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ENERGY RESEARCH AND DEVELOPMENT DIVISION

FINAL PROJECT REPORT

California Advanced Lighting Controls Training Program — Automated Demand Response

Addressing Energy Efficiency and Load Management in Disadvantaged Communities Through Skilled Workforces

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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission, and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The EPIC Program is funded by California utility customers under the auspices of the California Public Utilities Commission. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

This project was a multiyear demonstration project to develop a training program in automated demand response theory and equipment installation. The project was led by the national non-profit Center for Sustainable Energy in partnership with ASWB Engineering (a division of D+R International), Energy Solutions, the California Lighting Technologies Center, ICF International, the California State Labor Management Cooperation Committee of the International Brotherhood of Electrical Workers and National Electrical Contractors Association, the California Labor Federation, and Avery Engineering. The project developed a classroom and laboratory curriculum to train apprentices of the International Brotherhood of Electrical Workers to identify, install, test, commission, and maintain demand response technologies for lighting and heating, ventilation, and air conditioning systems. The project demonstrated how workforce development and training can increase consumer appeal and customer adoption of energy technologies to help achieve increased energy savings in existing buildings.

Keywords: Automated demand response, AutoDR, ADR, distributed energy resources, DER, workforce development, disadvantaged communities, training, lighting, HVAC, controls

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

Introduction

California continues to reduce greenhouse gas emissions associated with energy production and use in the state. Ambitious strategies to decarbonize the state's energy sector include increasing the percentage of renewable energy in California's electricity portfolio by 50 percent by 2030 (Senate Bill 350 [De León, Chapter 547, Statutes of 2015]) and reducing greenhouse gases from buildings by 40 percent (below 1990 levels) by 2030 (Assembly Bill 3232 [Friedman, Chapter 373, Statutes of 2018]).

As more intermittent renewable electricity sources such as wind and solar are added to the California electricity grid, the California Independent System Operator has identified an increasing need for demand-side flexibility to maintain both grid operations and reliability. Demand-side flexibility is the ability to reduce, increase, or shift customer electricity demand within a certain time frame, known collectively as demand response. Utility demand-response programs allow consumers to reduce their electricity use during peak times in response to time-based electric rates or other financial incentives. Automated demand response allows these shifts or reductions to happen automatically, for example when utilities send signals to building energy-management systems.

Automated demand response is a critical tool for both grid stability and increased grid reliability. By adding additional automated demand-response capabilities to the grid system, grid operators can better manage both variations in generation and increased demand during peak load events (when there is not enough energy to meet peak demand). Automated demand response can also be a tool in the transition to the much higher penetration of renewable electricity generating resources. The Lawrence Berkeley National Laboratory's 2025 *California Demand Response Potential Study* estimates that demand response resource capacity is significant across varying time scales. However, participation trends in investor-owned utility (IOU) programs show that adoption of automated demand responses has stalled.

Unlocking the potential for demand responses that both facilitate decarbonization and reduce costs for ratepayers requires addressing market barriers to customer participation in existing automated demand-response programs. One such barrier identified by program administrators at California's three major IOUs is a lack of trained installers. This project addressed workforce-related barriers to the adoption of automated demand responses through the development of technical training for electrical apprentices and electricians in California.

Project Purpose

In partnership with the California State Labor Management Cooperation Committee of the International Brotherhood of Electrical Workers and National Electrical Contractors Association, the Center for Sustainable Energy developed a course that provided both classroom and on-the-job training for installing, commissioning, and operating automated demand response communications equipment. The project team recruited and enrolled new electrical apprentices from disadvantaged communities, provided classroom and laboratory training at seven joint apprenticeship and training committees, and delivered on-the-job-training to apprentices from disadvantaged communities.

The project addressed workforce-related barriers to achieving greater energy savings (in both existing buildings and new construction) by demonstrating the importance of technical training in facilitating adoption of load management technologies (in this case, controls that enable participation in automated demand response programs). The project promoted load management technologies by teaching electricians how to specify, install, commission, test, and maintain demand-response enabling devices for lighting systems and heating, ventilation, and air conditioning (HVAC) controls. The project had the two added goals of (1) increasing the use of market-ready technology and communications standards in small and medium businesses and disadvantaged communities, and (2) helping realize the full potential of automated demand response by addressing workforce skills gaps resulting from a lack of training programs to keep pace with major advances in energy technologies.

Another goal was to transfer knowledge and facilitate market adoption of automated demand response technology and communications standards, as well as to provide information to help guide improvement of IOU incentive programs. By sharing the project approach and results, the project encouraged the development of similar training programs for other energy technologies throughout California to further reduce or eliminate workforce-related barriers to achieving decarbonization goals.

Project Approach

The Center for Sustainable Energy led the project, with the training provided in partnership with the California State Labor Management Cooperation Committee of the International Brotherhood of Electrical Workers and National Electrical Contractors Association and seven partner Joint Apprenticeship and Training Committees. The Center for Sustainable Energy coordinated efforts of all partners and training centers and worked to ensure that the training developed met project requirements. The project team also included ASWB Engineering (a division of D+R International), the California Lighting Technology Center, the California Labor Federation, the Demand Response Research Center at Lawrence Berkeley National Laboratory, Energy Solutions, ICF International, and Avery Energy Engineering.

The project team developed a new training and certification program focused on automated demand response equipment and communications protocols, including demand response automation server clients, advanced lighting controls with demand response functionality, HVAC controls with demand response functionality, and other automated demand response-enabling hardware, in addition to the open automated demand response (OpenADR) version 2.0 communications standard and basic concepts in integrated demand side management. The project team designed the automated demand response training to be a module offered in addition to the extremely successful California Advanced Lighting Controls Training Program, which is supported by the California Energy Commission (CEC) and California's three major IOUs: Pacific Gas and Electric Company, Southern California Edison Company, and San Diego

Gas and Electric Company. This design ensured integration of the training into an existing advanced energy career ladder for apprentices from disadvantaged communities.

After integrating the training into an existing national curriculum offered at training centers, the project team completed an extensive needs assessment and review of the curriculum to ensure the training would fit into existing courses available to electricians and also function as stand-alone training to promote broader adoption of automated demand response equipment. The team developed the training based on best practices in adult education and used an iterative approach to develop course materials and laboratory exercises that incorporated extensive feedback from instructional staff and stakeholders, increased instructor engagement and interest in the course materials, and proactively identified and addressed technical issues encountered with the laboratory exercises.

With progressive implementation of the training, instructors became more comfortable and increasingly familiar with the automated demand response equipment and communications standards. Training centers required less technical assistance from the project team to troubleshoot issues with equipment included in the course. Controls manufacturers improved their products in response to feedback collected by the project team during the development of the course materials, and also resolved issues with implementation of automated demand response that would have affected equipment installations at customer sites.

The project team also engaged its technical advisory committee throughout the project to ensure that the training adequately addressed workforce-related barriers to adoption of automated demand response, implemented strategies to reduce the risk of adopting automated demand response technologies, and aligned with the requirements of incentive programs offered by the IOUs and Title 24, Part 6 of the California Energy Code (CEC, 2019a). Advisory committee members included program administrators for the IOUs, electrical contractors, equipment manufacturers, and stakeholders in workforce education and development.

Project Results

The California Advanced Lighting Controls Training Program automated demand response training developed by the project team successfully demonstrated targeted technical training to address workforce-related barriers to the adoption of load management technologies that reduce greenhouse gas emissions, decrease costs for ratepayers, and improve both power quality and reliability. The project met the project goals and objectives for training and conducted extensive outreach to facilitate market adoption of load management technologies and to disseminate project information.

The development, procurement, and rollout of the course materials took about a year to complete, followed by 2.5 years of regular training at the 7 partner training centers. During this time, 655 electricians completed the full course, 378 of whom were apprentices residing in disadvantaged communities at the time they completed the course. An additional 818 electricians, acceptance test technicians, and other workers completed the online training that was developed to support the dissemination of automated demand response concepts to estimators, acceptance test technicians, and contractor sales staff.

The project team launched apprentice recruiting efforts in 2018 to increase the enrollment of workers from disadvantaged communities in the inside wireman apprenticeships. Recruitment included 1005 workers, with 637 residing in or near disadvantaged communities.

Key lessons learned from the development of the California Advanced Lighting Controls Training Program automated demand response project, and outreach efforts to develop on-the-job training opportunities for apprentices included the following.

- Though automated demand response equipment was commercialized before the start of the project, device and equipment testing during the development of laboratory exercises revealed that reported control capabilities for several implementations did not function as anticipated and required further development for those capabilities to be used reliably.
- Early involvement of instructional staff and regular testing of course materials throughout development were crucial for advancing technical training programs.
- Advanced controls and communications technologies required the involvement of information technology and communications department staff, which was not typical for electrical training at the time. Addressing increased coordination with information technology systems and how they relate to other trades should be assessed as building controls become more advanced and communication with external services is required to achieve deeper reductions in energy use in buildings. Reliable communications pathways are important to ensure that demand response resources are available.
- The value proposition for the adoption of automated demand response among small and medium businesses is unclear and relatively complex compared with other energy investments. Research efforts to modify existing automated demand response programs to simplify the value proposition or enhance the value proposition may address barriers to adoption within these markets.
- Small- and medium-sized businesses and public facilities located in disadvantaged communities could require tailored program designs to address barriers to adoption specific to this market. Research into the barriers to adoption of load management technologies and advanced controls specific to these market segments is needed to identify effective market transformation strategies and program designs.
- Contractors cited many risks of retrofitting existing advanced lighting controls and HVAC systems to enable automated demand response functionality. Additional investigation into these risks and strategies to reduce the risk of demand-response-only retrofits could help facilitate adoption in existing buildings.
- Existing incentive programs may not address the needs of small and medium businesses located in disadvantaged communities. Research and pilots of innovative incentive program designs could help spur the adoption of automated demand response equipment in existing buildings.
- Community choice aggregators (cities and counties that may buy or generate electricity for residents and businesses) could transform the market for load management

programs and increase adoption of automated demand response technologies. The barriers and opportunities for community choice aggregator-administered demand response programs need to be better understood.

Technology/Knowledge Transfer/Market Adoption

The project team engaged in multiple knowledge/transfer activities throughout the project. Several members participated in numerous regulatory proceedings at the California Public Utilities Commission and the CEC that have direct impacts on the role of demand response in resource planning, pilots that increase adoption of demand response in disadvantaged communities, energy storage procurement and multiple-use applications proceedings, the Self-Generation Incentive Program and distributed generation proceeding, the 2018-2023 demand response programs applications proceeding, and general demand response proceedings. The project team shared lessons learned in the numerous regulatory proceedings and influenced policy to allow greater adoption of automated demand response and promote the use of skilled workforces to help support the adoption of load management strategies.

The project team additionally attended several conferences and events to speak about the project and inform interested stakeholders on its progress. Lastly, members of the team wrote articles about the project and the lessons learned for publication on company websites and in third-party journals. The project team has been able to broadly share the project concept and results through these multiple avenues.

Benefits to California

The 2019 Title 24, Part 6 of the California Energy Code requires additional demand response capability in new construction and large retrofits. The California Advanced Lighting Controls Training Program automated demand response training will address workforce-related barriers and provide specialized skills to technicians that meet the new building energy code requirements. In the long term, this will reduce costs to ratepayers as properly functioning installations will provide the anticipated energy savings from load management and automated demand response controls and delay or avoid the costs associated with building new generation.

Benefits also include reducing demand, in turn providing savings on energy bills (determined, in part, by the program in which a participant is enrolled), and automating this process, shown to produce more consistent savings. Secondary benefits accrue to all users of the grid as this ability to modify demand translates to a more reliable grid and lower wholesale energy costs.

Where needed, project training included remedial courses in math and basic electrical connections, providing a secondary benefit to workers residing in disadvantaged communities. Recruited apprentices and apprentices who completed the training have specialized skills that will help them pursue an advanced energy career ladder.

Automated demand response provides more consistent reductions in electricity load in response to signals sent by utilities during times of peak load. A 2015 study by Navigant Research found that reduced peak demand in Massachusetts and Illinois was ultimately linked to reduced capacity market payments because demand reductions directly relieve local utilities from the necessity of procuring extra energy during those times. Ultimately, peak demand reductions provide much higher benefits than average load reductions since peak demand times often correspond with the highest prices. The study further noted that demand reductions also can reduce energy prices for hours by reducing the marginal generating cost of the system. A trained workforce that supports quality installations can also increase the reliability of automated demand response equipment and troubleshoot equipment issues that arise in the field. Increases in quality, coupled with the scale of market adoption made possible by a trained workforce, can both increase peak demand reductions and reduce costs for utility ratepayers.

CHAPTER 1: Introduction

The technological capabilities of building automation systems and customer adoption of advanced controls with load management features are advancing rapidly in California. As adoption of advanced controls increases, customers gain the capability to manage their energy use, decrease operational costs, and provide valuable services to electricity grid operators. However, despite advances in control capabilities, unlocking the full potential of controls and increasing adoption in hard-to-reach customer groups is limited by the availability of a workforce trained in the purpose, installation, and use of load management controls.

The Automated Demand Response Workforce Development Project, also known as the AutoDR Apprentice Training Project, was funded by the California Energy Commission's (CEC) Electric Program Investment Charge (EPIC) with the dual purpose of market transformation and facilitation. The project was led by the Center for Sustainable Energy (CSE) in partnership with ASWB Engineering (a division of D+R International), the California Lighting Technology Center, Energy Solutions, the Demand Response Research Center (at Lawrence Berkeley National Laboratory), and ICF International. This group, collectively known as the project partners, addressed the lack of skilled workforces as a market barrier. The project developed a training program to create a skilled workforce qualified to install and maintain automated demand response (AutoDR) communications equipment for advanced lighting systems and heating, ventilation, and air conditioning (HVAC) controls. With the implementation of training complete, this final report provides information on the development of training, outreach and market facilitation activities related to the value of training in expanding adoption of load management energy technologies.

This report provides detail on the implementation of the project, including:

- Development of teaching model and learning objectives.
- Identification of technical skills needed by an AutoDR workforce.
- Apprentice outreach and recruitment.
- Design of academic materials for classroom and laboratory training.
- Training rollout and launch.
- Ongoing implementation of training.

Purpose and Need

Over the past decade, there have been drastic changes in California's electricity market relating to supply and demand. As of 2018, approximately 34 percent of California's electricity now comes from renewable resources including solar and wind. The California Independent System Operator (ISO) has identified an increasing need for demand-side flexibility as more intermittent renewable power supplies are added to the California grid and supply-side issues become more critical to manage, for example the "duck curve."[1] By increasing demand-side flexibility and control, variations in generation supply and increased demand during peak-load events can be mitigated. Technologies that enable this flexibility are therefore critical tools for both grid stability and the transition to a much higher ratio of electricity generation from renewable sources that operate intermittently, as mandated by the 50 percent Renewable Portfolio Standard goal established by Senate Bill 350 (De León, Chapter 547, Statutes of 2015) and modified by Senate Bill 100 (De León, Chapter 312, Statutes of 2018), as well as the future 100 percent clean energy target established by SB 100 (CPUC, 2024).

Demand response (DR) is a strategy to economically manage onsite customer loads, increase demand flexibility, and provide other grid stabilizing services (CEC, 2019b). AutoDR improves the effectiveness of load management programs by allowing controls to automatically change energy demand in response to economic incentives, price signals, event notifications, or other signals. AutoDR equipment and communication standards have evolved significantly over the past 16 years. AutoDR originated from an initial conceptual design developed in 2002 at the United States Department of Energy's Lawrence Berkeley National Laboratory (LBNL). Today the open automated demand response (OpenADR) standard is the primary communication standard used for DR automation in California. As described by LBNL, OpenADR is "a communications data model designed to facilitate sending and receiving DR signals from a utility…to electric customers." Workforce training in both the AutoDR and OpenADR standards support initiatives that tap the potential for demand flexibility identified in the 2025 *California Demand Response Potential Study* (LBNL, 2024).

Project Overview

The Center for Sustainable Energy worked with project partners to develop a new training and certification program focused on AutoDR equipment and communication protocols including Demand Response Automation Server (DRAS) and other AutoDR-enabling hardware, the OpenADR 2.0 communication specification, the incentive and enrollment details of the AutoDR programs offered by California's IOUs, and DR control requirements in California's Title 24 Part 6 Building Energy Efficiency Standards. The AutoDR training and certification module is a new addition to the California Advanced Lighting Controls Training Program (CALCTP), which is supported by the CEC and the state's IOUs: Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), and Southern California Edison Company (SCE). The module is taught by seven partner joint apprenticeship and training committees (JATCs) and is offered online to existing acceptance test technicians (ATTs), contractors, and other staff who work with end users through ICF's online learning platform. The training developed under this grant agreement is continuing to be offered beyond the end of this agreement.

There were three primary goals of the AutoDR Workforce Development Project: (1) increase ratepayer participation in AutoDR and improve the effectiveness of DR programs by developing a skilled workforce to properly install, commission, operate, and maintain AutoDR

[1] The "Duck Curve" refers to a forecast of operating conditions for California's electrical grid with increased adoption of renewable generation where there are short, steep increases in net demand from customers, risk of oversupply of generation during certain hours of the year, and a decrease in the grid operator's ability to maintain grid reliability.

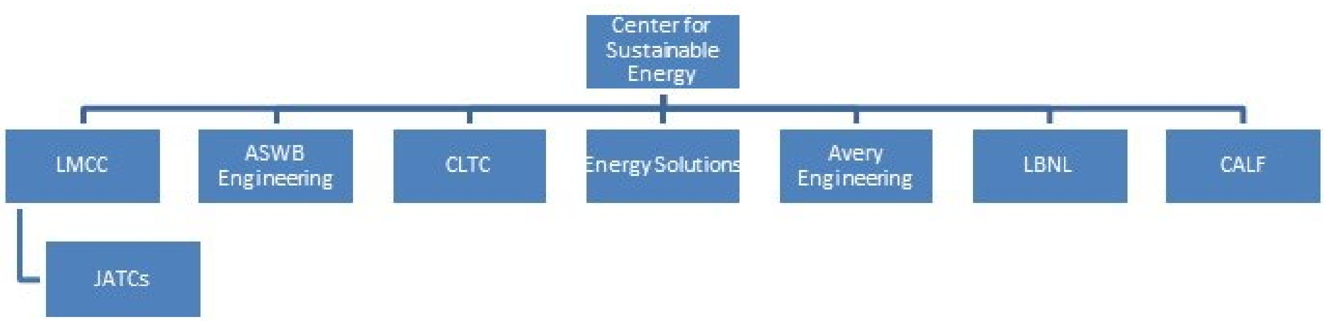
communications technologies; (2) increase economic opportunity in disadvantaged communities through local workforce development and increases in energy savings in existing buildings; and (3) provide training to technicians to advance to goals of Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009) to achieve greater energy savings in existing buildings. Specific objectives of the project were to:

- Develop a new CALCTP course focused on the proper selection, installation, commissioning, and maintenance of AutoDR communications equipment (CALCTP-AutoDR).
- Recruit and enroll individuals from disadvantaged communities into International Brotherhood of Electrical Workers - National Electrical Contractors Association (IBEW-NECA) inside wireman electrical apprenticeship programs to gain skills to embark on advanced energy careers.
- Provide classroom (lecture) and hands-on (laboratory) training for apprentices from disadvantaged communities in the new CALCTP-AutoDR curricula.
- Support opportunities for on-the-job training to apply the skills taught in the CALCTP-AutoDR curricula.
- Identify and disseminate best practices in AutoDR incentive program administration and workforce development.

Project Team

The project was led by CSE in partnership with subcontractors who represented a variety of DR stakeholders. Figure 1 shows the organizational structure of the project.

Figure 1: Project Organizational Structure



The project is structured with Center for Sustainable Energy as the prime contractor with ASWB Engineering, A Division of D+R International; California Lighting Technology Center; the California State Labor Management Cooperation Committee; Association of Energy Engineers; Energy Solutions; ICF International; the California Labor Federation; and Lawrence Berkeley National Laboratory as partner organizations. The Joint Apprenticeship and Training Committees, jointly funded by the International Brotherhood of Electrical Workers and National Electrical Contractors Association, are managed by the California State Labor Management Cooperation Committee.

Source: Center for Sustainable Energy

Subcontractors and their roles included:

- ASWB Engineering, A division of D+R International (ASWB):
    - ASWB led the development of classroom materials, advised on the selection of AutoDR enabling equipment to include in training labs, procured the materials included in the labs, commissioned the lab boards, led train-the-trainer sessions, provided technical assistance to the training centers, advised on AutoDR equipment to promote to IOU customers, and developed toolkit materials provided to electrical contractors to support AutoDR retrofits and installations.
- University of California at Davis California Lighting Technology Center (CLTC):
    - The CLTC selected equipment to be used in the lab portion of training, designed and constructed the lab boards, consulted on the integration of the AutoDR curriculum with the CALCTP, and supported the implementation of the training.
- The California Labor Federation (CLF):
    - The CLF led efforts to recruit workers from disadvantaged communities to enroll in electrical apprenticeships.
- Demand Response Research Center at Lawrence Berkeley National Laboratory (DRRC):
    - The DRRC consulted on educational materials related to the AutoDR OpenADR standard and advised on the value proposition and consumer acceptance of DR.
- Energy Solutions:
    - Energy Solutions developed the AutoDR Sales Best Practices report, consulted on AutoDR incentive program guidelines, and consulted on the selection of AutoDR equipment for customers interested in load management strategies.
- ICF International:
    - ICF International has managed the CALCTP project since 2008, developed the online CALCTP-AutoDR module, and consulted on overall course development.
- California State Labor Management Cooperation Committee (LMCC) of the IBEW-NECA (LMCC/IBEW-NECA):
    - The LMCC/IBEW-NECA coordinated training efforts between partner JATCs and supported the rollout of course materials to instructors, supported the development of on-the-job training opportunities for apprentices, and supported technology and knowledge transfer activities.
- Avery Engineering
    - Avery Engineering consulted on the development of course materials, supported the rollout of course materials, and supported technology and knowledge transfer.

Project Innovations

While AutoDR as a technology has been in use since 2003, this project provided innovative workforce development in the energy sector in several key areas. The project leveraged regional institutions and pre-apprenticeship programs to increase recruitment and training of workers from disadvantaged communities, created new career paths in the electrical industry by offering advanced training on load management technologies, and helped increase market knowledge and adoption of integrated demand side management strategies through workforce development and training. This was the first course developed to educate electricians on AutoDR control capabilities and enablement and helped build workforce capacity to support the adoption of DR controls for lighting and HVAC systems in small- and medium-sized businesses (SMBs).

CHAPTER 2: Project Approach

The AutoDR project was developed to build on earlier successes and integrate them into the CALCTP training model. The mission of the CALCTP is to make expeditious and significant gains in conserving energy used for lighting in California through the widespread deployment and effective long-term operation of advanced, high efficiency lighting and control systems. CALCTP educates, trains, and certifies electrical contractors, electricians, and other interested parties in the best practices and most effective techniques to install, tune, commission, and maintain advanced lighting control systems.

This section describes the project team's approach to the development of course materials, launch of the CALCTP-AutoDR course, outreach and enrollment of apprentices from disadvantaged communities into the IBEW inside wireman apprenticeships, and ongoing implementation of the CALCTP-AutoDR course.

Course Development

The educational program for Auto-DR was developed for master electricians, who in turn train journeyman electricians in an academic environment equipped with an electrical training lab. The program was hands-on, with approximately 25 percent of the course devoted to lecture and the remaining 75 percent to practical labs. In the labs, students practiced working with control systems with AutoDR capabilities. The educational design of the program adhered to adult learning principles[2] and incorporated interactivity between participants through group discussion, individual exercises, and demonstrations. The lecture material provided the foundation for the actual installation of lighting controls. Lastly, participants developed personal action plans to enhance their learning experiences.

Course development was conducted by developing specific learning objectives and approaches, obtaining and reviewing the latest resource documents related to AutoDR, researching AutoDR component documentation and brochures, reviewing training materials previously developed by ASWB, and identifying background content required by technicians, electrician lab tasks, and electrician field tasks as the foundation to the curriculum. The description of course materials follows.

Learning Approach and Objectives

Training developers used an informal needs assessment designed to guide the training strategy based on characteristics of the training's target audience. The primary focus of the needs assessment was the entry-level skills and knowledge of the trainees at the time they began their training. Special considerations were given to trainee's native languages, time, and

[2] Adult learning principles are those that help ensure training participants actually learn and can apply what they learn.

attendance constraints (for example, when trainees could attend the training and a format flexible enough to provide the training in different learning environments).

Development of the learning objectives used the same needs assessment, drawing from elements designed to determine training strategies appropriate for each of the major training components of the overall course design, classroom, lab, field, and online training. These results were refined to develop the terminal learning objectives[3] (TLOs), enabling learning objectives[4] (ELOs), materials, (such as workbooks, handouts, instructor guide, PowerPoint slides), pilot development and materials test strategy, and participant testing strategies along with development of certifications, such as the CALCTP Certified Installer Contractor or the CALCTP Acceptance Test Technician, where applicable.

Further development activities included creating classroom activity support materials (for example scenarios, case studies), soliciting subject matter expert review and feedback, testing question development for certification-level completion testing, and presenting additional materials not directly related to the core curriculum. These materials support deployment of the course to a broader audience with varying levels of background knowledge.

Academic Scope Development

The academic needs assessment was developed through a review of California's Auto-DR technical requirements for Title 24 and how those requirements have applied to the state's large IOUs (PG&E, SCE, and SDG&E)(CEC, 2019c). Researchers conducted thorough reviews of each IOU's AutoDR technical requirements and program guidelines. Upon completion of the IOU AutoDR technical program review, researchers developed an outline of academic requirements that would satisfy every IOU's AutoDR program requirements. That outline was developed as part of the course scope and subsequently incorporated into the academic materials. Researchers found it necessary to divide the installer training into two separate parts. The first part was identified as classroom training, which focused on academics and presented the fundamentals of DR and how AutoDR works. The second part was a laboratory course focused on the installation and connectivity of the hardware required for successful AutoDR implementation.

Key Course Concepts and Learning Objectives

The CALCTP job analysis committee, comprised of a diverse group of professionals from within the lighting industry, conducted a detailed analysis of the skills sets needed to demonstrate mastery of AutoDR installation. Through their analysis, the committee identified five training categories:

1. Energy Modeling And Calculations.
2. Codes And Standards.

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[3] The terminal learning objective or goal is a statement of the instructor's expectations of participant performance at the end of a specific lesson or unit.

[4] Enabling learning objectives or learning objectives are concise statements of the instructor's expectations of participant performance and might be considered steps in accomplishing the terminal learning objective.

3. Daylighting Concepts.
4. Human Factors.
5. Lighting Controls and Techniques.

The committee then created a list of skills in each category, which were subsequently advanced to the curriculum committee. Each item within the categories was then identified as either a basic skill or an advanced skill. The list of skills needed to demonstrate mastery was sent to the curriculum writers on the AutoDR project, ASWB, and the CLTC for development. The materials developed by the curriculum writers for apprentices were then customized for master electricians.

After attending this training, the participants were specifically able to:

- Describe the purpose and scope of DR, including:
    - Benefits to the Grid and Strategies for Small- and Medium-Sized Businesses.
    - IOU DR Programs.
    - Code Requirements.
    - Technologies Used.
- Demonstrate AutoDR equipment installation requirements (for example, demand response automation server [DRAS], virtual end nodes [VENs], thermostats).
- Identify site equipment and installation needs.
- Demonstrate, in laboratory settings, the wiring, connecting, and testing of AutoDR equipment.

Specific Learning Objectives

Participants were instructed in specific topics related to DR. Topics included an introduction to DR and an explanation as to when, where, and why DR events are triggered. Participants explored the dynamic role of DR and its evolution. Various market segments — commercial, industrial, and residential l— were examined to illustrate how their specific lighting system responses varied. Additional systems including HVAC, commercial and industrial processes, and pumping were also examined.

Utility DR programs and a general overview of utility program participation steps were reviewed. Course study also included individual DR program participation incentives, available DR-enabling technology incentives, and applicable building codes.

AutoDR course participants were systematically exposed to the specific expectations of electricians when conducting AutoDR system installations and were walked through the various types of equipment used for AutoDR installation and verification. Course content included general skills, knowledge areas, abilities, and responsibilities assigned to installation technicians. Hardware configurations were examined on both the utility and customer sides. Customer side control system options for lighting, HVAC, motors, and pumps were reviewed.

The laboratory component provided the basis for customer site AutoDR equipment installation, utility signal connection, and end-to-end utility verification testing course content. In the lab, participants:

- Practiced determining required equipment, with example customer scenarios.
- Practiced connecting actual AutoDR equipment.
- Confirmed and verified AutoDR equipment connectivity (point-to-point testing).
- Tested and verified utility connections (end-to-end testing).
- Prepared final customer documentation.

Integration With the California Advanced Lighting Controls Training Program

CALCTP provides training and certification to electricians, contractors, technicians, building operators, and building managers. By ensuring that energy saving lighting controls are properly installed and commissioned for maximum effectiveness, CALCTP maximizes energy savings from these lighting control systems. The training program included extensive, hands-on laboratory work that mimicked technical skills needed in the field.

The CALCTP team included the IBEW-NECA, California's electric utilities, UC Davis (CLTC), IBEW-NECA JATCs, among other major stakeholders. The CALCTP was an integral part of the project, and much of the CALCTP team participated in the development of the course curriculum, the lab content, and the training delivery.

Conformance With Best Practices in Adult Education

Course materials were designed and delivered to the highest performance standards in adult learning. The course design applied these adult learning principles, as follows:

- The instructional design was developed to achieve buy-in from adult students:
    - The instructor started by identifying the utility of the training, emphasized through demonstrating examples.
- The learning activities in the course and lab exercises built upon what adult students already know:
    - Throughout the training, some activities enabled participants to demonstrate their respective levels of experience and understanding.
    - Examples and stories were provided to connect AutoDR-specific knowledge to adult students' prior experiences.
- Adult students were engaged in the learning process:
    - Classroom and laboratory activities were designed to engage the adult learner in ways that helped direct the flow of the curriculum.
    - Classroom interactions between adult learners and educators provided choices that allowed groups to focus on content most relevant to their interests and needs.

- Guided laboratory activities provided opportunities to discover important information independently, while students still contributed their individual ideas for procedures reviewed in lab exercises.

- The adult student was set up for success:
  - The adult learner was exposed to a limited number of familiar, unfamiliar, and meaningful concepts at one time to ensure adequate time for the internalization and understanding of those concepts.
  - The adult learner was guided through training transitions smoothly with explanations of how the topics covered are related to each other and how they reflect learning objectives.
- The adult students applied what they learned:
  - The adult learners are actively engaged in problem solving activities and discussions of real-world scenarios where installation issues arise.
  - The classroom education applied to lab scenarios and real-world equipment setups to students, in a timely fashion.
  - This near real-time transition from classroom to lab exercises solidified the adult learner's retention of the concepts and content delivered in both the classroom and in the lab.

Laboratory Exercise Development

The AutoDR training included five separate hands-on laboratory modules to teach apprentices the most common methods and technologies used to enable and deploy AutoDR practices for lighting controls and thermostats. Laboratory work supplemented classroom training.

Laboratory training equipment was identified by conducting a full review of available lighting and thermostat products certified through the OpenADR alliance. Only products with OpenADR 2.0a or 2.0b certifications were considered. Qualifying products were then grouped into categories: third party virtual end nodes (VENs), lighting control systems with integrated VENs, lighting control systems with add-on VENs, and thermostats with integrated or cloud-based VENs. Products from each category were selected based on availability, manufacturer responsiveness, and cost.

A suite of products was purchased and tested to better understand product functionality and complexity. Products with less complexity and more intuitive user interfaces were prioritized. Over the course of several months and multiple testing activities, the project team selected AutoDR products and systems most commonly implemented in buildings that were readily available at a reasonable price. The project team also used recommendations from AutoDR program implementers to ensure that selected products were commonly available in California. Appendix A lists the final equipment used in each lab. Products from multiple manufacturers were used to expose students to a broad spectrum of AutoDR devices and configurations.

Lab Scenarios

Students used a laboratory workbook comprised of five laboratory exercises, providing the opportunity to gain skills and hands-on experience working with a variety of AutoDR technologies often used in combination with lighting control systems and smart thermostats. These labs focused on several important aspects of any AutoDR project: equipping systems with an OpenADR-compliant VEN, connecting that VEN to the utility DRAS, programming appropriate AutoDR response profiles, and testing the connections to ensure customers are ready to participate in their utility's AutoDR programs.

Each laboratory workstation represented a customer site. Since students were working in a classroom environment, one necessary step was addressed for each workstation in advance of the class. A DRAS account was established for the "customer" with the local utility and the VENs included in the following exercises were already registered under that DRAS account.

In the field, students identified the VEN installed at the customer's site or selected an appropriate VEN for end-use loads, then directed or registered these devices with the local utility. Customers may ask electricians to communicate with the utility to get a DRAS account, or they may already have their DRAS account information available. This is an important first step and AutoDR-readiness cannot be achieved without it. The DRAS account credentials were supplied in these lab exercises, but in the field once a utility is made aware of a client's enrollment in their incentive program, it sends a list of files to complete. These must be completed and returned to the utility so it can provide customer site-specific DRAS and client credentials.

Objectives of the lab exercise were to increase students' abilities to:

- Understand and apply common AutoDR parameters to bring AutoDR-enabled lighting control systems and thermostats online with a utility DRAS.
- Commission lighting control systems and thermostats with basic response profiles that align with California's Building Energy-Efficiency Standards requirements.
- Initiate test sequences and demonstrate lighting and HVAC system response when an AutoDR test signal is received.
- Document AutoDR system settings for building owners.

Lab 1: The Virtual World of AutoDR

Lab 1 is an introductory lab to the virtual world of AutoDR. Students learn about VENs, the utility's DRAS, and what is needed to connect the two together to start successfully receiving DR events. The information learned in this lab is universally applicable and necessary for any connection to the DRAS. Students will explore the creation of VEN client accounts and learn how to push a client test to these accounts, which will then be used for DR verification purposes in subsequent labs.

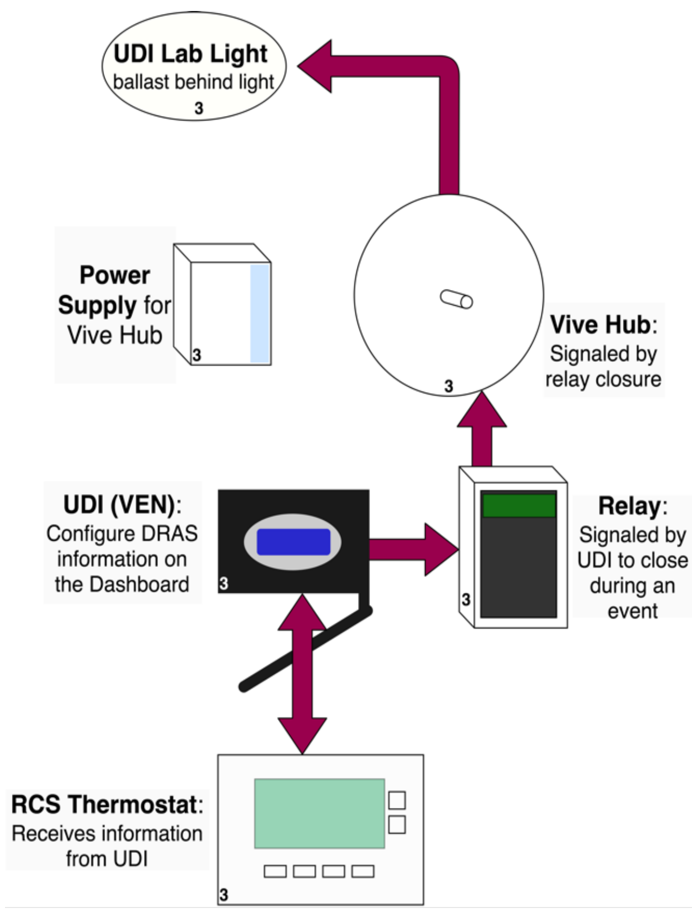
Next, students will access software associated with implementing AutoDR events from the device end. This can take shape as local software, firmware on AutoDR devices, or cloud-based software accessed through the internet. An example of each type is explored and a brief overview on the navigation of each variant is provided.

Lab 2: Using Third Party Devices With Lighting and Thermostats to Achieve AutoDR

In Lab 2, students learned to use third party devices to implement AutoDR. Third-party devices provide a technology-agnostic AutoDR access point (or VEN). For this lab, a universal device's VEN is used to connect a wireless lighting control system and a wireless (Zigbee) thermostat to the DRAS. Third-party devices are often the only available solutions for existing control systems (Figure 2).

First, students identified and verified the connectivity of the devices to ensure they were energized and to allow students to learn how each component is connected. Next, programming of the VEN occurred, utilizing the VEN client test accounts accessed in Lab 1; responses of thermostat and lighting systems were then set. Lastly, students initiated a client test to verify successful connection of the lighting controls and thermostats. Students set a short client test in the DRAS and visually confirmed the response of the system and its components.

Figure 2: Schematic of Lab 2



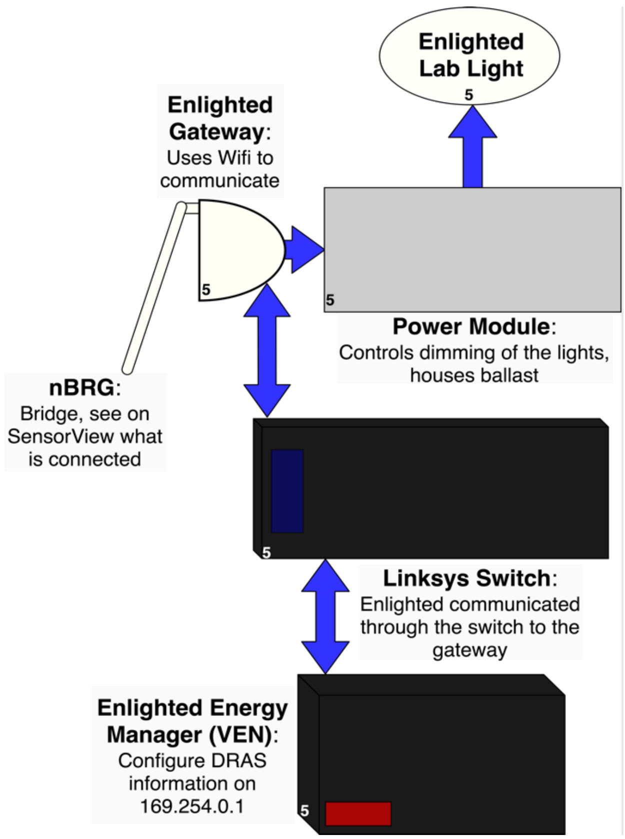
Lab 2 uses a Universal Devices, Inc. (UDI) ISY994i to communicate and initiate DR events with a lighting controller via a relay, and with a thermostat via wireless mesh networks.

Source: ASWB

Lab 3: AutoDR-Enabled Lighting – Systems with Embedded AutoDR Ability

Lab 3 demonstrated the use of embedded or integrated VENs for enabling AutoDR methods to connect a VEN to the DRAS. Each started with verification of connectivity of devices. Lab 3 focused on setting up a lighting system with embedded AutoDR capability. Some lighting control systems offered integrated VEN options (Figure 3). In this lab, students used one such system to navigate the software installed on a system gateway to connect to the proper client account and set DR responses for events. Finally, a client test verified successful completion of the lab.

Figure 3: Lab 3 Schematic



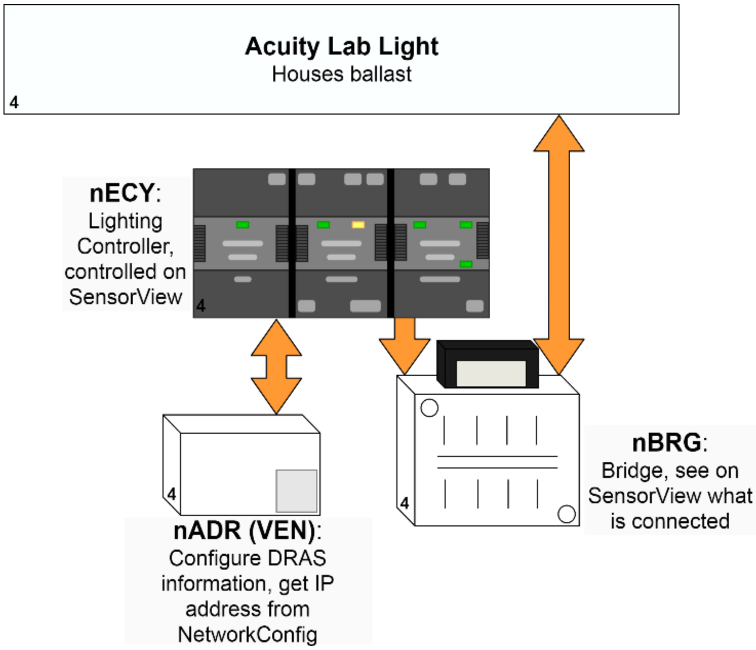
Lab 3 uses a lighting controller with embedded functionality to demonstrate how to set up AutoDR

Source: ASWB

Lab 4: Enabling AutoDR Using Manufacturer's Optional Equipment

Acuity's nLight® system was used in Lab 4 to represent optional VENs equipment from manufacturers. nLight® uses a combination of local software programs and device stored software. The student was taught to navigate each program and set DR responses and DRAS connectivity, after which verification of the system was completed (Figure 4).

Figure 4: Lab 4 Schematic



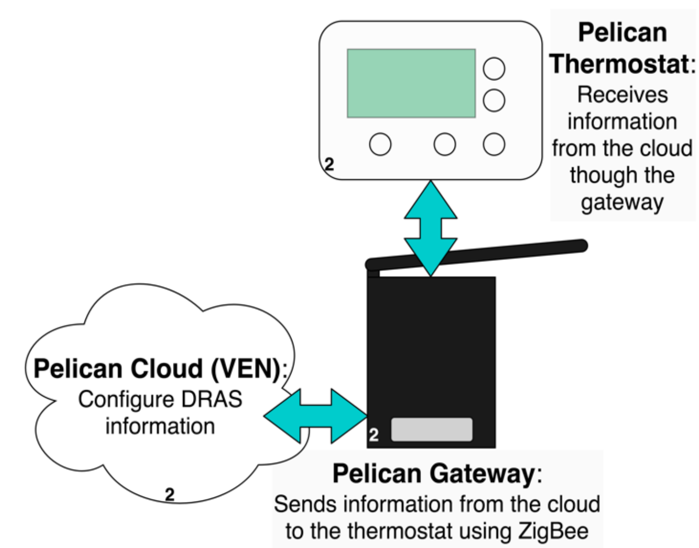
Lab 4 uses a manufacturer's optional equipment to enable AutoDR functionality.

Source: ASWB

Lab 5: Smart Thermostats – AutoDR Cloud Services

The last lab dealt with using a cloud based VEN to connect a Pelican thermostat to the DRAS. Being cloud based, this allowed the student to do all the programming of the system over the internet without the need to connect to the devices (Figure 5). At this point, students set DR responses and initiated their final lab client test.

Figure 5: Lab 5 Schematic



Lab 5 uses cloud-based services that communicate with site controllers to enable AutoDR functionality.

Source: ASWB

The training was designed to allow students to get as close to real world applications as possible. In the labs, the workstation represented the customer site. The components the students used were real VENs commonly used for AutoDR projects. The only aspect of the lab done in advance was creation of the DRAS account; however, the procedure to acquire and set up a DRAS account is still taught to the student. After the training, students should be able to identify the VEN installed at the customer's site or select an appropriate VEN for use with their lighting or HVAC systems before directing or registering these devices with local utilities. Students also learned to handle various VENs programming and implemented testing to verify correct operation.

Online Training Development

The course was designed for both in-person classroom and lab training in addition to online training. The different platforms were offered according to the training needs of the target audience. The in-person classroom and lab training included academic instruction by JATC instructors, with hands-on lab experience throughout the training. These segments were targeted toward the installers and technicians who will apply the training in the field; the online course was targeted toward estimators, sales staff, and ATTs for continuing education purposes.

Based on the target audience of estimators, sales staff, and ATTs taking courses for continuing education, the project team developed learning objectives for the online training. ASWB then selected and developed material from the full academic and laboratory course based on the learning objectives. The online training was provided within CALCTP's learning center.

The CALCTP learning center offered a comprehensive training platform and a single place for participants to access information, materials, and registrations for instructor-led training, webinars, and self-paced trainings. ICF's CALCTP learning center allows contractors to complete e-learning trainings when they are most available instead of taking time out of their schedules to travel to in-person training or attend webinars offered during business hours. Trainings covering technical, marketing, sales, and programmatic topics were available to CALCTP contractors, electricians, and others in the electrical industry.

The CALCTP learning center offered quizzes to contractors and tracked results, giving account managers insight into where contractors may be struggling and how best to support them. Many of the learning center courses were developed by instructional designers using adult learning principles. Features of these courses included intuitive navigation, user help, audio and video, interactive learning exercises, graphical illustrations, links to external web pages, a glossary of terms with hyperlinks to course content, quizzes and exams scored by the system, completion certificates, and a messaging system that provided easy interaction with instructors.

The AutoDR course was designed using flash-based interactions that reinforce learning objectives and concepts through activities, exercises, and case studies. Interactions can offer features such as matching, drag-and-drop, and click-to-display-information activities, and incorporate customized animations that enhance the learning experience. The CALCTP learning center is accessible on a variety of devices and platforms and is both responsive and mobilephone friendly. Contractors can start a course on their laptop, pick it up on their iPad, and complete it on their Android phone. The learning center saves students' course information to allow self-paced progress.

Course Rollout

Course rollout was done in partnership with the IBEW-NECA JATCs. During the course rollout, feedback and input from instructors and training centers were collected and used to modify the course materials. Details of the course rollout are discussed further in the following sections.

Participating Joint Apprenticeship and Training Centers

Within California, there are 24 JATCs that provide classroom and hands-on training to apprentices and journey-level technicians. This project partnered with a subset of seven JATCs, listed in Table 1 (Electricians School Edu, 2024). The training centers were selected based on their locations in or near population centers with high proportions of disadvantaged communities. In total, the seven partner JATCs regions cover approximately 80 percent of Senate Bill (SB) 535 (De Léon, Chapter 830, Statutes of 2012)[5] designated disadvantaged communities.

Table 1: Partner JATC Training Centers

JATC	Years in Operation	Apprentices Trained Since Founding
Inland Empire	65+ Years	4,000+
Fresno	50+ years	2,000+
Alameda	69+ years	2,070+
Los Angeles Electrical Training Institute	60+ Years	N/A
Orange County	50+ Years	4,000+
Sacrament	75+ Years	2,000+
San Mate	75+ Years	9,000+

Source: Center for Sustainable Energy

The training directors for each JATC chose the instructors to participate in course development and train-the-trainer sessions. Instructors were selected based on prior experience teaching the CALCTP academic and lab portions, work experience with building or lighting controls, and experience as Title 24 ATTs.

[5] SB 535 (De Léon) directed 25 percent of the proceeds from the Greenhouse Gas Reduction Fund go to projects that benefit disadvantaged communities. The California Environmental Protection Agency was given responsibility for identifying these communities. CalEnviroScreen 3.0 is used to determine the list of disadvantaged communities.

Train-the-Trainer Sessions

A series of train-the-trainer sessions was organized to collect feedback from instructors and enable them to effectively present the course materials to the students. These train-the-trainer sessions were conducted in person by ASWB staff, with support from CLTC technicians and CSE staff. The sessions were separated into "alpha" and "beta" sessions and held at the San Leandro Zero Net Energy Center and the Los Angeles Electrical Training Institute to facilitate attendance from JATCs located in Northern California and Southern California.

During the train-the-trainer sessions, the JATC instructors carefully walked through the academic and lab portions of the course. During the training, instructors collected feedback about the course from the perspectives of contractors, electricians, and apprentices. The alpha sessions presented academic material and laboratory exercises developed by the project partners and reviewed by engineers and CLTC staff but not yet presented to instructors or apprentices. Alpha sessions were used to identify potential technical issues that occur in the field and ensured that instructions were clear and easy to follow for both instructors and apprentices. The beta sessions presented refined versions of the academic and lab materials, incorporating changes both recommended in feedback and observed by staff in the alpha series of courses, and additionally presented the course in a substantially complete form, ready for introduction to apprentices. Figure 6 shows instructors being introduced to updated labs, in an alpha session using prototype labs.

Figure 6: Instructors Attending Beta Train-the-Trainer Session

This photo shows project staff working with JATC instructors to guide them through the lab exercise and collect feedback on lab exercise improvements.

Source: ASWB

Introduction of Academic Materials

ASWB staff conducted the academic portion of the train-the-trainer sessions at the San Leandro Zero Net Energy Center and Los Angeles Electrical Training Institute JATCs. The JATC instructors were trained using the standard course materials, including "check your understanding" questions included throughout the course workbook. The instructors responded well to the instructional materials presented. Specific, pointed questions and successful completion of quizzes to verify student understanding ensured that instructors completed the training with a comprehensive understanding of the course curriculum. The trainers provided their own anecdotal experiences as discussion points during the train-the-trainer sessions integrated into course materials. The association between field experience and real-world situations encountered with course study topics not only demonstrated their personal comprehension of the course curriculum, but also reinforced the benefits of training during subsequent sessions to enhance the learning experience for attending apprentice trainees.

Introduction of Laboratory Materials

The alpha and beta train-the-trainer sessions introduced lab exercises using two different approaches: a hands-on guided approach to completing the exercises and a hands-off problem-based learning approach. In the hands-on approach, the instructors were walked through the labs step-by-step. In the hands-off approach, the instructors were given the lab manual and situations without guidance, but with the availability of project staff to answer questions. The approach preferred by the JATC instructors depended on the individual; some instructors felt the need for a step-by-step walk-through, and others learned and understood the labs better when they were able to figure it out on their own. Feedback was integrated into lab materials to accommodate a variety of learning styles. Under all approaches, instructors were given general lab introductions so that all instructors were familiar with the devices on the lab boards.

During the lab portions of the train-the-trainer sessions, the instructors were given the opportunity to work directly with the course development team to review questions about lab procedures and corresponding devices to fully understand both the lab equipment and learning objectives. The train-the-trainer sessions were structured to allow instructors the opportunity to discuss and review the course in more detail to gain in-depth and thorough understanding of the material.

During the alpha and beta sessions, the project training staff additionally worked with equipment manufacturers to resolve technical issues that arose during the train-the-trainer sessions that could impact the full rollout of the course to apprentices.

A workshop was also convened to bring controls manufacturers together to introduce the CALCTP-AutoDR course, solicit feedback on course materials, and facilitate information exchange among manufacturers. Manufacturers were an integral part of making the CALCTP-AutoDR course a success. As this training was innovative in teaching skills for installing and maintaining AutoDR equipment, much of the work done to support the development of the training materials also improved the implementation of AutoDR in commercially available devices.

Construction, Commissioning, and Delivery of Lab Boards

After the train-the-trainer sessions were completed, feedback on the lab structure was integrated into the final lab board design by the CLTC. ASWB procured lab board materials from distributors and vendors, and lab board construction was completed in Davis, California, by CLTC staff. AutoDR courses were structured around a student-to-instructor ratio of ten to one, with two students working in pairs on each lab board. Five lab boards were constructed for each instructor participating in the project, for a total of 40 boards provided to JATCs. An additional lab board was constructed to facilitate the continued development and refinement of laboratory exercises and remote troubleshooting of equipment issues. Figure 7 shows a typical completed lab board in the final equipment configuration.

Figure 7: Completed Lab Board

This is an image of the completed lab board in the final configuration used for lab exercises.

Source: CLTC Staff

Once constructed, the lab boards for Southern California JATCs were shipped to the ASWB office in Orange, California for commissioning. For the lab boards constructed for Northern California, ASWB, CSE, and CLTC staff conducted commissioning at the board assembly location.

Commissioning

The commissioning of the first production run of lab boards, allocated for JATCs based in Southern California, uncovered many issues with AutoDR functionality. After identifying technical and software issues during the commissioning process, ASWB worked with the vendors of the devices on the lab boards to troubleshoot and further develop the necessary AutoDR capabilities of the devices to ensure reliable operation through many iterations of the course. While many vendors claimed to have AutoDR capabilities, the commissioning process revealed that although many devices reported AutoDR capabilities, in practice the AutoDR functionality was not fully developed and functioned below the level of reliability required for the implementation of the AutoDR. Software updates for malfunctioning controls were developed and released specifically due to the necessity of the AutoDR project and issues identified throughout the commissioning process. During this commissioning process, the manufacturers provided all support so that devices were able to reliably receive and execute an AutoDR event. By the end of the commissioning process all labs were complete and functioned reliably. Once all labs were confirmed to be working, the lab boards were approved and shipped to an assigned JATC training center.

The lab boards for Northern California were commissioned after the successful completion of the Southern California lab boards. Since most issues with the lab boards were resolved during the Southern California commissioning process, the commissioning of the Northern California lab boards was much faster and encountered only minor problems, which were resolved relatively quickly with the assistance of the manufacturers and on-site IT support at CLTC. Once all the labs were confirmed to be working by ASWB/CSE/CLTC staff, shipment of the lab boards to their assigned JATCs was approved.

Board Delivery and Setup

Delivery of the lab boards to JATCs was conducted by ASWB staff. Once delivered to the site, ASWB staff set up and conducted final commissioning of the lab boards, completed end-to-end testing of each device, and ran through each lab on each board to ensure proper functionality. To facilitate deployment of the lab boards to the JATC training centers, ASWB coordinated with the site IT team and manufacturers to ensure assistance would be available if needed during onsite commissioning. Throughout the onsite commissioning process, site-specific technical issues were anticipated. These technical issues were resolved with the help of either the site IT personnel or the equipment manufacturers, depending upon the cause. Once the final commissioning of the lab boards was completed by ASWB staff, the lab boards were ready for instructional use. As the last step of the setup process, ASWB staff met with the instructional teams to introduce the final lab board configuration and complete the instructor onboarding process.

Common Issues During Setup

During the board setup process, the team identified common issues unique to the classroom and not expected to be encountered in field installations, including:

- Internet connectivity of the boards.
    - Issue: When the lab boards first arrived onsite and were connected to the facility ethernet, many were unable to connect to the internet. After much trial and error, the team determined that the routers on the lab boards were using IP addresses for the lab board devices that were conflicting with the main facility's IP addresses, making it impossible for the devices to connect to the internet.
    - Solution: The solution was to change the IP address of the router to a non-conflicting IP address (that is, change from 169.254.0.1 to 10.0.0.1).

- UDI connection to correct the RCS thermostat.
    - Issue: The RCS thermostat connected to the UDI VEN through a wireless mesh network standard (ZigBee); due to the proximity of the lab boards to each other, many of the RCS thermostats were connecting to the wrong lab board UDI.[6]
    - Solution: This problem was resolved with the assistance of the manufacturer by turning on the boards one at a time and waiting for connection of the RCS thermostat to the correct UDI before moving on to the next board. If an RCS thermostat connected to the wrong UDI, there was also the option to delete it from the ISY994i AutoDR-enabled control device dashboard and connect to the correct one. While this solution was cumbersome, it was effective in connecting the RCS thermostats to the correct UDI.
- Enlighted sensor disconnected from the switch and deleted itself from the floor plan.
    - Issue: An issue that occurred many times at multiple JATCs was that the Enlighted sensor was accidentally deleted from the Energy Management System floor plan and disconnected from the switch.
    - Solution: This issue, resolved with the assistance of the Enlighted support team and ASWB staff, documented the procedure for reconfiguring the sensor since this was a common problem.
- DRAS login password updates.
    - Issue: Every three months the DRAS requires users to update their passwords for security reasons. This became an issue because during the training the students were often prompted to update the passwords they were setting themselves and not documenting updated passwords.
    - Resolution: This was resolved by having better coordination with the instructors and updating the shared Google sheet with the passwords.
- VEN connection with the DRAS.
    - Issue: For a VEN to receive a DR event from the DRAS, the VEN must have the proper credentials entered and be online on the DRAS. Oftentimes, however, the users would have trouble connecting the VEN to the DRAS due to either a user input error or a server issue.
    - Resolution: This was a common problem. A resolution that worked most of the time was to clear all VEN credentials and re-enter them. ASWB created a Google sheet with credentials, so students were able to easily copy and paste them in correctly. If the VEN credentials continued to be problematic, the staff instructed students to contact the DRAS manager.

[6] Note that this problem is very unlikely to occur in the field, as this is a unique situation with several UDI VENs at a single location, whereas in the field it would be one VEN per site.

Course Scheduling and Implementation

The CALCTP-AutoDR course was developed as a module that followed the full CALCTP curriculum. Apprentices complete the CALCTP in the fourth or fifth year of their apprenticeship, with the CALCTP-AutoDR offered to apprentice completing their fifth year of classroom training. Due to constraints in course scheduling and instructor availability it was not possible to offer the CALCTP-AutoDR course following the full CALCTP course at all training centers. For this reason, the CALCTP-AutoDR module was designed to function both independently and as a component of the CALCTP but was recommended to follow training in advanced lighting controls.

Training directors scheduled the CALCTP-AutoDR module following the rollout of course materials and delivery of the lab boards. To account for variations in training schedules and operating hours between training centers, a key feature of the CALCTP-AutoDR course design was the segmentation of academic materials and lectures into modules that can be taught in a wide variety of class schedules.

Initial Course Perception

Throughout the launch of the course, apprentices were asked to complete a short course evaluation to gauge initial perception of the course and provide feedback on course material. A sample course evaluation is included in Appendix B.

Initial course perception and overall approval ratings for the course were high for the class instructors, course content, and class presentation. Feedback from participants indicated that the trainees received the training well, thought highly of the course instructors, and were generally happy with the course content. There were some responses indicating uncertainty regarding whether the course would advance their careers or help them in their jobs.

While most trainees reported that they gained new information, a few indicated that they felt their electrical skills improved substantially as a result. Further course development could explore providing the students more involvement with the wiring of lab board devices, training on lighting control interfaces, training on energy management systems, and other load control devices; this work, however, was outside the scope of providing training on the AutoDR protocol.

Most issues cited in course surveys were related to computer hardware speed and reliability. The instructional team was tasked to ensure that workstation operations were maintained at more optimum levels. This indicated a key differentiating factor between the AutoDR course and other technical training provided to apprentices: the requirement of using computers as an integral part of the hands-on education. Since the instructional design relies on the labs to reinforce the course curriculum, it was imperative that the lab exercises functioned without significant hurdles to create an efficient and effective learning environment.

Specific participant feedback received included:

- Assessment of instructional staff.
    - More than 80 percent of participants surveyed either agreed or strongly agreed that instructors listened, were good presenters, provided clear instruction, and were well prepared.
- Initial perception of course materials.
    - More than 80 percent of participants surveyed either agreed or strongly agreed that course materials were clearly and effectively presented and that the timing of the course delivery was appropriate relative to the apprentices' other coursework and curricula.
- Perception of the benefit of the AutoDR course for career advancement.
    - Overall satisfaction responses were lower regarding career advancement and how the course would benefit trainees' jobs. While they absorbed and understood the course materials, several trainees were undecided in this area.
    - Based on the survey results, the instructional team determined that although the course material directly related to AutoDR functionality and concepts in energy management, the AutoDR curriculum should be tied to broader skills and career pathways in building controls, automation, and communications standards.

Outreach and Enrollment of Apprentices From Disadvantaged Communities

One of the primary objectives of this project was to reduce or remove barriers to achieving goals established by AB 758 in disadvantaged communities. In an effort to address the workforce related barriers to energy management and to overcome endemic challenges to enrolling individuals from disadvantaged communities into electrical careers, the project team implemented outreach and enrollment plans for prospective apprentices located in disadvantaged communities. By addressing workforce-related barriers, the project could help facilitate the adoption of not only AutoDR, but other load-management technologies that advance adoption of DR capable control standards in the Title 24, Part 6 California Building Energy Code.

The CLF Workforce and Economic Development program (WED) led apprentice outreach and recruitment efforts. WED was uniquely qualified to lead this task since it served as the lead technical assistance provider on the California State Workforce Development Board's Prop 39 pre-apprenticeship pilot and developed successful linkages to union construction apprenticeship programs for more than five years. The combination of effective recruitment and proven pre-apprentice training could increase the pool of qualified minorities, women, disadvantaged persons, and veterans able to participate in apprenticeship programs offered in the construction industry.

Development of Outreach and Recruiting Efforts

The WED worked closely with the seven partner JATCs to develop apprentice recruitment goals and plans to provide an adequate pool of prospective apprentices to take the CALCTP-AutoDR course.

The first step taken by the WED was to survey JATC partners to determine their needs and current apprentice numbers. The purpose of the needs assessment was to determine how many of the existing apprentices already fit the disadvantaged community requirement stated in the grant to identify previously identified barriers to enrolling workers from disadvantaged communities. One of the most commonly cited gaps in recruit preparedness was the lack of accessibility of math training and math enrichment so that prospective applicants can pass the apprenticeship test. The other identified need was to introduce JATCs to neighboring apprenticeship readiness programs that teach the multicraft core curriculum, commonly known as MC3.[7] MC3s are programs that create pathways to union apprenticeship for workers and introduce prospective apprentices to the building and construction trades. Graduates of the MC3 programs obtain an industry-valued certificate that enhances their entry and retention into construction-focused, registered programs throughout the state. MC3 programs cultivate individuals interested in a career in building and construction and prepares them to become successful applicants to an apprenticeship of their choice. Part of the MC3 preparation includes a course on labor history and math enrichment training, a key need identified by the partner JATCs since the math portion of the IBEW aptitude test has historically been a significant barrier to apprentice acceptance.

The WED then created AutoDR outreach material separate from existing JATC material, which highlighted AutoDR training. Partner JATCs received their own custom graphic and printouts, with detailed information on their training centers and the next apprenticeship application cycle.

The WED also linked JATCs with successful MC3s in their local areas, leveraging existing programs and resources and expanding the reach of the AutoDR project.

Summary of Outreach Activities

Following the development of plans and development of outreach partnerships, the WED began implementation of the outreach plans. The activities undertaken by the WED included:

- Onsite visits to JATCs.
- Consulting with the National Building Trades Council on MC3 programs.
- Coordination of the local MC3 programs with JATCs.
- Bridging connections between career and technical education programs in local high schools and with JATC partners.

[7] MC3s are composed of partnerships made of community-based organizations, workforce development boards, and labor unions. By pairing JATCs with their local MC3 program, there have been more opportunities created for people from disadvantaged communities to enter a union apprenticeship programs.

- Designed, printed, and distributed marketing collateral customized for the IBEW.
- Consulting with JATC coordinators on their apprentice needs and recruiting numbers.

To ensure that apprentices who enroll in the JATCs had the opportunity to take the CALCTP-AutoDR course, partner JATCs made the course a component of their curriculum for either fourth- or fifth-year apprentices. This ensured that there are trained technicians in the majority of disadvantaged communities to help achieve the goals of Assembly Bill (AB) 758 by reducing or removing workforce-related barriers.

Outreach to Small- and Medium-Sized Businesses and Public Facilities Located in Disadvantaged Communities

Apprentices selected for the AutoDR training also received on-the-job training with electrical contractors on customer installations. To increase on-the-job training opportunities for apprentices to specify, install, test, commission, and maintain AutoDR communications equipment, the project team implemented outreach for SMBs and public facilities located in disadvantaged communities.

The objective of the outreach was to recruit both SMBs and public facilities in disadvantaged communities into IOU AutoDR programs and promote the benefits of hiring contractors to install and activate the AutoDR communications technology. Secondary goals included creating awareness about IOU DR programs by providing more transparency about costs and benefits associated with adopting AutoDR, demonstrating the business case for adoption of AutoDR technology.

AutoDR outreach relied on the promotion of available rebates and technologies included in the AutoDR course laboratories. Outreach focused on the technology end users, the equipment vendors and manufacturers, installation contractors, and associations where end users may participate.

The Center for Sustainable Energy developed and implemented outreach plans for SMBs and public facilities, with support from Energy Solutions to leverage best practices from the administration of IOU AutoDR technical incentive programs.

Development of AutoDR Sales Best Practices

To better understand the motivations and barriers for SMBs and public facilities, Energy Solutions led the development of an AutoDR sales best practices guide. The project team interviewed AutoDR market actors including small businesses inside and outside of disadvantaged communities, public facility staff, current and potential utility AutoDR participants, AutoDR vendors, and AutoDR manufacturers to synthesize best practices for the promotion of AutoDR to SMBs. In general, SMBs are an underserved market in IOU programs. The primary motivating factor identified was that businesses and facilities equipped with AutoDR equipment will be able to better withstand current or upcoming changes in utility rates with the expected defaulting of customers onto PG&E's peak-day pricing or SCE's critical-peak pricing rates. Secondary benefits included additional financial benefits, and better control over facilities and reduced workloads for participation in programs due to automation.

Outreach Strategy and Target Audiences

The following strategies formed the foundation of the AutoDR outreach plan and guided the development and implementation of outreach tactics. A multipronged approach was necessary given the complexities of the customer journey for an SMB or public facility.

1. IOUs, manufacturers, contractors, local governments, community-based organizations (CBOs), and project partners identified buildings and businesses that were good candidates for installation or enablement of AutoDR controls.
2. Candidates were located in disadvantaged communities and in the service territories of contractors who received the AutoDR training.
3. Tailored marketing materials were designed for collaborative partners: IOUs, local governments, the Green Business Network (GBN), managers and contractors, business owners and operators, and facilities managers.
4. The team conducted outreach to promote participation in IOU AutoDR programs, collect feedback and information on program effectiveness and barriers to participation, and develop outreach partnerships with stakeholders.

Target audiences for participation in AutoDR programs were SMBs and public buildings located in disadvantaged communities. For the purposes of this project, small- to medium-sized businesses were defined as those with demand of less than 500 kW, defined per meter or utility account. This satisfied the requirements of SCE’s and PG&E’s Express and FastTrack programs, respectively. Installation contractors, vendors, equipment manufacturers, CBOs, GBNs, local chambers of commerce, and ATTs were also identified as target audiences due to their roles in customer adoption and consumer appeal of AutoDR technologies.

CHAPTER 3: Project Results

This chapter discusses the results of the implementation of the CALCTP-AutoDR course, including feedback received about the implementation, unanticipated challenges associated with the training, and results of the training. This section also addresses outreach efforts to enroll SMBs into AutoDR programs to provide additional on-the-job training opportunities to electricians, as well as the challenges and barriers associated with the recruitment of these buildings.

Course Implementation

Once the rollout of CALCTP-AutoDR course materials to partner JATCs was completed, the course schedules were coordinated with training directors to ensure that the course was taken by inside wire electrical apprentices in the fourth or fifth years of their apprenticeships. A need identified after the first courses were scheduled was for journeyman electricians to complete the course. Journeyman electricians who received the training could then support on-the-job training of the apprentices as they work with National Electrical Contractors Association (NECA)-affiliated contractors. To facilitate this change, courses for journeyman were initially prioritized over those for apprentices. This change in strategy supported the career trajectory of apprentices by building a base of trained electricians who provided supervision and guidance to apprentices while they completed their on-the-job training.

Following completion of the classes held for journeyman electricians, all partner JATCs scheduled training for apprentices. Courses were scheduled to be held at least once per semester, but frequency increased based on the size of the apprentice class, the number of lab boards available at the JATC, and instructor availability.

During the ongoing implementation of the course, issues were encountered that were not revealed during testing and development of the course materials and lab boards. Issues were in three general categories: hardware, software, and staff turnover.

Hardware Issues

Several hardware issues occurred during the project across the 40 lab board fleets deployed. Throughout the design of the labs and selection of materials, it was expected that commercial lighting controls and HVAC controls would have few hardware issues or malfunctions, but the failures of several devices suggested that further investigation into the reliability and failure rates of sensors and devices may be necessary:

- Sensors: Individual fixture sensors (occupancy, daylight harvesting, and dimming control) on two lab boards malfunctioned and required in-warranty replacement of the device, re-discovery, and setup to continue use of the board.
- Switches: One lighting control switch malfunctioned and required in-warranty replacement.

- Relay: A relay used to initiate a DR event through contact closure on a third-party lighting control system failed and required replacement.
- Wiring: Several advanced lighting systems use ethernet (Cat-5) cables to communicate with and provide power to sensors or controls. Multiple boards had cables that failed and required replacement.[8]

Software Issues

The software issues related to the implementation of AutoDR capabilities were resolved during course development and the rollout phase. Several software issues (beyond the implementation of AutoDR on lab board devices) were encountered that required additional technical support to the JATCs throughout course implementation.

- **Operation System Updates:** During the first class session after a long break from the last scheduled course (typically between spring and fall semesters), software patches and updates often delayed the students' abilities to complete the labs. Recommendations were given to JATCs to ensure that computers used to support the course were updated regularly; however, the majority of JATCs do not have a dedicated IT department and may lack the in-house resources required to maintain course computers.
- **Firmware Updates:** Several vendors developed firmware updates to their control systems after the course rollout. In most cases, the firmware updates did not impact the labs, though some updates required that lab materials be updated to help guide apprentices through updated control interfaces.
- **DRAS Updates:** Updates to the DRAS used to facilitate end-to-end testing of an AutoDR-capable control would delete or reset the accounts created for each JATC. The project partners worked with the DRAS administrator to ensure that server updates would preserve test accounts.
- **Change in DRAS Vendors:** The project partners were notified that the vendor that supplied the DRAS for PG&E would be changing. As a result of the change, the test environment used to support the ongoing training and testing of devices would no longer be available. The project team worked with the existing vendor to ensure that the current test environment remained available through the project term and started researching options for a longer-term solution.
- **Staff Turnover:** The project approach for training was to offer the initial train-the-trainer sessions to a cohort of instructors and then offer shorter refresher training sessions as needed to reinforce course concepts and introduce changes to AutoDR programs, technologies, and code requirements. Throughout the project, staff turnover at the JATCs among training directors and instructors necessitated the development of an instructor training model that addressed staff turnover and allow the project scale as demand increased for electricians trained in AutoDR. Utilizing strategies developed for

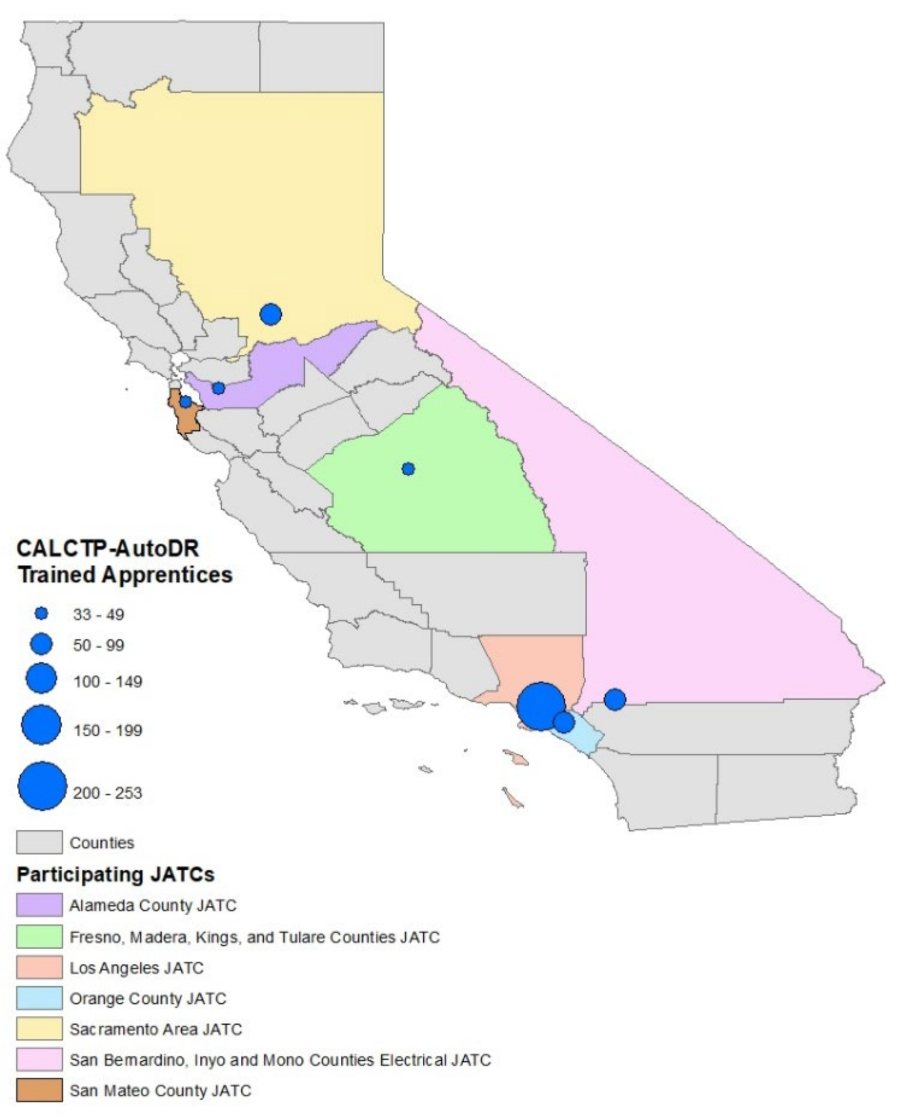
[8] This issue is likely unique to the lab environment as constant connection and disconnection of devices is not expected for field installations.

the CALCTP program, prospective instructors first needed to observe and successfully complete the CALCTP-AutoDR class at a JATC offering the course, as well as the online training developed by ICF. The instructors would then attend a seminar hosted by the instructional material team to reinforce core course objectives and concepts, followed by question-and-answer sessions and individualized instruction as needed.

Classroom Training Results

Following the course rollout in the winter of 2017, 655 electricians completed the CALCTP-AutoDR course. Of these, 378 were apprentices that resided in a disadvantaged community at the time they completed the course. A map showing the distribution of apprentices amongst the partner JATC's is shown in Figure 8.

Figure 8: JATC Training Center Locations and Trained Apprentices



This figure shows the territories of the participating JATCs and the number of CALCTP AutoDR trained apprentices from each JATC.

Source: CSE

Most apprentices from disadvantaged communities were trained at the Los Angeles JATC due to the large population covered by the training center and its instructional staff availability. The 655 trained apprentices were employed by more than 250[9] different electrical contractors during the project, representing a large diversity in trained apprentices and electrical contractors that received education on AutoDR. A detailed summary of trained apprentices is included in Appendix C.

Training directors have planned to continue to offer the CALCTP-AutoDR course and expand training to other JATCs.

Online Training Results

The online training hosted by ICF, International, reported the following student counts:

- 583 started
- 134 in progress
- 818 completed
- 329 completed/passed
- 34 failed

"Started" means the student opened the content, but never read it; "in progress" means the student started content but did not finish it; "completed" means all course work was completed but the student did not take the final test; "passed" means the student completed the coursework and passed the final exam with a score greater than 70 percent; and "failed" means the coursework was completed, but the student did not pass the final exam with a score of at least 70 percent.

Apprentice Recruitment

The WED coordinated with each JATC to implement apprentice outreach and recruiting plans. Recruitment and recruiting challenges are summarized below.

Recruiting Challenges

The challenges of apprentice recruiting were primarily administrative, but several endemic barriers for workers from disadvantaged communities were identified.

A key innovation of this project was to leverage existing infrastructure available for workforce development and existing networks of resources, which reduced or eliminated workforce-related barriers to achieving increased energy savings in existing buildings and support adoption of advanced energy technologies in new construction. Coordinating with existing networks and resources required that the WED and project partners adapt outreach strategies to meet the needs of community-based organizations, outreach coordinators, and other stakeholders that had previously built relationships in disadvantaged communities. Throughout the development of partnerships to promote the CALCTP-AutoDR course and inside wireman apprenticeships, the most common barrier to entry into the apprenticeship

9 This number is not fully representative of the contractors that provided on-the-job training to apprentices as this data was not reported for all apprentices that completed the AutoDR Course.

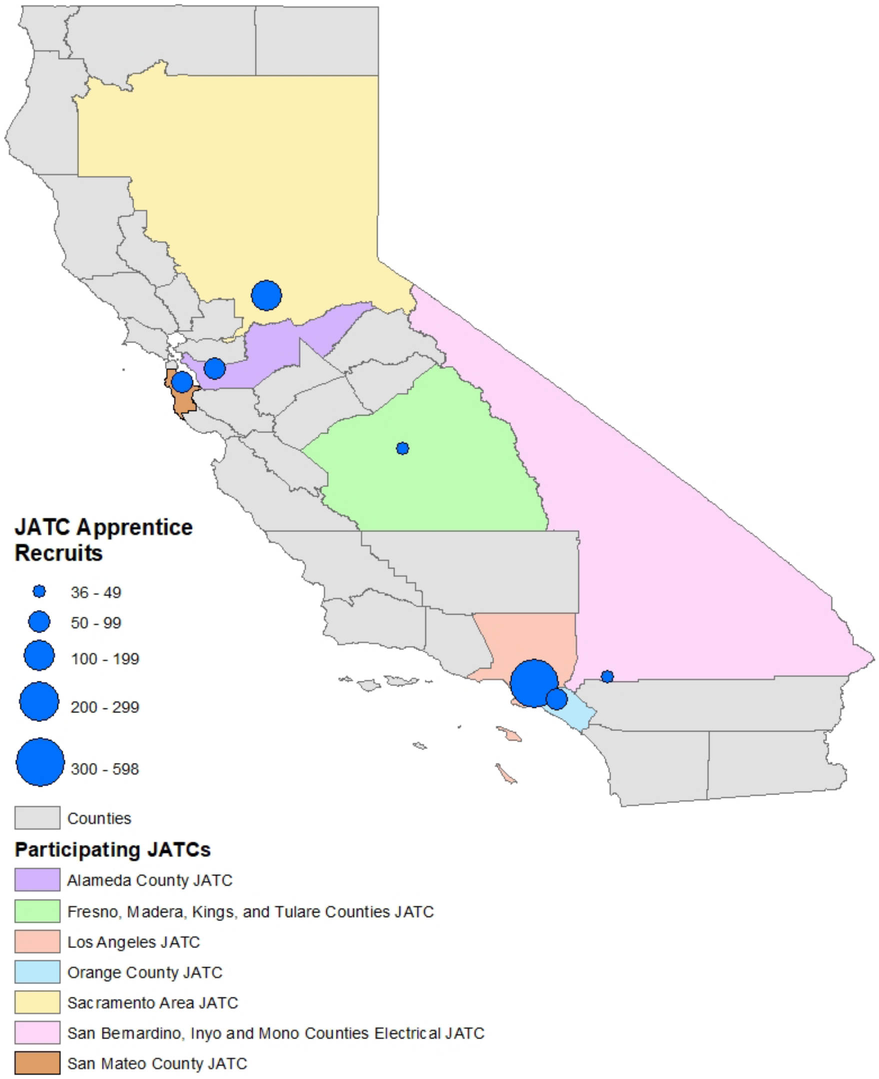
program identified by stakeholders was the need for math enrichment and tutoring services. These services were not included in the outreach and recruitment strategy. Instead, the WED coordinated efforts with other initiatives that could provide math enrichment or tutoring services to workers who expressed interest in applying for the apprenticeships.

Recruiting Results

Apprentice recruiting efforts were launched in 2018 to help build the enrollment of workers from disadvantaged communities into the inside wireman apprenticeships. A total of 1,005 workers were recruited, and of these 637 resided in or near disadvantaged communities.[10] Figure 9 is a map of the JATC territories and the numbers of workers recruited for inside wireman apprenticeships for each JATC. A more detailed summary of recruited workers is included in Appendix C.

[10] Reports of recruited workers only include ZIP codes to reduce personally identifiable information collected. Because ZIP codes are based on postal routes and disadvantaged communities are determined at the census tract level, ZIP codes can only function as an approximation of location that contains a disadvantaged community.

Figure 9: Joint Apprenticeship and Training Center Apprentice Recruits



Map of participating JATC territories and the number of workers recruited to enroll in the JATC during the grant

Source: CSE

Small- and Medium-Sized Businesses and Public Facility Outreach and On-the-Job Training

Throughout their five-year programs, apprentices completed their classroom training and paid on-the-job training with union contractors. The apprentices gained knowledge through a structured curriculum and superior skills in a wide range of electrical installations. On-the-job training was completed on a variety of actual customer installations. Increasing demand for the installation of AutoDR-enabled controls increased the likelihood that apprentices would have on-the-job experience with AutoDR outside of the classroom and lab environments.

An outreach and recruitment plan was implemented to recruit SMBs located in disadvantaged communities to participate in IOU DR programs and promote AutoDR incentive programs to electrical contractors when working with customers on retrofit strategies. The incentives received from the IOU programs would ideally fund the purchase and installation of AutoDR controls and promote hiring a trained workforce that had completed the CALCTP-AutoDR course. This was also expected to help drive demand for trained workers to retrofit existing buildings.

Outreach and Stakeholder Engagement

Energy Solutions, the administrator of PG&E's AutoDR incentive program, developed a set of sales best practices to improve outreach efforts to SMB's located in disadvantaged communities. A copy of the sales best practices guide is included in Appendix D. CSE then created a customer journey map to identify both target audiences and stakeholders. Table 2 summarizes the stakeholder groups and the number of representatives engaged through this project.

Table 2: Small- and Medium-Sized Business Stakeholder Outreach

Stakeholder Group	Representatives Engaged
Manufacturers	32
Electrical Contractors	15
Acceptance Test Technicians/Estimators	455
CBO's and Other Organizations	8
Green Business Network Coordinators	50
Local Governments	67

This table summarizes each stakeholder group engaged for outreach to SMB, and the number of representatives contacted directly, in attendance at round table discussions, or in attendance at webinars and training sessions organized by project partners.

Source: CSE

Challenges and Barriers to Increased Automated Demand Response Adoption

Stakeholders identified multiple challenges and barriers to adoption of AutoDR in existing buildings. Much of the information collected from this effort was anecdotal, but nonetheless indicative of barriers to adoption that may require further investigation.

- **Incentive Program Design:** Targeted outreach efforts were completed to enroll SMBs under PG&E's FastTrack ADR incentive pathway and SCE's AutoDR Express incentive pathway. These programs had lower administrative burdens than required for the customized incentive pathway available during the project and the technical skills taught in the CALCTP-AutoDR course were tailored to PG&E FastTrack or SCE Express incentives. Despite the lower administrative burdens associated with these incentives, small business groups, CBOs, and contractors indicated that the administrative overhead burden was higher than other opportunities, which reduced their willingness to market stand-alone AutoDR retrofits to customers.

- **Incentive Payment Requirements:** Program guidelines may require that incentives be paid directly to customers. Though these guidelines can help address the inflation of installation costs and aggressive DR strategies, this requirement can be a barrier to SMBs located in disadvantaged communities since some businesses need to fund the entire installation and pay contractors before they receive incentive payments. Vendors can fund installations upfront and be paid back via the incentive structure, and IOU administrators indicated that historically this was a common strategy, but that this strategy requires an agreement with customers on their use of technology incentives and may not apply to SMBs in disadvantaged communities.
- **Workforce Requirements:** Several contractors commented that without a labor or workforce training requirement, or without a requirement to link the receipt of incentives to installer certifications, customers would have little incentive to hire skilled workers due to higher labor costs.
- **Changing Event Hours for Peak Day Pricing (PDP) and Critical Peak Pricing (CPP):** The most likely pathway for customer participation to participate in AutoDR programs and receive technical incentives was through the PDP and CPP tariffs in PG&E's and SCE's respective service territories. During the project, the event hours for these programs shifted to later windows, which lowered the value of adopting AutoDR controls.
- **Costs and Benefits of Controls:** Though the CPP and PDP programs offer simple calculators to determine incentive levels for customers, as a stand-alone measure direct financial benefits may not outweigh the costs of the installations. A report on the value of demand response enabling retrofits outlines many co-benefits of advanced controls. However, these do not qualify for SMBs and therefore must be considered together with the nonenergy benefits of lighting controls. Without a uniform framework to quantify these benefits, SMBs concerned about their bottom lines may ultimately choose other investments (Schwartz, et. al., 2019).
- **Changing Market for Consumers:** During the grant term, the energy market changed dramatically for consumers due to the increased number of customers served by community choice aggregators (CCAs). The emergence of CCAs creates opportunities to design and implement load management programs that better serve the needs of customers in their service territories; however, this added additional complexity to reach SMBs created barriers to customers who want to receive AutoDR technology incentives through a PDP or CPP tariff since these would not qualify a CCA customer to receive IOU technology incentives.

CHAPTER 4: Technology/Knowledge/Market Transfer Activities

This chapter summarizes the knowledge transfer planning, activities, and outcomes in the overall effort to share data and information gained from the project and make it available to the public including targeted market sectors, potential outreach to end users, utilities, regulatory agencies, and others.

Knowledge Transfer Approach

The general aim of transferring knowledge was to move from initial awareness of AutoDR, its benefits to workforce development, and the AutoDR course, to the application and adoption of the CALCTP-AutoDR course. The researchers subdivided the knowledge transfer approach into individual strategies based on key audience type, which were in turn further subdivided into detailed tactics framed by goals tied to strategic outreach channels, per audience type.

Audiences

Reaching stakeholders required both understanding of and speaking to specific needs. Different stakeholders responded better to key messaging and tactics tailored to highlight benefits for specific audiences. The project team categorized stakeholders into different target audiences with specific roles, program benefits, and audience splits, highlighted in Table 3.

Table 3: Target Audiences for Knowledge Transfer

Audience	Role	Program Benefits	Projected Audience Split
Green Business Network	Provide environmentally minded business information and support to their members.	Inform members of energy efficiency & savings options. Potential qualification criteria to DR program; Auto DR controls incentives enrollment	25 percent
IOUs	Provide & administer DR incentive programs	Increases enrollment in AutoDR Incentive programs	20 percent
Local Governments/ Government Agencies	City & County Government	Lowers operational cost and can help achieve state mandated energy reductions.	20 percent

Audience	Role	Program Benefits	Projected Audience Split
Energy, Sustain-ability, & Property & Operations Managers at Small/Medium Businesses	Manage a single or multiple commercial property(ies) for their tenants (grocery & big box store).	Sales tactic to acquire new customers, compliance with Title 24; can help achieve cost or energy reductions mandated by their organization/business	10 percent
Contractors	Provide energy retrofits/lighting/controls &/or HVAC as part of their core services	Help to market efficiency retrofit services to customers → business generation	10 percent
Regulatory Bodies	The client and other connected regulatory bodies	Research that helps inform regulatory policies and standards	15 percent

Source: Center for Sustainable Energy

Channels

Recognizing that some channels were more effective with certain target audiences than others, the project team's approach ensured that the most efficient and effective channels were used for each audience.

Table 4 indicates the channels used to reach each target audience.

Table 4: Knowledge Transfer Channels

Channel Audience	Green Business Network	IOUs	Local Government	Facilities Managers	Contractors	Regulatory Bodies
DIGITAL						
Emails	x	x	x	x	x	x
Reports/Fact Sheets	x	x	x	x	x	x
Webinars	x		x	x	x	
Website	x	x	x	x		x
IN-PERSON						
Conferences and trade shows		x	x	x		
Content kit	x		x			
MEDIA						
Trade publications		x	x		x	

Source: Center for Sustainable Energy

Knowledge Transfer Results

The project team estimates that at least 800 stakeholders were directly reached and educated about the project from numerous presentations, conferences, forums, and meetings attended by members of the project team. Hundreds of additional individuals were reached through digital collateral and outreach, which included a dedicated project website, blogs, and e-mail announcements, and trade publications. These activities are summarized in the following sections.

Conference and Workshop Presentations and Attendance

The project team presented at several conferences to share the project concept and lessons learned. These conferences included the Peak Load Management Association's biannual conference (May 13-15, 2019, Minneapolis), the Local Government Sustainable Energy Coalition quarterly meetings, and the statewide Green Business Network annual coordinator's meeting. Workshops and presentations were also coordinated for NECA affiliated contractors, equipment manufacturers, and local business associations.

As a result of these conferences and workshops, the project team networked with regulatory, facilities, government, and industry representatives. Several load-serving entities, including CCAs, have shown interest in deploying AutoDR in their respective territories. The project team met with two CCAs to share both project results and market barriers.

Webinars

The project team produced three webinars to share the project concept and lessons learned with stakeholders. The webinars were produced for the statewide Green Business Network, the Local Government Sustainable Energy Coalition, and the San Diego Green Business Network.

As a result of these webinars, the project networked with local governments and stakeholders that work directly with small- and medium-sized businesses in disadvantaged communities. These stakeholders expressed interest in identifying strategies and developing tools to address market barriers to the adoption of AutoDR and other load management technologies in their communities.

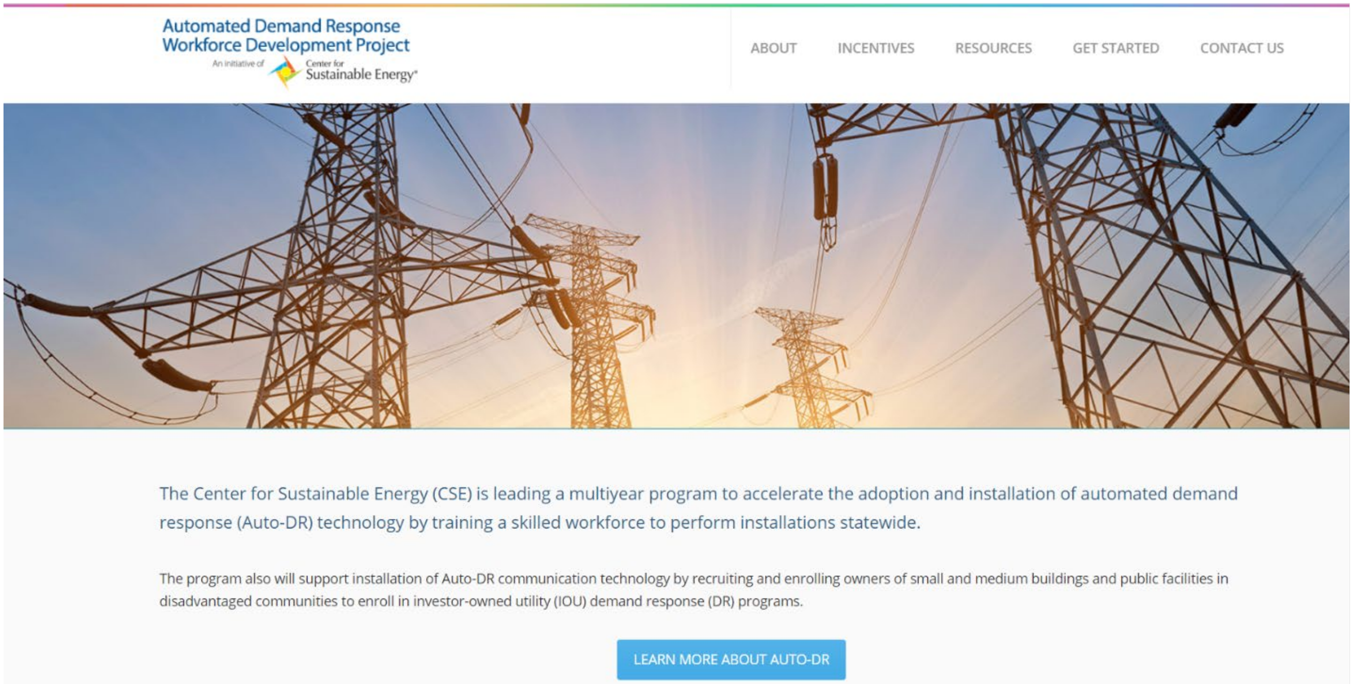
Articles

CSE published an article in *Whiley's Natural Gas* on multiple-use applications for distributed energy resources (DERs) and highlighted the AutoDR project as an example of how workforce development can support unlocking the value of DERs. The CLTC published an article in a lighting industry trade journal describing the benefits of training and workforce development to accelerate adoption of new technologies and energy conservation measures.

Digital Collateral and Outreach

CSE developed and hosted a full-scale project website that went live in 2017. A screenshot of the project website is shown in Figure 10.

Figure 10: Screenshot of Project Website



Source: Center for Sustainable Energy

Regulatory

The project team participated in numerous regulatory proceedings and initiatives at both the California Public Utilities Commission (CPUC) and the CEC and influenced policies based on project conclusions. Key California policymaking forums that the project team engaged with follow: California Public Utilities Commission

- **Demand Response (R.13-09-011):** Rulemaking to enhance the role of demand response for resource planning. CSE provided informal comments suggesting innovative DR programs the CPUC could implement. These included events triggered by marginal greenhouse gas (GHG) emissions rates and real-time pricing. CSE leveraged its experience with ADR to suggest communication protocols that could be in place for these programs.
- **Demand Response Program Applications (A.17-01-012):** Consolidated proceeding to approve demand response applications filed by PG&E, SDG&E, and SCE and resolve policy issues. CSE provided informal comments on the Draft Straw Proposal for Pilots Targeting Demand Response to Benefit Disadvantaged Communities. This input provided insights from the ADR project and encouraged the CPUC to consider pilot programs that leverage the use of skilled local labor and support workforce development in disadvantaged communities, and the project team's comments led to an

invitation to exchange ideas on PG&E's potential disadvantaged community DR pilot program designs. CSE continued to closely track this proceeding and attended workshops to identify potential changes to IOU DR programs, including IOU proposals to address identified annual AutoDR issues and changes to AutoDR guidelines; however, the issues addressed did not require input from this project.

- **Energy Storage (R.15-03-011):** This proceeding continues to refine policies and program details for the energy storage procurement framework and considers recommendations from the California energy storage roadmap, which was jointly developed by the California ISO, CEC, and CPUC. CSE participated in the Storage Multiple Use Applications (MUA) working group from February to August 2018. CSE discussed the work with EPIC-funded projects including ADR and the opportunities and challenges of stacking with DERs, which informed the MUA Working Group Final Report, issued in August 2019.
- **Self-Generation Incentive Program (R.12-11-005):** Rulemaking regarding policies, procedures, and rules for the California Solar Initiative (CSI), the Self-Generation Incentive Program (SGIP), and other distributed generation issues. CSE is actively engaged in this rulemaking and submitted comments advocating that SGIP-funded energy storage projects be eligible for participation in DR programs, including the AutoDR program. The CPUC adopted this recommendation and all SGIP-funded energy storage projects are now allowed to participate in DR programs.
- **Additional Proceedings:** CSE monitored several other CPUC proceedings to identify opportunities to share insights from the AutoDR project. These proceedings included, but were not limited to, the Energy Efficiency Rolling Portfolio (R.13-11-005), Smart Grid (R.08-12-009), and Distribution Resource Plans (R.14-08-013). However, during the course of the project, the issues actively addressed in these proceedings would not have directly benefited from additional insights regarding AutoDR.

California Energy Commission

- **2020 Load Management Rulemaking (Docket No. 19-Oir-01):** Rulemaking to form the foundation for a statewide system that automates the creation of hourly and sub-hourly costs or signals that can be used by end-use automation to provide real-time demand flexibility on the bulk electricity grid. CSE commented on the project's Draft Scoping Memo, drawing on lessons learned from the project team's work with several EPIC-funded projects. CSE supported the CEC's efforts and, among other things, encouraged the CEC to consider a forward-looking marginal greenhouse gas signal as well as how hard-to-reach customers (beyond low-income customers) could benefit from demand flexibility. CSE will continue to be actively engaged in this rulemaking and seek ways to effectively share findings from the AutoDR project.
- **2019 Energy Efficiency Action Plan (Docket No. 19-Iepr-06**): Consolidation of action plans into a comprehensive outlook on doubling energy efficiency savings, expanding energy efficiency in low-income and disadvantaged communities, and reducing greenhouse gas emissions from buildings. CSE attended workshops,

participated on a panel, and provided two sets of recommendations on the draft plan. Drawing from the AutoDR project, CSE recommended developing a clearer path for integrating energy efficiency and DR efforts, and strongly encouraged inclusion of workforce training in load management, enabling controls and the integration of controls across disciplines, as well as the continued development and advancement of standardized communications protocols.

- **2020 Building Energy Efficiency Standards:** Triennial updates to the California Code of Regulations, Title 24, Part 6, regarding energy and water efficiency requirements for newly constructed buildings, additions to existing buildings, and alterations to existing buildings. CSE is an active member of the California Energy Alliance (CEA) and supports the development of proposals that improve the state's building energy codes. CSE is currently engaged in initiatives to improve the code's DR requirements to ensure that more lighting systems are installed as ADR-ready, and other protocols followed.

Policy Development Beyond California

In addition to engaging the California regulatory agencies, CSE shared insights from this project to promote the advancement of DR policies in other jurisdictions.

- **2019 New Jersey Energy Master Plan:** CSE's recommendations on the Draft 2019 New Jersey Energy Master Plan, which established a comprehensive roadmap and strategic vision for meeting the state's climate goals in the energy sector, included the advancement of standardized communications and a focus on workforce training and education.
- **Unites States House of Representatives Select Committee on the Climate Crisis:** CSE's response to the House Select Committee on the Climate Crisis Request for Information emphasized the importance of deploying demand-response-ready technologies that enable buildings to interact with the modernized grid and respond to real-time signals about the carbon-intensity of the electricity mix to reduce a building's carbon emissions.

CHAPTER 5: Conclusions and Recommendations

The primary objective of this project was to develop a new training program to reduce barriers to the adoption of AutoDR communications equipment. Other objectives included increasing adoption of AutoDR in SMBs in disadvantaged communities and transferring lessons learned to improve the effectiveness of the IOU AutoDR incentive programs. The team was able to accomplish the primary objective and gain valuable insights and lessons learned to inform the development of workforce education and training for advanced energy technologies and market facilitation. Based on these lessons learned, the project team offers the following conclusions and recommendations.

Training Development and Implementation

The development and implementation of the training was a success, with all seven partner JATCs providing the training to fourth- or fifth-year apprentices. All partner JATCs indicated that they intended to continue to offer the training. Although the CALCTP-AutoDR training was designed to be adapted to a variety of formats for the partner JATCs, the development of workforce training programs should explore new models of delivery to facilitate broad adoption among workers who may face barriers to attending classroom training. Online and on-demand formats should be investigated along with development of tools to provide additional experience with advanced controls in a virtual environment. Advanced controls, including AutoDR, may be well suited to this format since the control features and functionality are accessed and enabled through software. To demonstrate proof of concept, the DRRC at LBNL developed an initial concept to provide a virtual AutoDR certification and testing tool to demonstrate this concept and support the future development of online AutoDR coursework, as well as certification tests for technicians and ATTs. While the concept was developed to support AutoDR workforce education, the concept also lays the groundwork to develop protocols for ATTs to verify installations for AutoDR functionality and test other load management capabilities in new construction or energy retrofits of existing buildings.

Recruiting Workers from Disadvantaged Communities

The JATCs are well positioned to recruit workers from disadvantaged communities to enroll in inside wireman apprenticeships and have robust outreach and recruitment efforts within these communities. Systemic challenges still remain for enrolling prospective apprentices; therefore, efforts to identify and address systemic barriers to entering advanced energy careers should be funded. These efforts should leverage the existing workforce development infrastructure and community-based organizations whenever possible.

Adoption of Energy Technologies in Small- and Medium-Sized Businesses and Disadvantaged Communities

Engaging SMB customers continues to be a challenge for all DR programs. A research study is currently underway to re-examine the structure of DR incentive programs in California and propose changes to the incentive structure for the future. Future changes to AutoDR incentive programs will shape the value that customers gain from participating in AutoDR, and refresh opportunities for building outreach under a new framework. In the future, building outreach efforts should therefore be modified to account for new incentives and program features that facilitate customer enrollment and make the program more attractive to potential customers. Strategies that accelerate adoption of load management technologies for disadvantaged communities and other hard-to-reach customer segments should also be developed.

Building energy code requirements can drive adoption of AutoDR in new construction and retrofits. Since the adoption of DR requirements with the 2008 California Building Energy Efficiency Standards, building controls have significantly progressed. However, customer knowledge, use, and deployment significantly lag behind the capabilities of these controls. Feedback indicated a wide range in the quality of installations of control systems for both retrofits and new construction, and it is unclear to contractors what the condition of an existing control system will be without having completed the installation themselves or completing a detailed site assessment. Addressing gaps in workforce technical skills and developing workforce training programs tied to the California Building Energy Efficiency Standards will therefore be critical to meeting California's goal of making all new commercial construction zero net energy by 2030. Training programs should evolve that address changes in building standards and ensure that technicians have the skills, tools, and processes available to test and verify that controls function as intended as energy efficiency standards evolve.

Automated Demand Response Incentive Programs

In the future, the researchers expect the structure of AutoDR programs within California to change, perhaps significantly. The ability of loads to flexibly respond to market signals on a short timescale will be more valuable than event-based DR load changes, so there will likely be an increase in fast-response, market-based programs in the future. Program changes will require new technologies that can meet the more complex requirements needed to address grid flexibility. These new technologies may require more skilled controls programming for both setup and installation. Therefore, considering this changing landscape, the AutoDR course should continue to evolve over time to incorporate new technologies and support new DR programs.

Additionally, in the future, there may be an increased emphasis on advanced AutoDR controls and software, so training relevant to these topics could also be incorporated into the course in the future. The structure and guidelines for incentive programs should also consider how workforce development and training can reduce barriers to adoption of energy technologies. The effectiveness of upstream, midstream, or downstream rebates for AutoDR, coupled with technical training and a skilled workforce, should also be explored further. In workshops, contractors indicated they were reluctant to pursue stand-alone AutoDR retrofit projects due to the high overhead costs associated with customer engagement in AutoDR and the relatively small budgets associated with installations. Integrating energy efficiency and AutoDR retrofits and ensuring effective acceptance testing associated with AutoDR could improve customer adoption of DR.

The CPUC has begun taking actions to address workforce standards within energy efficiency programs that will increasingly impact AutoDR projects since there is greater integration. For example, Decision 18-10-008 ordered that specific workforce standards be applied by all energy efficiency program administrator business plan portfolios for HVAC and lighting programs. It includes a requirement that certain advanced lighting controls installation, modification, or maintenance be installed by workers who have been certified by an acceptance test technician. For small and micro-businesses located in disadvantaged communities, direct-install integrated demand side management programs that include AutoDR capable measures may be the most effective strategy to increase adoption. Duke Energy had a successful program that used this strategy in the SMB market, and similar programs should be piloted for SMBs within disadvantaged communities in California. Such programs should include workforce development opportunities consistent with the goals outlined in the Environmental and Social Justice Action Plan (ESJ Action Plan), published by the CPUC in early 2019.

Community Choice Aggregator Participation

The proliferation of CCA programs has drastically changed the electricity landscape in California. Increasing from 5 operational CCAs in 2016 to 19 CCAs serving customers in 2019, CCAs now serve more than 10 million customers in the state, a significant shift from a market previously served by the three major IOUs. The IOUs continue to manage programs such as energy efficiency and DR within their service territories and CCA customers are eligible to participate in some, but not all, of such programs, depending on the program structure and overlapping CCA offerings.

Specific to DR programs that qualify for AutoDR incentives, several programs that are easiest for customer participation are designed around voluntary rate structures, including critical peak pricing and peak demand pricing. They are not available to unbundled customers, that is, CCA customers. However, CCA customers are eligible for some qualifying DR programs, including capacity bidding programs and the Demand Response Auction Mechanism Pilot, and can still receive AutoDR incentives from an IOU. As a result, future outreach efforts for ADR incentives need to be tailored to the CCA market to showcase their unique participation options.

Beyond IOU programs available to their customers, many CCAs are considering developing their own DR programs and several have administered pilots within their service territories. CCA-administered DR programs may provide additional opportunities for the deployment of AutoDR technologies. CCAs often have greater opportunities for innovative program designs because they have less regulatory oversight and can better tailor programs to meet local customer needs and load profiles. However, CCAs face several challenges and uncertainties regarding the development of their own DR programs. These include challenges around customer data access and distribution system data necessary for identifying grid needs, questions regarding cost recovery when an IOU offers a similar program and impacts on billing systems and customer experiences. The CPUC has begun to address some of these concerns. For example, Decision (D.)14-12-024 adopted the Competitive Cost Neutrality Principle to address cost recovery issues and followed up with implementation details in D.17-01-017, although D.18-11-029 found that these rules do not apply to AutoDR incentives. There are many details still to be worked out to fully unlock the potential of CCA-administered DR programs.

CHAPTER 6:
Project Benefits

This project supported deployment of AutoDR technologies and communications standards previously funded by the CEC through its Public Interest Energy Research electric program. Despite advances in the technology itself, customers enrolling in DR programs and receiving IOU AutoDR technology incentives had an inadequate supply of capable contractors, which led to poor installations and faulty commissioning of installed systems. These issues led to increased costs for ratepayers and impacted the effectiveness of AutoDR programs and building energy-efficiency code standards for load management technologies.

Lower Costs

The 2019 Title 24, Part 6 of the California Energy Code requires additional demand response capability in new construction and large retrofits . The CALCTP-AutoDR training addresses workforce-related barriers and provides specialized skills to technicians to meet the new building energy code requirements. In the long term, this will reduce costs to ratepayers as properly functioning installations provide anticipated energy savings from load management and AutoDR controls and either delay or avoid costs associated with building new generation capacity. AutoDR equipment allows customers to reduce operating costs and participate in utility DR programs by using automated controls and load management strategies. Skilled technicians also make these projects more financially viable by reducing project costs through combining installation efforts on integrated demand-side management projects, lowering payback times. Skilled technicians also decrease costs for ratepayers over the long term by decreasing the number of poor installations, call-backs, and by increasing the quality of controls retrofits. Demand response can also delay or avoid the need to construct new power plants and can act as a price control in competition with traditional generation.

The ability to reduce demand provides a means for savings on energy bills (amount determined, in part, by the program in which a participant is enrolled), and automating this process produces more consistent savings. Secondary benefits accrue to all users of the grid as this ability to modify demand translates to a more reliable grid and reduced wholesale energy costs.

AutoDR provides more consistent reduction of load in response to signals sent by utilities during peak load periods. A 2015 study by Navigant Research found that reduced peak demand in Massachusetts and Illinois was ultimately linked to reduced capacity market payments because demand reductions precluded the necessity of local utilities to procure extra energy during those peak periods. Ultimately, peak demand reductions provide much higher benefits than average load reductions since peak demand times often correspond with the highest prices. The study further noted that demand reductions also can reduce energy prices for hours by reducing the marginal generating cost of the system.

Greater Reliability

System reliability increases with the installation and commissioning of AutoDR systems by a skilled labor force. Long-term benefits also include workforce capability elevation, allowing repairs of field devices by providing a "quality kW" product for the utility ratepayer and reducing the probability of installations becoming stranded assets. Overall, increased adoption of AutoDR will also result in improved reliability by providing increased operational flexibility to ratepayers, load-serving entities, and balancing authorities.

Increased Safety

The training developed by the project team will continue to support deployment of additional AutoDR capabilities, as well as increased adoption of AutoDR through technology incentives and California Building Energy Efficiency Codes and Standards. AutoDR will increase demand-side flexibility and increase the ability of LSE's or balancing authorities to mitigate variations in generation and increased demand during peak load events. This improves safety by reducing the possibility of power outages. The improved skills of the electricians installing the equipment also provide less potential for injury to installing technicians.

Economic Development

The project increased economic opportunities in disadvantaged communities through local workforce development, promotion of energy savings in existing buildings, and development of career ladders for residents of disadvantaged communities to enter advanced energy efficiency careers, This created long-term opportunities for both deployment of energy technologies and energy savings in existing buildings. The project team recruited electrical apprentices from disadvantaged communities to take the AutoDR course, worked with the JATCs to recruit new apprentices from disadvantaged communities, and conducted marketing, education, and outreach to businesses located in disadvantaged communities to install AutoDR enabling equipment and enroll DR programs. These objectives developed a local skilled workforce in disadvantaged communities and provided increased job opportunities for apprentices. Future adoption of AutoDR will also decrease operating costs for business owners in disadvantaged communities.

Where needed, the project training included remedial courses in math and basic electrical connections, providing a secondary benefit to workers in disadvantaged communities by reducing entry barriers for workers entering advanced energy careers. Recruited apprentices and apprentices who completed the training also have specialized skills that will help them advance their careers in the energy industry.

Environmental Benefits

This project addressed barriers to the adoption of load management technologies that provide environmental benefits to ratepayers. Properly installed, commissioned, and maintained AutoDR controls provide environmental benefits to ratepayers in general and within disadvantaged communities. A pilot program authorized by the CPUC is currently underway that will demonstrate the environmental impacts of demand response programs in disadvantaged communities. Load management technologies also act as highly dynamic, flexible resources used to optimize onsite and system-level benefits and provide energy and cost savings, create a more stable grid for all electric utility customers, and enable high renewable resource penetration and the reduction of carbon emissions and other criteria air pollutants.

Consumer Appeal

AutoDR controls and other commercial and industrial load management technologies require a trained and skilled workforce for broad adoption. Trained technicians and contractors can work with customers to ensure that they understand AutoDR controls and select appropriate load-shedding strategies for participation in DR programs. This will reduce the prevalence of program fatigue and increase consumer appeal for demand-response technologies. Trained contractors, installers, and distributors help streamline and improve the customer experience, thereby increasing the appeal of the technology.

GLOSSARY AND LIST OF ACRONYMS

Term	Definition
AB	Assembly Bill
ATT	Acceptance test technicians
AutoDR	Automated demand response
California ISO	California Independent System Operator
CALCTP	California Advanced Lighting Controls Training Program
CBO	Community Based Organization (page 58 of 76 or report page "45"; Not properly introduced)
CCA	Community Choice Aggregator
CEA	California Energy Alliance
CEC	California Energy Commission
CLF	California Labor Federation
CLTC	California Lighting Technology Center
CPP	Critical peak pricing
CPUC	California Public Utilities Commission
CSE	Center for Sustainable Energy
CSI	California Solar Initiative
DER	distributed energy resources
DR	Demand response
DRAS	Demand response automation server
DRRC	Demand Response Research Center at Lawrence Berkeley National Laboratory
Duck Curve	The "Duck Curve" refers to a forecast of operating conditions for California's electrical grid with increased adoption of renewable generation where there are short, steep increases in net demand from customers, risk of oversupply of generation during certain hours of the year, and a decrease in the grid operator's ability to maintain grid reliability.
ELO	Enabling learning objective
EPIC	Electric Program Investment Charge
GBN	Green Business Network
GHG	Green House Gas
HVAC	Heating, ventilation, and air conditioning
IBEW-NECA	International Brotherhood of Electrical Workers and National Electrical Contractors Association

Term	Definition
IOU	Investor-owned utility
IT	Information technology
JATC	Joint Apprenticeship and Training Committees
LBNL	Lawrence Berkeley National Laboratory
LMCC	California State Labor Management Cooperation Committee
MC3	Multi-Craft Core Curriculum
MUA	Storage Multiple Use Applications Working Group
OpenADR	Open Automated Demand Response: A communications data model designed to facilitate sending and receiving demand response signals from a utility to electric customers
PDP	Peak day pricing
PG&E	Pacific Gas and Electric Company
Prop 39	California voters passed the California Clean Energy Jobs Act (Proposition 39) in November 2012 to create jobs, save energy, reduce energy costs and greenhouse gas emissions, and provide job training and workforce development in related fields. By focusing on public schools, community colleges, and other school facilities, the Act has created energy and cost savings, and has improved the classroom-learning environment for students and educators across California—all while advancing California's broader climate and energy goals.
RPS	Renewables Portfolio Standard
SB	Senate Bill
SCE	Southern California Edison Company
SDG&E	San Diego Gas & Electric Company
SGIP	Self-Generation Incentive Program
SMB	Small and medium businesses
Title 24, Part 6	California Title 24 references the state's "Building Standards Code". Part 6 (and 11) of Title 24 specifically references "California's energy code is designed to reduce wasteful and unnecessary energy consumption in newly constructed and existing buildings. The California Energy Commission updates the Building Energy Efficiency Standards (Title 24, Parts 6 and 11) every three years by working with stakeholders in a public and transparent process."
TLO	Terminal learning objective
Train-the-Trainer	Method of training instructors so they experience the curriculum as students to collect feedback about the course from the perspective of contractors, electricians, and apprentices with the goal of teaching more effectively.

Term	Definition
UDI	Universal Devices, Inc.
VEN	Virtual End Node
WED	Workforce Economic Development Program

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ENERGY RESEARCH AND DEVELOPMENT DIVISION

Appendix A: Final List of Equipment Used in Automated Demand Response Laboratories

June 2024 | CEC-500-2024-070

APPENDIX A:
Final List of Equipment Used in Automated Demand Response Laboratories

Table A-1: Equipment Used in Automated Demand Response Laboratories

QTY	Part	Manufacturer	Model	Lab
1	Wireless gateway	Pelican Wireless Controls	GW400	1,5
1	UDI VEN	Universal Devices Inc	ISY994r PRO 2 Relays	2
1	UDI relay board	Universal Devices Inc	NCD-Connector board	2
1	ZigBee Smart Thermostat	RCS Technology	TZB45u	2
1	VIVE lighting controller hub	Lutron	HJS-2-SM	2
1	VIVE dimmable module	Lutron	RMJS-8T-DV-B	2
1	VIVE power supply	Lutron	PS-J-20W-UNV	2
1	Pico dimmable switch w/ wall mounting kit	Lutron	PJ2-WALL-WH-L01	2
1	Energy Manager	Enlighted	EM-2-02	3
1	POE switch	Enlighted	SW-POE-8-8	3
1	Control Unit	Enlighted	CU-3e-IR	3
1	Smart sensor	Enlighted	SU-4e-01	3
1	Smart sensor cable	Enlighted	CBL-3-7F	3
1	Gateway	Enlighted	GW-2-01	3
1	Room control switch	Enlighted	WS-2-00	3
1	nLight Eclypse lighting controller	Acuity	NECY 120	4
1	Bridge and power supply	Acuity	nBRG8-KIT	4
1	nLight VEN	Acuity	nADR L400	4
1	Dimmable switch	Acuity	nPODM-DX-WH	4
1	LED luminaire with integrated nLight controller	Acuity	LBL2 200M 80CRI 40K Min1 NLIGHT MVOLT	4

QTY	Part	Manufacturer	Model	Lab
1	Smart thermostat	Pelican Wireless Controls	TS200	5
10	CAT5e cables – various lengths	Various	Various	All
1	Laptop, PC or Tablet (Windows OS)	Various	Various	All
2	LED luminaires (dimmable)	Halo	HALSLD612830WHUVJB	2,3
1	Wireless router	Linksys (or equivalent)	E2500 (or equivalent)	All
2	24V AC transformer (1.0A min)	various	Various	2,5

Source: Center for Sustainable Energy

ENERGY RESEARCH AND DEVELOPMENT DIVISION

Appendix B: Sample Course Evaluation

June 2024 | CEC-500-2024-070

APPENDIX B: Sample Course Evaluation

EPIC ADR Systems Training

Class Evaluation Form

Thank you for participating in this class. Your responses to the following will help us refine the course.

Name *(optional)*: ______________________________ Date: ____________________

Instructor: ______________________________

1. Please rate your overall satisfaction with this training.

Comments:	Excellent (5)	Good (4)	Average (3)	Fair (2)	Poor (1)
	☐	☐	☐	☐	☐

2. Below are the main learning objectives of this session. Please indicate your level of confidence that you can do the following:

	Excellent (5)	Good (4)	Average (3)	Fair (2)	Poor (1)
Distinguish between DR, ADR, OpenADR, DSM, Load Shed and Peak Management	☐	☐	☐	☐	☐
Describe Energy Management Systems (EMS), Virtual End Node (VEN) and ADR-capable vs. ADR-enabled	☐	☐	☐	☐	☐
Describe embedded and external VEN ADR ability; cloud software and services for ADR	☐	☐	☐	☐	☐
Navigate through the Demand Response Automation Server (DRAS)	☐	☐	☐	☐	☐
Discuss how lighting and smart thermostats can be paired with aftermarket products to achieve ADR	☐	☐	☐	☐	☐
Explain and apply for Utility incentives (Technology Incentives, Express vs. Customized Incentives)	☐	☐	☐	☐	☐
Conduct the procedures involved prior/during ADR installation (Site assessment, calculating load shed estimates, scope of work development, filing incentive application, installation procedures and commissioning)	☐	☐	☐	☐	☐
Initiate test sequences and demonstrate response when an ADR test signal is received	☐	☐	☐	☐	☐
Discuss how to commission products with basic response profiles that align with California Energy-Efficiency Standards requirements for DR (Air Conditioning, Lighting and Signs)	☐	☐	☐	☐	☐

3. Please rate the following based on your experience:

	Excellent (5)	Good (4)	Average (3)	Fair (2)	Poor (1)
The topics were relevant to my job responsibilities	☐	☐	☐	☐	☐
The slides and workbooks were clear and easy to understand	☐	☐	☐	☐	☐
The session provided practical takeaways that I can implement	☐	☐	☐	☐	☐
The presenter was clear and easy to understand	☐	☐	☐	☐	☐
Given the topics covered, the time allotted was sufficient	☐	☐	☐	☐	☐

4. Please provide any comments, ideas, questions, concerns and/or reflections that you have on the training. If you need more room to write, please use the back of this paper.

Thank you!

ENERGY RESEARCH AND DEVELOPMENT DIVISION

Appendix C: Recruited and Trained Worker Summary

June 2024 | CEC-500-2024-070

APPENDIX C:
Recruited and Trained Worker Summary

Table C-1: Joint Apprenticeship and Training Center Apprentice Recruits

JATC	Total Apprentice Recruits	Apprentice Recruits Living in a disadvantaged community ZIP Code	Percent of Apprentice Recruits Living in a disadvantaged community ZIP Code
Alameda County JATC	78	32	41 percent
Fresno, Madera, Kings, and Tulare Counties JATC	39	28	72 percent
Los Angeles JATC	598	465	78 percent
Orange County JATC	59	31	53 percent
Sacramento Area JATC	138	44	32 percent
San Bernardino, Inyo and Mono Counties Electrical JATC	36	21	58 percent
San Mateo JATC	57	16	28 percent
Total	**1,005**	**637**	**63 percent**

Apprentice Recruits were screened using available information using CalenviroScreen 3.0 census tract data. disadvantaged community Zip codes are those that intersect, encompass, or are contained within the top 25 percent scoring census tracts for SB535 designated disadvantaged communities.

Source: Center for Sustainable Energy

Table C-2: CALCTP-AutoDR Trained Apprentices:

JATC	Total CALCTP-AutoDR Trained Apprentices	CALCTP-AutoDR Trained Apprentices living in a disadvantaged community ZIP code	Percent of CALCTP-AutoDR Trained Apprentices Living in a disadvantaged community ZIP Code
Alameda County JATC	33	13	39 percent
Fresno, Madera, Kings, and Tulare Counties JATC	49	38	78 percent
Los Angeles JATC	253	182	72 percent
Orange County JATC	99	63	64 percent
Sacramento Area JATC	82	18	22 percent
San Bernardino, Inyo and Mono Counties Electrical JATC	91	54	59 percent
San Mateo JATC	48	10	21 percent
Total	**655**	**378**	**58 percent**

Trained apprentices were screened using available information using CalenviroScreen 3.0 census tract data. disadvantaged community Zip codes are those that intersect, encompass, or are contained within the top 25 percent scoring census tracts for SB535 designated disadvantaged communities.

Source: Center for Sustainable Energy

CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

ENERGY RESEARCH AND DEVELOPMENT DIVISION

Appendix D: AutoDR Sales Best Practices Guide

Month 2024 | CEC-500-2024-XXX

Automated Demand Response Sales Best Practices Guide

EPIC Automated Demand Response Workforce Training Project

September 15, 2017

PRESENTED TO

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Introduction

Energy Solutions interviewed automated demand response (ADR) market actors including small businesses inside and outside of disadvantaged communities, public facility staff, current and potential utility ADR participants, ADR vendors, and ADR manufacturers to synthesize best practices for ADR sales to small and medium businesses (SMBs). In general, small businesses are an underserved market. The information presented here explains motivators and barriers for these types of customers to help support the development of ADR projects within this sector. Small businesses equipped with ADR equipment will be able to better withstand current or upcoming changes in utility rates, as most commercial customers have already defaulted or will default onto a demand response (DR) time-of-use tariff such as PG&E's Peak Day Pricing (PDP) or SCE's Critical Peak Pricing (CPP) within the next two years. Additionally, businesses that participate in ADR programs can realize financial benefits and enjoy better control over their facilities due to facility technology upgrades. This analysis focuses on office, retail, and public facilities, but other small commercial customers such as industrial shops and small agricultural businesses could also benefit from ADR participation if they are flexible about when they can use energy. A variety of facility types will benefit from demand response as new demand response programs that incentivize load shifting are developed and as demand response event windows shift to later in the evening when small office and retail facilities may not be operating. Therefore, when approaching small businesses, it is important to keep an open mind and search for low-cost, easy-to-implement, and innovative solutions that can work across a variety of business types. Regardless of business type, valuable practices to apply for outreach to all sectors include the following:

- Meet face-to-face with decision makers when possible to build rapport and ensure their full attention.
- Focus on messaging that helps the decision maker to which you are speaking – for example a building engineer might be interested in saving time or bringing value to management, while a small business owner might want to gain remote visibility into their systems to be able to spend more time with family.
- Be prepared with quick responses to common customer objections, such as the thought that facility energy use is too small to benefit from ADR or that a project would be too time consuming for busy staff.
- Recognize that participation benefits must impact a customer's bottom line and tailor offerings to a customer's specific business model.
- Simplify pitch to customers by offering default, easy, no-brainer offers that can be implemented quickly.
- SMBs are a diverse market, so offer marketing material that is not only translated into a variety of languages but that also appeals to different cultures.
- Educate customers instead of just marketing to them.

Customer Type: Small Office

Small-to-medium office buildings with peak demand of less than 500 kW are typically 100,000 square feet or less. Low-rise office buildings may not have a robust control system; rather they may rely on package heating, ventilation and air conditioning (HVAC) units with localized thermostat controls and simple on/off switches or timer-based controls for lighting. Compared to low-rise buildings, mid-size office buildings are more likely to have central control systems to control package HVAC units or to provide limited lighting system controls. At this size, office buildings are less likely to have central plant-based HVAC systems with robust central controls. Conversely, most large high-rise office buildings have a central plant with an energy management system and more complex controls.

Customer Motivations

Ongoing automated demand response participation by office buildings who lease space to tenants is often motivated by the following factors:

- A desire to reduce operational costs, which can improve the value of a property for the business owner.
- The ability to realize savings from demand response participation without reliance on facility staff since load shed strategies are enacted on demand response event days without human intervention.
- The one-time automated demand response incentives that help buildings install or update their building controls systems.
    - Updated controls can provide facility managers with more insight into their building systems so they can better meet tenant and occupant comfort needs.
    - Updated controls also sometimes give facility managers the ability to view and adjust building systems online remotely.

Customer Barriers

Specific barriers to implementing automated demand response in office buildings include the following:

- Occupants in office buildings may be relatively stationary compared to those in other settings such as retail or industrial businesses; therefore, occupants may be more sensitive to changes in temperature or lighting since they experience the effects of demand response strategies for a longer duration.
- Building managers are sensitive to occupant comfort needs and may be reluctant to implement demand response strategies that cause discomfort, especially in the case of leased spaces, since comfort is a principal responsibility of building management.
- Consecutive demand response days can be particularly disruptive to office buildings as the same occupants may be subjected to curtailment strategies multiple days in a row, increasing their dissatisfaction with their space.
- Obtaining occupant buy-in can be difficult.
- The amount of load an office can comfortably reduce may be small in comparison to the

total building load, so the ongoing financial benefits of participation in a demand response program like Peak Day Pricing/Critical Peak Pricing may be too small to convince customers to undertake an ADR project, especially if they are satisfied with their current controls systems.

Overcoming Barriers

To overcome the barriers listed above, it is important to make sure that demand response strategies implemented in office buildings are not too aggressive, so as not to result in occupant complaints. The optimal strategy will vary by building and may depend on factors such as building insulation levels and occupant sensitivity, but early in the process, work closely with building engineers, facility managers, and ownership to identify any potential issues with implementing a demand response strategy.

Make the process easy for the customer by taking the following actions:

- Use deemed utility ADR programs, which have a streamlined application process.
- Make sure that project vendors and contractors are responsive to customers' needs during the project process.
- Provide customers with an upfront estimate of potential financial cost reduction from ADR participation such as an analysis that estimates savings from switching to Peak Day Pricing/Critical Peak Pricing.

If the application process is easy and the strategy is palatable, customers may still be willing to participate despite relatively low cost savings since participation is low-maintenance.

Staff in small offices may not have the bandwidth to manage a large and complex automated demand response project and would benefit from high-quality vendor and contractor relationships as well as from a streamlined application process with the utility.

Potential Demand Response Strategies

Customers with package HVAC units and without a central control system can consider installing smart or connected thermostats to provide enhanced visibility into unit operation and convenient control capability. One such thermostat manufacturer indicated that their product would only cost the end-use customer about $325 per thermostat. These thermostats could be used to enact a global temperature increase during demand response events – a 4 °F increase is a common strategy for office buildings. Customers with central plant HVAC systems and central controls can consider programming a global temperature reset into their control system. Many small offices are unlikely to have sophisticated lighting controls and lighting curtailment may be disruptive to office workers. For small facilities without any lighting controls, it is often cost-prohibitive to automate DR lighting curtailment unless the facility has plans to upgrade their lighting control system. However, small offices with controls capability can dim or curtail lighting in common spaces such as lobbies, conference rooms, hallways, and storage rooms, and they can consider dimming or curtailing 15-30% of lighting in office spaces if palatable to occupants. Potential strategies for small offices are summarized in Table 1.

Table 1: Potential Demand Response Technologies and Strategies for Small Offices

Existing System	Potential Technology Solution	Potential DR Strategy
Package HVAC without central control system	Smart/connected thermostats with integrated VEN	2 - 4 °F global temperature increase
Central plant HVAC with central control system	Programming and add-on or standalone VEN	2 - 4 °F global temperature increase
Lighting system without control capability	Add DR capable lighting controls system and VEN (features required by building code are not covered by the ADR incentive)	Dim or curtail lighting in unused spaces or common areas; dim or curtail 15-30% of lighting in office spaces
Lighting system with control capability	Programming and add-on or standalone VEN	Dim or curtail lighting in unused spaces or common areas; dim or curtail 15-30% of lighting in office spaces

Potential Financial Benefits

Typical one-time ADR incentives for small offices range from $500 to $8,000 and are limited to 75% of project costs for customers in PG&E territory and 100% of project costs for customers in SCE territory participating in the Express Program. On average, customers can save another $800 annually by participating in demand response programs.

Best Practices for Engaging Small Office Customers

- Highlight that older facilities can use the ADR incentive to improve their facility controls.
- For customers with existing controls, emphasize ease and reliability of participation due to full automation.
- Provide customers with upfront incentive and savings estimates as well as case studies of similar customers when possible.
- Work with building engineers and I.T. staff early and often to identify and overcome any issues before they derail the project.
- Use collateral that can be left in the property management office to serve as a reminder of program offerings, such as paper flyers.
- Highlight that demand response implementation can support LEED certification at a site, which is attractive to potential tenants.
- Resources for engaging these customers include: Building Owners and Managers Association (BOMA), International Facility Management Association (IFMA), local government partnerships, utility training centers, utility account representatives, county Green Business Certification organizations, and industry publications such as ASHRAE-sponsored events and Heating Plumbing and Air Conditioning (HPAC) Magazine.

Customer Type: Retail

Small-to-medium retail facilities with peak demand of less than 500 kW are typically 150,000 square feet or less. Retail facilities can vary greatly in form and function, ranging from small independent retailers to large big box stores to sites located in shopping malls. Small retail facilities are unlikely to have robust controls systems. Many retail sites are served by package rooftop HVAC units that provide conditioned air to an open space. Standalone retail facilities are not likely to be served by a central plant HVAC system, but retail facilities that are part of a larger complex, such as a mall, may rely on a central plant to provide space cooling or heating. Small retail sites are unlikely to have significant lighting controls, but larger sites may be able to control lighting on the circuit level. Food stores such as grocery and convenience stores often additionally have refrigerated storage cases and other cooled products that may be sensitive to changes in temperature.

Customer Motivations

Ongoing automated demand response participation by small retail sites is often motivated by the following factors:

- Small retailers may be highly motivated by the opportunity to reduce their operating costs due to low profit margins.
- Larger retailers such as chain stores are often interested in consolidating controls into a central server that can be viewed and operated remotely to increase the consistency of the customer experience across sites and eliminate the need to have trained facility managers at each site.
- Because customers move in and out of retail spaces quickly, retail sites can often employ more aggressive ADR strategies than other types of facilities, allowing for a comparatively higher level of demand response event load reduction compared to offices and resulting in higher ongoing financial benefits. These DR strategies are determined while understanding that a retail store also needs to get customers in the door be successful.
- Since customers in a retail facility can change day by day, consecutive DR events might not have a negative effect on a retail business.

Customer Barriers

Specific barriers to implementing automated demand response in retail sites include the following:

- Small retailers may lack the capital to pay for an expensive ADR retrofit.
- Sites may lack a dedicated facilities engineer, making it more difficult to identify potential issues with a proposed demand response implementation.
- Customers in this sector may be less familiar with energy management and ADR technologies, so consumer education may be required to familiarize customers with the concept of ADR and implementation options.
- Grocery stores are often very sensitive to temperature changes in their refrigerated cases. A low-cost ADR retrofit is unlikely to touch this aspect of the store.
- Larger multi-site retailers are often interested in a consistent strategy across many locations, resulting in larger and more complex ADR projects that need to be approved by

corporate level financial or energy management officers.

Overcoming Barriers

To overcome barriers to implementing automated demand response projects in this sector, consider the following strategies:

- It is important to minimize project costs for the customers – simple technologies will often suffice compared to the more complex controls that may be needed in office spaces, for example.
- Consider more aggressive ADR strategies where palatable to increase the potential ADR incentive to the customer.
- Educate customers on the benefits of ADR controls technologies and the potential cost reductions they can realize due to demand response participation. Outreach should also include a focus on the non-energy benefits technology can provide, such as networked lighting controls that can provide information about where customers travel within in a store and how long they spend in various areas. If the customer already has a lighting control system installed the discussion can focus on the added revenue stream from their existing equipment with little to no human resource cost or enablement costs.
- In many cases, it is important to engage with business owners or corporate level energy management staff as opposed to onsite employees.
- Make the process easy for the customer by using deemed utility ADR programs, which have a streamlined application process.

Potential Demand Response Strategies

Like small offices, small retail customers with package HVAC units and without a central control system can consider installing smart or connected thermostats to provide enhanced visibility into unit operation and convenient control capability. Customers can also install equipment to duty cycle package HVAC units during demand response events. A 50% reduction in HVAC duty cycle might result in higher load reduction than a typical 4 °F global temperature increase would, and since many retail sites consist of a main open area instead of enclosed spaces (as is common in offices), sufficient air mixing is still possible to maintain acceptable space comfort. Many small retail sites are unlikely to have sophisticated lighting controls, but retail sites can often withstand short-term lighting curtailment without it being overly disruptive. Therefore, during DR events, sites can consider curtailing lighting by circuit where possible (for example, curtailing every other overhead light in open areas) and/or curtailing non-essential decorative lighting. Potential strategies for small retail sites are summarized in Table 2Table 1.

Table 2: Potential Demand Response Technologies and Strategies for Small Retail Sites

Existing System	Potential Technology Solution	Potential DR Strategy
Package HVAC without central control system	Smart/connected thermostats with integrated VEN	4 - 6 °F global temperature increase
Package HVAC with or without central control system	Duty cycling equipment with integrated or standalone VEN	50% reduction in HVAC duty cycle
Lighting system without control capability	Add DR capable lighting controls system and VEN (features required by building code are not covered by the ADR incentive)	Dim or curtail lighting by 15-30% in open areas; curtail decorative lighting
Lighting system with control capability	Programming and add-on or standalone VEN	Dim or curtail lighting by 15-30% in open areas; curtail decorative lighting

Potential Financial Benefits

If both HVAC and lighting measures are implemented, sites could receive ADR technology incentives between $2,000 and $15,000, depending on their size. Ongoing demand response participation could result in annual DR event savings of up to $2,000.

Best Practices for Engaging Small Retail Customers

- Highlight that customers without controls can gain convenient control functionality at low cost due to the ADR rebate.
- Focus on potential non-energy benefits controls technologies can provide and how they can support the customer's business model.
- Highlight that customers with controls can reduce operating costs via ongoing DR participation, freeing up funds for other site needs.
- Engage directly with business owners and corporate-level energy managers.
- Consider more aggressive DR strategies, depending on what is acceptable to business operators.
- Provide customers with upfront incentive and savings estimate as well as case studies of similar customers when possible.
- Since retail decision makers often work outside of the actual retail site, especially for retail chains, use electronic collateral that can be emailed around to different decision makers.
- Resources for engaging these customers include: local small business associations, in-person contact, retail conferences for larger organizations, utility account representatives, and outreach via existing vendor or contractor relationships.

Customer Type: Public Facilities

Public facilities vary widely; examples include municipal, state and federal office buildings, schools, libraries, parks, healthcare facilities, and police or fire stations. Small public office buildings are likely to have features similar to small privately owned offices. Small public facilities are unlikely to have significant energy demand or control functionality. Large public facilities are likely to have centralized control systems and central plants to provide cooling and/or heating. To comply with California building code, large facilities may also have more advanced lighting control systems, particularly if they are new or recently retrofitted.

Customer Motivations

Public facilities can be a good target for demand response participation. Ongoing automated demand response participation by public facilities is often motivated by the following factors:

- State and federal buildings are often mandated to consider demand response participation where feasible and cost-effective.
- Public facilities are motivated to save energy to lead by example, so it may be easier to gain buy-in on the concept of demand response since facility managers feel it is their duty to reduce energy usage.
- These facilities may also operate on limited funding, motivating them to reduce operating costs as much as possible.
- Educational facilities sometimes have access to time-limited bond funding to contribute to facility energy use improvement projects, which could provide the financial support and motivation needed to implement an ADR project.

Customer Barriers

Although public facilities are a good audience for participation in DR programs, specific barriers to implementing automated demand response in these facilities include the following:

- Public organizations often have tight constraints on their ability to spend money on facilities projects, so low- or no-cost projects are particularly attractive to them.
- Public facilities often have stringent procurement rules requiring projects above a certain cost to be put out for bid in a competitive bidding process, and companies that meet specific requirements such as locally-owned businesses, small businesses, service-disabled veteran-owned businesses, women-owned small businesses, small disadvantaged businesses, or businesses in designated historically underutilized business zones may be preferred.
- Critical facilities such as utilities, water districts, and hospitals may not be able to reduce load without negatively impacting the public.
- Public office buildings may face the same concerns as private offices do related to occupant comfort and load reduction capability.
- Schools, especially the classrooms, are often not well suited for demand response participation as they typically lack significant energy usage on summer afternoons and evenings when demand response events are called, reducing their ability to participate in

DR programs.

Overcoming Barriers

To overcome the barriers to implementing automated demand response projects in this sector, consider the following strategies:

- Due to their large size and importance, utility representatives sometimes have strong relationships with public customers, so it can be beneficial to work with these representatives to gain a deeper understanding of customer needs and opportunities.
- Work with utility ADR programs to meet customer procurement requirements, as utility ADR programs may have special tools or partnerships for these customers.
- Provide low-cost technology options when possible and take advantage of any special public funding available to these entities, availability of which will vary by customer and location.
- When a DR retrofit is part of an energy efficiency project, public facilities can greatly benefit from interest-free on-bill financing, so they don't have to lay out upfront capital.
- Another way to overcome a limiting funding situation is to have the vendor sponsor the ADR project and receive the incentive and then reduce the invoice to the public facility by the incentive value. This way, public facilities can sometimes fund the upgrade from their operating budget instead of waiting for a more time intensive capital budget approval.
- If they meet the requirements, contractors working within this sector may want to register as small disadvantaged businesses, etc., to gain preference to work on public facility projects.
- Focus on larger facilities with sufficient load reduction potential, as they will benefit most from demand response participation.
- Target facilities without critical operations that would be interrupted by DR events. Offices, institutional facilities, small municipal facilities such as police or fire stations or community centers, and potentially administrative areas in educational facilities may be good facilities to target in this sector.

Potential Demand Response Strategies

Demand response strategies for public facilities are often similar to those used in privately-owned small offices. These may include a 4 °F temperature increase or duty cycling of HVAC units and dimming or curtailing 15-30% of lighting during DR events. For schools, consider excluding educational spaces like classrooms from the DR implementation. Larger facilities with more robust control systems may also be able to tie other equipment such as elevators, decorative features, pumps, and exterior equipment into the DR controls strategy. Potential strategies for public facilities are summarized in Table 3.

Table 3: Potential Demand Response Technologies and Strategies for Public Facilities

Existing System	Potential Technology Solution	Potential DR Strategy
Package HVAC without central control system	Smart/connected thermostats with integrated VEN	2 - 6 °F global temperature increase
Package HVAC with or without central control system	Duty cycling equipment with integrated or standalone VEN	50% reduction in HVAC duty cycle
Central plant HVAC with central control system	Programming and add-on or standalone VEN	2 - 6 °F global temperature increase
Lighting system without control capability	Add DR capable lighting controls system and VEN (features required by building code are not covered by the ADR incentive)	Dim or curtail lighting in unused spaces, open spaces or common areas; dim or curtail 15-30% of lighting in office spaces; curtail decorative lighting
Lighting system with control capability	Programming and add-on or standalone VEN	Dim or curtail lighting in unused spaces, open spaces or common areas; dim or curtail 15-30% of lighting in office spaces; curtail decorative lighting
Robust energy management control system	Programming and add-on or standalone VEN	Curtail unnecessary equipment such as elevators, fountains, and pumps, etc.

Potential Financial Benefits

If both HVAC and lighting measures are implemented, sites could receive ADR incentives between $2,000 and $15,000, depending on their size. Ongoing demand response participation could result in annual DR event savings of up to $2,000.

Best Practices for Engaging Public Customers

- Engage utility representatives along with public facility managers, as utility representatives may be in tune with the customer's needs and special resources available to public customers.
- Identify special requirements early in the process. These could include procurement rules, I.T. requirements, necessary contractor certifications, prevailing wage requirements, and more.
- Stress state and federal mandates for public facilities to participate in demand response where feasible and cost-effective.
- Focus on low-cost options and sites with sufficient demand to be able to participate in demand response.
- Take advantage of interest-free financing and vendor sponsorship to reduce the upfront cost to the facility.
- Equip contractors with the correct certifications to be able to bid on state and federal contracts.
- Be sensitive to special needs in spaces such as schools and critical facilities, which may require less aggressive DR strategies.

Appendix Tables

Table 4: Estimated DR Load Reduction Potential by Facility Type, Size and DR Strategy

		Utility Territory	PG&E	PG&E	PG&E	PG&E	PG&E	SCE	SCE	SCE	SCE
		Climate Zone	1	2	3	4	5	7	8	9	10
Peak Demand (kW)	**Facility Type**	**Load Reduction Strategy**	**Estimated Load Reduction (kW)**								
50	Office	HVAC - 4 Degree Temp. Reset	5	5	5	4	4	5	4	5	5
100	Office	HVAC - 4 Degree Temp. Reset	7	7	7	6	6	7	6	6	7
200	Office	HVAC - 4 Degree Temp. Reset	14	13	13	13	12	14	12	13	14
300	Office	HVAC - 4 Degree Temp. Reset	22	20	20	20	19	21	18	20	21
400	Office	HVAC - 4 Degree Temp. Reset	30	26	27	27	25	28	25	28	28
500	Office	HVAC - 4 Degree Temp. Reset	38	33	33	34	32	36	31	35	36
50	Retail	HVAC - 4 Degree Temp. Reset	5	5	4	4	3	5	3	4	5
100	Retail	HVAC - 4 Degree Temp. Reset	7	7	6	6	4	7	5	6	7
200	Retail	HVAC - 4 Degree Temp. Reset	15	15	13	12	10	14	10	13	14
300	Retail	HVAC - 4 Degree Temp. Reset	23	23	20	19	15	22	15	19	22
400	Retail	HVAC - 4 Degree Temp. Reset	32	31	26	25	20	30	20	26	30
500	Retail	HVAC - 4 Degree Temp. Reset	40	39	33	32	25	38	26	33	37
50	Office	Lighting - Dim Lighting 30%	3	3	3	4	5	3	5	4	4
100	Office	Lighting - Dim Lighting 30%	5	5	5	5	6	5	6	5	6
200	Office	Lighting - Dim Lighting 30%	12	11	12	9	12	12	12	11	14
300	Office	Lighting - Dim Lighting 30%	18	17	18	14	19	19	19	16	22
400	Office	Lighting - Dim Lighting 30%	24	23	24	19	25	25	25	22	29
500	Office	Lighting - Dim Lighting 30%	31	29	30	24	32	32	32	28	37
50	Retail	Lighting - Dim Lighting 30%	4	4	5	6	7	4	7	6	5
100	Retail	Lighting - Dim Lighting 30%	32	33	39	46	54	6	10	8	7
200	Retail	Lighting - Dim Lighting 30%	12	13	15	17	21	12	22	17	14
300	Retail	Lighting - Dim Lighting 30%	19	20	23	27	32	19	34	25	22
400	Retail	Lighting - Dim Lighting 30%	26	26	31	36	43	25	46	34	30
500	Retail	Lighting - Dim Lighting 30%	32	33	39	46	54	32	58	43	38

Table 5: Estimated ADR Technology Incentive by Facility Type, DR Strategy and Region (2017)

Facility Type	Approx. Sq. Ft	Peak Demand (kW)	Load Reduction Strategy	PG&E 1	PG&E 2	PG&E 3	PG&E 4	PG&E 5	SCE 7	SCE 8	SCE 9	SCE 10
			Utility Territory	PG&E	PG&E	PG&E	PG&E	PG&E	SCE	SCE	SCE	SCE
			Climate Zone	1	2	3	4	5	7	8	9	10
				Estimated **One-Time** ADR Technology Incentive								
Office	10,000	50	HVAC - 4 Degree Temp. Reset	$1,000	$1,000	$1,000	$800	$800	$1,500	$1,200	$1,500	$1,500
Office	20,000	100	HVAC - 4 Degree Temp. Reset	$1,400	$1,400	$1,400	$1,200	$1,200	$2,100	$1,800	$1,800	$2,100
Office	45,000	200	HVAC - 4 Degree Temp. Reset	$2,800	$2,600	$2,600	$2,600	$2,400	$4,200	$3,600	$3,900	$4,200
Office	65,000	300	HVAC - 4 Degree Temp. Reset	$4,400	$4,000	$4,000	$4,000	$3,800	$6,300	$5,400	$6,000	$6,300
Office	85,000	400	HVAC - 4 Degree Temp. Reset	$6,000	$5,200	$5,400	$5,400	$5,000	$8,400	$7,500	$8,400	$8,400
Office	105,000	500	HVAC - 4 Degree Temp. Reset	$7,600	$6,600	$6,600	$6,800	$6,400	$10,800	$9,300	$10,500	$10,800
Retail	15,000	50	HVAC - 4 Degree Temp. Reset	$1,000	$1,000	$800	$800	$600	$1,500	$900	$1,200	$1,500
Retail	30,000	100	HVAC - 4 Degree Temp. Reset	$1,400	$1,400	$1,200	$1,200	$800	$2,100	$1,500	$1,800	$2,100
Retail	60,000	200	HVAC - 4 Degree Temp. Reset	$3,000	$3,000	$2,600	$2,400	$2,000	$4,200	$3,000	$3,900	$4,200
Retail	90,000	300	HVAC - 4 Degree Temp. Reset	$4,600	$4,600	$4,000	$3,800	$3,000	$6,600	$4,500	$5,700	$6,600
Retail	120,000	400	HVAC - 4 Degree Temp. Reset	$6,400	$6,200	$5,200	$5,000	$4,000	$9,000	$6,000	$7,800	$9,000
Retail	150,000	500	HVAC - 4 Degree Temp. Reset	$8,000	$7,800	$6,600	$6,400	$5,000	$11,400	$7,800	$9,900	$11,100
Office	10,000	50	Lighting - Dim Lighting 30%	$600	$600	$600	$800	$1,000	$900	$1,500	$1,200	$1,200
Office	20,000	100	Lighting - Dim Lighting 30%	$1,000	$1,000	$1,000	$1,000	$1,200	$1,500	$1,800	$1,500	$1,800
Office	45,000	200	Lighting - Dim Lighting 30%	$2,400	$2,200	$2,400	$1,800	$2,400	$3,600	$3,600	$3,300	$4,200
Office	65,000	300	Lighting - Dim Lighting 30%	$3,600	$3,400	$3,600	$2,800	$3,800	$5,700	$5,700	$4,800	$6,600
Office	85,000	400	Lighting - Dim Lighting 30%	$4,800	$4,600	$4,800	$3,800	$5,000	$7,500	$7,500	$6,600	$8,700
Office	105,000	500	Lighting - Dim Lighting 30%	$6,200	$5,800	$6,000	$4,800	$6,400	$9,600	$9,600	$8,400	$11,100
Retail	15,000	50	Lighting - Dim Lighting 30%	$800	$800	$1,000	$1,200	$1,400	$1,200	$2,100	$1,800	$1,500
Retail	30,000	100	Lighting - Dim Lighting 30%	$6,400	$6,600	$7,800	$9,200	$10,800	$1,800	$3,000	$2,400	$2,100
Retail	60,000	200	Lighting - Dim Lighting 30%	$2,400	$2,600	$3,000	$3,400	$4,200	$3,600	$6,600	$5,100	$4,200
Retail	90,000	300	Lighting - Dim Lighting 30%	$3,800	$4,000	$4,600	$5,400	$6,400	$5,700	$10,200	$7,500	$6,600
Retail	120,000	400	Lighting - Dim Lighting 30%	$5,200	$5,200	$6,200	$7,200	$8,600	$7,500	$13,800	$10,200	$9,000
Retail	150,000	500	Lighting - Dim Lighting 30%	$6,400	$6,600	$7,800	$9,200	$10,800	$9,600	$17,400	$12,900	$11,400

Note: The one-time ADR incentive is based on the ADR FastTrack Incentive ($200/kW) in PG&E territory and the ADR Express Incentive ($300/kW) in SCE territory. PG&E ADR incentives are capped at 75% of project costs. SCE Express ADR incentives are capped at 100% of the project costs. Incentive estimates are based on 2017 program rules and are subject to change when new program rules are finalized.

Table 6: Potential Annual DR Participation Financial Benefits (2017)

			Utility Territory **Climate Zone**	PG&E 1	PG&E 2	PG&E 3	PG&E 4	PG&E 5	SCE 7	SCE 8	SCE 9	SCE 10
Facility Type	**Approx. Sq. Ft**	**Peak Demand (kW)**	**Load Reduction Strategy**	Potential **Annual** PDP/CPP Event Savings								
Office	10,000	50	HVAC - 4 Degree Temp. Reset	$288	$216	$216	$173	$173	$330	$264	$330	$330
Office	20,000	100	HVAC - 4 Degree Temp. Reset	$302	$302	$302	$259	$259	$462	$396	$396	$462
Office	45,000	200	HVAC - 4 Degree Temp. Reset	$605	$562	$562	$562	$518	$924	$792	$858	$924
Office	65,000	300	HVAC - 4 Degree Temp. Reset	$950	$864	$864	$864	$821	$1,386	$1,188	$1,320	$1,386
Office	85,000	400	HVAC - 4 Degree Temp. Reset	$1,296	$1,123	$1,166	$1,166	$1,080	$1,847	$1,649	$1,847	$1,847
Office	105,000	500	HVAC - 4 Degree Temp. Reset	$1,642	$1,426	$1,426	$1,469	$1,382	$2,375	$2,045	$2,309	$2,375
Retail	15,000	50	HVAC - 4 Degree Temp. Reset	$288	$216	$173	$173	$130	$330	$198	$264	$330
Retail	30,000	100	HVAC - 4 Degree Temp. Reset	$302	$302	$259	$259	$173	$462	$330	$396	$462
Retail	60,000	200	HVAC - 4 Degree Temp. Reset	$648	$648	$562	$518	$432	$924	$660	$858	$924
Retail	90,000	300	HVAC - 4 Degree Temp. Reset	$994	$994	$864	$821	$648	$1,452	$990	$1,254	$1,452
Retail	120,000	400	HVAC - 4 Degree Temp. Reset	$1,382	$1,339	$1,123	$1,080	$864	$1,979	$1,320	$1,715	$1,979
Retail	150,000	500	HVAC - 4 Degree Temp. Reset	$1,728	$1,685	$1,426	$1,382	$1,080	$2,507	$1,715	$2,177	$2,441
Office	10,000	50	Lighting - Dim Lighting 30%	$173	$130	$130	$173	$216	$198	$330	$264	$264
Office	20,000	100	Lighting - Dim Lighting 30%	$216	$216	$216	$216	$259	$330	$396	$330	$396
Office	45,000	200	Lighting - Dim Lighting 30%	$518	$475	$518	$389	$518	$792	$792	$726	$924
Office	65,000	300	Lighting - Dim Lighting 30%	$778	$734	$778	$605	$821	$1,254	$1,254	$1,056	$1,452
Office	85,000	400	Lighting - Dim Lighting 30%	$1,037	$994	$1,037	$821	$1,080	$1,649	$1,649	$1,452	$1,913
Office	105,000	500	Lighting - Dim Lighting 30%	$1,339	$1,253	$1,296	$1,037	$1,382	$2,111	$2,111	$1,847	$2,441
Retail	15,000	50	Lighting - Dim Lighting 30%	$230	$173	$216	$259	$302	$264	$462	$396	$330
Retail	30,000	100	Lighting - Dim Lighting 30%	$1,382	$1,426	$1,685	$1,987	$2,333	$396	$660	$528	$462
Retail	60,000	200	Lighting - Dim Lighting 30%	$518	$562	$648	$734	$907	$792	$1,452	$1,122	$924
Retail	90,000	300	Lighting - Dim Lighting 30%	$821	$864	$994	$1,166	$1,382	$1,254	$2,243	$1,649	$1,452
Retail	120,000	400	Lighting - Dim Lighting 30%	$1,123	$1,123	$1,339	$1,555	$1,858	$1,649	$3,035	$2,243	$1,979
Retail	150,000	500	Lighting - Dim Lighting 30%	$1,382	$1,426	$1,685	$1,987	$2,333	$2,111	$3,827	$2,837	$2,507

AND / OR

Note: Financial estimates are based on 2017 program rules and are subject to change when new program rules are finalized. The PDP/CPP event savings assumes the customer is already on a PDP/CPP rate and that they reduce their load by their estimated load shed potential during DR events. Assumes twelve 4-hour events. The PDP/CPP savings do not represent savings or losses from switching on or off the PDP/CPP rate, which can be significant.

Facility Type	Approx. Sq. Ft	Peak Demand (kW)	Utility Territory / Climate Zone	PG&E 1	PG&E 2	PG&E 3	PG&E 4	PG&E 5	SCE 7	SCE 8	SCE 9	SCE 10
			Load Reduction Strategy	Potential **Annual** CBP Capacity Payments								
Office	10,000	50	HVAC - 4 Degree Temp. Reset	$310	$310	$310	$248	$248	$233	$186	$233	$233
Office	20,000	100	HVAC - 4 Degree Temp. Reset	$434	$434	$434	$372	$372	$326	$280	$280	$326
Office	45,000	200	HVAC - 4 Degree Temp. Reset	$869	$807	$807	$807	$745	$652	$559	$606	$652
Office	65,000	300	HVAC - 4 Degree Temp. Reset	$1,366	$1,241	$1,241	$1,241	$1,179	$978	$839	$932	$978
Office	85,000	400	HVAC - 4 Degree Temp. Reset	$1,862	$1,614	$1,676	$1,676	$1,552	$1,305	$1,165	$1,305	$1,305
Office	105,000	500	HVAC - 4 Degree Temp. Reset	$2,359	$2,048	$2,048	$2,110	$1,986	$1,677	$1,444	$1,631	$1,677
Retail	15,000	50	HVAC - 4 Degree Temp. Reset	$310	$310	$248	$248	$186	$233	$140	$186	$233
Retail	30,000	100	HVAC - 4 Degree Temp. Reset	$434	$434	$372	$372	$248	$326	$233	$280	$326
Retail	60,000	200	HVAC - 4 Degree Temp. Reset	$931	$931	$807	$745	$621	$652	$466	$606	$652
Retail	90,000	300	HVAC - 4 Degree Temp. Reset	$1,428	$1,428	$1,241	$1,179	$931	$1,025	$699	$885	$1,025
Retail	120,000	400	HVAC - 4 Degree Temp. Reset	$1,986	$1,924	$1,614	$1,552	$1,241	$1,398	$932	$1,211	$1,398
Retail	150,000	500	HVAC - 4 Degree Temp. Reset	$2,483	$2,421	$2,048	$1,986	$1,552	$1,770	$1,211	$1,537	$1,724
Office	10,000	50	Lighting - Dim Lighting 30%	$186	$186	$186	$248	$310	$140	$233	$186	$186
Office	20,000	100	Lighting - Dim Lighting 30%	$310	$310	$310	$310	$372	$233	$280	$233	$280
Office	45,000	200	Lighting - Dim Lighting 30%	$745	$683	$745	$559	$745	$559	$559	$512	$652
Office	65,000	300	Lighting - Dim Lighting 30%	$1,117	$1,055	$1,117	$869	$1,179	$885	$885	$745	$1,025
Office	85,000	400	Lighting - Dim Lighting 30%	$1,490	$1,428	$1,490	$1,179	$1,552	$1,165	$1,165	$1,025	$1,351
Office	105,000	500	Lighting - Dim Lighting 30%	$1,924	$1,800	$1,862	$1,490	$1,986	$1,491	$1,491	$1,305	$1,724
Retail	15,000	50	Lighting - Dim Lighting 30%	$248	$248	$310	$372	$434	$186	$326	$280	$233
Retail	30,000	100	Lighting - Dim Lighting 30%	$1,986	$2,048	$2,421	$2,855	$3,352	$280	$466	$373	$326
Retail	60,000	200	Lighting - Dim Lighting 30%	$745	$807	$931	$1,055	$1,303	$559	$1,025	$792	$652
Retail	90,000	300	Lighting - Dim Lighting 30%	$1,179	$1,241	$1,428	$1,676	$1,986	$885	$1,584	$1,165	$1,025
Retail	120,000	400	Lighting - Dim Lighting 30%	$1,614	$1,614	$1,924	$2,235	$2,669	$1,165	$2,143	$1,584	$1,398
Retail	150,000	500	Lighting - Dim Lighting 30%	$1,986	$2,048	$2,421	$2,855	$3,352	$1,491	$2,702	$2,003	$1,770

Note: Financial estimates are based on 2017 program rules and are subject to change when new program rules are finalized. Potential CBP capacity payment is based on the amount paid to aggregator and assumes nomination every month of the summer. The actual amount received by customer wholly depends on a customer's agreement with their aggregator. Potential CBP payments do not include capacity penalties for failing to shed load or energy payments for participating in DR events.

Resources:

- SCE Auto-DR Express Technology Incentives Calculator - https://sceonlineapp.com/measures/ExpressTechIncentives.aspx
- PG&E ADR FastTrack Calculator - http://pge-adr.com/act/fasttrack
- Forecasting Climate Zone Map - http://capabilities.itron.com/CeusWeb/FCZMap.aspx