Delivering Effective Virtual Energy-Focused Trainings: Successful Strategies and Lessons Learned from the Virtual Cohort In-Plant Training Pilot

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ABSTRACT

While there are always barriers to energy efficiency efforts, few challenges have been as severe as the global COVID-19 pandemic. Many manufacturers throughout the United States and the world have been trying to determine how to safely open and operate their plants. To minimize the number of people working within facilities and maximize the physical distance between workers, only essential facility engineers are allowed into plants to ensure proper operations. The Department of Energy's Better Plants Program created In-Plant Trainings (INPLTs) to help partners develop in-house expertise in energy efficiency. Delivering INPLTs in the traditional in-person fashion is infeasible under these circumstances. To continue providing INPLTs during this difficult time, the Better Plants Program piloted Virtual Cohort In-Plant Trainings (VINPLTs) on wastewater treatment and ammonia industrial refrigeration systems from October 27 to November 19, 2020. This paper provides an overview of the pilot, then discusses successful strategies and lessons learned from this pilot for delivering effective virtual energy-focused trainings.

INTRODUCTION

Manufacturing plants in the United States consumed about 26.3 quads of energy in 2019, which is 35% of the total domestic source energy [1]. The US Department of Energy (DOE) launched the Better Plants Program in 2011 to improve the energy efficiency of industrial

facilities and water and wastewater treatment plants, as well as to train future generations of the manufacturing work force [2]. As of December 2020, more than 235 manufacturing and water and wastewater treatment organizations, representing over 3,000 plants, have partnered with the Better Plants Program [3]. By partnering with the Better Plants Program, these partners pledge ambitious energy efficiency goals, typically 25% savings in 10 years, and receive technical support, technical resources, and high-profile recognitions for their outstanding achievements.

To address one of the major barriers of implementing energy management systems, lack of in-house expertise on energy efficiency [4], the Better Plants Program created In-Plant Trainings (INPLTs) to help partners. INPLTs are multi-day workshops performed by industry-recognized experts. Unlike many other training programs [5], INPLTs include both classroom- and field-based sessions that train attendees to identify energy conservation opportunities in their facilities, quantify savings from these opportunities, and implement projects to realize the savings [6]. The Better Plants Program has hosted over 120 INPLTs with more than 2,160 participants, helping to identify over $41M of energy cost savings by September 2020.

While there are always barriers to energy efficiency efforts, few challenges have been as severe as the global COVID-19 pandemic. Many manufacturers throughout the United States and the world have been trying to determine how to safely open and operate their plants. To minimize the number of people working within facilities and maximize the physical distance between workers, only essential facility engineers are allowed into plants to ensure proper operations [7]. Delivering INPLTs in the traditional in-person fashion is infeasible under these circumstances. As requested by partners [8], to continue providing INPLTs during this difficult time, the Better Plants Program piloted Virtual Cohort In-Plant Trainings (VINPLTs) on wastewater treatment and ammonia industrial refrigeration systems from October 27 to November 19, 2020. This paper provides an overview of the pilot, then discusses successful strategies and lessons learned from this pilot for delivering effective virtual energy-focused trainings.

VINPLT Pilot Overview

The VINPLT pilot was open and free to all Better Plants partners, lasting for 4 weeks from October 27 to November 19, 2020. The training had two topics: wastewater treatment and ammonia industrial

refrigeration systems. Wastewater treatment training had eight 2-hour (9–11 A.M. Eastern Standard Time [EST]) online training sessions, which were delivered on Tuesdays and Thursdays. The wastewater treatment training also had two question and answer (Q&A) sessions (9–11 A.M. EST) on November 4 (Wednesday) and November 18 (Wednesday). The ammonia industrial refrigeration training had eight 3-hour (11–2 P.M. EST) online training sessions, which were also delivered on Tuesdays and Thursdays. The final hour of each session was mainly for Q&A.

The VINPLT pilot was conducted via Zoom, a popular videoconferencing platform. The training organizer selected Zoom due to its popularity among partners and some of its features, such as live polling, breakout rooms, online chatting, chat text downloading, and video recording, downloading and transcribing. Kahoot quizzes with prizes for winners were used at the end of some sessions. More details on the Kahoot quizzes are provided in the next section.

About 25 people from 10 companies—four food manufacturing companies and six public wastewater treatment plants—attended the VINPLT for wastewater treatment. Over 220 people from seven food manufacturing companies, representing more than 110 manufacturing plants, attended the VINPLT for ammonia refrigeration systems. About 90% of the participants for the ammonia refrigeration systems training came from one food manufacturing company. Both trainings had some participants who were responsible for operating equipment and plants and some participants who were from the corporate energy team with limited access to equipment operations during the pandemic. Certificates of professional development hours (PDHs) were created and emailed to participants upon request.

Homework was assigned after some sessions to collect equipment operation data and identify energy conservation opportunities. For the wastewater treatment training, participants were required to submit lists of energy savings opportunities with the scale from 1 to 10 based on estimated implementation cost and energy savings. For the ammonia refrigeration systems training, the homework assignments included completing check sheets for compressors, condensers, evaporators, and defrost and identifying energy opportunities.

Surveys were conducted at the end of the 4th (midterm) and 8th (final) sessions to collect feedback and suggestions for improvement. Table 1 shows some highlights of the survey results, which were very

Table 1. Highlights of Survey Results

Survey questions	Wastewater Midterm Survey	Wastewater Final Survey	Ammonia Midterm Survey	Ammonia Final Survey
Number of responses	12	9	67	48
Average rating of overall workshop experience (Rating from 1 to 4; 4 is excellent)	3.75	4.0	3.47	3.67
I left the workshop with specific ideas for reducing my plant's energy intensity	Strongly agree: 75% Agree: 17%	Strongly agree: 78% Agree: 22%	Strongly agree: 36% Agree: 61%	Strongly agree: 73% Agree: 25%
Average rating of pace of delivered materials	3.50	3.58	3.45	3.63
Average rating of balance between delivered materials and exercises	3.67	3.58	3.48	3.60

positive overall. On average, more than 63% of the participants indicated that they had excellent experience. Almost all participants agreed that they left with ideas to improve the energy efficiency of their facilities.

Successful Strategies and Lessons Learned

This section discusses some successful strategies and lessons learned that were identified from the pilot to deliver more effective VINPLTs in the future. These successful strategies and lessons learned were primarily based on the feedback collected through midterm and final surveys, conversations between the training organizer and participants, and the organizer's personal impressions on the trainings.

Registration Process

Better Plants partners registered for the trainings by emailing the organizer. The organizer then sent meeting invites with Zoom links and training materials to the participants. Some pretraining plant information was also collected through email.

Although the registration process worked well, it could be more streamlined, made more efficient, and less error prone by using specialized platforms and technologies for events registration management. These platforms and technologies can allow participants to visit a website to register and download training materials. The meeting invites and links can then be sent out automatically.

Leadership Buy-in

As noted previously, about 90% (200) of the participants for the ammonia refrigeration systems training came from one company. These participants were also more active during the last Q&A hour of each session and were responsible for 95% of the completed check sheets. They also volunteered to present energy savings opportunities and savings from their five plants in the final session.

Buy-in from senior leadership is critical for successful energy efficiency activities [9]. The primary reason for the outstanding participation from this particular company was probably due to senior leadership buy-in obtained during the training's planning phase. This company has about 110 plants in United States and uses about 2,000 GWh of electricity ($100M electricity cost with the assumed price of

$0.05/kWh) every year to operate its ammonia refrigeration systems. Three energy treasure hunts performed early in 2020 showed that ammonia refrigeration systems had significant energy savings potentials for both percentage and absolute savings, which inspired the senior leadership to perform energy assessments for ammonia refrigeration systems in all plants within two months. The company consulted the Better Plants Program for options and agreed to use VINPLTs as the main strategy for this endeavor. The company worked with the Better Plants Program to design the schedules and contents to fit their needs and mandated all plants to participate in this VINPLT. The company also created its own homework to facilitate the energy assessments.

General Scheduling

The survey results data showed that the general scheduling (i.e., pace of delivered material) worked well for participants (Table 1). In other words, having two 2–3 hours sessions (Tuesday and Thursday) per week for 4 weeks worked well for both trainings.

Before the trainings began, some participants for the ammonia industrial refrigeration training were concerned that 3-hour training sessions might be too long and that they might need to leave early due to other job duties. To address this concern, the first 2 hours were focused on new contents, and the final hour was dedicated to Q&A. The participation records showed that after 2 hours of lectures, about 70 to 80% of participants stayed and attended the final hour for Q&A. The participants later indicated that the training experts answered many great technical questions and that 1-hour Q&A was beneficial.

For the ammonia refrigeration systems training, completing check sheets for compressors, evaporators, and condensers were assigned as homework on Tuesday to be due Thursday the same week. Unfortunately, only 39 check sheets were completed. One possible reason is 1 day was not sufficient time for most participants. One way to solve this issue is to expand the training to 8 weeks and have one session per week, which gives participants at least 1 week to complete the homework.

The starting time for the wastewater treatment training sessions was 9 A.M. EST (6 A.M. PST), which might be too early for participants from the West Coast. Two participants from the West Coast attended the training.

Participants Engagement

Kahoot quizzes (Figure 1) and Zoom's live polling feature (Figure 2) were used to enhance participant engagement. Kahoot is an online game-based learning platform widely used in schools and other educational institutions and can be played via a web browser or the Kahoot app. Kahoot quizzes have single- and multiple-choice questions that can be used to review knowledge. The scores of the quizzes are decided based on the correctness of answers and the speed of entering answers. Reference books of wastewater treatment and ammonia refrigeration systems were used as prizes for quiz winners.

Table 2 shows the number of Zoom polls and questions in Kahoot quizzes in each session. These polls and questions were designed to gather information about participants' technical background, their roles in their plants, and identified energy conservation opportunities, as well as to enhance participants' understanding of the training contents.

Although the surveys did not include questions to evaluate the effectiveness of Kahoot quizzes for retaining participants, some participants provided very positive feedback on the quizzes in Zoom's chat box during the Q&A time.

As shown in Table 2, the ammonia refrigeration systems training had only one big quiz with 46 questions in the final session. To engage participants and enhance their understanding of the material throughout the 4-week training process, it might be more beneficial to divide this big quiz into four or five mini-quizzes.

Homework

The homework assigned to the wastewater treatment training participants was to identify energy conservation opportunities. Only 21% (5 out of 23) of the participants submitted their homework, and 23 opportunities were reported collectively. For the ammonia refrigeration systems training, 39 check sheets were completed. In the final session, five participants from the company with the most participants and one participant from another company presented their identified opportunities with 4 to 12% savings at their plants. Overall, the homework completion rates were below the training organizer's expectations.

By studying survey results and interviewing participants, the organizer identified below four primary reasons for low homework completion rates.

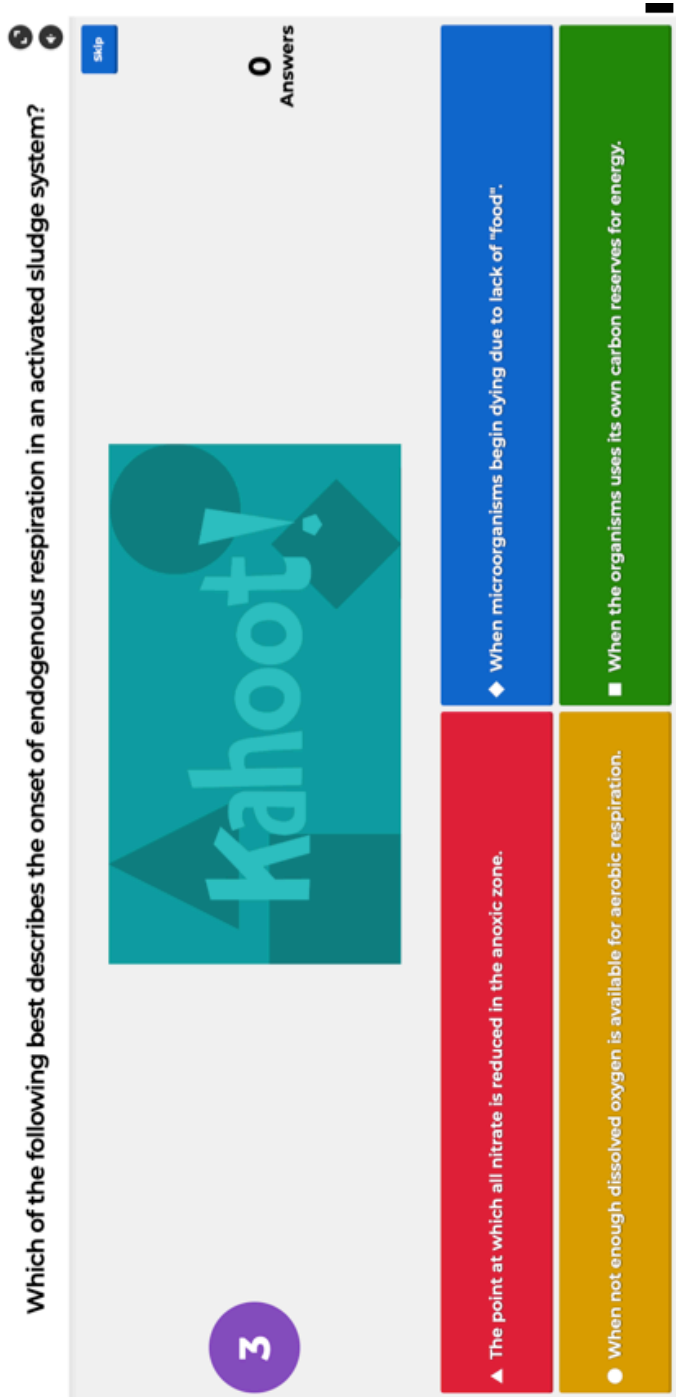

Figure 1. The Screen Capture of an Example Kahoot Quiz Question

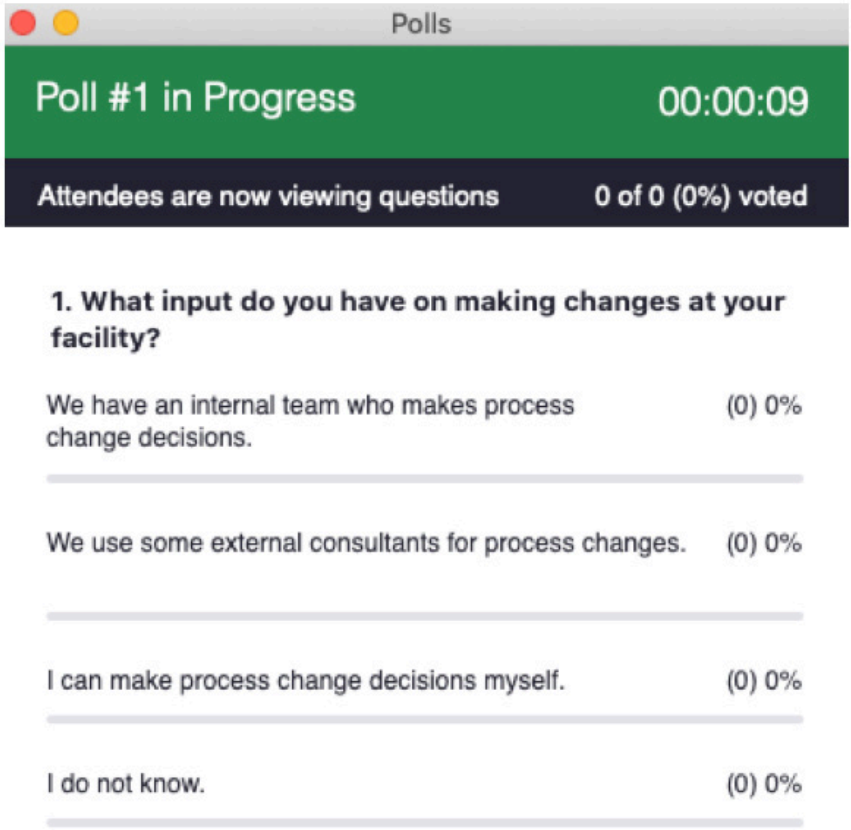

Figure 2. The Screen Capture of an Example Zoom Poll

1. Some participants were located at the corporate office. Due to the pandemic, they were not allowed to travel to plants to collect operation data and identify opportunities.
2. Due to other job responsibilities, one day (assigned on Tuesday and due on Thursday the same week) was not sufficient for some participants to complete the check sheets for ammonia refrigeration systems.
3. Some participants needed more technical help and more detailed directions to complete the homework because of relatively little engineering background.
4. Some participants attended both training topics and did not have time to complete the homework when attending four training sessions per week (about 10 hours per week).

Table 2. Zoom Polls and Kahoot Quizzes

Training Topic	Sessions							
	1	2	3	4	5	6	7	8
Wastewater treatment	2 Zoom Polls	3 Zoom Polls	N/A	6 Kahoot Quiz Questions	10 Kahoot Quiz Questions	10 Kahoot Quiz Questions	N/A	7 Kahoot Quiz Questions
Ammonia refrigeration systems	N/A	N/A	3 Zoom Polls	1 Zoom Poll	5 Zoom Polls	3 Zoom Polls	6 Zoom Polls	46 Kahoot Quiz Questions

Several solutions to address these issues and improve homework completion rates are proposed.

1. Encourage participants without the access to plants and equipment operational data to work with participants who do.
2. Design training content, homework assignments, and schedules to give participants at least one full week to complete the homework.
3. Use live polls, pretraining screening, or other mechanisms to better understand the background of participants and dedicate sufficient time in the training sessions to provide appropriate guidance for completing the homework.
4. Deliver multiple trainings topics consecutively rather than in the same week to provide more homework time for participants who are attending both topics.

SUMMARY

To continue providing INPLT to partners during the COVID-19 pandemic, DOE's Better Plants Program piloted VINPLT on wastewater treatment and ammonia refrigeration systems from October 27 to November 19, 2020. The survey data showed that participants had very positive training experiences. To deliver more effective INPLTs in the future, the training organizer summarized below successful strategies and lessons learned from studying the survey results and interviewing some participants.

1. Specialized platforms and technologies can be used to automate and streamline the registration process. Participants can be directed to a website to register for trainings, submit pretraining screening data, download training materials and video recordings, and receive PDH certificates.
2. Obtaining buy-in from senior leadership was paramount for great participation. About 200 people from one company attended the ammonia refrigeration systems trainings because senior management mandated participation.
3. Having two 2–3 hours training sessions (Tuesday and Thursday) per week for 4 weeks worked well for both trainings. However, to

give participants attending both trainings more time to complete the homework, these training topics could be delivered one session per week.

4. Live polls and Kahoot quizzes were effective for retaining and engaging participants and enhancing their understanding of the training material.
5. The rate of homework completion could be improved by giving participants more than 1 day to complete the homework. Some participants might need more detailed directions to complete homework assignments.

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Kristina Armstrong holds a Bachelor of Science in Chemical Engineering from University of Missouri-Rolla (now Missouri University of Science and Technology) and Master of Science in Mechanical Engineering from Colorado State University—Fort Collins. For her graduate degree, she focused on alternative energy technologies and materials. Her thesis work combined an overview of the practices of life cycle analysis at the energy/waste/food nexus with a specific analysis on the life cycle energy implications of combining microalgae growth and wastewater treatment. She has worked at Oak Ridge National Laboratory since September 2015, first in the Center for Transportation Analysis and then with the Energy Efficiency Research and Analysis Group. Her previous work at ORNL included the development of a fiber reinforced composite energy analysis web-based tool and conducting a technology assessment on the status of wide bandgap power electronics. Her current focus is assisting on the efforts to update the DOE AMO software tools (e.g., PSAT, PHAST, SSMT, EnPI), providing engineering support during development.

Dr. Sachin Nimbalkar is a group leader at the Oak Ridge National Laboratory. He has more than eight years of professional experience which includes working as a R&D staff at ORNL. Dr. Sachin provides technical support to DOE's Better Buildings, Better Plants Program Partners (mainly industrial and wastewater treatment partners) through energy road map development, baselining analysis, in-plant training, and field visits to investigate feasible measure to reduce process energy requirements. Dr. Sachin has conducted several training and demonstration workshops throughout the US, India, China, Ukraine, Costa Rica, and Turkey covering energy efficiency in process heat systems, system specific and cross-cutting energy audits, and ISO 50001 implementation steps and tools. Sachin has contributed for the development of several DOE software tools, including the process heating tools (PHAST and PHMT) and the EnPI tool. Dr. Sachin has

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