Operator: The broadcast is now starting. All attendees are in listen only mode.

Ryan Livingston: Hello, everyone. Good afternoon. Thank you for joining our webinar today. I wanted to introduce myself. My name is Ryan Livingston, and I support the U.S. Department of Energy's Federal Energy Management Program and the Better Buildings Initiative. Today, I'll be your moderator.

Once more, I'd like to welcome you to this June 2019 edition of the Better Buildings webinar series. In this series, we'll be profiling the best practices of the Better Buildings challenge and alliance partners in other organizations working to improve energy efficiency in their buildings. We'll move to the next slide.

Specifically today, we are going to discuss opportunities to improve air management in small and medium-sized data centers. Research has shown that nearly half of all data center IT equipment resides in small or medium-sized data centers. These data centers face unique challenges, but also have immense opportunity to improve air management, thereby reducing infrastructure and energy costs.

Although this webinar is focused on small and medium-sized data centers, the *[break in audio]* and principles _____ ____ could apply to any size data center. Today's webinar will focus on practical solutions for air management in small and medium-sized data centers. Our discussion will focus on air management techniques, practical application, and what we've learned from Lawrence Berkeley National Laboratory's Center of Expertise on Energy Efficiency in Data Centers, and from goal achieving Better Buildings Data Center Challenge partner Sabey Data Centers.

Before we get started with our presentations, I wanted to remind the audience that you will be holding your questions until the end of the hour. Throughout today's webinar, please send in your questions to the chat box on your webinar screen. We will try and get as many of them as we can. Also, today's webinar will be archived and posted to the Better Buildings webinar series webpage for your future reference.

So, I'm now pleased to introduce our fantastic presenters for today. Our first panelist will be Steve Greenberg. He is a senior energy management engineer at Lawrence Berkeley National Lab's Center of Expertise on Energy Efficiency in Data Centers. So, Steve has researched and applied energy efficient building and industrial systems for a variety of clients on three continents over the past 36 years. His data center engineering expertise spans over 19 years and includes centers ranging from server closets to supercomputer centers in excess of 15 MW.

He has been involved in design, design review, commissioning and retrofit, and has taught several workshops on data center energy efficiency for the Department of Energy, _____ companies, and ASHRAE. Steve holds a bachelor's degree in mechanical engineering and a Masters of energy and resources from the University of California at Berkeley.

So, Steve will be followed today by our second presenter, John Sasser, who is a senior vice president of operations for Sabey Data Centers, and our Better Buildings Challenge partner. With over 20 years of management experience, John is responsible for developing the conceptual basis of design and operations for Sabey Data Centers, managing data center client relationships, overseeing construction projects, and planning for electrical utility capacity.

With a background in engineering facility, John specializes in ensuring Sabey Data Centers' solutions meet customers evolving needs. John's passionate about energy efficiency, resulting in approximately $5 million in award utility incentives, along with an Energy Star score of 100 for Sabey's Intergate.Quincy center.

John also happens to be an inventor. He received a patent for a mobile commissioning assistant to better protect data center airflow. Prior to joining Sabey, John worked for Capital One and the Walt Disney Company. He has spent seven years with the Navy Civil Engineering Corps. John is also past president and founding member of the Western Washington State Chapter of AFCOM, a leading international data center operations industry group. So, we will be looking forward to hearing from John and his experiences with Sabey a little later.

I'll add that the Department of Energy's Better Buildings Initiative and Better Buildings Data Center Challenge is very appreciative to be joined by leading experts from our national labs and industry partners on the forefront of energy efficiency like Steve and John today. Thank you both for being here, gentlemen.

So, without further ado, Steve, when you're ready, please take it away. Next slide, please.

Steve Greenberg: Good afternoon, everybody. Next slide, please. All right, so I'm gonna briefly describe air management opportunities in data centers, and share with you some of our own experiences at the Lawrence Berkeley Lab.

In the early days, we had a data center that had what some of you may have experienced, which was generally the data center was cold, but there were hotspots everywhere. We had fans used to try to keep equipment cool. We had put in some very high-flow floor tiles in an attempt to get cool air to where it was needed. Next slide.

The problems of air management that need to be dealt with are air going where you don't want it and not where you do want it, and that's the basic problem of air management. It simply means forcing the cool air to go where it's needed and preventing it from mixing with the hot air. So, we have problems of bypass air and recirculation air, and the solution is better air management.

So, the very first step is using hot and cold aisles. As the right side of the slide shows, the blue arrows are the cool air coming up through the floor. The red arrows are the hot air coming out of the IT, out of the computing equipment. Those aisles alternate so that you have cool air coming up and going into both racks, and then coming out of alternate sides of the racks to form a hot and cold aisle arrangement.

There are a variety of techniques that I'll get into that describe how to better isolate the hot and cold air. The benefits from those include energy savings from reducing the fan energy and improving the efficiency of the air-conditioning system. In doing so, there are two big benefits, one of which is a better environment for the IT equipment and the other one is increased capacity of the cooling system. Next slide.

It's the poll, so please vote on this. If you've never been – there you go, there's a question for if you haven't been in a data center. So, everyone is supposed to respond to this.

Ryan Livingston: Yeah, I'll jump in here, Steve. This is Ryan again. We just want to poll the audience today and see what their experience with data center has been to date. So, we'll give everyone a few moments to respond, and then we will post the results. Thank you for your participation.

Steve Greenberg: All right. So, that response doesn't surprise me. Most people who have been in a data center have been in a cold one. A cold data center is the sign of opportunities for improved air management. Next slide.

Again, the basic concept of good air management is to keep the hot and cold airflow separate, which is exactly the opposite of what one tends to do in normal office space where mixing is a good thing. But here, mixing is a bad thing. So, the ideal is shown in this illustration, where the cold air is supplied to the rack. It goes through the rack, it doesn't mix, and then it goes back to the cooling equipment. Next slide.

But in reality, we have two problems. We have bypass, which is cool air that goes back to the cooling equipment without having run through the IT equipment. Then, we have recirculation, which is hot air going back through the IT equipment without having been cooled by the cooling equipment.

You can have bypass and recirculation at the same time; most data centers do have that, to a certain extent. You can have it external to the rack, as shown. You can also have internal to the rack. Both are bad. The recirculation is worse in terms of IT equipment getting air that's warmer than it should. Next slide, please.

Bypass air, again, is common in pretty much any air-cooled data center. If you have more supply airflow than you need, you'll tend to get more bypass. Misplaced perforated tiles, like it's shown there on the right. A perforated tile on the hot aisle, that will result in bypass. Cable penetrations are a common source. Airflow velocity that's too high coming out of the floor tiles. Next slide.

Recirculation air, also bad. This is where air that's been heated by the IT equipment recirculates back to the inlet of the IT, and that's caused by too little supply airflow. Rarely, but that definitely will increase recirculation. Lack of blanking panels inside the rack, gaps between racks, and short equipment rows where the air recirculates around the end. Next slide.

This is looking down at the floor inside a rack, and this is a common problem. Cable penetrations through the floor not being properly sealed, as on the left. On the right, you can see the cables have been neatly bundled and there are these black pillow-like objects that block the excess cutout area to reduce that bypass airflow problem. Next slide.

Here's an example of blanking panels, which are simply filling the gaps within the rack where there's no IT equipment. All of those should be closed off with blanking panels. Otherwise, you'll get recirculation within the rack and raising the inlet temperature to the IT equipment.

Here's an example of where we fixed that problem, and it dropped the inlet temperature for the IT equipment by about 20° both at the top and middle of that rack. So, blanking panel, very mundane. Some people can't be bothered to deal with them, but it makes a huge difference in the performance of the cooling system. Next slide.

Restrictions and congestion. Again, good air management is about getting the air to go where you want and not where you don't. If you block the airflow where you want it to go, then it can't get to where it needs to go. So, on the left is an example of congested floor and ceiling cavities packed full of cables, probably a lot of which are no longer in use. On the right, is a much better example of those spaces that then enables the air to flow freely where it should. Next slide.

Balancing is necessary to get the optimum airflow. Whenever significant changes are made in the data center, it should be checked, and balance is necessary. One of the very early steps of this process is to make sure that there are no perforated tiles, except in the cold aisles. Next slide.

Too much open tile area is at least as much of a problem as too little. It will result in very low underfloor pressures, which will make it difficult for adequate airflow to reach the tops of the racks. Whenever you see wide-open tiles, that's an indication that things are probably out of balance. One can measure this either with temperatures, as is shown here on the lower right of this slide, or in a more sophisticated way with pressures. But the bottom line is, the IT equipment needs to get an adequate supply of cooling air. Next slide, please.

Here is an elevation view of a row of racks, and this is a very common distribution problem. You've got air that's colder than it should be in the center, at the bottom center of the rack. You've got that green band of temperature that's in the proper range, and the recommended range. Then, at the tops and typically worse at the ends of the racks because the hot air comes around the end as well as over the top, you've got areas that are too hot. Then, you've got bypass air there at the bottom escaping around the ends of the aisles. Next slide.

Here's a better approach to help improve air management. You've got the typical underfloor plenum, where the cool air is supplied. It comes up into the cold aisles, it passes through the IT equipment. Then, rather than returning just through open space, we use the above-ceiling space as a return air plenum. We put perforated grills above the high aisles to facilitate that airflow, and then the CRAC or CRAH units – that's computer room air conditioner or computer room air handling units – pull that air out of the plenum and cool it for return to the underfloor space. Next slide.

Then, there's a whole range of barriers that can be put in the hot aisle or cold aisle to force the air to go where you want it to and not where you don't. There's some simulations at the bottom. These can be done, again, in the hot or cold aisle. One thing to remember is that putting barriers in the data center may block access to fire and smoke detection and suppression systems. So, any changes need to be done in coordination with your fire authority. But they can be very effective. Next slide, please.

Here are some examples. Strip curtains, these are the ones like you see in cold storage. They also work very well for data centers. Many data centers use them. Next slide.

The concept, again, is better isolation of hot and cold air. This is just an elevation view, showing how that works. You put the barriers between the hot and cold aisles, and also at the ends of the aisles, to direct the air. Next slide, please.

Here's a cold aisle containment example, where you put basically a lid on top of the racks in the cold aisle and then also, doors at the ends. That keeps that air from becoming bypass air. We did a containment study and it showed that we could get fan energy savings on the order of 75 percent. Next slide.

What we did was we put in a temporary – it was an experiment – barrier, and realized that we could, we only slowed the fans down from 100 percent to basically two-thirds, but because of the cube law relation between flow and power, we saved three-quarters of the fan energy and full met the cooling needs of the equipment. Next slide.

It's important to remember that what matters is the air temperature entering the IT equipment. ASHRAE, the American Society of

Heating, Refrigerating, and Air Conditioning Engineers has, in collaboration with all the major IT manufacturers, come up with a set of thermal guidelines with a recommended range and an allowable range. One should always shoot for the recommended range. But when you look at that range, it's a low 64° roughly and a high of roughly 81°F, such that the so-called cold aisle should be a comfortable temperature for people, making the hot aisle very warm and uncomfortable. That's normal operating, and the IT equipment will be perfectly happy there. Keeping in mind that range. Next slide, please.

What happened was, when we did that cold isolation, is the three temperatures – low, medium, and high, which are shown on the left as the blue, pink, and yellow lines – they converged and dropped in temperature to where they were below the bottom of the recommended range. What that allows one to do is to raise the supply air temperature of the cooling air and still easily meet the cooling requirements. In the process of raising that, the cooling system and plant can operate more efficiently because it has a lower thermodynamic lift in order to make those temperatures. Next slide, please.

Here's some more examples of containment. Here's a cold aisle containment with a hard lid and doors at the end. On the left side, there is a hot aisle containment. This is an APC arrangement with in-row cooling in lieu of CRACs or CRAHs. Then, there are some heat shrink tiles on the right. That's where, if there's a fire in the space, they soften and drop out so that the fire detection and suppression system can function normally. Next slide.

In summary, what are we trying to do with air management? We're trying to isolate the hot and cold air streams. There are various ways to do that. A hot and cold aisle with good isolation is an effective way. If we reduce the bypass, then we can supply less airflow and still meets the IT needs. In reducing that airflow, we can save significant fan energy.

Likewise, we can raise the air temperature if there's no recirculation air artificially raising the temperature of the air being delivered to the IT equipment. So, the chillers or CRACs will be more efficient because they can operate at a warmer temperature. If there's either an airside or waterside economizer, those can operate for many more hours and deliver more hours of compressor-free cooling during the year. So, it's a win all the way around.

The cooling system capacity and the ability of the raised-floor system to deliver cooling are increased with air management. You can get closer to the rated performance of the cooling equipment with good air management. The other thing that's important to remember is the IT equipment will be happier because it's getting a more uniform air temperature delivered to it, and fewer pieces of equipment will be outside the recommended range. Next slide.

There are other methods than underfloor air distribution for getting cooling air to the system. Those include row-based cooling units and rack-mounted heat exchangers. These are basically moving the cooling closer to the IT equipment, making a closer coupled system, which improves the isolation and thereby the cooling system performance. Next slide.

Here is an in-row based cooling. This is now a plan view. An example of this is the APC in-row cooler, where these cooling modules are placed in the row next to the rack. The hot aisle is contained. The hot air goes right through the cooling system, then back out. The main data center space is basically cold, the cold aisle, if you will. You can do this with no raised floor. The airflow goes in a horizontal loop instead of a vertical one, if you will. So, there's no above-ceiling plenum and there's no below-floor plenum in this arrangement. Next slide.

You can also put so-called rear door heat exchangers on the backs of the racks. There are both passive and active versions of those, but they all work basically the same way. There's some liquid – it might be cooling water, it might be refringent – that flows through those coils. The hot air from the IT equipment passes through those coils, cooling it back to a neutral temperature. Then, it can go straight from there into the next rack.

So, this is where the hot aisle/cold aisle... Everything outside the racks is the cold aisle, basically. The hot space is just between the IT equipment and the heat exchanger within the rack itself. Next slide.

Reviewing again various techniques. Sealing air leaks in the floor, like cable penetrations. Preventing recirculation with blanking panels in the racks and blanking off any space between the racks, under and above the racks as well. Managing the floor tiles, especially no perforated tiles in the hot aisles. Then, otherwise improving the isolation of the hot and cold air with plenums, strip curtains, or complete isolation doors at the ends of the aisles, and so forth.

The impact of that can be very significant. You can reduce the supply airflow, saving most of the fan energy. You can increase the temperature of it as well, which improves the efficiency of the system and plant. You increase the capacity of the system as well as making your IT equipment happier because you're better complying with the thermal guidelines. Next slide, please.

Another thing I should mention is that at the Center for Expertise here, we're working on air management packages for small – well, targeting small data centers, but the idea is that there are a number of packages of air management strategies that are generally cost-effective. Prepackaging them helps especially small data centers figure out a retrofit strategy that is likely to be very cost effective.

So, we're doing a number of computer models selection of strategies. We'll estimate the energy savings on a normalized basis, and then we'll put out lookup tables with the existing strategy and then potential retrofit strategies. This fan energy performance is an example of how we can get that information out there.

The reference, you're using 100 percent of the fan energy, and then these five packages will do a number of things that will reduce the amount of airflow needed and/or improve the fan energy performance. You can see the overall fan energy dropping to as much as ten percent of the original energy.

That's just a very small example of the various strategies that we'll be looking at and disseminating right around the end of this calendar year. You'll be able to find it on the Center for Expertise for Energy Efficiency in Data Centers website, which is listed there. Next slide.

There's my contact information. Next slide. Okay. Thank you, everyone, for your attention.

John Sasser: All right. Thanks, Steve.

Ryan Livingston: All right.

John Sasser: Sorry. Go ahead, Ryan.

Ryan Livingston: Sorry, John. I'll jump in real quick and just say thank you, Steve. That was excellent. I'll do a quick plug again for questions. Feel free to send your questions into the webinar chat box during the presentations today. We're collecting them now and will go through them during the Q&A period.

So, without any other delay, our second presenter, John Sasser, please go ahead.

John Sasser: Thank you, Ryan. Next slide.

Again, this is John Sasser with Sabey Data Centers. Just to let people know who we are, Sabey Data Centers is a data center real estate provider. Primarily, we do wholesale colocation. For those of you who are not familiar with colocation, essentially what a colocation provider does is provides the facilities, including the power, the cooling, the physical security for customers to put their IT equipment in.

In the wholesale colocation model, there's essentially two things that our customers pay us primarily. They pay rent, and the rent is based on a per kilowatt basis. Again, it's different than the traditional commercial real estate office, where you're paying per square foot. Here, you're really leasing the capacity. You're leasing the power and the cooling capacity, along with the space to put your IT cabinets.

Then, in the wholesale colocation model, the second major payment that you pay to the provider is the electricity. The electricity is based typically on the metered electricity used, along with the cost for the HVAC and other losses that are required to power that equipment and keep it cool.

Again, Sabey Data Centers, we are a colocation provider, a data center real estate provider based in Seattle, Washington. We have campuses in central Washington, our Intergate.Columbia and Intergate.Quincy campuses. We had a campus in Ashburn, Virginia, which is just outside of D.C. And we have a 32-story building in New York City at the base of the Brooklyn Bridge. Next slide, please.

When I looked at solutions for airflow management for small and medium businesses, one idea that came to mind, which while admittedly is a little bit self-serving, is hey, just migrate it to a colocation provider. There's a couple of reasons I say that. One is, as with a lot of outsourcing, it allows you to work with a provider who specializes in that. A lot of the colocation providers you'll find operate with very high efficiency and reliability because again, we focus on operating data center facilities. That's all we do.

I also realize, of course, that this is more of a strategic decision. This is not something you can go in and make a decision one day. Hey, I'm gonna outsource everything and go to colocation. It's a strategic decision. But if it is something you're looking at, say, you're at end-of-life at one of your facilities and you need to do a refresh, or expand, or build a new one, keep in mind that not all colocations are the same.

Generally speaking, I'd say over the last few years, most have been getting more efficient. But some have a greater focus on efficiency than others. When you talk to those colocation providers, you may want to ask questions about their operational approach, and their design approach to efficiency, and what results they've seen in their facilities. As an example, one of the things that we do is we actually require our customers to use containment.

Steve talked earlier about the benefits of hot aisle/cold aisle containment. We've required hot aisle containment as part of our approach since 2008. There's always going to be some benefit in doing containment, but there is a greater benefit if everyone and all cabinets within the data hall use containment. If a colocation provider says sure, you can do containment, that's not going to be as effective from an energy standpoint as yes, you must do containment in that facility. There's other approaches besides hot or cold aisle containment, but containment is certainly, I'd say, a best practice.

The other thing that colocation providers can do is they provide what's called remote and services. These are typically services related to the equipment that are not involved with any sort of programming, that sort of thing. It's more physical services. Very often, server admins do that kind of work. So in a lot of places, that's an IT function where you have facilities that are taking care of the air-conditioning system and electrical system, that sort of thing. Then, you have an IT that is racking and stacking equipment, installing the cables, installing the blanking plates that Steve mentioned, and even containment might go more on the facilities side.

But as a colocation provider, and most colocation providers do this, very often we offer these remote and services. Let's say your server admins don't want to be bothered with blanking plates or sealing up some of the gaps between or under cabinets. We can take care of that for you. We have a lot of practice doing that for various customers. So, we have a lot of the solutions in mind. Next slide, please.

In the latest Uptime Institute Survey, they found that the respondents indicated the average industry PUE is 1.67. That's a little bit higher than the 2017 results. But generally speaking, over the years, the PUE has been going down.

I think most people on the call may know what this is, but just in case, PUE is power utilization effectiveness. Essentially, it's a measure of the energy overhead. It's the total energy used by the data center facility divided by the amount of energy that's used by the IT equipment is essentially what that ratio represents. Ideally, you want that to be as close to 1.00 as possible. A PUE of 1.00 would be perfect. It would mean all of the energy going into the facility is actually being used by the IT equipment.

Our most efficient data centers average an annual PUE of 1.13. Those are in our central Washington facilities. Over our entire portfolio, our weighted average annual is 1.32. You compare that to the industry average that Uptime found of 1.67, we're doing pretty good.

Part of that, going back into the colocation industry, you've seen a lot of new colocation data centers over, say, the last 10 to 15 years especially. The more recent data center builds also tend to be more efficient. There's more efficient UPS modules being used. Economizers are used as part of the package. You're seeing a lot of people doing some of the things that we've been practicing really since 2008. Since 2008, we're required hot aisle containment, so our designs are based on hot aisle containment.

All of our data centers use some form of economizer and the form we use may vary, depending on the climate. In Seattle, we use a lot of airside economizer, direct evaporative cooling. Central Washington, we use a lot of indirect evaporative cooling. We use waterside economizer in New York. That's just an example of the different economizer strategies one may use in different environments. But in each of them, we're using some form of economizer in our data center.

In all of our data centers, we use variable speed fans. The fan speeds are controlled based on differential pressure. Essentially what we're doing there is we're trying to match the amount of fan energy we use, the amount of airflow that is being moved through our air handlers, with the amount of air that's being moved through the servers by the server fan. That's that ideal situation where you're moving just as much air as the server fans are moving, and you're not seeing the bypass and the recirculation air that Steve mentioned in his presentation. We don't meet that ideal, but we come pretty close in a lot of our data centers to eliminating that bypass and recirculation air.

Another practice that we've been doing since 2008 is we build on slab. We have no raised floor. That simplifies management. This goes back to the first bullet base, either the hot aisle containment required. If we didn't require hot aisle containment, we would need some means of getting the air right in front of the server racks.

By using hot aisle containment, we can simply flood the room. That removes a lot of the complexities associated with the raised floor, the management of the tiles, the delamination, what's going on underneath the raised floor. There's advantages to raised floor, but if you can simplify it and move it out of the equation, you can also increase some of the efficiency 'cause there do tend to be some losses involved in pressurizing that raised floor and trying to get the air to the right place.

Of course, I mentioned the high-efficiency UPS modules. All of the recent UPS modules we have are 96+ percent efficiency, and that's in double conversion mode. Next slide, please.

Indirect economizer cooling. I mentioned in central Washington, we use indirect economizer cooling. Essentially how this works is we are adding moisture to the outside dry air. That cools the temperature of that outside air. We use a heat exchanger that transfers that heat between the data center air and the outside scavenger air. Again, we use that in our central Washington facility.

This diagram also shows, similar to some diagrams Steve showed, that ideal situation where you're flooding the room with cool ambient air, but not cold, just like 70° air. In the hot aisle, it is very hot. We have measures temperatures of 100° in our hot aisle. That's okay; that's what they should be. Next slide, please.

I mentioned solution 1: move to our data center. Solution 2 is, of course, more likely in most people's short-term view, which is improve the existing data center. I'm not gonna go through all of these in detail because Steve covered them really well in his presentation, but I'll touch on a few.

We talked hot aisle, cold aisle, blanking plates. So, network switches – network switches are notorious, and I'll address that in another slide – cable management, containment, system controls, ducting and controls. Let's go into the next slide, please.

Switch airflow management. Those top of rack switches and other switches are notorious in not doing the traditional front to back airflow. In your ideal case, and as is the case with most servers, they draw in air in the front and discharge it in the back. In many cases, switches don't do that. Sometimes they will go side to side. Sometimes they will pull in from the back, the hot air, and discharge the even hotter air into the front.

There are commercially available solutions for that sort of thing. The first solution is, if you can talk with your network engineer, and have them order a switch that draws in the air from the cold aisle and discharges it into the hot aisle, that's gonna be the simplest solution. But there are some commercially available solutions that will help with this particular issue. Next slide, please.

Cable management. Steve showed some pictures of underfloor cable management and above-ceiling cable management. You should also think about in the back of your cabinet. If you look at the cabinet on the left especially, you see the cables are all over the place. That's going to potentially put some back pressure on the server fans and they're not going to operate as well. Especially if your bypass air control is not perfect, you'll get more recirculation air if you have poor cable management, and you're just not gonna circulate air as well.

What you want is you want nicely dressed-out cables, and if you look at the cabinet on the right, at the top part of the cabinet anyway, you'll see that they are much more organized-looking and they're not going to block that exhaust air quite as much. Next slide, please.

Hot aisle versus cold aisle containment. We talked a little bit about that. People tend to have a preference of one over the other, potentially depending on their experience. My opinion is that cold aisle containment tends to be best suited for retrofits. Say you already have a raised floor environment. You want to retain that, you want to do some containment, but you can't really redo your entire HVAC system. Doing something like Steve showed with the lid over the cold aisle and doors at the end of the cold aisle may be a very good solution for that.

We do hot aisle containment in all of our new data centers. What that allows us is, in addition to the efficiency, it allows us a great deal of flexibility. If you contain your cold aisle, you're designing that cold aisle typically for a certain amount of airflow and you're not going to get more than that amount of airflow. So, that pod of cabinets, you have a certain amount of airflow that you can support.

In a hot aisle-contained environment, you have much more flexibility because you can see here that you're flooding the entire space. You don't have that underfloor restriction, or even if it were a ducted restriction of how much supply air you can get to the cold aisle, your primary restriction's gonna be in the return ceiling plenum. We can design a pretty tall return ceiling plenum with not a whole lot of restriction. So again, you're trying to have the fewest restrictions, and that's gonna get you the best flexibility in terms of how much air you can deliver to those server cabinets. That's why we prefer hot aisle containment. Next slide, please.

Controls. One of the benefits you're going to achieve when you use hot aisle containment and an economizer is that you can expand the amount of time that you're on pre-cooling and reduce your fan energy. Somehow, you have to control the fans to get to the appropriate speed. I mentioned earlier, we use differential pressure control for that. In that strategy, what we're trying to do is we're trying to achieve a certain differential pressure setpoint where the hot aisle is slightly negative compared to the cold aisle. So, if there is any bypass airflow, it's going from the cold aisle to the hot aisle and not creating hotspots, but you want it to just be slightly negative.

What we've found is when customers install more equipment, they turn it on, our fans automatically adjust to compensate to maintain that setpoint. So, they'll speed up slightly to maintain that setpoint. Similar if someone takes a piece of equipment out, our fans will match the airflow required by the servers. Next slide, please.

That is the conclusion of my presentation. Thank you all for your attention.

Ryan Livingston: Okay. This is Ryan again, everyone. Great presentation, John. Thank you. We're going to now proceed to our Q&A portion of today's webinar and see what kind of questions everyone has entered. Again, if you've been holding onto your question, feel free to put it into the webinar chat box at this time and we will attempt to address it for you.

It looks like we have a few questions for Steve here. The first I will ask of him generally, what's the most cost-effective way to isolate hot and cold aisles when you already have raised floors?

Steve Greenberg: That's a really good question, right, 'cause most of the data centers, the new ones tend to be pretty well set up and the existing ones are all over the place. So, what do we do about all these existing data centers? Most of them have raised floors.

I would say that the slide I showed with the strip curtains is the most cost-effective way. It's not as effective as doing a hard enclosure either on the hot or cold aisle, but it gets most of the savings and it's a lot less expensive. You can also do variations in order to make your fire authority having jurisdiction happy, including curtains that drop down either based on temperature or fire alarm activation. So, there's a lot of things to play with there.

You can do either hot or cold. The advantage to hot is, as John pointed out, most of the space is the cold aisle then, and so more of the space is at a comfortable temperature. But you can do either hot or cold aisle containment. Hopefully that _____.

Ryan Livingston: Great question, great answer. Let's see. I think we got one or two more here for you as well, Steve. Yeah, again along the themes of cost, could you roughly estimate the cost to implement the cold aisle containment via the hard top enclosed method that both you and John touched on? I suppose that depends on a few factors, but generally?

Steve Greenberg: Yeah, it depends on a lot of factors, so there's probably an order of magnitude of variation in cost for that depending again on, I would say as much on satisfying the fire safety requirements as on getting the enclosure in place. It also has to do with whether you have uniform rack top heights and so forth. Then, there are quite a number of manufacturers out there who have products that can provide that enclosure system.

So, I'm somewhat loathe to put any numbers out there. I would say contact some vendors and get some quotes, but also be sure to be in touch with your fire marshal about what would be acceptable.

Ryan Livingston: Very good point, yeah. Don't want to make any changes there that will get you in trouble with that.

Steve Greenberg: Right. The worst is to put something in and then have to take it out again.

Ryan Livingston: Then, you're guaranteed a higher cost, for sure. We'll give Steve a break here for a moment and shoot some questions John's way. John, here's a question. Do some UPSs use bypass in normal operation, thereby making them even more than 96 percent efficient? Are you aware of any that operate this way?

John Sasser: Yeah, there's a number of UPSs out there that are offered by various manufacturers that run, just as the question suggest, in a form of bypass. A lot of people like to call them ecomodes, and usually the manufacturers have some other name for it.

The theory of the operation is that they're primarily bypassing the electronics in their normal operation. If there's a voltage disturbance, they will quickly go to a fully protected mode where the electricity is running through the electronics. Those have been out for at least ten years. Again, a variety of manufacturers do that. I hear different things in the industry about those UPSs.

I think it may depend on your topology and may depend on your particular circumstances in terms of whether you would actually want to adopt something along those lines. For example, we do not use any of those ecomode UPSs. The reason we don't use them is a lot of our topologies use downstream static transfer switches. There can be coordination challenges between that bypass ecomode and those downstream static transfer switches where you get unintended transfers. But they do exist and they can approach 100 percent efficiency in bypass.

Ryan Livingston: Very interesting. Interesting as well that you take a little bit different of approach. Again, going back to what Steve was saying, it depends on your situation. Many solutions.

Let's see. Another question for John. Do you – or I guess Sabey – does Sabey's AHU – I assume that's air handling unit – use supply air temperature control?

John Sasser: Yeah, so I didn't go into this part of our control strategy, but the way we control the supply air, the discharge from our air handlers is we manually set that, have a set point where our air handlers seem to achieve a certain temperature. We don't actively control to save the temperature sensors in the space. We'll set a discharge temperature of, let's just call it 70°, from the air handler, and each of the air handlers is trying to achieve 70°. With that, and with using containment, and with using differential pressure to control our fan speed, we find that that really provides a nice, stable temperature within the codiles of our hot aisle contained data centers.

Which is a little different than a lot of people think. A lot of people think that you're controlling to a temperature sensor like you would, say, in an office, where it gets a little warmer, the fans kick on and it cools down, they turn off. That's not really how we control it. Those air handlers are running all the time. They're making that 70° air all the time. Our fans ramp up and down slightly to maintain that differential pressure setpoint.

Ryan Livingston: Got it. Good answer, yes, about maintaining that constant, I think. Okay. Thank you, John. We have about three minutes left here to close, so I think I'll go back to Steve with maybe one or two more questions. Steve, to you. If it's a small data room and this is what we're talking about today, small and medium-sized data centers, that is made up of a single row of racks, is aisle containment still feasible?

Steve Greenberg: Yeah, that's a great question. So, for your really, your server closets or whatever, the answer is yes, there are still ways to do that. One of them is... Well, so like the rear door cooling scheme can be applied all the way down to a single rack. That's a strategy.

There are also hot side chimneys that are an attachment to the racks that direct the hot air to the return plenum, where it'll be cooled by the HVAC equipment in return. So, the answer is yes, there are air management strategies all the way down to a single rack, but certainly a single row.

Ryan Livingston: Perfect. Good to know. Let's see if we have time for maybe one more question. You know what? There are a few more questions, but I think I'm going to move to our last couple of slides here today. Your questions are very much appreciated, and they can be directed to our presenters today at a later date as well, for further follow-up.

So, we're already on the next slide here. In closing, I'd like to share that we'll be having the next instance of our Better Buildings webinar series planned for Tuesday, October 1, again at 3:00 P.M. Eastern, entitled "Straight Talk: Talking to Multi-family Tenants about Utility Benchmarking." This webinar will identify strategies for obtaining tenant consent to share their utility data. It will also explore ways to engage multi-family residents about the benefits of energy efficiency upgrades. So, please register for this webinar now. You are able to do so on the Better Buildings Solutions Center website. Next slide.

I want to highlight the upcoming 2019 Better Buildings/Better Plants summit. This will be taking place next month in July, July 10-12 in Arlington, Virginia, which is the D.C. metro area. Pre-conference activities will be taking place the day prior, on July 9^{th}, including a tour of two of our local and goal-achieving Better Buildings Data Center Challenge partners, Visual Realty and Iron Mountain. The tour is a full-day event with transportation and lunch provided.

So, should you be wishing to learn more about the tour or the summit at large, please go to the Better Buildings Solutions Center website, where you can browse the agenda, you can reviewed detailed session descriptions, read about keynote speakers and events, and much more. So, please utilize the link that's provided in the slide to check that out. We hope to see you there. Next and last slide.

With all this in mind, I once again would like to sincerely thank our presenters, Steve and John, today very much for their time and expertise shared. Following today's webinar, please feel free to, again, contact them directly with any questions you may have, or in the case that we weren't able to get to your question that you had entered.

If you'd like to learn more broadly about the Better Buildings Challenge or Better Buildings Alliance, please check out the Better Buildings Solution Center website, or feel free to contact myself or my colleagues Kendall or Megan with their emails here.

I will also encourage you to follow our Better Buildings Initiative on Twitter for the latest and greatest from DOE, the Department of Energy, and all our partners.

Lastly, as a registered attendee of today's webinar, you will be receiving email notifying you when the session is archived and available online for your reference. Thank you everyone for attending today's webinar on air management solutions for small to medium-sized businesses. Have a great afternoon and the rest of your week. Thank you.

[End of Audio]

Questions answered by panelists offline:

1. ***What is the status of immersion cooling of servers?***

   Steve: Immersion cooling is an available technology with multiple vendors. Rather than vertical racks, the servers are placed in a horizontal tank of oil, accessed through the top. The oil is circulated through a heat exchanger for cooling. There are other schemes in development, including phase-change systems, but these are not readily available.

   John: Some adoption, but it doesn't yet seem widespread. Questions of serviceability and commercial viability remain. Certainly, a trend to keep an eye on.

2. ***How much is the cooling load due to lighting and how do you take care of it?***

   Steve: The lighting load in data centers is typically a small fraction of the overall load, around 1%. But on a per-square-foot basis, it's comparable to office space, and similar technologies can and be used to reduce the consumption, e.g. LED fixtures or retrofit lamps and controls. Two considerations: often the lights are installed in a data center space and then the racks, with the result that the lights are above the racks and not above the aisles; moving the lights to above the aisles make the lighting much more efficient. Best practice includes no lighting on in an unoccupied data center.

   John: In a data center, the lighting load is typically immaterial compared to the compute load. This is especially true in more modern data centers with widespread adoption of LEDs. We make no special provisions for cooling lighting.

3. ***Is automatic Fault Detection and Diagnosis built in?***

   John: Typically, there is some provision for this. Most data centers have extra, redundant cooling equipment. One example of a cooling strategy is to measure whether an air handler is meeting discharge temperature. If it doesn't, after a certain amount of time, the automation system will turn it off, assuming that it has suffered an internal fault. Another unit stages on, or the fans in the remaining units stage up, depending on the specific strategy.

4. ***For the heat shrink isolation, you mentioned about the cover will drop when there is a fire. Would this interfere with the smoke detector?***

   Steve: Yes, any solid cover will interfere with smoke detection, so most likely the detection system would need to be modified. They advantage of the drop-out panels is that they would allow the heat to be detected and the fire suppression system to function. But again, consult with your fire Authority Having Jurisdiction as to what would be acceptable.

John: This type of solution is often used to avoid having to alter the existing fire protection systems. It is possible that the presence of the lid might slightly hinder the smoke from getting to a smoke detector depending on specific locations. Most likely, the smoke would still get to a detector quickly, due to the air circulation through the servers.

5. ***Do you know of any installations which recapture waste data center heat to provide heating elsewhere such as office heating or domestic hot water?***

Steve: Yes, this is relatively common in Europe. See, e.g. https://www.datacenterknowledge.com/data-centers-that-recycle-waste-heat In the US, there are examples where there are liquid-cooled machines or racks. The heat can be used directly e.g. at the National Renewable Energy Laboratory https://www.nrel.gov/computational-science/data-center-cooling-system.html or the temperature can be boosted with a heat pump, as is being done at the Lawrence Berkeley National Laboratory.

John: Yes. Sabey uses waste heat in a number of our facilities for office or other heating. I have seen examples in articles of larger scale waste heat re-use (in Seattle and Europe). Mostly this is for office or other similar heating - with some discussion in Europe of setting up district heating systems from hyperscale data centers. With air-cooled servers, the waste heat tends to be low grade (100F if you are lucky), and the best way to transport it remains hot water loops.

6. ***Roughly how much does it cost to implement the cold aisle containment via the hard-enclosed method?***

John: Costs can vary widely for each system, depending on the particular situation. Variables include specific kind of containment, ceiling height, rack height, pod configuration, etc.

7. ***If it's a small data room, single row of racks; is aisle containment still feasible?***

John: Yes, it can still be feasible. The method and feasibility will depend on the layout of the room and the cooling system, but we have certainly contained single row pods.

8. ***Generally, what's the most cost-effective way to isolate hot and cold aisles when you already have raised floors?***

John: It may depend on whether you have a dropped ceiling with a very clear overhead. If you do not, cold aisle containment is likely the best option.

9. What is the theory of switch airflow management?

John: Many switches are manufactured with undesired airflows (either side-to-side or back-to-front), causing them to pull hot air into the switch and discharge even hotter air into the cold aisle. Not good for the switch and it creates hot spots for nearby servers. They may also not be mounted to the front rails, causing gaps for bypass air. Switch airflow management devices typically seek to passively duct cool air to the intake of the switch and exhaust air to the hot aisle.

10. What type of glass are you using for containment…green house, glass/plastic or…?

Steve: Materials vary depending on the vendor and user requirements. Some use plastics (often these will need to be fire-resistive depending on AHJ requirements); others use tempered glass. There are opaque surfaces as well, again using a variety of materials.

John: Containment is typically some form of fire-rated plastic. It's important to make sure that it is fire-rated.