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US Department of Energy Better Plants Program's Approach to Manufacturing Workforce Development

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ABSTRACT

Multiple studies suggest that by 2030, millions of jobs may go unfilled because of a significant skills gap between the current manufacturing workforce and the workforce needed to support the shift toward advanced and sustainable manufacturing. According to US manufacturers, finding the right talent is more difficult now than in previous years. Developing a well-trained workforce will play a critical role in transforming the manufacturing sector into a net-zero contributor of greenhouse gas emissions by 2050. To help reduce energy, water, waste, and greenhouse gas emissions as well as build a strong, sustainable manufacturing workforce, the US Department of Energy created the voluntary Better Plants program in 2011. This study discusses the program's various workforce development activities, including in-plant trainings, virtual in-plant trainings, and in-person bootcamps. The target audiences, training objectives, and topics designed to upskill workers for a low-carbon manufacturing future are described. Feedback that was collected (e.g., new training topics, certifications, hands-on activities) while working with more than 270 US manufacturers for the past 12 years on workforce development are discussed. Finally, some strategies are proposed to address the feedback.

Introduction

The manufacturing sector contributed $2.4 trillion to the US economy in 2021, accounting for 10.7% of the GDP (US Bureau of Economic Analysis 2023). It also employed approximately 13 million people, with an average hourly rate of $31.83 as of March 2023 (US Bureau of Labor Statistics 2023). Manufacturing is the foundation of the US economy and plays a critical role in supporting middle-class families (Nash-Hoff 2020). However, multiple studies have indicated that the US manufacturing sector could have 2.1 million unfilled jobs by 2030 because of the skills gap between the current manufacturing workforce and the workforce needed to support the shift toward a digital and low-carbon manufacturing future (Deloitte 2021). These unfilled positions will have a moderate to very high effect on maintaining and improving production levels, responding to new markets, supporting new products, and implementing new technologies (Deloitte 2021).

The Better Plants program is a voluntary initiative launched by the US Department of Energy (DOE) in 2011 to improve the energy, water, waste, and carbon efficiency of industrial facilities and of water and wastewater utilities (US DOE 2023). By partnering with the program, partners commit to ambitious long-term efficiency improvement goals, typically 25% savings in

10 years. The Better Plants program provides partners with technical assistance, including various workforce development activities to improve in-house expertise—the lack of which is one of the major barriers to energy efficiency.

This study discusses the objectives, target audience, technical topics, and effectiveness of these workforce development activities (i.e., in-plant trainings [INPLTs], virtual INPLTs [VINPLTs], and energy and decarbonization bootcamps) designed to upskill workers for sustainable manufacturing. Feedback that was collected from participants is discussed along with how the team plans to improve these training activities. Some challenges (e.g., low travel and time budget, limited hands-on activities, lack of access to delivery approaches by underserved and underrepresented communities and companies) identified while working with over 270 US manufacturers for the past 12 years on workforce development are also discussed. Finally, some strategies are proposed to address these challenges.

In-Plant Trainings

Overview

The INPLTs include both classroom- and field-based sessions that train attendees to identify energy conservation opportunities, quantify savings from these opportunities, and implement projects to realize the savings (Guo et al. 2019). These trainings are 3 to 4 days in duration depending on the system type, plant size, and process complexity and are led by industry-recognized experts. The training experts and participants spend about half the time touring the host facility to understand the manufacturing processes and identify savings opportunities. Therefore, participants can apply what they learned from the classroom training sessions and use equipment to diagnose energy system operations and collect data. On the final day, all findings (i.e., energy conservation opportunities and estimated savings) are presented by the participants to the plant management team to acquire their feedback and buy-ins for implementation.

The Better Plants program annually holds two rounds of INPLT application solicitations for the partners, which usually begin in March and September, respectively, and the program typically awards 6 to 12 INPLTs per solicitation based on funding availability. The Better Plants program offers INPLTs for 11 topics, as listed in Table 1. The objectives of INPLTs are to help participants in the following areas:

- Understanding of the basic working principles and fundamental knowledge about the training topic systems
- Knowledge of best maintenance practices
- Knowledge of common energy conservation opportunities
- How to use software tools to quantify savings
- How to use equipment to diagnose energy system operations and collect the needed data to quantify savings

Table 1. The training topics of INPLTs, VINPLTs and Energy Bootcamps

Training Topic	INPLTs	VINPLTs	Energy Bootcamps
50001 Ready	•	•	•
Compressed air systems	•	•	•
Pump systems	•	•	•
Fan systems	•	•	•
Steam systems	•	•	•
Process heating systems	•	•	•
Industrial water efficiency	•	•	•
Ammonia refrigeration systems	•	•	
Municipal water treatment	•	•	
Municipal wastewater treatment	•	•	
Energy treasure hunt	•		
Process cooling systems		•	•
Motor systems		•	•
Combined heat and power systems		•	
Manufacturing waste reduction		•	
Lighting systems			•
Building envelopes			•
HVAC systems			•
Understanding utility bills			•
Renewable energy			•
Road mapping for greenhouse gas emission reduction			•
Total	**11**	**14**	**15**

The Better Plants program has conducted more than 145 INPLTs for more than 2,500 participants, and these trainings have led to the identification of more than $53 million in energy cost savings since 2011.

Feedback and Future Plans

On the final day of every delivered INPLT since the first one in 2011, evaluation forms were distributed to gather feedback on the effectiveness of the events and to collect suggestions for improving future INPLTs. More than 94% of all the respondents indicated that they would recommend the INPLTs to other plants in their organizations. More than 75% of respondents rated the INPLTs as effective or very effective (on a 1–5 rating scale in which 1 is Not Effective, 3 is Moderately Effective, and 5 is Very Effective) across six learning criteria: (1) identifying energy efficiency opportunities, (2) identifying factors affecting system efficiency, (3) performing energy and economic analyses, (4) creating an energy management system, (5) using software tools, and (6) improving system operation and maintenance. Participants also provided comments for future improvement, and these suggestions are summarized as follows:

- Spending more time on plant tours to better understand the manufacturing process
- Allocating more time to teaching how to use diagnostic tools for operation data collection
- Providing more INPLTs in general and submitting and approving applications on an ad hoc basis
- Offering new training topics: process cooling systems, indirect (i.e., non-energy) benefits of energy efficiency
- Justification for energy efficiency projects and acquiring buy-ins from the management
- Applying for funding from state and federal governments

In the application form of August 2022 (the first time after the pause during the COVID-19 pandemic), to support the Justice40 Initiative, facilities located in disadvantaged communities (DACs) were given 10 points on the application score to increase their chances of being awarded. The Better Plants program awarded six (6) INPLTs for facilities located in DACs in August 2022, among which three (3) INPLTs (2 for compressed air systems and 1 for wastewater treatment) had been delivered by the time of writing.

The Better Plants program has piloted VINPLTs on process cooling systems in June 2022 and manufacturing waste reduction in May 2023, and the INPLTs on these two topics will launch soon.

Virtual In-Plant Trainings

Overview

The COVID-19 pandemic was one of the greatest challenges faced by manufacturers. To safely open and operate their plants, manufacturers implemented many measures to minimize the risk of infection. For example, many reduced the number of people allowed into their plants to the minimum amount of facility personnel who could ensure reliable production. Additionally, significant efforts were made to maximize the physical distance between workers. This measure made it challenging to deliver INPLTs in-person. To address this challenge and continue to provide INPLTs during this difficult time, the Better Plants program piloted VINPLTs on industrial refrigeration and wastewater treatment operations in October 2020. Because of the positive responses and requests from participants, the Better Plants program continues to offer

VINPLTs year-round for 14 energy topics, as listed in Table 1, and made the VINPLTs open to all US manufacturers. People can register for the latest training topics at bptraining.ornl.gov.

Every VINPLT comprises four to eight 2.5-hour online training sessions delivered via Zoom for consecutive weeks, typically one session per week. To maximize the benefits from attending VINPLTs, homework assignments are provided to participants at the end of the sessions and are due by the next session. Zoom polls and Kahoot! quizzes are used to engage participants, collect real-time feedback, and emphasize the key points.

As of June 2023, more than 1,300 people have attended these VINPLT sessions, and more than $11 million in energy savings opportunities have been identified. More information about VINPLTs is provided by Guo et al. (2021) and DOE (2020).

Feedback and Future Plan

An online survey form with eight questions (listed in Table 2) is shared after the final session of each VINPLT to collect feedback.

Table 2. Survey questions about the VINPLTs

#	Questions	Answer Choices
Q1	How do you rate your overall experience of the VINPLT?	Excellent; Great; Good; Acceptable
Q2	What do you think of the overall length of the VINPLTs? (4 or 8 weeks, 1 session per week, and 4 or 8 sessions total)	Too short; Just right; Too long
Q3	What do you think of the length of each session?	Too short; Just right; Too long
Q4	What topics are you interested in for future VINPLTs?	The list of currently offered topics
Q5	Did you find the homework helpful for you to better understand the material?	Yes; No; Did not have time to complete
Q6	What do you like about the VINPLT? (Open question)	N/A
Q7	What do you dislike about the VINPLT? (Open question)	N/A
Q8	What are your comments or suggestions for improving this VINPLT? (Open question)	N/A

The VINPLTs were well received by participants. Of the 293 respondents, 69% rated the VINPLTs as “Excellent”, and more than 80% said the length of the overall program and each session were "Just Right” (Figure 1 and 2). As for homework assignments, 69% of respondents found the homework assignments helpful, but 29% said they did not have time to complete them (Figure 2).

Some highlights about the answers to Q6 (“What do you like about the VINPLT?”) and feedback on areas for improvement (i.e., the answers to Q7 and Q8) are summarized in Table 3.

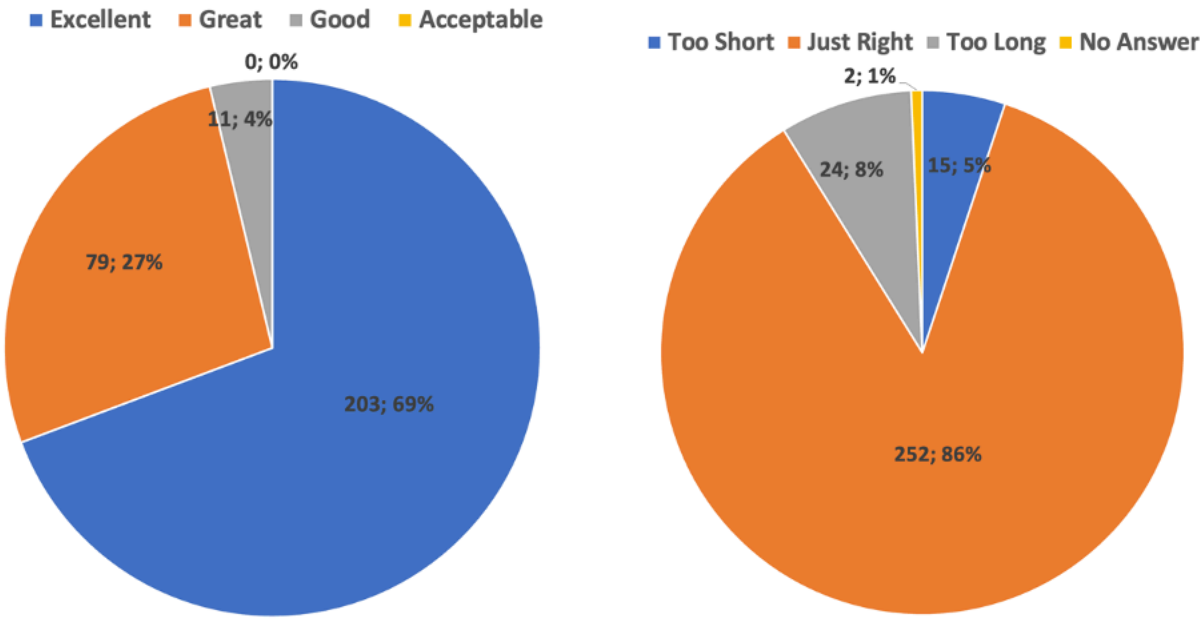

Figure 1. Responses to Q1 about the overall experience (left) and Q2 (right) about the overall length (right)

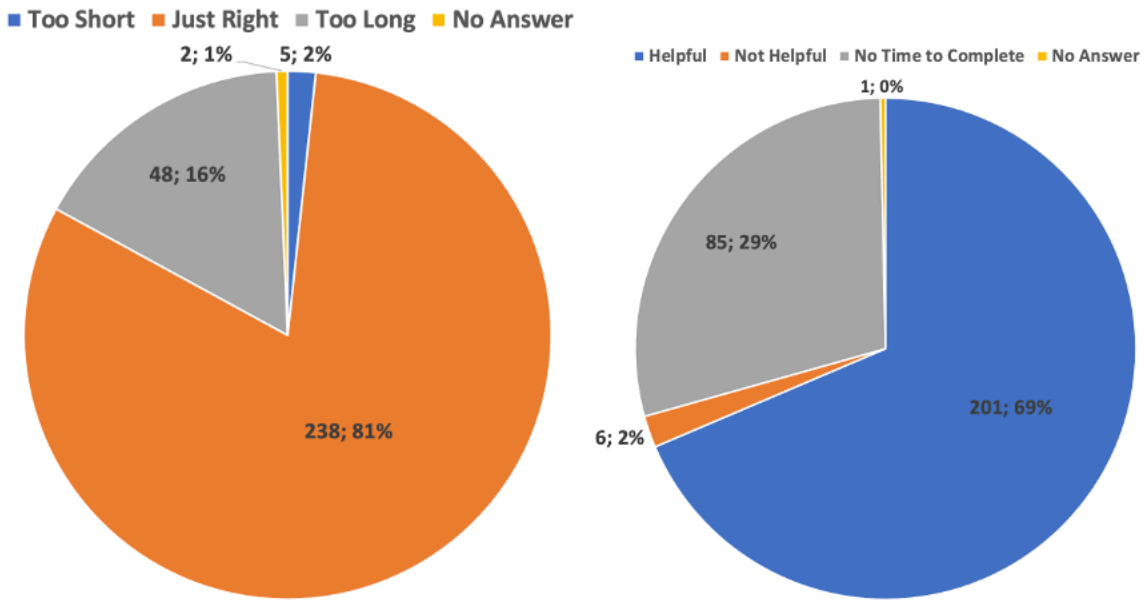

Figure 2. Responses to Q3 about the length of each session (left) and Q5 about the homework assignments (right)

Table 3. Some highlights of the collected feedback on VINPLTs

Q6: What did you like about the VINPLT?	**Q7: What did you dislike about the VINPLT?**	**Q8: What are your comments or suggestions for improving this VINPLT? (Open question)**
Content: • Detailed sessions about how to use the DOE resources/tools (e.g., MEASUR) **Format and Scheduling:** • All sessions are recorded, so participants can watch to catch up or share with coworkers. • The virtual format makes it easy to fit into the schedule without missing work. • The virtual format makes it easy to fit into the schedule without missing work. • It was a lot easier to set a side 2.5 hours a week instead of a few days at once. **Instructors** • Most instructors are very knowledgeable about their topics **Participants Engaging Mechanisms** • Kahoot! quiz games are fun. (11 responses mentioned Kahoot! quiz games)	**Content:** • Not many opportunities for hands-on demonstration. • No opportunities to meet and network with the class participants. • Not being able to learn from other participants or participating plants. • The virtual treasure hunts in the final session for the wastewater treatment VINPLTs. **Format and Scheduling:** • The homework assignment questions are great, but they take a lot of time. (18 comments out of the 27 responses were negative because they did not have time to finish) • Hard to pay attention while sitting at a desk for very long and while receiving emails. • 2.5-hour sessions are too long.	**Content:** • New topics (e.g., lighting, building envelope, and HVAC; "Carbon Emissions for Beginners"; "Understand Your Utility Bills"; "Funding from State and Federal Governments", "Industrial Heat Pumps"). • More real-life examples, case studies, pictures, videos. • Live demo or short videos for operation. • Shorten the sessions to 2 hours. • More time for using diagnostic equipment to collect operation data. • More time on case studies, especially the details on the project implementation. • More information on estimating project cost. **Instructors** • Guest speakers, outside vendors with technology offerings relevant to subject matter. **Others** • Provide certifications after the trainings like the Certified Energy Manager certificate from the Association of Energy Engineers. • Promote the list of upcoming training topics.

Energy Bootcamp

Overview

The Better Plants program launched the first and second Energy Bootcamps in August 2022 and January 2023, respectively, and will launch the third Energy Bootcamp in October 2023. The bootcamps are 3.5 days of workshops with an optional day for science tours at Oak Ridge National Laboratory.

Energy Bootcamp, with extensive hands-on activities, was created to educate attendees on the key aspects of energy efficiency and fundamentals of industrial systems. The course covers energy management (based on ISO 50001), process heating, steam, compressed air, and other motor-driven systems, along with an introduction to alternative energy options. Finally, attendees learn how to use diagnostic equipment along with DOE's free software tools for identifying energy savings opportunities and quantifying cost savings. Younger energy managers or people who are new to industrial energy efficiency and energy management systems are the workshop's target audience. Energy Bootcamp is open to all US manufacturers and organizations, but Better Plants and Better Climate Challenge partners have priority registration.

Feedback and Future Plans

Energy Bootcamp has been impressively popular, and all 75 seats were taken 3 weeks after the registration opened. In total, 54 and 52 responses were collected for the August 2022 and January 2023 Energy Bootcamps, respectively. The survey results indicated that the top two reasons for attending were "acquire new skill" (46% of the responses) and "update skills" (30% of the responses). About 69% of respondents would "highly recommend" and 19% would "recommend" the workshops to their colleagues and friends. About 58% of respondents "strongly agreed" and 29% "agreed" that the workshops met their expectations.

The team received 24 responses regarding networking after Energy Bootcamp in August 2022. Nine responses indicated that more networking opportunities were needed. Thus, the team designed and implemented a people bingo game for Energy Bootcamp in January 2023. No comments on networking were received in the January 2023 Energy Bootcamp, and 34% of the responses indicated that they liked the people bingo game.

Of the 12 comments about the hands-on demonstration sessions, only 1 was negative. However, several comments were received from participants who wanted more time with the demonstration tables.

Decarbonization Bootcamp

The Better Plants program plans to host its first Decarbonization Bootcamp August 22–24, 2023, with optional science tours for some decarbonization technologies on August 25, 2023. Individuals who are new to greenhouse gas emissions and passionate about decarbonizing manufacturing are the workshop's target audience. The workshop will also benefit seasoned engineers who need a refresher on the fundamentals. The sessions will engage participants to discuss with peers the challenges and opportunities they face on decarbonization and work together to brainstorm solutions. The participants will learn the following:

- How to perform carbon emission baselining, benchmarking, and assessment
- How to develop a successful decarbonization road map
- Fundamentals of renewable energy and low- or no-carbon fuel types
- Strategies for electrification
- The latest trends for key decarbonization technologies

A survey link will be shared after the workshop to solicit feedback on the topics, contents, and structure of the bootcamp.

Discussions

Pedagogical Effectiveness

Although the overall responses to the described training activities have been positive, no pedagogical studies have been performed to compare these workforce development activities with the ones housed in other DOE programs, such as the 50001 Ready Cohort, Weatherization Assistance Program, Federal Energy Management Program, and Solar Workforce Initiatives. For example, the 50001 Ready Cohort provides long-term support (i.e., 6 to 12 months) for participants, and the participating facilities are expected to work together with the training experts and become 50001 Ready by the end of the cohort. However, almost all Better Plants workforce development activities do not have an official mechanism to engage partners on implementing these identified projects.

Some comparative pedagogical studies will help develop more effective training mechanisms for audiences with different backgrounds and needs.

Training Topics

All major energy systems are covered by these Better Plants training activities. Nevertheless, participants requested trainings for other topics, including:

- Applying for grants from states, federal governments (e.g., Inflation Reduction Act), and utility companies
- Energy efficiency training designed for maintenance staff and senior managers
- Project justification and how to obtain buy-in from the executives
- Non-energy benefits of energy efficiency and decarbonization
- Carbon emissions for beginners
- Digital twins and augmented reality

Certifications

All these Better Plants training programs currently offer attendees Professional Development Hours certificates. The Michigan Department of Environmental Quality accepts the continuing education hours from INPLTs for the renewal of water and wastewater operator licenses. However, some participants requested more formal certifications, such as Certified Energy Manager, from the Association of Energy Engineers after attending the VINPLTs and bootcamps.

Some participants indicated that they need a map to guide them through all the available credentials on the market so they can find credentials that can better serve their goals and match their backgrounds; they would also like to find information on how to obtain these credentials.

Hands-On Activities

The demo and hands-on activities during the INPLTs and bootcamps received much praise, and more time for these activities was frequently requested. The reason could be that so many online and in-person training courses exist, but few provide the opportunities for participants to use instruments to collect data and the software tools to quantify savings.

An energy apprenticeship program that focuses on hands-on activities could help meet this demand. This apprenticeship should provide a safe and effective hands-on training platform for participants to understand the working principle of major energy systems and their controls (e.g., steam traps and inlet vanes of compressors) and to install meters and other data collection equipment (e.g., ultrasonic flow meters, insertion-style compressed airflow meters, power meters). The program can use cutaway and dissectible models for industrial components and whole system demonstrations. The trainees can practice using diagnostic equipment and installing meters, sensors, and data collections systems on a real, functioning energy system.

Conclusions

This DOE Better Plants program provides workforce development opportunities for US manufacturers through INPLTs, VINPLTs, and energy and decarbonization bootcamps. These training programs covered all major energy systems, energy management systems, and other relevant topics. These programs have trained over 3,800 people and identified more than $64 million in energy and water cost savings opportunities.

The overall responses to these training programs were positive. However, no pedagogical studies have been performed to compare them with other training programs provided by DOE offices and organizations. The participants of these training programs requested some new topics (e.g., how to apply for grants from state and federal governments) and help with navigating the certifications landscape to better serve their careers. More time on manufacturing processes and hands-on activities for the diagnostic equipment and with manufacturing operations were also requested.

Acknowledgment

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