*Kim Trenbath:* Hi, everyone. Welcome. I'm Dr. Kim Trenbath and I'm here with my colleague, Amy LeBar from the National Renewable Energy Laboratory. We're based out of Golden, Colorado. This is our plugin process loads webinar. It's called Boots on the Ground: Understanding Real-World Energy Use Management Strategies and Technologies for Plug Loads and Beyond.

I just want to remind everyone that this webinar is being recorded. You can always access the webinar later by going to our website and I'll talk a little bit more about that later. Next.

We have a great agenda for today. First, I will talk about the plugin process loads technology research team update. So, we have some great resources that I want to highlight. Then we'll have a technical presentation from Bob Dahowski from the Pacific Northwest National Laboratory. After Bob's presentation, we will go to Q&A. Bob's presentation is called Highlights and Lessons Learned from an Army Plug Load Study. Next.

I'm happy to present the Plug Load team. We are the Better Boeing's Alliance Plugin Process Loads Technology Research Team. I'm Dr. Kim Trenbath. I'm the innovation lead for systems technology, research, and development at NREL. I'm the technology team lead. Amy LeBar is a mechanical engineer researcher at NREL and she is the PPLTRT co-lead. So, the co-lead of this team. Omkar Ghatpande is our electrical engineer as well as a research engineer at NREL. Robin Tuttle is a project manager, but she is our stakeholder engagement manager for the Plugin Process Loads team. You can reach us at any time at our email: PPL@NREL.gov. Next.

All right, moving into the PPL team update. Next.

I always like to highlight our website. This is a one-stop shop where you can go to learn about control measures for plugin process loads in your commercial buildings. The website address is up here at the top. Again, you can reach us at PPL@NREL.gov. Again, this website has tons of content. It includes resources, fact sheets, links to webinars, some blogs, other facts about plugin process loads in commercial buildings. I highly encourage you to go directly to this website to find information that will be useful to you in your control strategies for your buildings. Next.

I wanted to feature some resources on this call. These are more recent resources that we've published. I wanted to bring your attention to the first bullet here – on demand PPL webinars.

Similar to this webinar, all of our PPL webinars are recorded and listed on the PPL website that I presented earlier. These webinars include ones like the second bullet, which is called Trust the Process: Strategies for Reducing Larger Commercial Building Plugin Process Loads. There's a lot of information on these webinars. We have guest presenters from outside of NREL talk about their best practices for reducing PPLs in their buildings. Also, some information on how they've integrated plug loads with other building end uses and finally some information on how you can accomplish some low to no-cost strategies for controlling plug loads. These are all in our webinars, so please check those out.

The second webinar that I – the second bullet and the featured webinar that you see here has a guidance document that goes along with it. That is the third bullet – this process loads guidance. This is called Reducing Commercial Building Process Loads and Refrigeration Unit Energy Consumption. This is a resource for controlling some of these larger process plug loads, larger plug loads, which we call process loads in your commercial buildings. This includes internal mobility, refrigeration, some water as well as many other aspects of these larger commercial building process loads. Then finally, the featured resource at the bottom is the automatic receptacle control resource. What they are and why they should be commonplace in building energy code. While this is directed for code adopters, it's always really important for all users of ARCs to understand what they are and how they work, and so that's what this fact sheet does for automatic receptacle controls in commercial buildings. Next.

We have a new publication. This is a Power Point presentation on medical imaging equipment, with a focus on energy efficiency of these MIEs. We also heavily emphasize MRIs in this slide deck as well. So, this slide deck, published on our website, provides an overview of existing work, reviews existing literature on MIE energy use, and identifies energy efficiency opportunities. Next.

Similar to the published Power Point that I presented on the slide before this, we are having an upcoming webinar focused on medical imaging equipment. This webinar features best practices and case studies on metering medical imaging equipment such as MRIs. This webinar is going to be August 1st, so please sign up. The link is here on the slide deck that will be sent out after this meeting. It's called measuring to managing submetering strategies for plug and process loads in healthcare facilities. This webinar is part of the Better Buildings summer series webinars. So, we're really excited to welcome representatives from the healthcare industry to talk about their metering of their MIEs. Next.

The PPL team has been very busy over the past few months. We did a lot of presentations, and I want to highlight a couple of them here. We had a PPL focus presentation at the Better Buildings Better Plants summit. In this presentation, one of our colleagues from the Pacific Northwest National Laboratory presented on taking control, monitoring and managing lighting, and more where PPLs is part of the more. Co-presenters include Chris Wolgamott from the Northwest Energy Efficiency Alliance, and Nick Burke from the University of Kansas Health Center. The link here will take you to the slide deck as well as all the other Better Buildings and Better Plant Summit presentations. Please check that out. It's really informative. In addition, in April, the PPL team presented at the U.S. Department of Energy Building Technologies Office 2023 peer review. In this peer review, Amy LeBar and Omkar Ghatpande presented on their poster focused on medical imaging equipment. This was called Healthcare Decarbonization Through Medical Imaging Equipment Efficiency Market Transformation. In addition to that poster presentation, I presented the portfolio of work that we do for PPLs at NREL. This was called The Impact of the Better Buildings Alliance Plugin Process Loads Technology Research Team. Next.

I wanted to bring your attention to our colleagues at the Pacific Northwest National Laboratory. They run the integrated lighting campaign. As always, we like to promote the Integrated Lighting Campaign because one of the categories is integrating lighting with plug loads. So ILC recognizes innovative lighting projects that push the envelope in terms of integration, energy savings, novel capabilities, and non-energy benefits. We are very, very interested in projects that integrate the lighting controls with plug load controls. So, if you have any questions about this, please email Axel Pearson at axel.pearson@PNNL.gov. Or you can visit the integrated lighting campaign's website that you see at the bottom here. We're always interested in these connections and I'm starting to find out that I think a lot of you might be doing these integrated controls but not giving yourself enough credit for them. So, we really welcome your responses and we want to hear from you. Next.

I'm pleased to welcome Bob Dahowski, and we are going to start our technical presentations. So, Bob, if you're able, go ahead and turn on your camera. I see you. That's great. I'll read your bio and then I'll turn it over to you.

Bob Dahowski is a senior research engineer at the Pacific Northwest National Laboratory. He has more than 25 years of experience with numerous facets of building energy efficiency, building energy simulation and analysis, advanced technologies, carbon management, and tech-economic analysis. Bob works extensively with federal and state government energy managers and engineers on building energy auditing and system evaluations and monitoring to meet a variety of goals, including analyses of facility energy efficiency, decarbonization, resilience, and climate change impacts. I'm pleased to turn it over to Bob for his very interesting presentation.

*Bob Dahowski:* All right. Thank you, Kim. Thank everybody out there for joining us today. As Kim mentioned, I'll be talking about the plug load study that we performed for the Army. As many of you are probably aware, the largest energy consumer in the U.S. is the Department of Defense. Within DOD, the Army operates the largest number of buildings. Approximately 160,000, and over 1 billion square feet. So, this presentation will highlight the first of its kind study for the Army to evaluate in detail the plug load and miscellaneous electric loads within representative Army buildings. We feel that the lessons learned are not fully critical for the Army and the greater DOD but most of them are also quite relevant to the broader civilian and commercial building sectors. Next slide.

The purpose and focus of this presentation is really to highlight the study, its objectives and approach, and present some of the key findings and recommendations that have been uncovered. At the end, I'll also highlight where to find the final report and a number of related publications that you might be interested in. Next slide.

Okay, so the study was commissioned by the Office of the Assistant Secretary of the Army. It had a number of key objectives and goals. Those are listed here. So primarily, the focus was to evaluate plug load energy use within representative Army buildings, and ultimately raise awareness and inform policies and actions to drive savings. The focus was really to answer a number of key questions. Some of those are listed here including how much the plug loads and miscellaneous loads contribute to Army facility energy use. Which types of devices consume the most in select Army buildings? What type of strategies are available to manage these loads? Ultimately, the Army's interested in understanding ways to reduce energy use and identifying measures again, that can reduce energy use consumed by MELs across the Army. One other objective that we wanted to look at too, among others, was to understand the equipment density of select plug load devices in representative not only Army spaces but more broadly commercial spaces. Next slide.

So, in terms of overall highlights and findings, of findings and recommendations, the study identified that plug loads account for on average about 25 percent of total building electricity over five building study. This varied of course from building to building, ranging from a low of 9 percent in one of the buildings, the company operations facility, to almost 40 percent within the barracks that we evaluated. Each of these buildings not only had centralized electrical cooling systems but also natural gas providing the building heat. So, the range of overall building energy use contributed by the plug loads and miscellaneous electric loads are also shown here. The report also presents actionable recommendations supported by operational load data through extensive metering towards achieving large, and sustainable cost reductions and importantly, without negatively impacting mission performance. We certainly think that there are many ways to reduce plug load energy use, but the key again is to do so without impacting professional performance as well as people's personal performance. We all have plug loads. We don't want to lose those capabilities. It's important to focus on managing them appropriately where they still sustain our professional and personal missions.

What we have found from the study is that conservatively, we believe the Army can save over 80 million kilowatt hours valued at over $5 million dollars per year within just the five building categories evaluated within this study. These five building categories are some of the largest building categories within the Army and represent about 20 percent of the total Army-wide facility floor area. Looking more broadly, certainly there's opportunity for much greater savings within the rest of the Army building assets. The study identified a number of keys to success. Many of these will be similar to others you've seen from other studies and other recommendations, and I think that's a good thing. First, improving adherence to existing policies. So, the Army has energy policies in place that govern many aspects of management of plug load systems. However, we found that for a variety of reasons, by decision in some cases, and perhaps by neglect in others, some of those – in fact, some important policies are not being followed consistently. Another item for success that we often see if focusing of purchasing of equipment, purchasing efficient equipment, purchasing equipment that's appropriate for your use and needs, but beyond that, we would also add focusing on contracting criteria for contracting with vending machine providers or large office equipment providers to make sure that energy performance is written into those contracts explicitly and managed throughout the course of those agreements. Three, we want to ensure that the consistent application of power savings and setting embedded within devices. Many devices as we know integrate embedded power control energy management savings settings, but if they're not often set from the factory, come out of the box that way, so ensuring that they're set up properly and sustainably through the course of their operation, we find is a considerable opportunity for ensuring ongoing savings.

And finally, and I think one of the most important pieces that underlies all this is the ability to engage, educate, and empower personnel at all levels to support policies and operational best practices particularly as it relates to plug loads. We'll talk about this later, but it's important to remember that we are all plug load operators and to a large degree technicians. We're all on the front line of operating and using these devices for whatever purposes, so it's incumbent I think on any approach to look at proper management and effective management of these devices and systems that number one, we focus on the individuals that actually interact with them the most. Finally, the old adage is never more true as with plug loads. It's really hard to manage what you don't understand. So, equipment monitoring is really critical to improve the understanding of how these devices operate, how their loads fluctuate under different conditions and settings in order to also validate success going forward. Next slide.

So, from a high level perspective, these are some of the – in fact, the ten highest savings opportunities that were identified from this study. These include a mix of measures that focus on policy implementation. As I said before, reinforcing existing policies or implementing new policies. The measure, the recommendation with the highest savings potential surprisingly for us was actually implementing sustainable computer policies, to shut down systems not only every night but set them back into low power mode, sleep mode, hibernation mode after a certain period, 30 minutes of inactivity. A lot of us are accustomed to that where we are. Our IT folks here at PNNL manage to provide cybersecurity updates in a way that allows us to shut down computers when they're not in use, go to sleep, and so forth. Surprisingly, this Army installation, we found that it was actually a policy coming down from the IT center to have staff keep their computer on all the time. We subsequently learned that this is actually common Army-wide, and have subsequently learned beyond that that this is becoming more prevalent DOD-wide, and even for other organizations that some of you may be involved with, including the Department of Energy.

Now, this is a significant waste of energy but clearly cybersecurity risks dictate and take some precedence over energy use at some level, but I think there's a way we can find a path forward where both of these important measures can coexist with one another. And what we've done here provides an initial attempt to quantify the savings or the value of making sure that computer energy management systems align properly with computer operating system update needs and things like that. For just the five building categories, we estimate the savings at over 31 million kilowatt hours per year, just shy of $2 million dollars per year, but if you expand that to the estimated 1 million computers that exist across the Army, this suddenly grows almost threefold. Additional measures that we've identified as being top priorities include again, focusing on policy implementation with other power management features. Policies regarding space heaters, which is always a challenge for organizations. But also, as I mentioned, purchasing and contracting areas of focus to make sure we're purchasing the right equipment with the proper energy efficiency and that measures involving energy performance are written into vending contracts to ensure that the vendor is aligned with not just making sales but also ensuring the efficient operation of their machines.

Additionally, a number of other power management options are recommended here. Some equipment does not have built-in controls. Things like commercial coffee makers use a lot of energy. There are other options that we'll talk about a little bit further on. Then finally, others may require more detailed system design review. One of the more surprising results from this study, and it's detailed in the report, is in regard to elevators. There was one elevator in the buildings that we looked at this site. It's a hydraulic elevator serving two floors. It was not used very much but surprisingly, the bulk of its energy use went to heating the hydraulic fluid. It remains uncertain just under what conditions that's required for elevator operation safety. I think that's one area that's been highlighted for further review amongst some others. Next slide.

So, getting into the approach of the study a little bit. As I mentioned, we set out to look at plug loads in a comprehensive manner across five representative Army building types. Those types are identified here, so they include a typical administration building. This is on an Army installation. This is really housed by a civilian contracting element. We also looked at a typical TEMF, which stands for tactical equipment maintenance facility. So, this is basically a vehicle maintenance shop with associated office space, meeting space, and breakroom. We looked at a typical battalion headquarters building. So effectively this is really a military-focused admin building. Then a typical barracks. UEPH stands for unaccompanied enlisted personnel housing. So, this is effectively housing for single soldiers. It's quite akin frankly to what you might find in terms of housing on a college or university campus dormitory. The final building type was a typical company operation facility or COF. This consists of partial – a portion of office and admin space and operational space for company leadership, but the bulk of the space is really comprised of storage space that effectively just mainly has lighting to provide lockers and other storage areas for soldiers' gear and equipment.

Looking across these different representative buildings, these are selected to be representative of much larger set of Army facilities, approximately 20 percent of the entire Army floor area. As you can see, over 900 devices were inventoried through these buildings. Ultimately, about 40 percent of those devices were monitored, and we'll talk about that in a minute. But in terms of the number of devices, the admin building you can see clearly has the most devices. These are color coded based upon the device category breakouts. So blue is audiovisual communications equipment. Orange is computing equipment. Gray is break room. Yellow is occupant comfort. Lighter blue is documents and imaging equipment. Green is shop equipment. Darker blue is facility loads and the red is laundry equipment. So of course, this varies significantly based upon the use and mission of each space and provides a good indicator of what's being used and ultimately the energy use that we'll get in a minute here. Next slide.

So, this slide just breaks down these device categories a little bit. There really is no standard taxonomy for plug load devices that's been agreed upon, but this is the approach that we've taken. I won't read through all of this but a lot of this should make sense according to the categories that we've described. A couple things to point out: the shop equipment, so this is all equipment that was in the vehicle maintenance shop – a number of different things from lift cranes to air compressors to power units, large battery chargers and things like that. In terms of facility loads, these were a variety of mostly miscellaneous or hardwired – direct-wired equipment within buildings supporting the function of the building including significant telecom and networking infrastructure. The one elevator I mentioned in the battalion headquarters building, fire and security systems, even down to the level of the infrared plumbing fixture controls within restrooms. Those were all captured and inventoried at some level. Next slide.

A brief introduction to our data collection approach. This is what underpinned the entire study. Beyond the inventory, we went back and performed a comprehensive metering on select panels and circuits within each building. Some photos of that operation is shown on the bottom left. We also performed comprehensive level of device level monitoring for a significant subset of actual individual plugin devices. So, photos of those are on the top right. This was performed with a commercial plug load management system from Ibis Networks. They've since changed their name to Watt IQ. So, this system relied on a host of individual sockets into which devices were plugged into that captured the data, sent it wirelessly through a secure Zigbee mesh network to the gateway which received it and then via a cellular modem sent that up where we could access the data basically in real time and use it to compile and analyze the information that we were seeing. Additional information that we had from the site included old building interval energy data in a couple of forms. One was 15-minute interval data from the Army's metered data management system and then we also had for most buildings, one-minute interval data from the site's EMCS. Next slide.

Results of this metering effort really underpin the overall – the entire analysis of this study frankly, from understanding estimates of annual energy use to understanding the unique behavior of operations from each device and each circuit to identifying opportunities for improvement and savings. And so, for each of the equipment and select circuit that was monitored, we had about anywhere from 18 to 22 weeks of data logs at one-minute intervals such as shown for one particular week at the top right. Because this was a huge amount of data and very difficult to analyze by itself, we ended up going through a process to aggregate that into what we call aggregate weekly 15-minute interval profiles as shown in the bottom right. We developed these for specific devices but also an average for all devices of a given type. This really helped us understand and evaluate and assess how different types of equipment were really behaving overall, and so there are literally dozens of these load profiles presented in the full technical report, and we'll use them throughout parts of the rest of this presentation. One of the key features of these load profiles is the alternating light and dark backgrounds. What these represent are the different periods within each day, so the lighter appears in white indicate the daytime periods from 6:00 A.M. to 6:00 P.M. every day, and the darker gray stripes represent the period from 6:00 P.M. to 6:00 A.M. So with a load profile superimposed on this chart, you can really tell pretty quickly how the equipment is behaving, whatever devices it is, and how its energy management functions are operating or are set.

In this case, again, you get to understand what these different signatures suggest and what type of equipment they are operating. If you have any ideas, I'd be interested to see if you're right. What this actually is both profiles represented it from a desktop computer. So again, this highlights the difference between the daytime and the nighttime, and even the weekend loads really highlights that the computer management has been effectively disabled on all systems. So, the lower chart represents the average of all of the desktop PCs that were monitored. Again, you can see very little reduction in energy use and load between the weekday daytime periods and the nighttime or weekends. A couple of interesting things you can see is the spike on the evening of Wednesday typically. Our premise or suggestion on that is that's likely a time when a lot of the updates are pushed out to the computers. We haven't verified that, but at least at the time of the study, that's what we believe is indicated by that spike and perhaps of the other smaller spikes later on in the week. Next slide.

So, building up from all of those individual load profiles, we're able to look at the total energy used by plug loads and miscellaneous electric loads within each of the buildings. That is expressed here in terms of energy intensity for each of the buildings again colored by category that we looked at before. So, what jumps out here, number one, is that the admin building not only has the highest number of devices, it also has the greatest energy use or energy intensity of any of the buildings that we monitored. The bulk of that – one of the greatest number of devices was computing and the greatest contributor to energy use is also computing in the admin building. Again, as we showed before the COF is both the lowest number of devices, and also the lowest energy use of all the buildings we looked at. The last bar at the bottom represents the composite across all buildings that we looked at, all five buildings at this site.

So, this provides the average intensity contribution according to each category of equipment. You'll notice that the dark gray bar at the very right side represents what we call occupant units. This is the energy for plug loads that are actually being used within the occupant units within the barracks. Because we couldn't get into the barracks and inventory or monitor specifically the devices within there, we don't know actually how that portions out. We were able to capture and identify the total plug load use within those spaces from the aggregate panels within the electrical room, but we really don't know specifically how much of those are – belong to each category. We did get in to see a few units in the barracks. Some of the soldiers invited us in to take a look and just see what they had. And from that experience, I think it's safe to say that the bulk of that dark gray bar would actually belong in the top three categories shown. So, the AV equipment, televisions, gaming systems would be a big contributor, computing systems also as well as breakroom or kitchen equipment. So, each unit had a shared kitchen between two soldiers, and it had a small refrigerator, microwave, and stovetop. If we were to break that gray bar down, I'm confident that the highest user would be probably in computing perhaps in the breakroom category. Next slide.

Breaking down these results, it's a little bit finer level of detail, we get to the following. These are the highest consuming energy devices, device types and devices. So, on the left side we see the highest consuming device types. So, this is a bit of a lower subtype of each category that we talked about. The bars are colored according to the main category that we've introduced before. So, clothes dryers by far use as a type of device, use the most energy of any across the buildings that we looked at, followed secondarily by laptops, telecom and networking devices, vending machines and monitors. In terms of actual individual devices, those are listed on the right side, the chart on the right. Of course, immediately we run into an exception to that rule, but we didn't want to include our networking panels in this comparison. Now networking panels really consist obviously of a variety of multiple different components and devices, however we were unable to actually access those systems to inventory or monitor them individually and only had circuit level. So, they're really not individual devices, but we included them here for comparison against others that are. So, if you look at actual individual devices, the top two energy consumers are both vending machines, refrigerated vending machines in the barracks, followed by the air compressor serving the temp at the vehicle shop, then the elevator in the battalion headquarters, vending machine and the TEMF clothes dryer. The average clothes dryer in the barracks, telecom panels again, refrigerators, battery chargers, even fire alarms, space heaters, and so forth. Let's go to the next slide.

Here we'll get into a little more detail on some of the specific equipment types. I won't go into extreme detail as this is provided in some of the reports. But for computing systems, the chart on the right highlights the range of energy use on an annual basis for each of the different types of devices within the computing category. As you can see, desktop PCs on average use exactly twice as much as the average laptop. That's what we found in this study. However, when you also consider that each of the desktop PCs that we saw – the 14 that were monitored plus others that we didn't monitor – they each had their individual dedicated uninterruptable power supply connected to them. And so, when you actually want to compare desktops versus laptops, it would probably be good to consider any UPS that's also accounted for that would actually enhance the savings. Given that laptops have a built-in battery, it may not be as good or provide its power as long as UPS but certainly would provide a similar buffer for most instances. Again, on the bottom left, we see the load profile that we saw before for desktop PCs with the green lines indicating a relatively simple approach for estimating savings from improving power management or enabling power management. So clearly, from this analysis, the Army could expect to save well over 46 percent by enabling computer power management to coincide with their cybersecurity focus. Now, again, when you apply this to all the computers within the Army, this starts being considerable savings opportunity, and expanding that to DOD and other agencies, it becomes a much bigger, bigger deal and really represents the largest high priority plug load energy and cost savings measure identified by this study. Next slide.

Here's a similar slide for the office equipment. Again, the chart highlights the energy use by space heaters as well as large, multi-function devices which I think in many cases act much like a large space heater, especially when they're not working. Most of the time, they're keeping warm to be ready for that next job. What we found is that smaller, multi-function network devices use on average one-sixth of the energy of these large devices and are operating just as well. In fact, just prior to our study, the battalion headquarters had made a switch from these large multi-function machines to smaller network devices and were enjoying and didn't see any real impact on overall mission and productivity. A couple examples here at the bottom – these load profiles – the top one is actually from the TEMF, the vehicle maintenance facility. If you look closely at the blue line, this machine actually had energy management function set up, however, it was incomplete. You can see it went to a low power mode at 6:00 every day, but then woke up again around midnight. So again, I may give them a C for effort there, but the implementation was not quite accurate or complete and not only was it operating and ready to go from midnight to

6:00, but also even on weekends. So, a big opportunity there. The other machines that were located in the admin building, none of them had any sort of power savings controls set up. Next slide.

Vending machines – again, one of the big energy users that we found. One of the big findings here is not going to be surprising but replacing old outdated refrigerated vending machines with new Energy Star versions is highly recommended. You save a lot doing so, but one of the surprises too is that Energy Star certification is important but not necessarily completely sufficient. So, the top load profile there for the average of the non-Energy Star vending machines that we looked at averaged about 3600 kilowatt hours per year. The second one in the middle represents the Energy Star machine, Coke Machine, shown in the middle photo. This was in the TEMF. It used about 1800 kilowatt hours per year. You can see from the profile that it was actually locking out the compressor for a few hours every night. That seems like a good thing. What was interesting is we noted that that machine was identical to one we have here at PNNL in our office building. So, we did some comparison between the energy use and load profiles from each of those machines, identical model, identical year, and there are some obvious differences. The one at PNNL shown on the right photo has its lighting disabled. We're also able to see that the set point temperature for the unit here at PNNL was a few degrees higher than that one in the TEMF in the Army installation. There may be other differences, but you can see very clearly that the load profile and behavior of these machines, otherwise identical, is extremely different. This highlights the importance of not only purchasing Energy Star but understanding and setting controls appropriate for the type of machine for your needs and your location. Next slide.

I'll skip through this pretty quickly, but the main point here is again, we looked at a number of different devices in the breakroom appliance category. Something that we all hear about all the time, but we really confirmed is that replacing old, outdated refrigerators with newer models makes a lot of sense. So, comparing 20 plus year old refrigerators to newer refrigerators even up to 20 years old resulted in significant energy reduction. Another area of focus is commercial coffeemakers. Other presenters have presented on this before. I think the biggest thing here when you have large volume needs for coffee is to brew that into an insulated carafe and then use that rather than keeping coffee on a heater all day long. Another approach that seems to work well from an energy perspective – you could question the waste perspective – is a Keurig or single-use unit as shown here uses considerably less energy. Next slide.

So, to wrap up a little bit, there are a number of things that we looked at. Many of these are fairly simple approaches, but we also put together some thoughts on more comprehensive life-cycle approach towards best practices and managing plug load. So go ahead and click again.

First one is recognizable to most of us – purchase equipment that's needed, suits the application, and is energy efficient. That one makes a lot of sense. A lot of us are required to do that or in the habit of doing so. Next.

But one of the next important measures of steps in this process is really to set up the equipment to best utilize any embedded or external control settings that are appropriate for the device, the use, and the application it's in. This is something that we've found is too often neglected. Next.

Certainly, in terms of operation, turn things off when it's not needed. Turning off equipment for just 12 hours each weekday and all weekend will reduce the operating hours by 64 percent. Next.

Monitoring is also critical. We've talked about that. The next one.

Reviewing equipment needs. This one is really important and a precursor to the purchase step. The most effective way to save 100 percent of energy use and 100 percent of purchase cost is to avoid purchasing equipment that's not needed. So that's important to keep in mind. Finally, one more.

Throughout this process, as we've discussed, it's critical to engage personnel, educate them, and empower them to use the equipment appropriately and monitor its behavior. Next slide.

So, in summary, I wanted to talk quickly about why we should care about plug loads. There are a number of reasons. In this study, we've learned that plug load is comprised of about 25 percent of the pie in terms of electricity use across five typical Army buildings. These are mostly an overlooked and expanding end use. The number of devices that we each have is growing and it's pretty remarkable. I think we often take it for granted how many devices we rely on every day. They're all around us and yet really, we don't know how they behave and how much energy they use. In this study, we found that in these Army buildings, there are anywhere from 4 to 10 plug load devices per occupant. The energy use of these devices collectively range from about 500 to 2000 kilowatt hours per occupant every year. As I said earlier, one of the key things that sets plug loads apart from other end uses is that we are all plug load operators and technicians. Plug load devices are all around us. We interact with them every day almost every minute to some degree. They are not locked in mechanical rooms or electrical rooms or require dedicated technicians for the most part. Some do, and relatively simple management measures as we've shown can cut many devices' energy use in half or more. I think a more comprehensive approach that we've talked about integrating kind of a life cycle management approach can really save even more. Next slide.

Finally, to wrap things up, as I mentioned, we have a very detailed technical report. It's about 200 pages detailing all aspects of this study, presenting findings, presenting literally dozens of the device level and circuit level load profiles that we introduced. Additionally, for those of you who want an easier to digest version, there is a six-page study highlights linked here as well as a two-page summary of equipment types as we outlined a minute ago. Next slide.

Then finally, I do want to recognize the entire team that contributed to the success of this project. That includes our Army sponsors and others, particularly those at the Fort Carson Energy Team, Copas Boyer electricians who helped get the electrical panel metering in place, Greg Sullivan of Efficiency Solutions for his energy monitoring expertise and guidance, and of course, the rest of our team here at PNNL. I'd be happy to take any questions you've entered into the Q&A. Going forward, happy to take any other questions directly or comments, contact me at the information provided. So, thank you very much.

*Kim Trenbath:* Excellent. Thanks, Bob for your great presentation. I particularly found that it was really interesting that you confirmed that 25 percent of the energy consumption in your buildings was due to plug loads. That is a significant piece as you said of the energy pie, and you were looking at plug loads specifically not – sometimes there's plug and process loads that are included at some of the numbers. So, we're looking at 25 percent which is a significant amount. So, we're going to get into some of the questions for Bob right now. There were no questions for me, but I just want to remind the guests on the call that if you're interested in asking a question, type your question into the Q&A section and we are compiling those on the back end here, and we are going to have Bob answer those one by one. So, Bob, are you ready for your first question?

*Bob Dahowski:* Sure.

*Kim Trenbath:* Okay, great. Okay, so this question is did the study – one second. I need to take a better look at it here. Okay, the question is did the study also assess the benefit of managing plug loads and MELs to leave more space for additional building electrification without needing to upsize electrical panel capacity and distribution asset sizes? A comment here – these capital cost savings can be large as we pursue electrification and charging electric vehicles at buildings.

*Bob Dahowski:* That's an outstanding question. The study really did not focus on that. The study actually was initiated probably about a few years before the pandemic set in and we actually ended our monitoring just as the pandemic was starting. Fortunately, we had enough data at that time before COVID changed the dynamics of working in some of those buildings. No, at that time we did not really focus on that, but that is clearly another driver I think for focusing on plug loads and process loads. Reducing these loads as the number of devices increases, I think, is critical for focusing on electrification, making more capacity available for other systems that may need to switch from fossil energy to electricity, for electrification or decarbonization. Also, very important for energy resilience. The Army of course is very concerned about not only energy efficiency and energy resilience but also going forward working on electrification and decarbonization. Plug loads, as I call them an overlooked end use, I think it is going to necessarily be an important end use and will need to be in the spotlight as we work on some of these other challenges. That's a very good point.

*Kim Trenbath:* Thank you, Bob. The next question is are there any lessons learned or occupant pushback for metering insulation at the devices and panels?

*Bob Dahowski:* That's a really good question. We actually expected more questions, more occupant inquiry regarding the monitoring that we were doing in the buildings. Fortunately, with the energy team we were working with on the site, we were able to select buildings that had energy managers that were knowledgeable and aware of the importance of these things. So no, actually, we didn't really get any pushback. In fact, it was surprising that we were engaging in some of this work, performing some of the metering, installing the device level meters, doing the inventories. We got a number of interesting questions in fact from some of the soldiers just looking for input on how they can better be aware of their devices at their homes even in ways that they can use this information to help them save energy and reduce utility costs. So, in fact, it was the opposite of what we expected. People were very gracious and welcoming into their spaces in the time that we had to impose and really interested in learning from what we were doing.

*Kim Trenbath:* Thank you, Bob. Our next question is are there plans to conduct another metering study after some or all of the priority updates are made? How much savings do you expect from making these updates?

*Bob Dahowski:* Yeah, that's a great question too. Part of the study, again, was really focused on identifying the situation as it currently exists, understanding how much plug loads contribute to energy use, and looking at options for savings approaches. The study was not designed to actually implement measures at this time or as a follow-on at this point. I think it would be interesting to do that, to see what type of savings could accrue. Again, the focus was really to identify and identify opportunities within Army policy and behaviors to enact change, impacts for good. I would like to follow this up to see what would happen implementing some of these measures. I am aware of one study that was performed by a colleague I think at LBNL who worked at a site, an Army installation, and in fact, found that identifying some measures and getting the buy-in from the hierarchy really resulted in a quick change and reduction of energy. Again, I think the Army may be more predisposed to this given their culture, but I think relying on people trying to do good, educating them as to how devices behave, what types of measures can, relatively simple measures can be deployed. Giving them the power to do that I think can result in some good and very quick results.

*Kim Trenbath:* Thanks, Bob. We have time for one more question and a 30-second answer to this longer question. There's a lot of difference in the annual energy use for device for large, multi-function devices and smaller multi-function devices. The recommendation that you presented seems to be to switch to small. Please provide examples of switching from large to small, including the type of machine and where it would be located in the office.

*Bob Dahowski:* Yeah, I think there's a few examples. Coffeemakers is one. It's not office equipment but I think the more you can get away from these large commercial coffeemakers, again, depending upon your application that makes sense. The biggest example was in terms of multifunction copy/print devices. Most of these we found were just being used for printing, group printing. So, I don't remember necessarily the brands or specific types. It's probably in the report, but just switching from a very large traditional copier with printing capabilities to more of a smaller tabletop device, we found saved tremendous amount of energy and again, where it was done in the battalion headquarters building, we noticed they were happy with those systems. Not only did they use less energy, they took up less space. Again, they had the full networking capability and just didn't need to use – spend so much energy to maintain their readiness for a job and stay warm. Like I said, with the big ones acting as space heaters most of the time.

*Kim Trenbath:* Great. Well, thank you, Bob. Those are all the questions that we have for today. So, thank you very much for your presentation. We encourage everyone to sign up for our next TRT which is going to be August 1st and this one features metering for medical imaging equipment. Thank you all and have a great summer.

*Bob Dahowski:* Thank you.

*[End of Audio]*