this bridge and exactly pinpoint the savings that we're getting. Next slide.

And so with the closing statements here you can see as we're going through these case studies, energy improvements, they oftentimes go hand-in-hand with these additional benefits because of course some of these were maintenance-targeted projects that we looked at but others were energy improvement projects and it turns out as we're going through them they just ended up being a positive feedback loop helping each other out. And so we see increased productivity and throughput when we're improving our warehouse operations side, modernization of old hardware and software, oftentimes when you're focusing on more energy efficient products the products themselves are more modernized as well and so they run better, which is the case with putting VFDs on our hardware, and then we're also increasing the longevity and the stability because we're getting rid of all these gyrating unstable responses in the system.

So earlier when you were seeing all these spikes it's not good for the motor either to be gyrating all the time. We're adding stability with better controls and better hardware. We're also helping the motor life as well. And lastly we're able to work with utility companies in order to help craft our power usage around their rates too so the greatest example is like doing massive power outages in California. We can actually help change our algorithm to give power back to the grid and consume less during those times, things like that. And that's it for me so next slide. Thank you.

Bruce Lung: Thank you very much Alex and Catherine. Those were great presentations. We have a few minutes left for questions and I'm sorry we're not going to be able to get to all of them but if we can go to the Slido real quick and start looking at some of the questions that came up, the first one that had a lot of likes was whether there's a tool available that can guide a manufacturing company in a step-by-step approach to carbon reduction. I don't know if we have any of that in the scope of this presentation but Catherine or Alex if you have anything real quick please let us know.

C. Cooremans: Okay, no, I'm not able – I'm not capable to answer this. It's a very broad question so is a tool available? There are many tools I think. The Multiple Benefits approach is also a tool available because actually if you try to assess the carbon reductions then energy becomes an additional benefit, energy reduction, so it's the other way around. So no, there are many tools actually I think.

Bruce Lung: Okay. I think related more to your presentation there's 1 important question about if benefits consist of a mix of calculated and assumed values how do you guarantee specific improvement of productivity? What are the metrics for that?

C. Cooremans: Thank you for the question. I didn't have time in my presentation to discuss productivity improvement. Actually to simply answer that question it is not possible to measure – in industry it is possible to measure a productivity increase; it is extremely difficult in an office building. If you read the research, existing research works there are many different answers. All point to an improvement, almost all point to an improvement, so this is why we make very conservative hypotheses taking a 1-percent improvement or 1-percent and 25 improvement.

Bruce Lung: Okay. One question I'll bring up here to the front, was digital twin modeling employed to predict outcomes? And maybe Alex you can take this one. I've noticed this is something we've been seeing in some other partners' activities so Alex I don't know if you want to take that one?

Alex Zhang: Yeah, sure. Can you guys hear me right now?

Bruce Lung: Yes.

Alex Zhang: Okay, perfect. Digital twin modeling, we have not quite – actually I would say yes. So what we do is especially for the warehouse rooms I would pretty much call that a digital twin but I think it depends exactly on the level of digital twinning so we're not doing like a digital twin motor or something like that. The motor itself we won't model that heavily; we'll just take the raw data from it. But what we've really focused on modeling is the thermal aspects, the rooms, the products themselves, and then we're constantly adding as well so like the outside weather, things like that to try and bolster the model.

Bruce Lung: Okay, excellent. Yeah, I would be interested in seeing how that would work. One additional question I think I'll throw over to Catherine, somebody said, "It seems a lot like Six Sigma analysis would adjust these factors." Can you say how different or better this is, the Multiple Benefits approach toolkit is than Six Sigma?

C. Cooremans: I think yeah, it's a good remark. I think Six Sigma is much more complicated than what we do and – but it is complimentary in a way. What we do here is really an investment analysis and this may be different is that Six Sigma is more on processes or it's a type of management system. We are really more on an investment analysis, which can be used with any type of lean analysis with Six Sigma analysis or quality analysis or any type of analysis actually. Six Sigma may help to make the Multiple Benefits analysis because it means that you already have some answers.

Bruce Lung: Excellent, okay, great. Another one that I think is kind of important here is how would you value the training, operations, and maintenance staff to ensure and improve energy efficiency? And I think in the context of this thing how to train them typically to assess and look for energy benefits?

C. Cooremans: Sorry, this is for me? I'm sorry, I don't see the question. Can you – ah, how would you value the training, operations and maintenance? Yeah, it's definitely important. What can I say? Yes, of course. It's – of course corporate culture is important. Energy management is important, not only energy management in the way that you measure everything but just that you develop also a culture inside the company and training is part of the culture so it's extremely important.

Bruce Lung: Okay. I've got one here for Alex. How did you do the M&V energy benefits on the blast freezer project?

Alex Zhang: For that one it was actually handy for us because we still have all of the refrigeration equipment wired and so what we do is we look at the thermal load from the product that's going in and so if you know say for example there's 50 pallets of 2000-lb strawberries going in there you can look at the thermal properties of that of how much heat needs to be removed from that to blast effectively and then we compare that to the refrigeration system running so what's the refrigerant flow, what's the refrigerant temperature, what's the air temperatures, supply and return, and then we look at those differences, to calculate how much energy the refrigeration system is using and that's how we do the M&V.

Bruce Lung: Okay, great. Thank you. I think we'll probably go 1 more question real quick here and I think 1 that a lot of people have been asking is where are these materials and the toolkit available? Ideally I would think it would be from the Multiple Benefits website but Catherine if you have some more insight on that we'd appreciate it.

C. Cooremans: Yeah, thank you. So all materials and toolkits, all the results of this European project will be publicly available at the end of the project, of the Multiple Benefits Project and so this will be in the spring of 2021. I don't know exactly so if you want to go to the website you will have more information. But the answer is yes, everything will be available. We're just finishing the test phase. This is why it's not fully available right now.

Bruce Lung: And when do you anticipate that the test phase will be completed, by May?

C. Cooremans: Definitely by May since the final conference will take play in May, as I mentioned on the 11th of May, so yes, definitely by then we will have completed everything and everything will be publicly accessible.

Bruce Lung: Well I think we've gone over the 1-hour mark so I think we'll just abide some concluding remarks if we can just go to the next slide on the summit here. The next Better Buildings Summit will take place it's going to be in May, May 17th through 20th of 2021. This will be a virtual, no-cost event featuring engaging and interactive sessions as well as opportunities for attendees to network with their fellow industry peers and experts. That's 1 thing we were not able to do last year so that will be a differentiator. Registration is coming soon so please visit the Better Buildings Solutions Center to learn more. The next slide, this webinar is actually part of a series of webinars going through the 2020 and 2021 years. We've got a great line-up of presentations through April so we invite you to visit the Better Buildings Solutions Center and register for upcoming webinars today.

The next webinar that we're going to have we hope you'll be able to join us on January 19th for a webinar on One Size Does Not Fit All: Lessons Learned from Financing Large and Small Energy Retrofits. This webinar will go into the financial and operational challenges for both small and large energy efficiency projects and how they're overcome. The next slide is on our Workforce Portal. We encourage you to visit the new Workforce Developmental Portal. This will be something that provides next steps towards careers in energy efficiency and you can learn about resources, information, training, education, and even some job opportunities.

We also have some on-demand webinars. This is something from our library of previous webinar series if you want to watch recorded webinars, and by the way this webinar has been recorded and will be available in the future as well. We'll have a whole bunch of webinars from last year's summit, the 2020 webinar series, and technical presentations from national labs so please visit the On-Demand Webinars Library to find these previously archived presentations.

With that, I would like to thank our panelists very much for taking time to be with us today as well as for the attendees who stayed with us and had some very good questions. Feel free to contact our presenters directly or to submit additional questions if we couldn't get to your question today. I would encourage you all to follow the Better Buildings Initiative on Twitter for all the latest news as well as on LinkedIn we have Better Buildings and Better Plants posts. You will receive an email notice when the archive of this session is available on the Solutions Center. Thank you one again and we look forward to seeing you all soon.

C. Cooremans: Thank you. Thank you to everyone.

[End of Audio]