Eli Levine: All right. Good afternoon. Thank you for joining us. We're excited to get started today. This is our fifth in the online learning series webinar focused on compressed air systems, so I know this is a topic that's of high importance to many of you and we're pretty excited to present it today because I think there's a lot to get out of this one. So, next slide, you get to see my picture. We'll move on to the next slide.

So, as I mentioned, this is number five here focused on compressed air systems. Should you have missed any of the previous ones, and I know I've been bad about signing up for a couple webinars and then having to go back and miss it in real time, but I encourage you to go back and watch the recordings of all of them. We've had them all recorded and transcribed online so you should be able to watch them at your convenience as well, though it's always better to join us in person 'cause then you get to ask questions.

I just want to point out next week is our last scheduled week. We all get a collective break from Tom Wenning. I'm kidding, Tom, and his colleague will take over the reins for leading a topic on water efficiency, so we're looking forward to seeing you again next Thursday.

Next slide. And most importantly, as we've highlighted in the past, we're shaping up to have a really great 2020 Better Buildings Better Plants Summit. This year will be a virtual leadership symposium like everything else in life is these days, but we hope you can join us. It's free to register. Please sign up. There's a lot of really great content that we're looking forward to providing there.

We've had really strong registration as well, so if you go to our summits for the purpose of sharing with, meeting with the community and talking with other folks, I think there's a really nice opportunity to talk with your colleagues and peers at this as well and we're going to try to structure our meetings to facilitate that as much as possible.

Next slide. So, I'm getting ready to pass this off to Tom. Before that, I think we'd like to take a poll here. Marissa, is this something we should pull up right here?

Marissa: Yes, I'll go ahead and launch it now.

Eli Levine: Wonderful. We're – as I mentioned, we're about – this week we'll be five sixths of the way through our online learning series. Just wanted to know if this is something that, you know, how are you enjoying them? Would you like to see more of that, and if you would like to see more of them, what are the topics that you're interested in? Like, are there areas that we can – how can we best develop the content so that it's relevant for you? So I believe that there's a way Marissa just please chime in with how folks should be responding to this. But, you know, if there's a way for people to enter, please submit your feedback. That would be really helpful for us to know. The turnout's been really strong on these, so we're encouraged by that, but we don't want to keep doing them if it's not what you're looking for or if there's a way for us to put more relevant content out there for you.

We'll give everyone a minute or two to respond.

Marissa: Thank you. Do you have another topic in mind, if you wouldn't mind just putting it in through the questions box? Then we'll be sure to record those for you.

Eli Levine: All right. Well, hopefully you were able to turn in your feedback. Obviously, if you are watching this on a recording or if you weren't able to do this, or would feel more comfortable, please send us a note. We'll have all of our contact information at the end of the screen, at the end of it. We very much want to put together content that's most relevant for you guys at this time. So turning this over, Tom, over to you. I'm looking forward to all of the really great content you're looking to share about compressed air this time around.

Tom Wenning: Excellent. Thank you, Eli. And so I do want to reiterate what Eli was saying, You know, we're five sixths of the way through these webinars and, you know, we're really looking to see what we should be doing next, if you all like these, if you don't like them, if you like hearing my voice for your afternoon nap or if you want one of my colleagues to put you in that slumbered state. Right?

So, you know, if you do get a chance, and there are really specific things you want to hear about, please don't hesitate to reach out to us. I mean, you can do that right now in the chat box or that question box or alternatively reach out to your team, reach out to the better plants e-mail address. We're trying to be really responsive here.

So, all right. I think we can kind of switch over. We're going to be talking about compressed air today, one of my favorite topics because – why is it so favorite? Well, it's ubiquitous and there are big opportunities everywhere. So, this should be a good one.

Hopefully you all will follow along, pay attention and maybe learn a thing or two today. So, Marissa, let's switch things over and get going.

So, today as I mentioned, we're going to be stepping through compressed air systems. Some of you may be super familiar with this area already, others maybe not. So we're going to go through kind of a soup to nuts at a really high level, you know, why should we care about these systems, what are they, and then maybe to some of us, the important stuff, how can I change some things to put some money back in my own pocket. And we'll also talk about some of the software tools and instruments available for looking at these systems. Okay?

So, why should we care about compressed air systems at all? Well, they're pretty ubiquitous. I can't say that I've ever been into a manufacturing facility yet that does not have a compressed air system. That's my personal dream one day is to walk into a facility that has zero compressed air and is serenely quiet. It's a little bit of a tall order and so you know, why do we have compressed air all over the place? Well, one is kind of that convenience aspect, for sure. But compressed air over time has been used for a lot of different applications.

Some of the ones that you may have in your own facility could include conveyors, certain pneumatic tooling, you know, maybe there's some grinders or impact wrenches, things like that. Machines and the actuators, the solenoids, a lot of those are driven by compressed air, but in addition, pain sprayers and robotic arms, you know, it's fairly easy to just drop in a line and plug in the compressed air and use it.

In addition, you know, some of the reasons that compressed air has been so powerful over time or some of the benefits that it has had over kind of electrical alternatives, you know, everything from kind of smoother power to better variable speed and torque control, certainly for our pneumatic tolling. And then there's the situations where there's possibilities of explosions or volatile compounds in the air. We don't want to risk having electrical shocks that may lead to other things.

So, compressed air has been really popular for all these reasons. The problem with compressed air, and the reason we really want to pay attention and focus a lot on compressed air is because one, it uses a lot of electricity for most of our facilities. On the DOE studies and the compressed air challenge information that's out there, you know, it's typically not uncommon for a plant's electric bill to be consumed somewhere in the order of about 5 to 20 percent right in the compressed air system.

And so it's not a small number, but the problem or maybe the eye opening aspect of a compressed air system is that they're extremely inefficient. It's a very robust technology, but it's an extremely inefficient technology. You know, compressed air, it's kind of like the analogous of driving a semi-truck to work every day, you know. Do you need a semi-truck to get your butt from your house to the plant very day? But, you know, it does the job of betting you from Point A to Point B, but there's probably some better alternatives and definitely some cheaper alternatives.

Really, the most surprising aspect that not a ton of us know about with compressed air is just how much of our electricity that we put into that machine actually gets turned into useful work for us. Surprisingly or unsurprisingly for some of us, the majority, 85 percent plus of all the electricity that we put into that compressed air machine, 85 percent of it gets turned directly into heat. And for most of us, we just dump that outside. Okay?

So, at best, at best, you know, 15 percent of the electricity that goes into that box comes out in some form that we might be able to use and in most cases, it's worse than that though. On average, I would argue you know, compressed air systems are on the order of about three to five percent efficient. Okay? That's total efficiency there.

So again, that's like driving that semi that's going to be loaded down with a whole bunch of stuff and maybe you're applying the brakes the whole time while you're driving that semi to work, versus something that's a little bit of a better option. Okay? So, we're going to probably spend a little bit more time on this later on.

At a high level though, okay, let's understand what are our compressed air systems comprised of? You know, what am I referring to when I say compressed air system? For the most part, all compressed air systems have the same look and feel. There's different configurations. There's different equipment that get plugged in, but by and large, it's the same general configurations. It's the same setup, of sorts.

So, here I have a diagram that has essentially a full compressed air system. Everything from the generation side to the end use, okay? And then we have the piping and the distribution that goes around there.

On the left hand side here is our generation, so in this case, we have two compressors where they're compressing air, they're pumping it into our header system that gets pushed out. There's a dryer in the system. Okay? And from the dryer, we might have the air receiver, you know, an air tank, or maybe there's a couple air tanks in our system. And then it gets sent out through the distribution system out to the plant, and this is where it's going to go to our end users. Okay?

And our end users can be a number of different things. We mentioned some of them, but there's these hand tools, right, some of them are driving pieces of equipment, maybe robots, things like that. But this is the full system. Okay? It might look a little complex and as you're thinking about your own facility, you might be going through the iterations of okay, well, I know I have this over there or this over there. You know, how does that all work?

A better way or a much more simplistic way is to just put it in block diagrams and I guess this is the engineering approach of taking a complex world and really simplifying it. So, this block diagram really encompasses almost every single facility I've ever gone into for the most part, with some slight variations. But this is, you know, everything from our supply side, so our compressors, we have our receives, in this case, we have what we call a wet receiver because it's coming before a dryer. You know, we have a dryer in our system. We might have a filter or a couple.

And then we might have another big dryer on the back side. We call that the dry receiver. And then if you have a pressure flow controller, you might have that in there before it goes out into the facility. Okay? And so what we're looking at here is essentially the whole facility. You could easily do this for your own facility to really simplify things, to just simplify the layout of the system here. And really this helps us to kind of visualize the supply versus demand side. Okay?

To make it really simple, supply side is everything on the left-hand side, so that's our compressors and all the stuff that goes on treating the air and then the demand side is everything where that compressed air is used, where it's demanded. Okay?

And so this is one of the maybe first steps, if you're really going to be looking and diving into your compressed air system, you know, drawing a really simple drawing like this, you know, my young children could do this. So, most of us could do this, and this is a great starting point.

So once we've done that and we've kind of understood our system a little bit, we need to understand our compressors. You know, what kind of compressors are out there. And there's a pretty large world of compressors. This is not a new technology. This is a technology that's been around for a very, very long time. But there's really two big camps of compressor types.

So there's, on the left hand side, we have our positive displacement compressors, and then over on the right hand side, these are our dynamic compressors. Most of us, most manufacturing, certainly in the small to midsized manufacturing, lives on this left hand side with positive displacement compressors. The two main types of positive displacement, one, there's reciprocating and then the second one is this rotary. Okay?

Reciprocating is somewhat similar to like a car piston, right? Some of you, certainly if you're like maintenance guys, you probably have a little shop at home, right, and you might have a little small compressor at your house. That's a reciprocating compressor. There's a little piston in there that just chugs along and sucks air in and then it pumps up the pressure.

For industrial facilities, we're seeing less and less reciprocating. And there might be some small systems that you place around the facility, but for large main systems that supply a whole facility, that's definitely an older technology that we're just not seeing very much of. Most of us live over here within this rotary world. Okay? And within the rotary world, you can see there's a couple different breakdowns there even, but the most common within our facilities are these helical screws.

And there's two variations, there's two flavors of that nowadays. One is oil flooded and the other is oil free and there's some pros and cons of each depending on your application and what you're doing, but these are the big ones that we see within most small and medium sized.

If you're a really large manufacturing. You have really large compressed air needs. That's where you start getting over onto this right hand side with this dynamic compressor. And the main one there for our industrials are centrifugals. Okay? We'll step into some of this stuff, but really you don't see these unless you get into, again, really large facilities. Okay?

So, to kind of recap and maybe provide some visuals here, the three big ones that we're going to see within manufacturing are reciprocating, rotary screw and then the centrifugals. Okay? And you can see a little bit of a visual of each type. So reciprocating, you know, it's just these little pistons. This is what you might still have in that pancake compressor at your house. It sucks air in, the valves change and then as the piston pushes out, it compresses it and pushed that compressed air into a different chamber. Whereas a rotary screw, this medium or this middle option here, this rotary screw, what happens is air is sucked in on one end and those screws get tighter and tighter and it compresses that air, okay, and then it pushed it out the back side. And so these are positive displacement, these two are positive displacement.

Whereas the last one, our centrifugals, again, this is our dynamic, you can kind of see it looks maybe a little bit like a pump impeller. Well, yea, it is. Right? It works on the same principles as like pumps and fans, but instead of pumping a liquid fluid, we're pumping air. And we're taking that energy and we're kinetically imparting a lot of momentum, and that's what's going to pressurize the system.

So with these centrifugals, the air would come in on say the front face of it and then these things are spinning crazy fast, in some cases thousands or RPM, you know, 30, 40, 50,000 RPM, and as that air gets sucked in, it goes through and then it pushes it out. Okay? And then in this case, there's a couple stages here, so it might redirect this right back into the next one. It pumps it up a little bit more. Keeps doing that. Okay?

But, these are the three main types of compressors that you'll see within a manufacturing facility. Okay? But within most, you know, 80 percent of the world, we're looking really at these positive displacement, reciprocating and rotary screw. For really large facilities, again, that's where we start looking more at the centrifugals. Okay?

So, kind of understanding those three main types of compressors that we typically see, the next level of detail with all these compressors is really how they're controlled, and there's a couple basic methodologies. There's a couple different basic approaches for how these compressors are controlled.

So we're going to step through and just better understand the types of compressor controls that are applied to those various compressor types. Okay? So the first one that is maybe one of the easiest to think about is just basic on/off controls. Okay? So as your system pressure goes down, it flips a switch and says, "Hey, we need more air." The compressor turns on, and then it'll just keep going until it pressurizes the system up to maybe a maximum level and then the switch gets kicked again and it just turns things off.

These are the most common control that you would have on a reciprocating compressor. Okay? So this is, again, if you think back maybe to your garage, that little pancake compressor you have in your garage or your shop that's the methodology there. It kicks on when you need it, kicks off when you don't. Okay? And really, this is the most efficient way of running these things. Again, it runs when you want it, it doesn't when you don't need it.

The second type of control methodology is just load and unload. And really this is a very common methodology for our rotary screw compressors. Okay? This is one of the more common types of approaches here where it will load up and it will be producing air, but then when it unloads, essentially the motor's still turning. It's still turning the screws on the compressor, but it's not allowing air to go through. Okay?

And so it's – it's unloaded but it's still drawing a lot of energy and in some cases, it can be you know, 50 percent of the power drawn. It could be more than that in some cases. And in others, might be a little bit les, but this is a very common approach for how our rotary screw compressors are operated. This third one on here is also very common for our rotary screw, as well as this gets into centrifugals here, this inlet modulation, which really just it modulates the amount of air that gets sucked into a compressor. Okay?

And so in this case, in some cases, it's tied into this load, unload as well as another option, but it will continually modulate that little inlet valve to always allow just enough air to be going through continuously maintain the system pressure. Okay?

The fourth and this is one of the newer, but very common approaches now are our variable speed controls. Okay? And for our VSD equipped compressors, it, to a large extent, gets very similar performance ratings to the on/off controls because it allows the compressor to ramp up and ramp down, to just run at the point that it's needed. Okay? So it's not drawing a lot of extra energy to, you know, unnecessarily just turn the motor or produce air. Right? So VSDs or VFDs are really powerful and are very popular options.

Plus, the benefit of these things is they also provide a soft start ability, so for compressors that are constantly cycling on and off, you know, that does help our – the life of the motor and helps with the winding protection and everything in there. But the limit really on VFDs or these VSDs is that they can only go so low before they just don't work quite as effectively. So they can work all the way down continuously to about 15 percent of the motor load or the equipment output and then typically they'll turn on and off. Okay? So some different controls strategies across all of these.

So stepping in these just a little bit more. The start and stop, as I mentioned, these recips, this is the main one that we see there. Again, you might have a couple of these around your plant, maybe for some small demands. You might have it in your workshop at home, but the most common start/stop approach really is in reciprocating. There are some cases where we do see this in rotary screws, but I think we'll talk about this a little bit more in the next slide here as to how that works.

More often than not, because it's reciprocating, these are smaller systems, so we typically see them under that 30 horsepower range and because it is reciprocating and one of the reasons we don't see quite as many of the really large reciprocating compressors anymore in industry is because there's typically a higher maintenance cost associated with it.

All right, so our load and unload. Here's a very visual, where we were tracking a compressor over time and you can see at the high end, on our left hand column here, this is our horsepower. Okay? So this is the horsepower of energy being drawn by that compressor.

So when the compressor is loaded and it's pumping air out into the system, you know, it looks like we're a little bit above 125 horsepower being drawn, but once we've pressurized the system, okay, then it goes into this unload mode. So that's about right here. It starts to unload, and this is where we stop putting air into the system, but what happens is it doesn't turn off. In this case, this is for an oil injected rotary screw, so there's this blow down period, where it has to relieve the pressure in our oil, okay, and so that takes a little while.

You can see it just slowly ramps down until it gets down to a point where it starts to just level off a little bit, but if we look over here, I'm giving you a really deceiving chart here because that low load point, we're still above 70 horsepower. Okay? So in this case, we went from, you know, 125, 126 up here to a little over 70. So we're not even at 50 percent. We're still using a lot of energy when this thing's not producing any air for us. So that's – this is very typical in our load, unload.

For our rotary screws that also have load unload with an on/off, what that might look like is after it's down here and it's unloaded for a while, in some cases, this thing will turn off and that'll go all the way down to zero. Okay? And then when the system demand all of a sudden kicks the switch, "Hey, we need air out there," all of a sudden, this guy will come right back on, and that's where it meets up. It goes right back to being loaded. Okay?

So this is an option in some compressors, some of the rotary screw compressors that can be enabled, but it's still an issue that for a lot of these compressors, it can't go from fully loaded to just off. These things need a little bit of time to ramp down before they can fully shut down and that's, in many cases, a function of being oil injected. Okay, so we're trying to protect our motor, protect the compressor. So, this is a very common approach for these load, unloads. Okay?

Now, the next one that we mentioned was this inlet modulation. Okay? So inlet modulation valves can be used on screw compressors. They're certainly used on centrifugal compressors, but over here on the right hand side of the screen you can see one for a centrifugal compressor.

Looks a little bit like an iris of sorts where these little valves will be actuated on the top and then they'll turn to face this and so all the air will just pass right in. Okay? And then right here what it's showing is it's pretty much closed off. So this is to limit the amount of air that gets sucked into the compressors. Okay? With the inlet modulation, it does have kind of a range of applicability. It can typically modulate our compressors anywhere from about 40 to 100 percent, give or take on that bottom end there. Okay?

So, another very common approach that you might see within here. And if we look at this top right hand column or sorry the top right hand graph here, this is showing a pretty common pressure or sorry, the power versus capacity for a screw compressor. And in this case, it's showing two of them where where there's one here and then the second one is down here, and this is where we have one that has a blow down and one that has no blow down. Okay?

And this is really important because once we hit this 40 percent capacity mark, it makes a really big difference because you can see for what I would call a modulating compressor, where it just modulates across that entire range, even when you're not producing a single bit of compressed air for the system, that machine's still drawing 70 percent of its full load power. Okay?

So take an already bad or a very poor efficient machine and combine in the fact that you can't really turn it down too much. You're still drawing the same amount of air. You might really be paying through the nose to run some of these machines. So something to be cognizant of. Okay?

Now, the last one, a major control, is our variable frequency drives, or the variable speed drives, and this is essentially just turning that compressor to the point that it's producing enough air for the system, not more, not less. Okay? So it allows it to ride along with the pressure demands of the system and it's really the most efficient way of delivering air to our systems. Okay?

So the graph that we're looking at here is actually very similar to the graph we would look at for an on/off control where it's more or less a one to one type of an approach where you know, if you are at 50 percent capacity, you're using roughly 50 percent of the power that's needed. Okay? And then for this one, as you keep going down, I think I mentioned it on the previous slide, you get to a point where it can't continuously continue to, you know, just slow down. There's a point where it just has to turn off for a little bit and then it'll cycle and then on/off type of a fashion. Okay?

So, these variable frequency drives are really important and they're fairly strategic in terms of how you use them. In terms of the controls, if you don't have a VSD or if you don't have a system controller, almost all compressors have local controls that you would set and for most compressors, you would set a band as to, you know, when it should turn on and when it should turn off. So think of them as those little switches. You know, the pressure gets too low, a switch is going to flip and it's going to say, "Hey, we need compressed air in the system, let's start producing." Okay?

So, in this case, you know, if we're just looking at one compressor here, okay, you know, we might set this at let's say a hundred PSI, but you know, as it runs up and as it compresses air into the system and as the system pressure rises, you know, we'll get to a point where, okay, we don't need any more compressed air in the system.

In this case, you know, we have a ten PSIG higher, so at 110, this one kicks out. Okay? So in older systems, this is a really common approach in that we would just stagger these bands all the way down until a point where you know, we just can't go any lower. And in this case, this 85 PSI is really common for a lot of industries.

You know, that might be the absolute minimum requirement needed to turn our equipment, actuate the cylinders, things like that. And so this is a really common approach for those manual controls at each compressor. Okay? But what you can see is wow, there's a pretty big gap in there. There's a pretty big range and you know, in this case, it goes all the way from let's say a low of 85 all the way up to 110. Okay? So our system can be really bouncing around a little bit and you might be saying, "Well, what if we just - what if we just made those closer, you know, instead of putting this big guy up all the way at 110, what if we just dropped everything and made it closer?"

Well, I mean, that sounds great in theory, but if we're working on the manual controls what may happen is that these compressors start fighting one another and no one really knows who's supposed to be on. So, there are cases where you might get two of these compressors running at the same time, barely putting anything out and you know, no one really knows what's going on. So, that was a really common issue for a very long time.

So one of the changes that we're seeing a lot of are going to these networked controls or you know, that you might call them a smart controller or it's just automated controls with kind of a central computer that's doing the work for us. And a lot of these are really set up in the same way in that they are trying to maintain a single set point in the system and what we do to maintain that is allow the controller to pick which compressors to turn on and off at any given point.

So, you can see a difference in this one. Instead of having the, you know, those little I-bars scattered all the way across, we just have a single little band in here and we just let the system kind of track how to maintain that band. Okay? So this is a much better way of really controlling our systems and it also gives us some maintenance benefits, so being able to cycle through our compressors to make sure they're having even run times and things like that.

So, what does that look like in theory? And, you know, what are some of the other things to keep in consideration? So one of the big ones is really setting up our variable speed drive or our VFD equipped compressor to act as what we call the trim compressor, so it's always going to be the one that is trimming. It's going to be modulating to meet the varying demand of the system.

And here's a case or a really basic block drawing that shows, okay, here's how we step through the arrangement and run time of the compressors as our demand starts to go up and as it starts to go down. Okay? And so, what you can see here, this VSD compressor, it's always able to track and maintain. If you remember back to that previous graph, you know, it can go more or less down to zero. It has the best control. Okay? So we can go up and down. We can go up and down and follow it as it goes up and down, but then once we get to a point, you know, let's say right here, you know, we maxed out our VSD, so at that point, we can kick on one of our fixed speed compressors.

So that would be, that might be one of our rotary screws with a load unload control. Right? So we kick that one on. We just run it at 100 percent because that's going to be the most efficient for that compressor. Okay? And then we just still let the VSD go up and down, up and down to meet the needs. And then as it keeps going up, we might change. We might kick over to a different, maybe a larger compressor.

And so this is a really standard kind of a block diagram view of how these compressors might be staged, you know, as your consumption goes up through the day and as it come back down. So that way, we're really always maximizing and utilizing the most efficient compressor at every given time. Okay?

All right, so after we have created our air with our compressors and after we have figured out how to best control some of those things, you know, the next step in that system diagram is for the air to start going out to the system, but one of the first stops that it needs to take are our air dryers. And you might be asking, "Why the heck do we need air dryers in our system? Why do we need to be drying our air?"

And I mean, that's a really good question, right, because what happens is that for most of our facilities, there's a lot of moisture. There's a lot of water that is in the air naturally and as we compress that air, water is incompressible. Okay? And it stays in that air as it's traveling through the system. And as we compress air, it gets really hot. Okay? So that water vapor can stay in the air.

The problem is that at some point, that air starts to cool down naturally. It'll naturally cool down in your pipe and because we've compressed that air so much, it actually raises the dew point of our air, meaning that air can't hold that water anymore. And in this case, if we take 50 degree air as it enters the compressor and we pump it up to 100 psi, it raises the dew point up to 115 degrees. Okay? So if that air drops below 115, all of a sudden, water starts to condense and it starts to form, you know, water droplets in our system.

For most of us, we don't want that in our compressed air piping. We don't want it in our machines. We don't want it in our actuators, our cylinders. Certainly if we're spray-painting, we probably don't want it there. Right? And so we need to get it out because if we don't, it leads to corrosion issues. It leads to contamination issues. And so, strategically, we need to one, be able to cool the air, and two, we want to be able to dry the air to make sure we get that moisture out so we're not harming our system. Okay?

And so there's a couple different types of dryers that are used traditionally in manufacturing systems. The most common and probably the one at many of your facilities are what we know as refrigerant type dryers. These are really cheap to buy, for the most part, and they're fairly cheap to operate. They essentially work on the exact same cooling cycle that we used in our refrigerators, in our chillers, in the little AC unit to cool your house. IT's the exact same thing here, it's just instead of cooling our house or cooling the stuff inside of our refrigerator, we're just cooling the air down. Okay?

So, the standard operating procedure for a lot of these is that it will cool the air all the way down to 30 to 40 degrees F and that will knock out most of the moisture content in that air and then it may reheat it and then pump that compressed air or allow that compressed air to flow out into the system and it'll be nice and dry. Okay? These things are almost always air cooled, meaning they'll dump the heat that is created through this process. They'll dump that heat just to the ambient air. So if you have this in your facility, you're making your facility warmer. If you have it outside, you're pumping that heat outside. And so, you know, part of the placement of these things, okay.

A second type of a dryer that we see is something we have called as a desiccant type of a dryer. So, desiccant material really there's a material that's inside of this dryer that will absorb the water as air passes through it or by it, okay. The most common type that are in industry are something that we know as the twin tower regenerative dryer and essentially what is happening is that these towers are filled, it could be with a silica gel or kind of a ceramic or an aluminum type of material, but they're materials that they want moisture. They attract moisture.

And so as we pump our air through the system, what happens is as it goes up, the air gets dryer and dryer because the water's being sucked out of the air and it's being held onto by that desiccant material and then as it gets up out of the top and goes in our system, it's really nice and dry. In some cases, these desiccants are able to often get down to a negative 40 dew point temperature, which is great if you need that dry of air. Okay?

The problem with many of these things is that it's more costly. And you might be asking, "Well, why is it more costly?" Well, the problem is after this desiccant is all saturated, okay, what has to happen is we need to get that moisture out of the desiccant now. We need to get that water out of that desiccant and out of that system. We're not going to throw the desiccant away or anything. And so what we do is we have to regenerate it.

So while one side might be helping produce dry air for our facility, the other side is regenerating and typically what that means is we're taking compressed air in a lot of these cases. We're using some of the compressed air that we made and we're pushing that water out. We're reversing the reaction. So we're able to take that water and start pushing it out of the system and that regenerates our desiccant, so that way, it can cycle back through the next round to pick up and dry our air again.

So for these things, these two towers will just cycle back and forth. While one is being charged up or while it is absorbing a lot of water, the other side is being discharged, it's being regenerated and a lot of compressed air is typically used to do that. In some cases, it can be anything from 5 to 15 percent, sometimes even more than that of the compressed air that you generated with the compressor, that's just being poured through these guys to regenerate our desiccant.

So these things can be really costly. There is another version out there that might use heated compression r they might have little heaters on these. These things are a little bit more efficient. You know, they might be down on this five percent range, maybe a little bit less than that even if you're using the heated compression, but these desiccants typically will be more costly than our refrigerant styles when we're looking at the total cost of ownership. Okay?

All right. So now we know some of the major components of our system. We talked about the different types of compressors. We've talked about the dryers. And that's really all on the supply side. Okay? So that's really where we're making compressed air. There's a couple strategies that you can use on that side, but the other half of the coin 'cause really this is a two-sided coin here, one we can either produce that air more efficiently on the compressor side or we can figure out just how to use less air. Right?

And so, there's a lot of opportunities on the consumption side, on the demand side that really can play back and have some major impactful savings opportunities for us back in the compressor. So we're going to talk about a couple of these things.

So one of the most common, unfortunately, losses that we see are really purely in just leaks. I mean, this is kind of sad to say, but our systems degrade. The couplings start to get a little bit weaker over time and we just start leaking air out of our system all over the place. Historically, based on some of the DOE studies, we've seen upwards of 20, even 30 percent air loss just in the leaks. So you're compressing all that air and then, you know, a fourth to a third of it is just lost. It's unused air just lost through the system.

And personally I've been in facilities that have bene upwards of 50 percent, so 50 percent of the air that is generated at the compressor is lost in a facility and not used at all. And if you remember back to that first couple of slides, I mentioned these systems are terribly inefficient to start with, so if you're generating a lot of air at let's say five percent efficiency and then you lose 50 percent of it, what does that do to your overall efficiency here?

So paying attention and really trying to zone in on leak loss is one of the biggest paybacks that you can get. The diagrams or the pictures that I'm showing here are some of the common tools for this – for finding and evaluating leak loss. These are known as ultrasonic leak detectors. Essentially they listen for a frequency, you know, as air comes out of a hole, it produces a sound, and these little devices, you know, you can point them around, you can be using them in a really busy or a loud environment and you can point them towards general leak loss areas and you can start to zone in and identify things even when you can't hear just with your ear itself, these devices allow you to really zone in and find these opportunities.

So these are fairly cheap to purchase. They're really easy to use. If you're a Better Plants partner, we have a lot of these that we can, you know, lend out so you can be looking for these. That way, ideally you can identify the leaks and reduce that leak rate. If you can get down to roughly a ten percent leak rate in your facility, that's actually not too bad. That's a pretty good low level of leakage in a facility. So, this is a major opportunity, this leak loss and identifying it.

Here's a chart that you can refer back to later, but essentially what this is showing is the level of leak loss through various sized holes, you know, everything from a really, really tiny one, you know, 1/64th of an inch all the way up to you know, a quarter of an inch is huge, you know, three eights of an inch is deafening. Okay? But it shows the SCFM, the standard cubic feet per minute out of each of those holes based on the system pressure that you might have.

And one of the things to really note here is that as your system pressure goes up, you know, so if you're running the system at a really high pressure, you're also losing a lot more through your leaks. Okay? That's something that's known as artificial demand. So, really if we're able to reduce our leaks, if we're able to fix them, in some cases, it's almost like a double win for us. So, really important, really important to be looking for those things and fixing them as much as possible.

Typically what we've seen and experienced over time is there's three really good ways of doing this. One is just having a routine standard operating procedure maybe where you do a bit of a maintenance walk and this could be as the last guy is leaving the facility before you shut it down for let's say the weekend, right, or on the weekend, you know, have somebody walk around and if the facility's not running, you know, a lot of times you can just – you can hear these things as you walk through a facility. If your facility's never off, if you're always running, then that's where these ultrasonic leak detectors can make a big difference because you don't need the facility to be quiet to all of a sudden start finding where those leaks are at and trying to figure those things out. But a maintenance walk is one really excellent way of identifying these leaks.

The second one is starting an employee tagging program where you enable employees to identify some of these leaks and tag them and feed that work order back into the system. And you can set these things up such that, you know, it could be a bit of a game or a competition within your manufacturing facilities. There are some companies that we've worked with that have really turned this into an internal competition and have made it fun and there's some prizes associated with it even because even small leaks cost big money. Right?

And so, you know, the folks at the end of the line, they happen to be where most of the leaks are at. Okay? And so, they are probably the best ears and eyes and hands on the ground level to immediately identify and tell you, "Yeah, it's been leaking like that for the last couple months." Well, if we would have fixed it, we would have saved thousands of dollars. You know?

The third way of looking for leaks is doing something we call bleed down tests and this is really possible only when your facility is not running. In some cases, this might be on a weekend when you don't have anything operational. It could be during a maybe a lunch break or something or a shift change if it's long enough where you can essentially bleed down the system and then make some estimates as to the volume and how much leak loss you have in your system. So, it's another really powerful way that you can be looking for leak loss. Okay?

So, another major opportunity on the demand side is really trying to understand where we're sending our compressed air or where are we using our compressed air and asking the question, why do we need compressed air instead of something else, knowing that our compressed air systems are one of the most inefficient processes, do we really need to use compressed air? And there's a lot of cases where you don't need compressed air. You can get by with something different and more and more, there are more opportunities now that you can be swapping equipment out for electric driven options instead of the traditional compressed air.

So a couple of these really inappropriate uses, I mean, these are bad uses of compressed air, one is cabinet cooling. Another one is liquid agitation or stirring. Maybe you have paint or something or water tanks that need to be agitated. Compressed air is not a good way to do that. Vacuum generation, maybe you're operating some suction cups or something, unregulated open blowing, so blowing off parts. This is incredibly common all over the place, but then air motors and atomizing are two more what we would call standard inappropriate uses of compressed air. You see them all over the place.

There's a couple pictures over here on the right. These are essentially all unregulated open blowing. You know, and these cases, they're just the end of a pipe, right. And so there's major opportunities to maybe not use compressed air in some of these cases. If we're trying to just blow off chips or maybe remove some water, a lot of times, some of those things can be accomplished by using just a fan or a blower.

You know, think of maybe the hand dryer when you go into a bathroom. More and more, they have – what are they, the Dyson hand dryers. It's just a high-pressure fan that's blowing a lot of velocity. It's blowing a lot of air to remove the water from your hand. In some cases, you can do that for chips or water from parts. Okay? So there are much more efficient, much more effective ways of doing some of these things. But it's asking those questions.

Some other things, you know, vacuum pumps are much better than using compressed air to then create the vacuum. And electric motors. Electric motors maybe for stirring things or hand tools are another excellent example instead of using compressed driven hand tools, going over to electric driven tools.

They've been making pretty big bounds, leaps and bounds towards better equipment on that side. In some cases, you know, equipment that can be feeding back data to you on a regular basis so you know what the impact or torque on any given screw might be. Right? So you know right away if you're going to have a defect part or something that might have some issue. So, some other benefits to switching away from compressed air.

So, another big opportunity within our compressed air systems, which it's definitely related to the demand side, but its impact is felt on the generation side, are lowering our pressure set points of the system. So what does that mean? It means really dropping the entire system pressure to the lowest possible point without impacting equipment. Okay? And the reason that this is such a big opportunity is because of the savings potential. For every two psi that the system pressures drop, it's about 1.5 to 2 percent energy savings. So it's almost a one to one savings in some cases.

You know, if you drop one psi, you can expect one percent energy savings. That's not only from just the compressed air generation, you know, based on the physics of compressing air, but it saves in that legal loss rate that we had talked about a few slides earlier, and there's some really big impacts by just slowly ratcheting down that pressure. And a lot of people struggle with that concept because over time, you know, somebody had raised their hand and said, "Hey, I'm not getting enough air pressure over here. My piece of equipment's not working." And the typical knee jerk reaction in most of our facilities is okay, well, we'll just increase the pressure over at the compressor. We'll just jack it up through the roof. It says it goes up to 125. Just set it there.

The problem is, we really pay for it. We pay through the nose in some cases. And in a lot of cases, we never address the root cause of why that person or why that process was seeing low pressure. In some cases, it's just pressure drops through our system, so our dryers start to foul up or our filters definitely foul up. It could be piping, you know.

One really common bad use case that we see is when somebody needs compressed air, you know, you take that big flexible hose, you know, the big red one and you plug it up there and there's about 80 to 100 feet of extra hose that's just coiled up on the ground and then you know, you're – I don't know, you have a little hand tool at the very end of it and you're like, "Oh, I can't get enough air through this thing." Well, that's because you're trying to suck a ridiculous amount of air through 100 feet of tiny hose. Okay? That's a major pressure drop.

In the world of compressed air, sometimes we joke about it being the last dirty 30, you know. You might have a 30 pound pressure drop across just a ridiculously long hose because people just don't know better. Right? And so the knee-jerk reaction is not necessarily to just put on a shorter or a fatter hose. It's, "Well, I'll just raise the system pressure higher. Okay, and that'll fix it."

Well, it does, but again, you're just paying for it all over the place. And so those are really common. Things that are a little bit more uncommon though are areas where you actually do need a higher pressure. There are a couple processes where you might need 100, 110, 120 psig, but more often than not, most equipment, most of the equipment that's designed and sold nowadays, it's rated for 90 psig. In some cases, it's rated for less than that.

There are pieces of equipment that you can get hat operate effectively at 60 psig. So the lower we can reduce our system pressure, the better. And so for those areas where we really do need high pressure, really it's maybe looking at modifying how we are delivering compressed air to that one thing. So if there is a high pressure need amplifiers or boosters are a really effective approach. So instead of increasing the pressure for everybody, you know, for that ten percent use case, let's compress it a little bit higher for that one time, that one process or piece of equipment.

And some of these other cases where it might be a system issue, you know, of dirty filters or kind of this piping issue, then it's just a question of, well, can we do this a little bit better and honestly, one of the most common and best ways to zone in on what's your lowest pressure point, right, is, you know, week after week, maybe just knock down that pressure point just a little bit, you know, maybe one or two psi and after a couple weeks, you'll get to a point where all of a sudden, somebody does raise a hand and say, "Hey, I'm not getting enough air over here. I'm having issues."

And that's a really good opportunity 'cause one, all right, we know the lowest system pressure that we need and we just bump it up just a tiny bit, but then we can investigate that one piece of equipment or talk to that one operator who's not getting enough air and we can zone in to see, okay, is it because you have 130 feet of the little tiny hose? Or is there something else going on? Why does your system not, you know, why can't you accept the pressure that's being delivered.

So, this is powerful. Again, all because it comes back to that one and a half to two percent for every two psi. So these are big.

So, another common opportunity here, and this is where we're moving back towards the compressor. Okay? Another common opportunity is to relocate our compressor intake, so where we're sucking our air that we're going to compress, move that to a cooler place. Okay?

So in a lot of cases, especially up north, drawing in outside air to compress it because for most of the year, the air outside is going to be a little bit colder, a little bit chillier, a little bit more dense than the air inside of our facility. And then just figure out the strategies on when you draw from outside, when you don't draw from outside because there are a couple compressors that if they are exposed to freezing temperatures, you might run into some issues so you might need to dilute the air a little bit, but at the end of the day, if we can compress cooler air, it's better because that cooler air is slightly more condensed or is more dense. So nature's already compressing it for us a little bit. That means our compressors don't have to do quite as much. Okay?

So some really good strategies on that front. These are typically really simple to implement. Could be just a little PVC pipe that goes form your compressor inlet out the wall to outside. Okay? So, some really simple things.

All right, so another very simple, very common opportunity that exists in a lot of the systems is going to a no-loss drain and these are typically in our distribution systems. They might be at our really at our dryers or at our tanks where there's condensation that's occurring and water's dropping out of the system and the historical thing that was used for a very long time are just these interval based timed dryers, so every five seconds or every 30 seconds, it just blows compressed air and it blows all the water out and it's fairly effective, mostly costly because it just wastes a lot of compressed air.

The newer technology that's been on the scene for quite some time now are these no-loss drains and they essentially work on kind of, in a lot of cases a float type of approach where you know, it is based on the liquid level, so as liquid collects in an area, it will wait for the liquid to get to a certain level and then it will push the liquid out without using compressed air that gets blown out of the system. So this is a really common opportunity and a really simple opportunity. And if you get really smart, you actually have some of these things tied in with some alarms or reports that get kicked back on pieces of equipment. So really good opportunity for the drains.

Another major opportunity is recovering waste heat and this is really only for our air-cooled compressors, which are most of them, probably most of them in your facility, but these are a little bit trickier because all of a sudden now we're starting to talk about ductwork and how we're going to maybe arrange or get air pushed around our facility, but if you remember back to the very first couple of slides, you know, what's the efficiency of these systems? Well, maybe five percent efficient. Right? Where is most of the electricity, what's happening to most of that electricity that comes into our compressor? Well, 80 to 90 percent gets turned into heat. Okay?

So if you want to be efficient with a compressed air system, you need to figure out how do we capture that 80 to 90 percent of the electricity we paid for, how do we use that effectively. Well, for a lot of us, the simplest and most effective way of capturing this is to duct that exhausted right back into our facility, so during the wintertime, instead of running your steam system, instead of running a hot water system or make up air units, or anything like that, instead of burning natural gas, we're taking the energy, the electricity that we already paid for and we're just going to duct that right back into our facility to heat our facility. Okay? And that's a super effective way of doing this. Most of these are set up where they have a damper so when you don't need to heat the facility, the damper switches positions and it kicks that heat outside. Okay?

So this is one of the most simplistic ways of capturing that waste heat. There are other more complex ways of doing that. You can potentially heat water with some of these things. If you have a hot water need within your facility, maybe for washing parts or maybe you have a large domestic need, you know, you can set these systems up to generate hot water instead. Okay? But this waste heat recovery is something to think about, again, because 80 to 90 percent of the money that you put into this thing just gets turned into heat, which for the most part, most of us just dump right outside. Okay?

So here's a second example of that waste heat. The first one on the previous slide was in terms of HVAC heating, so heating our facility. This second one is setting it up for water, so heating our water. In some cases, we can even get up to 180 degree water. Really, these are best situated if you need that year round. Okay? 'Cause there is a little bit more of a capital cost in terms of getting the right heat exchangers in there.

All right, so we talked about the overall system, okay, in terms of the types of compressors. We talked a little bit about the end use and some of the opportunities from limiting leaks to the no loss drains. We talked about some of the control strategies. Well, for a lot of us, you know, that's a lot of moving parts. How do I pull this together into something that I can take action on? And that's where DOE has really spent some time over the years and has some nice, effective, streamlined tools to help us to understand what are the opportunities and what are the cost savings for this stuff.

So the main tool that I want to point you to and call out here is the AIRmaster + software tool. This allows us to do modeling on our system, so it allows us to create a model of your compressed air system and then it allows us to go through and do the what-if analysis of if we were to change our control strategy or if we were to reduce our system pressure or if we reduced our demand or leak rate, things like that, you know, what does that mean in terms of dollars and cents because for most of us, that's the most important piece.

So this AIRMaster tool is excellent. It's out on the DOE website completely free. A lot of capabilities in here. There's a second tool that goes along with that AIRMaster tool and that's known as the LogTool. And the LogTool really is set up to help us transform our utility data that we get from loggers, so really logger data, and we'll transform it. It helps us to do some of the quick energy analysis. It's specific to AIRMaster.

This LogTool helps us to take again that logger data, which we might have five second data off of our compressors and we want to convert that. Maybe what's our day type look like? You know? What does that compressor profile look like each hour of each day? This tool is set up to be really slick so we can just dump in our logger data and then pretty quickly turn around and spit out the inputs for AIRMaster. So this is also free. It's up on the DOE website.

The third tool that at some point is going to really gobble up and replace AIRMaster and that log tool is what we know as our MEASUR software tool. And we're going to talk quite a bit more about the MEASUR software tool in I think some of the upcoming webinars, but this software tool is really the newest version of the DOE's effort to consolidate all of the software tools under one common framework. Okay?

So right now, we have most of the various systems that you'd fine in a facility within here, so everything from pumps to fans to steam and process heating. There's a module in here for doing your own treasure hunt. Okay? Here before too long, we're going to roll in that air master functionality, so compressed air systems as well as that log tool functionality.

And so this software tool is set up to help us analyze each of these systems so it can help us to set up a system model and then just walk us through the ability to do the what-if analysis to see what the energy savings are for changing any of the variable parameters. In addition to those system modeling capabilities and analysis capabilities, this software tool also has a lot of small calculators, so I think there are roughly 45 to 50 small calculators in there currently and that is being added onto every day, everything from you know, calculating what's the loss of a compressed air leak, how do I measure that, or you know, what are the system sizing calculations that I need to do that leak down test. Okay?

There's some motor equipment calculators in there if you need to be able to estimate what's the motor load of a motor. Okay? There's lighting calculators. There's unit converters. There's a lot of small things, but this is going to be one of the software tools that I think we're going to focus on a little bit more. Again, similar to all the DOE stuff, completely free. Really powerful. Really powerful stuff.

So, we're getting close to the end here, and so I just wanted to give a little bit of a recap as to, you know, what we had talked about and some of the things to think about. Okay? So of the energy saving possibilities, I want to list out the top five here just to recap it.

So the first and foremost is looking at the end use of where you're using compressed air and questioning do we really need compressed air. Do we really need a system that is five percent efficient to deliver our compressed air for this component or can we do something else? Is there an electric alternative. Okay? And so really trying to eliminate some of those inappropriate uses. You know, does Fred really need to be blowing himself off with compressed air to cool himself down? Right? Can we get a fan? Can we get something else to help him out? So questioning why are we really using compressed air.

And then as we start to work back out towards the compressors, minimizing our compressed air leaks, as hopefully you recall, 20 to 30 percent of most system air is lost through leaks. So there's a big opportunity just identifying and reducing leak rate. And then as we keep going, lowering the system pressure to the minimum level allowable, okay, so working overtime to reduce that compressed air pressure.

Again, it's that two percent savings for every two psig. Okay, so that's real money and so we want to try to zone in and lower that level as much as possible and then when people do start screaming or when processes start to scream, you know, asking questions, okay, what – why? Why is there not enough air there? Is there a pressure drop right before that? Is there something else going on? Okay?

And then number four, so lowering our inlet air temperature. So maybe ducting in outside air to compress that instead of that hot compressor room air. Okay? I've been in many compressor rooms and I've even seen people drying their laundry in there. It's nice and toasty. So can we get cooler air to compress instead of that hot air? And then the last thing is you know, for the compressed air that we are putting out in the system, are we providing the right quality of compressed air. Okay? So this really gets to the types of dryers that we might be using, those regenerative dryers, those desiccant dryers that we talked about, you know, they might be using five to fifteen percent of the compressed air just to regenerate, so you're wasting all that air right there. Can you get by using a refrigerant dryer? Okay? So, some of these questions on the strategy that we're using and what's needed out in the system.

So these are the top five and these are a little bit more simplistic. We can go, you know, beyond this and then we're starting to talk a little bit more well, okay, the control strategy and what compressors we're using, things like that, but these are the simple ones to really start with, to really wrap our mind around. Okay?

And so I have a couple rules of thumb, just to kind of log into the back of your head because these are powerful. These are really powerful when it comes to compressed air. So the first one is lowering the compressed air set points by 2 psig results in this case approximately 1.5 percent savings. In your facility, it might be more, it might be up to 2 percent, might be a little bit less, but this is – this is pretty close to what we see very commonly.

The second item is lowering that compressed air inlet air temperature by ten degrees will result in approximately two percent savings. Okay. So if you – again, if you think about that, that room where all your compressors are sitting and how nice and toasty warm it might be, if we can just suck in air from outside, most of the time, that's some real savings as well. Okay? The third kind of rule of thumb here is this 80 to 90 percent of all the electricity that you paid for is going into heat and you know, as we think about that, is there a way that we can reuse that? Is there a way you can pump that back into your facility, especially during the wintertime.

You've already paid for it. Is there a way you can use it somewhere effectively? And then these last two, these are combined here, okay, but they go to the inefficiency of compressed air in many cases, so for any facilities that might be using a compressed air driven motor, maybe a little motor that you're using to stir some paint, right, one horsepower, a one horsepower air motor requires roughly seven to eight horsepower back at the air compressor. So, I mean, this just further drives at that inefficiency aspect of things. Okay?

So, that's not a – not something to gloss over. Okay, so if we can replace a one horsepower air motor with a one horsepower electric driven motor, you know, there's a big delta there, because currently if you're using that one horsepower air motor, you need seven to eight horsepower back at the air compressor. Okay. So big things.

And then this last piece is really that one horsepower air motor, just so you know, needs about 30 scfm at 90 psig. Okay? And if you're using a higher pressure, you're using more air through there. So some really good rules of thumb just to keep in mind and have close to you as you're thinking about opportunities in your system.

So, as with many of the system areas that we look at within the Department of Energy, we have a lot of tools. We have a lot of resources and there are training opportunities associated with it. Some of the best ones that we have are listed here. Everything from a source book, so if you want a little bit more information about compressors or dryers or the strategies, the source book is kind of an all-encompassing resource to go look at, but beyond that, we have some really practical and useful resources, these Better Plants energy treasure hunt info cards or the cheat sheets of the data points that you might want to look for. You know, they're spelled out within these cheat sheets what should you look for, what's the data that you need.

So these are really good. If you want some more information on the efficiency or efficiency opportunities, we have these tip sheets. There's these best practices. If you want or are looking for more hands-on type of training, we have these better plants in-plant trainings as well as the compressed air challenge folks have classroom trainings that they do all around the year that are really good.

And then finally in terms of some of our software tools, again, we have that MEASUR tool, which is really pretty fantastic all around and then we have the AIRMaster and Log Tool, which are just incredible for modeling and analyzing our compressed air systems.

Before we end today, I'm going to leave you with a couple bits of homework. Okay? So, we went through all the compressed air information, right, and I want you really to be thinking about your compressed air system and I'm zoning in on three different opportunities. Okay? So one is identify what is your compressed air pressure set point. What is the system pressure in your compressed air system at your facility? So that hopefully would be a fairly simplistic one to think about.

And you know, if you remember, the next step would be to think about well, can we lower that at all? Okay, so that's homework number one. What's the system pressure?

Number two, try to identify five leaks. It sounds like a lot. It's not really that many. I suspect you probably have quite a few more than that in the system. So, you might not even have to look very hard, but try to identify five leaks in your system. If you can tag them, great. If you can take a picture of them, great. But see if you can identify five. Okay.

And then a third item is see if you can identify one application where you're using compressed air that you might be able to use something else. You know? Try to identify one inappropriate use of compressed air. Maybe you use compressed air to blow off parts, right, or to clean parts. Maybe you're using compressed air driven motors. So, think about that. See if you can identify one.

Okay. So, those are the homework pieces of this week. We're going to open it up to questions here. If the – okay. We're like I said, we are opening it up to questions and if you have any, for most of you, there's the go to webinar software up probably on the right hand side of your screen somewhere with a little chat and question box. Feel free to put it in that way. Alternatively, if some of you have been super isolated and just really wanting some human contact and to talk, you can virtually raise your hand and we can see about unmuting you. Okay.

And so, again, type in any questions and I do want to put in another plug for what I said and what Eli was saying at the very beginning, if you want these to continue also put in or enter in some of those ideas or topics that you might want to hear about in the future, whether that was some of the DOE tools, whether it's other system areas, learning about some of the fundamentals there or any of that stuff. Please, we're really interested in seeing some of that stuff.

Okay, so let me jump into a couple questions. I see that several have come in here. I'll try my best to get to a couple of these.

All right, so one of the questions that has come in is in regards to really the ratings of some of these things. So Angel, you've asked what is the typical horsepower per CFM in a screw air compressor. So I'm not going to answer that directly but I'll give you a slightly different way that I typically approach had most of industry approaches these things. So instead of horsepower per CFM, a lot of the main players in industry rate them in terms of kilowatts per hundred CFM. Okay?

And so the standard or I would say maybe the rule of thumb for that is roughly around 20. So give or take, some of the compressed air technologies are less than 20 kilowatts per 100 CFM. Some are a little bit more. Okay? It just depends on the technology. And I would point you to a really good resource, the compressed air and gas industry, CAGI, C-A-G-I. They have a database or they have data sheets that a lot of manufacturers have filled out and they're up on the website and so you can really you can go out and see, you know, what or you can pull up the data sheet for your specific type of compressor and you can see, you know, what the manufacturer says is that kilowatts per hundred CFM. But again, that rule of thumb is right around 20.

A different way, if I'm going to flip this for you, another way typically when estimating the output of these compressors is that a lot of compressors are right around the area of generating 4 CFM per horsepower. Okay? Again, that's one of these just rules of thumb, so some are a little bit less and some are a little bit more, but it's right around four. Okay? So four CFM per horsepower. So if you have a hundred horsepower motor or a hundred horsepower compressor that you're walking up to, chances are in the back of your head without even looking at the nameplate, it's probably putting out or it has the ability to put out right around 400 CFM. Okay? So, those are just some rules of thumb for you. Okay?

So, let's see here. Another question that has come in, what's a typical value of cubic meters or consumption for any specific industry? So Ivan, can't give you a real good rule of thumb there. In my world and in the idealized world, it'd be zero, right, because of how inefficient these systems are, but I would point you to, again, a couple of these resources. So that CAGI group, the Compressed Air Gas Institute, they have some – they have a handbook with some standard consumption values by end use.

Similarly, the DOE has their compressed air sourcebook, which you can also get through the compressed air challenge, and they have some really good information in there. But it varies widely by industry. Perhaps another resource even you could check out is our DOE plan energy profiler, which does have some 50,000 foot level estimates by different industries. Okay. So, let me see.

Another question that has come in here, do air leak programs save energy when using load and unload compressors? So, absolutely. The answer is absolutely, 100 percent yes. Any chance you can reduce compressed air leaks in your system, you're going to save energy and especially with load and unload compressors.

Now, with that, I'll open a can of worms here just slightly for the small percentage of the population that has centrifugals, if you have a centrifugal compressor, there's a very small chance that if you reduce our air leaks, you might not save energy, and that's because centrifugals are a slightly different beast in that they will go into a blow off mode when they get too unloaded. And so the long and short is you should still be correcting your leaky system. You should still be fixing leaks all the time, all the time.

But, if you have centrifugals, you just have to be a little bit aware that you're also going to have to maybe figure out some other strategies and there's chances are if your system's not able to respond and you're blowing off and you're not seeing that electricity savings, you've got major opportunities with how you control the system. Okay.

Let's see here, Annand, it looks like you've hit us up with a couple questions here. I'll see if I can get to one or two of them. Are there any viable electric diaphragm pumps that would be good for replacing the pneumatic diaphragm pumps? So, Annand, there are some that are out there. Right? I don't think a lot of people are jumping in that direction just yet because I suspect similar to you, they don't realize they exist or are a little hesitant for some of them. But they are out there. I'm not going to give you any vendor names since we're DOE and we're very technology and product agnostic on that front. So, there are a couple out there though.

And similarly, Annand, it looks like you are asking about moving away from the pneumatic mixers and stirrers, so that you can move them around, so perhaps you have, you know, the 55 gallons of paint or lubricants, things that need to be mixed, right, and I would say Annand, there are electric replacement options that are closed, non-spark systems so you don't have to worry about that.

And ultimately, you're dealing with the same level of like connection points, right, where you're either delivering electricity or you're delivering that compressed air through a line of some sort. You know, with that said, obviously for electric safe systems, there are much higher safety standards, so there's going to be a premium cost for some of that stuff. Right?

Let's see here if I can get to another one. Sorry, folks. I'm trying to read some of these here. Let's see, the top five, were those arranged in any highest or priority benefit type of levels. So JP, I don't – not really. What I would say with those top five are really those are some of the starting points of being able to think about some energy savings in your facility. There are a lot of options that exist in terms of enhancing the efficiency of our system and I would say with compressed air, you know, always start with the things that are easy for you and so just whatever's easiest. Right?

And for most of us, you know, one of those items was that leak rate reduction and I would say that's probably the one you want to start with, but truly, there's no priority in there. But I would say in a lot of cases and compressed air certainly fits this, if you start at that end use, you know, where it's being used, you start there first and you try to reduce your consumption, that savings cascades in a major way through the system.

So if you only have limited time, start at the end use and then work backwards towards the compressor. I think a lot of us generally have the inverse mindset of well, we'll start with the compressor or we'll start with the motor, you know, right. And then we'll go to see where we're using it and typically you end up spending a lot more money that way whereas if you start on the inside, you start at that end use and then you work out, then you're really going to see some of the magnified savings opportunities.

Okay. Let's see. The sonic leak detection tool that I had mentioned, what's the typical leak detection range and so Reed sent this one in. Really, it varies from manufacturer to manufacturer, but my experience has been that you can be pretty far away. Like, you can be shooting at ceilings that are upwards of 30, 40, 50 feet in the air and you can be hearing some of those and seeing, visually seeing some of those leaks with the pieces of equipment.

So, the standard one and we have this in our tool chest, so if you're a Better Plants partner and you want to test out some of these ultrasonic leak detectors, you know, reach out to us. We'll send them to you, but they look almost like a little, you know, gun of sorts and some designs are a little bit different. It looks like a little tablet almost. But you just point it around and you might even be able to wear some headphones with it so you can see the decibel reading and you can hear it and it's not uncommon to be able to pick these things up, you know, really far away.

Now with that said, if it's a pinhole leak, right, if there's a really tiny leak coming out of a connector or if you just have some threaded pipe that's not sealed and there's just a really tiny leak, you will need to get a little bit closer and with these things, as you get closer, you start turning up the sensitivity and so you can really zero in on some of those.

So, with that, you know, those are the standard or at least the old type. There is a newer version of leak detector that really visualizes it as well, so it almost looks like a thermal imaging type of leak detection system. And it looks like Annand has asked about it. We do not have one of those yet, but Annand, once we do, you can be at the top of the list for borrowing it.

But these leak detection programs are really important. Everyone, you know, everyone likes to talk about, well, we're focusing on the low-hanging fruit. You know? This is leaks, especially, are low-hanging fruit. The problem is, and you need to remember this, low hanging fruit always grows back. Leaks are always going to be present. It's always going to be a battle for picking them and cleaning them and all of that. And so, for low-hanging fruit, the mindset is really you need a standard operating procedure. You need some systems in place. You need processes in place. It's not a one-time deal. You need to keep going back out because that fruit is constantly, constantly growing. Okay?

And it looks like John, you just sent something in kind of following up here saying that you all, so John is I guess I won't name your company here, but major manufacturer, an auto manufacturer. They found a significant natural gas leak in their iron while they were looking for air leaks. Okay? And so, you know, that is a great example that these ultrasonic leak detectors are not just useful in compressed air systems. They're useful in any compressed gas system. So, natural gas or compressed nitrogen if some of you have those or argon or you know, the welding areas. Right? So, these things are fantastic for all of those. So John, thanks for sending that really good example in here.

Let's see here. I've got to search through. A couple people have asked about the imager. Let's see here. So Pranav has sent in a question, can you confirm how we can get classroom training with COVID? And so, Pranav, I want to say that right now, DOE, we've been actively trying to figure out how and what we want to – how we want to proceed with things, right, and so I guess there's a couple resources, especially you know, in the grand scheme of things, that you might want to think about.

So obviously we have our online series and hopefully all of you are enjoying them and coming back week after week, but in addition, you know, through the Better Plants program, we also have our summit coming up this summer about a month from now and that's going to be virtual. Okay? And so that's going to be I think a stellar event. It's free. So you know, please find some time to jump onto that. But then, you know, beyond that, in the COVID world that we're living in, we're playing it day by day. So we don't know.

The Better Plants program, we're planning on hosting kind of a workshop focused on these fundamentals down here at Oak Ridge in August. That may or may not happen. Better Plants typically we partner and have something at the Association of Energy Engineers, a big event, their world event in the fall. If that's in person, we're going to be there. Right? But there are some other really good resources like that, you know, AEE has a lot of really good things, but right now, Pranav, there's not many classroom trainings being offered, but certainly once the world starts getting back to normal, you know, we'd love to help you a little bit more or at least point you in the right direction for some of this stuff.

Let's see here. Were there any others? Oh, Pranav, it looks like you also sent another question asking about if you're in kind of the southeast area where it is really hot and humid and it looks like you're coming from South Carolina, is it a good idea to be ducting in that outdoor air?

And I would say what you probably want similar to the setup that most people have on their compressed air exhaust or their heat exhaust, you know, you probably want a diverter that season by season you can flip it, so it's kind of like an economizer. Right? Where you know, for the heat typically we pump it into our facilities in the winter and capture some savings that way and then in the summer, we'd reverse it and we want to pump that heat from the compressor outside. Well, likely it's similar setup what you want to do on the air intake where maybe during the winter or cooler months, you can be drawing in that cooler outdoor air and then during the summertime, you can duct from the indoors, but you've got to realize that you are going to be, you know, paying for the conditioning of that air and so there is a little bit of a give and take there.

Okay. And Kurt, you did send I a reminder here that the CFM per kilowatt or the horsepower per 100 CFM are greatly affected by the output pressure and Kurt, you're absolutely 100 percent right. And for folks that are really interested in some of those dynamics, really, you want to dive in a little bit deeper, I'd really point you to some of the resources that exist either through the Better Plants and that sourcebook or our in-plant training. If and when we get back to normal times, and we're doing in-plant trainings, we really go into a lot of depth with some of this stuff. In that Compressed Air and Gas Institute, they have some really great handbooks as well.

So, let's see. I don't know if I can keep up with these. You folks are really good here, though. I appreciate it. Prasath, it looks like you've sent a couple and I might take some of these offline with you, but earlier, you asked if we were having a poll and can you have some of the trainings and case studies for the new technologies such as heat recovery and whatnot.

And you know, Prasath, maybe I'll use this as a little bit of our parting ways here. You know, the Better Plants program has a really great resource. We call it our Better Buildings, Better Plants Solution Center and the solution center has a thousand plus different write offs of really case studies on what other companies are trying, in terms of projects and practices, okay and there's a lot of really good things that are already out there that you can learn from your peers and some of those things are hopefully going to be some of the topics at our virtual events coming up here.

So I would really recommend and point you to go check out that solution center. We have a lot of really good write-ups there. Many of you that are listening and you know, the companies that you represent have, you've done great things and you've captured some of that stuff in the write-ups.

So, I really would point you to that resources and check out some of the things. But then, maybe as a way to wrap this up a little bit more, you know, if there are specific topics, again, I'm going to hit on do we want to continue this, what do you want to hear about? Right? What do you want to hear about? Send that stuff in. You can either do it here, you can afterwards, you can send a note to me or others or directly to the DOE guys. You know, what do you want to hear about? What do you want to know about? What do you want to learn about?

And we're going to try to be as responsive as possible to, you know, hopefully help us through these rough times that – or maybe not rough, but very abnormal times that we all are in right now. So, with that, Eli, I don't know if you're still there or unmuted, and if you want to say anything closing thoughts.

Eli Levine: Just to acknowledge that you haven't lost me. Thanks. It was great to see everyone's active participation here. Really good session, looking forward to seeing everyone next week for Sachin talking about water efficiency.

Tom Wenning: Yes, my colleague Sachin. He'll keep you all awake. I may have lulled you to sleep but he'll keep you awake for sure. So, with that, thank you everyone. Really appreciate you stopping by. Have a great day. Stay safe. Stay healthy.

[End of Audio]