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Evaluation of the US Department of Energy Weatherization Innovation Pilot Program (2010–2014)

Erin Rose
Beth Hawkins
Bruce Tonn

May 2017

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Environmental Sciences Division

EVALUATION OF THE U.S. DEPARTMENT OF ENERGY WEATHERIZATION INNOVATION PILOT PROGRAM (2010–2014)

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ACRONYMS AND ABBREVIATIONS

AMI	Automated metering infrastructure
ARRA	American Reinvestment and Recovery Act
BPI	Building Performance Institute
CECLP	Coalition to End Childhood Lead Poisoning
CEO	Commission on Economic Opportunity
cfm	Cubic feet per minute
CIF	Carbon incentive fund
CL&P	Connecticut Light and Power
Commerce	Washington State Department of Commerce
CRA	Community Reinvestment Act
CTEHHI	Connecticut Efficient Healthy Homes Initiative
DHCD	Utah Division of Housing and Community Development
DOE	US Department of Energy
ECM	Energy conservation measure
ESPC	Energy savings performance contract
EPS	Energy Pioneer Solutions
ESCO	Energy services company
FOA	Funding Opportunity Announcement
GHHI	Green and Healthy Housing Initiative
HELP	Home energy loan pool
HERS	Home Energy Rating System
HFHI	Habitat for Humanity
HHI	Healthy housing intervention
HUD	US Department of Housing and Urban Development
HVAC	Heating, ventilation and air conditioning
IEQ	Indoor environmental quality
IHD	In-home display
JCI	Johnson Controls, Inc.
LEAP	Local Energy Alliance Program
LIHEAP	Low Income Home Energy Assistance Program
NCHFA	North Carolina Housing Finance Agency
NHCLF	New Hampshire Community Loan Fund
ORNL	Oak Ridge National Laboratory
PAGE	Performance and Accountability for Grants in Energy
PD	Project Description
POAH	Preservation of Affordable Housing
PPL	Pennsylvania Power and Light
PRISM	Princeton Scorekeeping Method
PWC	People Working Cooperatively
PY	Program year
RESNET	Residential Energy Services Network
RISE	Replicable, Innovative, and Sustainable Energy
ROC	Resident-owned community
RPO	Rental property owner
SAHF	Stewards of Affordable Housing for the Future
SEAM	Societal Externality Assessment Mechanism
SES	Socioeconomic status
SGIG	Smart Grid Infrastructure Grant

SIR	Savings-to-investment ratio
SOPO	Statement of Project Objectives
SWIFT	Streamlined Weatherization Improvements for Tomorrow
UI	United Illuminating
UNCC	University of North Carolina Charlotte
VEIC	Vermont Energy Investment Corporation
WAP	Weatherization Assistance Program
WIPO	Weatherization and Intergovernmental Programs Office
WIPP	Weatherization Innovation Pilot Program
WPN	Weatherization Program Notice
WRAP	Winter Relief Assistance Program

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EXECUTIVE SUMMARY

This report contains results from analysis conducted on each of the Weatherization Innovation Pilot Program (WIPP) grants awarded to 16 organizations by the US Department of Energy (DOE) in 2010. The purpose of WIPP was to explore the potential adoptability or replicability of innovative processes or technologies for the enhancement of DOE's Weatherization Assistance Program (WAP). DOE initiated the WIPP grant to accelerate effective innovations in home energy efficiency and other WAP mission-related goals for income-qualifying households of low socioeconomic status. This study was performed alongside a broader, national evaluation of WAP conducted by Oak Ridge National Laboratory (ORNL) for DOE.

Awarded WIPP projects were selected from a pool of traditional WAP and non-WAP applicants that provided compelling arguments for how their proposed innovation(s) could enhance process and impact-oriented outcomes for weatherization and energy efficiency in the residential sector. The 16 grantees were

- City of Danville, Illinois
- Washington State Department of Commerce
- Energy Pioneer Solution
- Local Energy Alliance Program
- Stewards of Affordable Housing
- Utah Division of Housing and Community Development
- Habitat for Humanity International
- People Working Cooperatively
- YouthBuild USA Inc.
- Commission on Economic Opportunity
- Community Environmental Center
- New Hampshire Community Loan Fund
- University of North Carolina–Charlotte
- Vermont Energy Investment Corporation
- Coalition to End Childhood Lead Poisoning
- United Illuminating Company

Grantees ventured to advance weatherization through four approaches: (1) financial mechanisms and incentives; (2) adapting existing workforce training and volunteer engagement business models to create new jobs and reduce costs; (3) using new energy efficiency technologies and more efficient service delivery techniques; and (4) combining weatherization with a "green and healthy homes" focus. This evaluation underscores the importance of piloting these innovations before they are included alongside or in replacement of standard WAP mechanisms, to ensure compatibility and alignment with WAP goals and mission.

The DOE WIPP grant expended nearly two-thirds of the ~$30 million appropriated by the US Congress over the course of the grant cycle. The grant cycle was extended by up to 2 years for some of the grantees that were unable to meet objectives and production goals within the original 2-year grant cycle. The ~$19 million expended by DOE leveraged an additional $26.3 million from a diverse set of funders consisting of foundations, nonprofits, utility ratepayer funds, states, municipalities, philanthropies, and private sector investment. Of the 19,251 housing units for which retrofitting was planned, a total of 7,732 homes were served (40%).

Overarching and key findings were derived through various data collection tasks uniquely designed in conjunction with each of the WIPP grantee management teams. These individualized evaluation plans were structured to align with the DOE approved Statement of Project Objectives outlining the project

tasks, proposed leveraging amounts and sources, planned productivity and outlays, and innovation outcomes. Evaluation plans for each grant included the following tasks if applicable and feasible: energy impact and cost-effectiveness analysis; grantee, staff and program recipient surveys; on-site observations and inspections of work completed; and case studies documenting the process, strengths, and challenges of the pilot design. These tasks allowed evaluators to characterize each project's ability to establish necessary partnerships, secure leveraged funding and resources, and implement an effective strategy to meet project goals. These tasks also provided descriptive statistics related to WAP high-priority populations served and energy and non-energy impacts.

WIPP Project Advantages, Challenges, and Apprehensions

Grantees that applied innovative, but not overly complex, features to well-established programs founded on evidence-based practice seemed to prove better able to fully realize the potential of the piloted idea within the grant cycle. These grantees experienced fewer challenges than pilots requiring major policy amendments (e.g., US Department of Housing and Urban Development rules related to misaligned incentives for tenants and property owners), projects with multiple innovations (e.g., alternative financing, new technologies and approaches, and volunteer labor piloted in combination), innovations that were not market ready (e.g., carbon credits, new technology not yet deployed), and those that sought to replace traditional WAP providers with workforce development strategies reliant on volunteer labor lacking in building science experience and training.

Uncertainties inherent in innovation resulted in unexpected inabilities to perform the proposed tasks for a myriad of reasons. The initial 2-year grant cycle proved challenging for grantees not ready for work to begin. Approval of contracts (e.g., new legal considerations for innovative financing mechanisms) and energy auditing tools not previously approved at the state level resulted in delayed weatherization work and expanded timeframes. Innovations that required changes or waivers to establish new policy or protocols also resulted in delayed production and reductions in planned leveraged funding and total outlay. Grantees characterized as traditional WAP providers were not challenged by the DOE regulations, reporting requirements, or evaluation tasks. These advantages provided these projects the means to move forward with their innovation and production goals without delay.

In most cases, WIPP grantees operating as, or in partnership with, public utilities had several advantages. These grantees had privileged access to household energy usage data. Access to these data allowed for targeted implementation and guidance of weatherization and energy education programs, as well as internal monitoring and evaluation of electricity impacts from in-home displays (IHDs). Additionally, public utility partnerships made it feasible to examine an on-bill financing pilot and for a home energy retrofit loan forgiveness program. Finally, well-established utility energy efficiency programs provide platforms for add-on features (e.g., healthy housing interventions [HHIs]) to be delivered alongside or after weatherization.

It was also observed that nontraditional WAP providers do not always serve, or serve at the same scale, the WAP-targeted, high-priority populations designated by statute (i.e., persons of elderly or disability status, households with children, and high energy users).[1]

[1] WAP was created by Congress in 1976 under Title IV of the Energy Conservation and Production Act. The purpose and scope of the Program as currently stated in the Code of Federal Regulations 10 CFR 440.1 is "to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high energy burden." (Code of Federal Regulations, 2011)

Overarching Findings from Grants with Innovative Financing Approaches

WAP functions to provide federal grants to states (based on a funding allocation formula) and its services are delivered to income-eligible households at no cost to them. The WIPP grant allowed DOE to explore alternative financing mechanisms to potentially assist WAP in terms of cost and reach. In the end, it must be determined whether the financing mechanisms being explored are attractive complements to WAP's current operations and whether they are truly cost-effective and sustainable.

Under this grant, on-bill utility financing proved effective in negotiating and finalizing nearly 200 loan agreements. However, these transactions were time- and resource-intensive, as were most of the projects performed under the WIPP innovative financing umbrella.

ESCOs provide a means for energy retrofits, such as weatherization, to occur in situations in which the building or property owners are unable to pay cash for the endeavor. ESCOs offer ESPCs to ensure the projected cost savings from the installed ECMs perform as expected. This is critical, as the ESCO is repaid through these cost savings. However, the use of ESCOs for improved energy efficiency in weatherizing multifamily properties proved resource-intensive for all parties involved in the transactions (i.e., owners, investors, ESCOs, and project managers).

Two projects revealed that generating carbon credits through low-income weatherization has potential for inclusion in WAP. However, using CIFs to leverage weatherization costs also proved to be resource-intensive. The administrative costs to navigate all the processes and requirements for carbon credit validation could be higher than the expected revenue produced by selling the carbon credits. However, it does appear that once the processes and costs required for carbon credit validation are achieved, CIFs could be replicated as an effective model.

Overarching Findings from Grants with a Workforce Development or Volunteer Labor Component

Organizations that have an established history in securing leveraged and in-kind resources through private sector investments, donations, and volunteer engagement offer valuable avenues for home rehabilitation (e.g., roof repairs) and healthy-homes work (e.g., door ramps) to be completed while partnering with traditional WAP providers or as a means to ensure deferred homes are eventually weatherized. Despite the efforts of these nontraditional providers to perform at the same caliber as WAP subgrantees in weatherizing homes, volunteers and persons in workforce development programs too often lacked building science expertise and experience possessed by the trained and traditional WAP workforce. Volunteer labor was observed to impede and decrease the installation and quality of weatherization measures. WIPP project managers and evaluators linked failed work quality inspections to work completed by volunteers. On-site organization and training of volunteer labor was determined by project managers to be undependable and time consuming, even for tasks requiring minimal skill levels, making the process inefficient. The evaluation indicated that weatherization delivered through WAP as an evidence-based intervention for the improvement of energy efficiency will remain so only with a dependable, skilled, and trained workforce dedicated to its mission.

The evaluation did find, however, that well-established volunteer programs that target energy efficiency education were able to effectively deliver residential energy coaching alongside WAP that resulted in validated energy savings.

Overarching Findings from Grants Involving New Technologies and Techniques

Grantees that aimed to incorporate new technologies that were not market ready, or were still in the research and development stages, were faced with unforeseen challenges and production delays. For

example, exploring the application of a newly developed savings-to-investment ratio buy-down tool, based on the value of carbon emission reductions and societal benefits, was ambitious within the timeframe of the grant cycle.

However, the approach of integrating new techniques or technologies into established weatherization programs encountered fewer obstacles (e.g., the installation of IHDs alongside a utility weatherization program). As a result, traditional weatherization providers proved capable of integrating innovation into or alongside their programs, provided the innovation was not overly complex.

IHDs were studied by several grantees and were found to offer incremental electricity savings on top of weatherization energy savings. The benefits of such devices, alongside household consumer energy education, are more fully realized by high-energy user households. One grantee's approach to close-proximity production resulted in an increased number of homes served because it minimized travel times, but it appears these saving accrued mostly to subcontractors rather than to WAP. The potential benefits of this innovative approach need further exploration.

Overarching Findings from Green and Healthy Homes Grants

Opportunity exists for comprehensive healthy housing measures to be completed in concert with WAP. When combined, the core missions of energy efficiency programs and healthy housing programs have the potential to produce complementary and synergistic benefits at both the household (e.g., improved health and safety) and societal (e.g., improved health care outcomes) levels. The two pilots performed under the WIPP grant offer two different but effective Weatherization Plus Health models promoted by the National Association for State Community Services Programs.

It was observed through this evaluation that the experience and quality of cross-training for both agency and contract staff are instrumental for meaningful engagement with occupants, and for advancing energy and healthy housing outcomes. The effectiveness of cross-training traditional weatherization auditors and crews to complete health impact assessments requires further investigation. Although weatherization providers are capable of delivering HHIs in concert with their energy efficiency programs, traditional HHI providers appeared to be better equipped to understand and address place-based drivers for health disparities than were traditional weatherization providers. Observations made early in the grant cycle revealed that even cross-trained weatherization providers displayed more difficulty in engaging occupants on health status and assessing home hazards compared with traditional HHI providers. Conversely, the traditional HHI provider operating under this grant was able to deliver effective home energy efficiency services (i.e., energy saving impacts).

Research in this area suggests that HHIs (i.e., including community health workers to help engage residents and complete health impact assessments) is an effective strategy for improving indoor environmental quality and health outcomes. However, the evaluation was unable to measure the health impacts of either green-and-healthy-homes grant because of a lack of the necessary metrics to do so.

1. INTRODUCTION

This report presents the results of Oak Ridge National Laboratory's (ORNL) assessment of Weatherization Innovation Pilot Program (WIPP) projects as directed by the Department of Energy (DOE). In August 2010, DOE's Weatherization and Intergovernmental Programs Office (WIPO) announced that $30 million from the Weatherization Assistance Program (WAP) annual budget would be competitively awarded to 16 grantees to demonstrate innovative approaches to weatherizing income-eligible single-family and multifamily homes through a WIPP grant. Congress authorized the use of the funds in the Energy and Water Development and Related Appropriations Act of 2010 (P.L. 11-85). The weatherization innovations provided exploratory studies relatable to and in compliance with the WAP mission and guidelines. Grantees included nontraditional partners and weatherization providers such as private companies, non-profit organizations, universities, city governments, and utilities. WIPP aimed to build the capacity of new weatherization providers and increase cost-effectiveness[2] while leveraging non-federal financial resources[3] with DOE funds and expanding the skills of existing WAP providers. Although DOE's funding opportunity announcement (FOA) suggested a target of a 3:1 non-federal to federal funds leveraging rate, not all grantees chose this target goal in their original proposals.

The grantees were

- City of Danville, Illinois (Danville Utilities)
- Washington State Department of Commerce (Commerce)
- Energy Pioneer Solution (EPS)
- Local Energy Alliance Program (LEAP)
- Stewards of Affordable Housing (SAHF)
- Utah Division of Housing and Community Development (DHCD)
- Habitat for Humanity International (HFHI)
- People Working Cooperatively (PWC)
- YouthBuild USA Inc. (YouthBuild)
- Commission on Economic Opportunity (CEO)
- Community Environmental Center (CEC)
- New Hampshire Community Loan Fund (NHCLF)
- University of North Carolina–Charlotte (UNCC)
- Vermont Energy Investment Corporation (VEIC)
- Coalition to End Childhood Lead Poisoning (CECLP)
- United Illuminating Company (UI)

Grantees ventured to advance weatherization through four approaches: (1) financial mechanisms and incentives; (2) adapting existing workforce training and volunteer engagement business models to create new jobs and reduce costs; (3) using new energy efficiency technologies (e.g., energy information displays) and more efficient service delivery techniques (e.g., a block-by-block neighborhood approach to weatherizing homes); and (4) combining weatherization with a "green and healthy homes" focus (e.g., indoor environmental quality [IEQ] improvements). Table 1.1 presents the 16 grantees within their respective project categories.

[2] Under WAP, energy conservation measures need to pass a savings-to-investment ratio (SIR) test—the present value (PV) of the energy cost savings over the life of the measure (e.g., 20 years) needs to exceed the PV of its cost (i.e., an SIR $\geq$ 1.0).
[3] Agencies could include any in-kind resource as a match to supplement DOE funds for WIPP activities that, according to Weatherization Program Notice 11-08, increased the energy efficiency of WAP-eligible dwellings and improved their health and safety. In-kind resources include the use of any vehicles and equipment, or administrative and management services that also are used to deliver traditional WAP activities.

WIPP grantees operated their programs across the continental United States in diverse housing stocks and in different climate zones, and some operated in multiple locations (i.e., HFHI, LEAP, and Youthbuild). Figure 1.1 presents a map of the WIPP grantees.[4]

Table 1.1. WIPP grantees categorized by project type

WIPP project category	Grantee
Financing approaches	City of Danville, (Danville Utilities)
	Washington State Department of Commerce (Commerce)
	Energy Pioneer Solutions (EPS)
	Local Energy Alliance Program (LEAP)
	Stewards of Affordable Housing (SAHF)
	Utah Division of Housing and Community Development (DHCD)
Workforce development and volunteers	Habitat for Humanity International (HFHI)
	People Working Cooperatively Inc. (PWC)
	YouthBuild USA Inc.
New technologies and techniques	Commission on Economic Opportunity (CEO)
	Community Environmental Center Inc. (CEC)
	New Hampshire Community Loan Fund Inc. (NHCLF)
	University of North Carolina–Charlotte (UNCC)
	Vermont Energy Investment Corporation (VEIC)
Green and healthy homes	Coalition to End Childhood Lead Poisoning (CECLP)
	The United Illuminating Company (UI)

HFHI—Yellow
LEAP—Blue
YouthBuild—Green
All other grantees—Red

Figure 1.1. Map of WIPP grantees.

[4] Three grantees included more than one organization in their project: HFHI, LEAP, and YouthBuild.

2. METHODOLOGY

The ORNL evaluation of WIPP involved a variety of impact and process assessment tasks designed to reveal statistically defensible energy and non-energy impact results. Impact evaluation relied on energy usage data and survey results to determine energy savings, cost-effectiveness (e.g., savings-investment ratio, or SIR) and household-reported benefits. Process assessment focused on project planning, implementation, and overall potential for project replicability. Consequently, the research conducted through and on these pilots unearthed valuable information related to innovations relevant to energy efficiency in the residential sector. The following three overarching questions were devised to guide the evaluation of the program:

- How does the project compare with the standard WAP in terms of work quality, monitoring and quality assurance, cost-effectiveness, energy savings, benefits to low-income households, and non-energy benefits?
- Did the resources leveraged through the project perform as proposed?
- In terms of project scalability and replicability, what are the primary lessons learned?

Table 2.1 connects the WIPP evaluation task with their associated intended outcomes. Not all of the presented evaluation tasks were conducted for every grantee. Each project was assessed for evaluation task assignments and, because of the unique nature of the projects, individualized evaluation plans were developed.[5] Additionally, it was the intent for all grantees to participate in an energy impact analysis of their projects. However, only 7 of the 16 original projects completed an energy impact assessment because of delayed production and the need for adequate post-intervention data. Table 2.2 itemizes the WIPP evaluation tasks used for each grantee.

Table 2.1. WIPP evaluation outcomes and associated tasks

Outcome	Evaluation task
Energy impacts[a]	• Collected pre- and post-weatherization: billing histories • Used comparison homes from the ORNL national evaluation of WAP[b] • Provided grantees with detailed program, housing, and building data
Cost-effectiveness	• Collected data on weatherization expenditures • Compared data with energy cost savings
Client satisfaction	• Collected occupant survey results from selected grantees
Non-energy impacts	• Conducted grantee and recipient surveys
Replicability and adoptability of innovation	• Case study reports • Volunteer debriefings • Results from other analyses

[a] See Section 3 for more information on energy impact analysis.
[b]ORNL led two evaluations of WAP as directed by DOE. Comparison homes were pulled from the retrospective evaluation of the WAP as it was delivered in Program Year 2008.

[5] It was necessary for the evaluation plans to be modified over the course of the grant cycle as the projects evolved and in cases when project implementation was delayed.

Table 2.2. WIPP evaluation tasks used per grantee

Evaluation Task	Approach	Grantee	
Case studies/key informant interviews	• Telephone and in-person interviews with stakeholders • On-site visits in the field • Review of relevant documents	• All grantees[a]	
Surveys: grantee, staff, and occupant	• Grantee: o Modified from national WAP evaluation S1: Grantee Program Information Survey	• All grantees (including affiliates) (n=17)	
	• Trainee/weatherization staff survey : o Modified from national WAP evaluation, trainees of Weatherization Training Centers Survey, and Weatherization Staff Survey	• Trainee/Weatherization Staff Survey (n=11): o YouthBuild was the only grantee to receive this survey	
	• Occupant (random sample; n=476): o Modified from national WAP evaluation Occupant Survey—customized for each WIPP project	• EPS (n=83) • PWC (n=101) • CEO (n=84) • NHCLF (n=60) • CECLP (n=25)	• UNCC (n=24) • VEIC (n=60) • CEO (n=84) • UI (n=39)
Billing analysis	• Billing histories collected for a sample of units and buildings; pre- and~1 year post-intervention • Grantees completed housing characteristics data forms (DF2/3) depending on the housing types	• EPS • PWC • CEO • NHCLF • VEIC • CECLP • UI	
Observations/ inspections/volunteer debriefings	• Conduct observations of trainings and work in progress • Conduct semi-structured informal debriefings with staff and volunteers	• HFHI • PWC • UNCC • CECLP • UI	

[a]Case studies could not be conducted with the Danville Utilities and YouthBuild.

3. RESULTS

The DOE WIPP grant expended nearly two-thirds of the ~$30 million appropriated by the US Congress over the course of the grant cycle (Table 3.1). The grant cycle was extended by up to 2 years for some of the grantees that were unable to meet objectives and production goals within the original 2-year grant cycle. The ~$19 million expended by DOE leveraged an additional $26.3 million from a diverse set of funders consisting of foundations, nonprofits, utility ratepayer funds, states, municipalities, philanthropies, and private sector investment (Table 3.2). Of the 19,251 housing units for which retrofitting was planned, a total of 7,732 homes were served (40%). Although many of the pilot programs were unable to meet their production or leveraging goals, the lessons learned from each pilot provided important information to DOE regarding the adoption and replicability of innovations within the nexus of energy, housing, and health.

Table 3.1. Initial funds awarded and funds spent by project end; units planned and completed—per grantee[a]

Grantee	Initial grant	Cumulative federal outlays (% of grant spent)	Planned no. of units	Total units completed (% of goal)
Innovative financing approaches				
Danville Utilities	$1,015,746	$171,854 (17%)	300[b]	10 (3%)
WA Department of Commerce	$3,000,000	$386,995 (13%)	2,240[b]	0
EPS	$812,418	$812,418 (100%)	250	202 (81%)
LEAP	$1,898,938	$1,898,938 (100%)	1700[b]	845 (50%)
SAHF	$2,590,523	$936,698(36%)	2500[b]	260 (10%)
UT DHCD	$850,000	–	450	0
Workforce development and volunteers				
HFHI	$3,000,000	$1,185,384 (40%)	1,770	436 (25%)
PWC	$1,500,000	$1,500,000 (100%)	673	324 (48%)
YouthBuild	$1,374,020	$676,221 (49%)	998	410 (41%)
New technologies and techniques				
CEO	$2,449,607	$1,591,044 (65%)	2,500	2,501(100%)
CEC	$3,000,000	$2,750,378 (92%)	1,400[b]	968 (81%)
NHCLF	$600,000	$590,996 (99%)	425	385 (91%)
UNCC	$2,005,945	$1,698,479 (85%)	800	95 (12%)
VEIC	$719,380	$616,890 (86%)	750	116 (15%)
Green and healthy homes				
CECLP	$1,287,598	$1,131,574 (88%)	210	212 (101%)
UI	$3,000,000	$3,000,000 (100%)	2,285[b]	968 (42%)
TOTAL	**29,104,175**	**$18,947,869 (65%)**	**19,251**	**7,732 (40%)**

[a] Initial funds awarded and planned number of units are reported from the grantees' original grant proposals before any project modifications were made after the grant was awarded by DOE.
[b] These grantees planned to provide services to the multifamily sector; values are for number of units, not number of buildings.

Table 3.2. Planned leveraging amounts and actual amount leveraged by project end—per grantee[a]

Grantee	Planned leveraged funding	Actual leveraged funding received	Percent of planned funds received
Innovative financing approaches			
Danville Utilities	$1,200,000	$40,405	4%
WA Department of Commerce	$9,000,000	–	–
EPS	$2,959,150	$1,863,135	63%
LEAP	$5,696,814	$3,175,996	56%
SAHF	$8,750,000	$398,575	5%
UT DHCD	$2,550,000	–	–
Workforce development and volunteers			
HFHI	$9,000,000	$2,860,990	32%
PWC	$5,200,000	$2,218,255	43%
YouthBuild	$4,020,593	$2,931,296	73%
New technologies and techniques			
CEO	$9,291,200	$4,868,793	52%
CEC	$9,000,000	$63,935	1%
NHCLF	$2,400,000	$3,005,752	125%
UNCC	$6,214,400	$798,317	13%
VEIC	$1,200,000	$200,000	17%
Green and healthy homes			
CECLP	$3,862,793	$349,020	9%
UI	$11,047,475	$3,541,005	32%
TOTAL	**$91,392,425**	**$26,315,474**	**29%**

[a] Leveraged funds planned are reported from the grantees' original grant proposals and awarded amount before any project modifications were made after the grant was awarded by DOE.

The work completed under the grants was conducted across all housing types. According to the information collected by the grantees in WIPO's grant reporting system, Performance and Accountability for Grants in Energy (PAGE), most work (56%) was conducted in the single-family site-built housing stock, followed by large multifamily buildings (36%), mobile homes (8%), and shelters (<1%) (Table 3.3).

Considering that the mission of WAP extends beyond energy impacts to alleviating undue hardship on households of low socioeconomic status (SES) and, more specifically, persons of elderly or disability status and households with children, the demographics of the populations served by each grantee were explored. Based on the information accounted for in PAGE, 35% of the work completed was conducted in homes occupied by the elderly, 14% in homes occupied by residents with disabilities, 39% in homes with children, and <1% in homes occupied by persons of Native American status (Table 3.4).

Several projects conducted client surveys to gain occupants' perspectives on the quality of work completed in their homes. As shown in Table 3.5, of the clients surveyed, the majority were satisfied or very satisfied with the work completed in their homes.

Table 3.3. Number of units completed per grantee by housing type as reported in PAGE[α]

Grantee	Owner-occupied single-family site built	Renter-occupied single-family site built	Multi-family	Owner-occupied mobile home	Renter-occupied mobile home	Shelter	Total
Innovative financing approaches							
Danville Utilities	0	10	0	0	0	0	10
WA Department of Commerce	0	0	0	0	0	0	0
EPS	176	24	0	2	0	0	202
LEAP	0	0	845	0	0	0	845
SAHF	0	0	260	0	0	0	260
UT DHCD	0	0	0	0	0	0	0
Workforce development and volunteers							
HFHI	419	1	0	16	0	0	436
PWC	241	50	0	32	1	0	324
YouthBuild	67	336	0	1	0	6	410
New technologies and techniques							
CEO	1,493	555	285	127	33	8	2501
CEC	29	46	893	0	0	0	968
NHCLF	0	0	0	385	0	0	385
UNCC	95	0	0	0	0	0	95
VEIC[b]	NA	NA	NA	NA	NA	NA	NA
Green and healthy homes							
CECLP	136	76	0	0	0	0	212
UI	181	301	486	0	0	0	968
TOTAL	**2,837**	**1,399**	**2,769**	**563**	**34**	**14**	**7,616**

[α] Several projects targeted a specific housing type(s), while others served all types of housing stock.
[b] Although this information was not reported in PAGE for VEIC, ORNL survey results revealed that, of those who completed the survey, all study participants were homeowners, 84% resided in single-family site-built dwellings, and 16% resided in mobile homes.

Ideally, every WIPP project would have undergone an energy impact analysis at scale. These data-driven results would have been instrumental in supporting confident programmatic decisions for WIPO related to the innovations measured. However, because of delays in production for a myriad of reasons, less than half of the original set of WIPP grantees produced enough units in time, or collected the data necessary for analysis to be conducted.

When available, the sources of energy usage data used for energy impact analysis were billing records collected from gas and electric utilities, as well as from bulk fuel (e.g., fuel oil) providers. However, simply comparing pre-weatherization annual energy usage to post-weatherization usage does not furnish a reliable measure of energy savings, as weather changes from one year to the next and can cause the amount of space heating and space cooling energy required by a housing unit to change. To control for changes in the number of heating and cooling days, this analysis employed procedures to weather-normalize energy usage data using a standardized software tool called the Princeton Scorekeeping

Table 3.4. Number of units completed per grantee by occupancy

Grantee	Elderly-occupied	Disabled-occupied	Native American-occupied	Children-occupied
Innovative financing approaches				
Danville Utilities	3	2	0	4
WA Department of Commerce	0	0	0	0
EPS	35	47	3	73
LEAP	NA	NA	NA	NA
SAHF	104	71	0	95
UT DHCD	0	0	0	0
Workforce development and volunteers				
HFHI	188	104	0	155
PWC	112	116	0	139
YouthBuild	323	65	2	27
New technologies and techniques				
CEO	1,002	305	0	954
CEC	98	24	15	538
NHCLF	157	163	0	72
UNCC	15	1	0	49
VEIC	NA	NA	NA	NA
Green and healthy homes				
CECLP	71	1	0	128
UI	254	79	4	383
TOTAL	**2,362**	**978**	**24**	**2,617**

Table 3.5. Percentage of client reported satisfaction by program or grant

Program or grant	Client satisfied or very satisfied with services
National WAP	94%
PWC	96%
CEO	94%
NHCLF	93%
CECLP	88%
UI	87%
EPS	83%
UNCC	79%
VEIC	78%

Method (PRISM).[6] The model produces estimates of weather-adjusted annual energy consumption for each home based on monthly usage data and daily outdoor temperatures using a variable degree-day based regression analysis. Gross energy savings for each home were calculated as the difference in the normalized annual consumption between the pre-treatment and post-treatment periods. When available,

[6] See "PRISM: An Introduction," Margaret Fels, *Energy and Buildings 9*, #1–2, pp. 5–18 (1986). http://www.marean.mycpanel.princeton.edu/~marean/

energy impact analysis for WIPP projects used a treatment and comparison group approach whereby gross energy savings were adjusted by the comparison group change in usage to yield net savings.

Table 3.6 displays the energy impact results in two categories: electric baseload (in kWh) and natural gas or bulk fuel heating (in therms). Explanatory factors for these results are expressed in further detail in the individual grantee subsections following Table 3.6. Individual tables of results are found in appendices A–H.

Table 3.6. Gross energy savings results by grantee with usable data

Grantee		PRISM (after attrition)					
		Electric baseload (kWh)			Natural gas or bulk fuel heat (therms)		
		N	*Mean*	*Median*	*N*	*Mean*	*Median*
EPS (NG heat)	Normalized annual consumption pre-weatherization	59	12,456	11,670	74	857	816
	Gross savings	59	1,579 (±699)	895	74	173 (±42)	157
	Gross savings (%)	59	12.7% (±5.6%)	7.7%	74	20.2% (±4.9%)	19.2%
PWC[a]	Normalized annual consumption pre	48	12,711	12,021	73	1,089	912
	Gross savings	48	1124 (±846)	867	73	137 (±68)	160
	Gross savings (%)	48	8.8% (±6.7%)	7.2%	73	12.6% (±6.2%)	17.5%
CEO[b]	Normalized annual consumption pre	191	19,286	18,759			
	Gross savings[c]	191	1,134 (±558)	461			
	Gross savings (%)	191	5.9 % (±2.9%)	2.5%			
NHCLF (bulk fuel heat)	Normalized annual consumption pre	5	9,774	11,253	8	602	576
	Gross savings	5	37 (±913)	136	8	124 (±81)	110
	Gross savings (%)	5	0.4% (±9.3%)	1.2%	8	20.7% (±13.5%)	19.1%
VEIC	Normalized annual consumption pre	21	9,710	9,577			
	Gross savings	21	636 (±689)	268			
	Gross savings (%)	21	6.6% (±7.1%)	2.8%			
CECLP (NG heat)	Normalized annual consumption pre	19	9,766	9,348	32	1,002	942
	Gross savings	19	−7(±719)	83	32	118 (±57)	102
	Gross savings (%)	19	−0.1%	0.9%	32	11.8% (±5.7)	10.9%
UI[d] (NG heat)	Normalized annual consumption pre	11	5,026	3,904	17	961	797
	Gross savings	11	107 (±374)	201	17	39 (±84)	27
	Gross savings (%)	11	2.1% (±7.4)	5.2%	17	4.1% (±8.8%)	3.4%

Note: 95% confidence intervals shown for mean gross savings.
[a] Energy savings were estimated in electric heated homes for 20 of the PWC WIPP households; gross savings were estimated at 2,118 kWh (±2,286) with a total energy savings of 9.7 percent (±11.4 percent).
[b] Nearly 50% of the homes with housing characteristic data were reported to have electric heat.
[c] Energy impact analysis for CEO was conducted with a comparison group for calculation of net savings. This analysis is described with results presented in section 3.3.1.
[d]Energy savings were estimated in electric heated homes for 87 of the UI WIPP households; gross savings were estimated at 872 kWh (±385) with a total energy savings of 7.9 percent (±3.5 percent).

3.1 INNOVATIVE FINANCING APPROACHES

3.1.1 City of Danville

The municipal utility company located in Danville, Virginia,[7] partnered with VEIC to implement its WIPP project. Danville Utilities aimed to develop a revolving loan program that would assist rental property owners (RPOs) with investments in energy savings measures for single-family and small multifamily buildings. They planned to do this in conjunction with community outreach efforts to recruit participating RPOs. Danville Utilities initially planned on weatherizing 300 units. Over the course of the grant cycle, this projection was decreased to 100 units. Through WIPP, Danville Utilities also aimed to expand the local pool of trained contractors in order to deliver the energy upgrades, create a system providing tenants with energy use feedback through smart meters, and implement a rental property energy use disclosure system to encourage tenant occupancy in these units.

Early in the grant cycle, project managers with Danville Utilities reported that reaching their goals, as stated in their original statement of project objectives (SOPOs), to match leveraged funds to DOE WIPP funds at a minimum of 1:1[8] was proving to be difficult. RPOs did not perceive a 50% owner contribution to be a beneficial investment; they stated that, if they planned to pursue energy efficiency upgrades, they would apply for "free" weatherization through WAP, regardless of the long waiting list. Vendor commitment also proved difficult. Only two of the recruited contractors chose to participate, with many others opting out because of prescriptive WAP policies and procedures and a protracted DOE approval process. For example, contractors and RPOs stated that, "less stringent reporting requirements and a more flexible priority list allowing preferred weatherization measures to be chosen, could encourage more buy-in on behalf of RPOs." An additional recommendation was to allow for a project SIR rather than a measure SIR.

Upon completion of the WIPP project, Danville Utilities had weatherized ten single-family rental homes. Through Danville Utilities' revolving loan fund, four loans were issued[9] and the remaining RPOs contributed 50% out-of-pocket. Leveraged fund outlays totaled $40,405, providing only 4% of the intended 1:1 match. In September 2013, because of all of these challenges—and despite Danville Utilities' efforts to overcome market challenges within the rental property sector (i.e., outreach attempts to RPOs through volunteers, civic groups and neighborhood associations, and exploring more compelling financing options)—Danville Utilities terminated its project. Its cumulative federal outlays totaled 17% of its initial grant amount.

3.1.2 Washington State Department of Commerce[10]

The Washington State Department of Commerce (referred to hereinafter as Commerce) project, "Replicable, Innovative, and Sustainable Energy" (RISE), intended to include a partnership with community development financial institutions and utility companies to establish an energy efficiency loan fund for qualified multifamily property owners and developers in conjunction with the creation of a carbon incentive fund (CIF) to complement the loan fund. The cornerstone of RISE was to provide a one-stop shop of bundled services that included a flexible combination of energy efficiency loans and carbon

[7] http://www.danville-va.gov/505/Utilities
[8] The City of Danville's original SOPO states, "While [DOE's] FOA suggests a target 1 to 3 leveraging rate, the Danville WIPP is addressing a market segment that has minimal participation in existing WAP programs, and is proposing to do that while leveraging from RPOs at a dollar-for-dollar match."
[9] Loan terms were a $3,250 cap per unit, 3 year maximum at 3–5% interest, reaching a total of $13,180.
[10] http://www.commerce.wa.gov/Programs/services/weatherization/Pages/default.aspx

credit incentives, free audits, utility rebates and incentives, and a pool of pre-qualified contractors to recruit for the work.

Developing direct agreements with lenders to manage low-income loan administration with this bundled package proved to be an insurmountable challenge within the timeframe of the grant cycle. RISE project managers faced challenges due to lack of access to sufficient technical assistance to address particulars associated with financing and loan program design.

RISE project staff reported that CIFs can be developed at the state level and replicated as an effective model to leverage weatherization costs. A methodology was developed for calculating the CIF available based on the carbon reductions through weatherization. Additionally, regional carbon emission factors applicable to weatherization measures by fuel source were identified. A $986,000 CIF was established to contribute $10–20 per ton of carbon savings attributed to the energy savings from weatherization measures. Carbon emission savings credits were to be held by Commerce to be retired or, if feasible, sold into a future carbon market. In addition, meetings with key stakeholders may have resulted in increased attention to the need for energy efficiency improvements in the multifamily housing sector. The RISE project team engaged a community development financial institution to develop and administer the loan fund for the RISE pilot, utility companies to secure energy rebate commitments, and local weatherization agencies and contractors to explore opportunities for participation. Three utility companies agreed to assist with pre-authorizing rebates for recommended measures, outreach and customer referrals. Four WAP agencies committed to in-kind and financial support.

Similar to the City of Danville case, project managers stated that property owners expressed more interest in "close to free" weatherization provided through WAP than in participating in RISE. In addition, since loan terms and options had yet to be solidified, RISE was able to market only a *concept* to property owners, rather than a *product*, resulting in increased uncertainty. This pilot was unable to clearly demonstrate the financial advantages, particularly in comparison with WAP's financial terms, necessary to secure low-income multifamily property owner participation. Owing to the short grant cycle, as well as market challenges, project scale, and reduced support from key stakeholders, DOE recommended in July 2012 that Commerce not pursue a grant extension and terminate the project.

3.1.3 Energy Pioneer Solutions[11]

The EPS WIPP project planned to engage community service agencies as referral sources for WAP-eligible households in Nebraska, obtain pre-utility data, conduct energy audits, schedule and monitor retrofits, complete on-bill financing loans with the utility company as the intermediary, and analyze post-weatherization utility data. Costs for the program were paid from DOE grant funding and leveraged energy savings dollars through the on-bill payment method. The policies and practices were already in place, including on-bill utility payments with Hastings Utilities. EPS was able to successfully weatherize 202 of the proposed 250 homes. EPS was not required to deobligate any of the awarded WIPP funds (~$800,000), and it secured 76% of its proposed leverage-funding amount (~$1.9 million).

EPS reported a relatively difficult time with recruiting households to this program because of the presence of traditional WAP agencies in its communities and the need for marketing efforts. Households that participated in the EPS program had a median income of around $24,000 and were owner-occupied. The data suggest that EPS targeted neighborhoods with homes predicted to have high energy savings potential. For example, 61% of the EPS homes weatherized were built before 1940. It is well established that WAP agencies do not typically target their program recipients in this way. Instead, they accept

[11] http://www.energypioneersolutions.com/

applications from all households within the service territory and receive referrals for weatherization from other assistance programs under the Community Action Agency service umbrella; then, according to statute, they give priority to families with children, elderly or disabled persons, and households with high energy use or a high energy burden.

EPS found it more cost-effective to complete the weatherization audit and work[12] in-house; it created a wholly owned subsidiary, Energy Pioneer Insulation and Construction. Under the WIPP grant, 292 energy audits were conducted with 196 on-bill financing transactions completed. In total, $236,400 in loans was paid out with an average loan cost of just over $1,200. With a 7% interest rate, the on-bill payment amount averaged around $25 for 60 months. Each EPS customer signed a consent form acknowledging that budget billing was a monthly average with the customer paying the same amount each month, but that individual bills might go up or down based on the calculations of the utility company and factors such as electricity prices and weather conditions. EPS billed the customer through Hastings Utilities, a customer-owned utility company. The loan payment was included as an additional line item on the customer's current bill.

Each computerized energy audit conducted relied on customer energy usage data collected from Hastings Utilities before the audit, and calculated projected energy savings so that the customer could view the anticipated energy savings and monthly loan payments. One critical component of this project was the ability to return to the home post-weatherization if the projected savings were not realized. This allowed EPS to further investigate factors contributing to lower-than-expected savings and to complete additional work, if necessary, at no cost to the customer or DOE.

The overwhelming majority of homes weatherized by EPS were single-family detached houses heated by natural gas. The energy impact analysis concluded that, in homes with natural gas heating, savings were approximately 20% (within EPS's goal estimations of 20 to 25%). The baseload electricity savings in these homes appeared to be nearly 13%. It is also notable that EPS used a computer-based audit tool for all of its weatherization jobs and made it a priority to install attic and wall insulation when it was cost-effective to do so. Largely because of the availability of WIPP funding, EPS was able to replace furnaces in 39% of homes and air-conditioning units in 25%. The average EPS job cost was approximately $3,200. DOE WIPP funds contributed nearly two-thirds of the cost, with the remainder paid for by the client through the on-bill financing.

It is uncertain whether this project would have been cost-effective or as comprehensive without the WIPP funds. EPS project staff reported high administrative costs, especially since the utility company also required EPS reimbursement for personnel staff time related to the on-bill loans and payments, as the intermediary between the customers and EPS. Finally, EPS spent approximately 10% of its DOE funding on health and safety measures, which may have not been possible without WIPP; it is unlikely EPS would have been able to recoup the costs of these measures from utility savings alone. Field observations concluded that EPS staff had genuine concern for their clients and aimed to provide effective energy education, improved health and safety in the home environment, and adequate understanding of the financing mechanism agreed to.[13] Client satisfaction surveys of EPS WIPP project recipients revealed that 83% were satisfied or very satisfied with EPS.

Overall, EPS completed just over 80% of its production goal and 76% of its leveraging goal. Nearly 200 on-bill loan transactions were completed with Hastings Utilities as an intermediary between the customers and EPS. Local utility cooperation with respect to implementing on-bill financing was essential for this

[12] Heating, ventilation, and air-conditioning work was contracted out under the EPS WIPP grant.
[13] For example, EPS customers needed to understand the "soft" lien on their homes. If the customer moves before the loan is paid in full, the balance is either paid off at sale or transferred to the new owner.

grant project to work. Based on these data, it seems plausible that this project could be replicated by local weatherization agencies with leveraged funding and in partnership with local utilities, and it is plausible to project adequate energy savings in the home for determining measure packages and loan agreements.

3.1.4 Local Energy Alliance Program

LEAP is based in Charlottesville, Virginia.[14] It partnered with the Green Jobs Alliance to demonstrate the use of an energy services company (ESCO) in the multifamily sector, as well as to achieve additional energy and water efficiency gains through a comprehensive tenant engagement and maintenance training program coordinated by Greenroots Strategies Inc. In addition, LEAP intended to investigate and pilot a carbon monetization revenue stream from carbon credit sales.

A billing analysis was not conducted for the weatherization work completed by LEAP, as insufficient billing data were provided by Dominion Power, the local utility company. However, average costs per unit[15] were calculated from data forms provided to the evaluation team by LEAP for one completed multifamily complex with 138 electrically heated units (26 buildings with 2–8 units/building) that received identical measures. Energy conservation measures (ECMs) installed at the building level included attic insulation, lighting, heating, ventilation and air conditioning (HVAC) systems, and water heaters. New windows were installed in the buildings as non-ECMs. All units received programmable thermostats and refrigerators. LEAP project managers reported that the RPO's out-of-pocket contributions exceeded $1 million, and DOE WIPP contributions were approximately $100,000. However, some inconsistencies exist between these interview findings and the quantitative findings produced from data forms completed by LEAP (Table 3.7). It is hypothesized that the remaining reported contributed costs were used for program operations.

Table 3.7. Total DOE and non-DOE costs per unit for sampled LEAP property

	ECM cost per unit	Renovation cost per unit	Total costs per unit	Total costs for property
DOE WIPP funds	$758	$0	$758	$104,604
Non-DOE funds	$1,243	$4,731	$5,974	$824,412
TOTAL	**$2,001**	**$4,731**	**$6,732**	**$929,016**

LEAP's goal of using an energy savings performance contract (ESPC) to implement WIPP services was not accomplished. The ESCOs approached (i.e., Johnson Controls, Inc. [JCI] and Siemans) expressed concern that some properties would be too small to support the costs of savings guarantees. In addition, RPOs had pre-established affiliations with local contractors and construction companies, and they expressed reluctance to hire outside their network; therefore, LEAP chose to not pursue other ESCOs.

LEAP explored another alternative funding innovation, voluntary carbon credits. LEAP's goal was to earn carbon credits generated by weatherizing single-family and multifamily homes, and then sell the credits to recover at least part of its weatherization investments. Theoretically, the revenue from the sales of carbon credits could then support the weatherization of more homes. Pursuant to these goals, LEAP worked with its weatherization clients and the main utility in its region, Dominion Power, to sign over ownership to LEAP of any carbon credits that may be awarded through its weatherization program.

[14] http://leap-va.org/
[15] According to PAGE, the average cost per unit for all 845 units was $1,820.

This process requires that an auditor, known as a validation/verification body, validate a prepared project description (PD) and then verify actual emission reductions. LEAP prepared a comprehensive PD[16] and hired Stantec (located in Victoria, British Columbia) as the validation/verification body. Clean Energy Solutions Inc. of Cambridge, Massachusetts, provided technical support to LEAP to estimate the energy savings and ensuing carbon emission reductions. This process was reportedly time-consuming and rigorous. The validator allowed only those units to be included in the PD that were weatherized after the PD process had begun: two single-family homes and four multifamily developments (with 528 units total).

Stantec required the collection of utility bills from both weatherized homes and control homes. This was achievable for the single-family homes, but not for the multifamily developments, resulting in delays. Further delays were due to Stantec's concern regarding the accuracy of the sampling methodology used by the LEAP/Clean Energy Solutions team to estimate the multifamily energy savings.

Stantec required extensive documentation of measures installed in the homes and units, reviewed all databases/spreadsheets, and required extended explanations of the methodology and software (PRISM) used to estimate energy savings and the weather data used to normalize annual energy consumption estimates. Requests for clarification and additional information by Stantec caused more delays and increased costs for this project.

Information needed to be collected each year in which carbon credits were to be claimed to verify that the estimated energy savings, and thus the estimated carbon emission reductions, were indeed occurring. Strictly interpreted, this means that every year for 10 years, LEAP would have to visit every weatherized home and unit in the multifamily buildings to document that all of the installed weatherization measures were actually still in place. LEAP and the validator worked on a sampling approach to reduce the time and cost of this provision, which would probably have made this approach to creating carbon credits cost-prohibitive.

In October 2014, LEAP estimated that its expenses in this process were approximately $40,000 and that if it were awarded carbon credits, it hoped to sell them for $20,000. It was indicated that the University of Virginia was a likely buyer of the credits. In December 2014, LEAP announced that the verification process was complete; it had been awarded 996 verified carbon units, or carbon credits, totaling 996 tonnes of CO_2 equivalent; and it had initiated its "Save A Ton Program" to sell the credits to third parties. Generating carbon credits through low-income weatherization is an attractive idea; however, the administrative costs to prepare the PD and meet the initial and ongoing requirements for carbon credit validation were, in this case, higher than the revenue expected from selling the carbon credits. However, the process that LEAP tackled for developing the PD provides a model that other low-income weatherization providers can build on.[17]

3.1.5 Stewards of Affordable Housing for the Future[18]

SAHF is a consortium of 11 not-for-profit member organizations whose missions involve the preservation of affordable multifamily housing in the US and its territories. SAHF members provide affordable housing to more than 115,000 households of low SES. More specifically, SAHF members serve the same

[16] The PD was developed according to the guidelines found in Voluntary Carbon Standard VM0008 "Weatherization of Single Family and Multi-family Homes," version 1.1. This standard was authored by the Maine State Housing Authority and several consultants. Clean Energy Solutions Inc. of Cambridge, Massachusetts, helped LEAP prepare the PD.
[17] LEAP's PD is an open-source document.
[18] http://www.sahfnet.org/

high-priority groups as WAP: persons of elderly or disability status, and families. Central to the SAHF WIPP grant was the use of ESPCs, a retrofit financing mechanism successfully used by municipalities, schools, universities, hospitals, and federally owned properties for improving energy efficiency. Together, private investment and WIPP funds resulted in energy retrofits of two large multifamily properties owned by the Preservation of Affordable Housing[19] (POAH)in the state of Rhode Island that resulted in projected energy savings of 14 and 17%.[20] The grant had intended to retrofit between 30 and 50 properties across its members' portfolios; however, only 260 of the planned 2,500 units were completed during the WIPP grant cycle. SAHF was awarded nearly $2.6 million and planned to leverage $8.75 million. A total of $1,335,274 was expended, with the DOE portion accounting for $936,698. The total amount leveraged in private funding was $398,575.

This WIPP study served to respond to issues or assumptions pertaining to the efficiency potential for the sub-sector of public and assisted multifamily housing. In June 2010, the Benningfield Group published a report specific to the energy efficiency potential (by 2020) of multifamily projects assisted by the US Department of Housing and Urban Development (HUD) and of Low-Income Housing Tax Credit projects. According to the study, nearly 68% of the five million households receiving assistance from HUD live in multifamily housing. The reported "achievable energy efficiency potential" for this sub-sector was estimated to be 29%, in part because most of the building construction was completed before energy efficiency codes were established. Only 9% of HUD-assisted buildings were built within the last 20 years. The potential for energy savings is significant for low-SES populations that depend on the preservation of affordable housing in the United States. At the time of the study, the median income for HUD-assisted renters ranged between $9,900 and $13,130 for a family of four (depending on the category of renter household). These households spent an average of 13.5% of their monthly income for energy (approximately 1/3 of their total housing costs).

For those properties where tenants pay for their utilities, SAHF asserted that owners of privately owned HUD-assisted properties do not invest in energy efficiency and water conservation measures because the full benefits from such investment do not accrue to them. When the benefits are split between the property owners and the tenants (i.e., there is a split incentive), tenants pay the same rent and pay lower utility bills without contributing to the investment. But in privately owned HUD-assisted properties, there is a variation on the split incentive—the benefits of lower utility costs primarily flow to HUD.

SAHF and HUD devised a method to allow property owner to retain the utility savings for the entire term of a loan used to finance retrofits. The option to use ESPCs for HUD properties was already available, based on HUD guidance. The only change that SAHF needed to negotiate with HUD was the existing policy related to misaligned incentives. SAHF negotiated with HUD for the right to allow its property owners to raise rents in their buildings based on projected energy savings; under this arrangement, tenants would not pay the owner of a HUD-assisted property more than their already established fixed income–based payments. This income-based payment included both rent and utilities allotments. SAHF proposed that HUD allow the property managers to *reduce* the utility portion of the tenant bill, based on the energy savings projections, and *raise* the rent portion to allow for the investment to be paid back over the term of the loan. There were concerns that tenants in that housing sector would bear the burden of risk if the projected energy savings were not achieved because energy retrofits underperformed. However, within the newly configured payment, tenants pay no more than is required based on their income as established by federal guidelines. But the payment is *restructured* to allow the savings to accrue to the owner, rather

[19] POAH is a not-for-profit organization with approximately 70 properties in its portfolio (personal communication with Toby Ast, POAH Director of Energy Management, 2014). POAH is one of the founding members of SAHF, which was established in 2003; Retrieved from; http://www.poah.org/

[20] ECMs and water conservation measures included in the JCI scope of work: interior/exterior lighting, light controls, faucet aerators, low-flow showerheads, programmable thermostats, Energy Star Refrigerators, and weatherstripping.

than to HUD, as reimbursement for the property owner's assistance in reducing utility costs. Although this process was eventually approved by HUD, it was not until January 18, 2013, that a memo was published and sent to "participating multifamily hub and program center directors" alerting them to the pilot and the approval for owners retaining utility savings. This was nearly 28 months after the start of the grant cycle and nearly 4 months after the original grant cycle end date.

SAHF contracted with JCI, which delivered a cost benefit analysis of energy and water retrofits in several privately owned affordable multifamily properties. SAHF also partnered with the Low Income Investment Fund as the lending partner. Interviews with key staff of JCI and the Low Income Investment Fund revealed that, although they found the mission of preserving affordable housing through energy efficiency valuable, the level of effort required for audits and investments was not at a scale that made the work profitable. As stated, SAHF had proposed completing between 30 and 50 properties across the portfolios of multiple members, but it completed only two.

Numerous barriers interfered with the SAHF ESPC demonstration project performing as planned.

(1) SAHF's production was delayed until the DOE contract office approved SAHF as the ESCO and approved other contract bids. The grantee had identified JCI (i.e., the ESCO) as a partner in the WIPP grant proposal and therefore did not initially follow the procurement rules established by DOE.

(2) Achieving a waiver for a standard federal policy is time- and resource-intensive. In the end, the successful development of "policy flexibilities" allowed the utility savings, necessary to repay the ESCO, to accrue to the property owners (investors) and not to HUD. Although this policy exception was not tested during this grant period because of time constraints, certain aspects of the policy flexibilities have been considered as policy incentives for other HUD energy conservation demonstrations.

(3) The process for executing ESPCs was longer than the grantee expected. Because of the barriers to production on the front end of the grant (e.g., the HUD policy change), the lengthy process of the JCI ESPC precluded participants from securing projects within the grant cycle (i.e., Homes for America). In the end, only 260 of the planned 2,500 household units were included in the demonstration.

Although the SAHF WIPP project did not perform as planned and required a 2 year grant extension, it proved valuable in illuminating the issues underpinning unrealized energy saving opportunities and investments in privately owned assisted housing. The SAHF ESPC demonstration was one of the few grants that attempted to effect policy change necessary to remove institutional barriers to increased energy efficiency in the residential sector. In this case, SAHF executed a negotiation dealing with the sensitive subject of split incentives to encourage private owners of HUD-assisted properties to invest in ECMs in the hopes of preserving affordable housing.

3.1.6 Utah Division of Housing and Community Development

Under the state of Utah WIPP project, DHCD planned to install weatherization measures in single-family houses using an innovative financing mechanism: a performance-based revolving loan fund. Although none of the awarded WIPP dollars were spent because of conflicts with the rules for the DOE grant, project managers were able to leverage $1.96 million for a major multifamily weatherization effort using a state housing trust fund to secure participation from a major financial institution. DHCD administers WAP for Utah. It also administers the state's housing trust fund—the Olene Walker Housing Loan Fund. If the proposed pilot proved successful, income-qualifying families in need of ECMs and efficiency upgrades could apply for low-interest loans to offset the cost of weatherization. The money saved from the measures would be used to repay the loan.

DHCD's WIPP proposal contained a grant funding request of $850,000 to be matched by $2.55 million in local funds for a project total of $3.4 million. The objectives of the proposed project involved weatherizing 450 owner-occupied homes after establishing a performance-based revolving loan program operated through DHCD in conjunction with WAP. The planned loans were structured for a maximum of 15 years with an interest rate of 2.75%. The grant would use data tracking technology to monitor achieved energy savings compared with projected savings in a sample of weatherized units. Project staff hoped to use the tracking technology to conduct follow-on treatments to optimize energy savings potential.

Before the WIPP grant was awarded, DHCD had established connections with Community Reinvestment Act (CRA) loan officers representing Utah-chartered industrial banks. They planned to partner with the private lending institution GE Capital to borrow grant matching funds by using the state's AAA credit rating to back the loan. However, the Utah attorney general's office discovered that the authority of the state to borrow from a private entity must be explicitly stated in a statute. Knowing that it would not be able to approach the state legislature for approval until February 2012, DHCD asked what else it could do to secure the loan. GE Capital stated it would need a loan loss reserve to move forward with the CRA loan. DHCD approached DOE WIPP project officers with the idea of using WIPP funds as the loan loss reserve required by GE Capital for the CRA-based loans. DOE reported that the funds could not be used for this purpose, so DHCD reallocated funding within the state's housing trust fund to back the loan.

After determining the roles all partners must play to secure the CRA-based loans to complete the weatherization work, DHCD was faced with marketing the pilot revolving loan fund and recruiting owners of owner-occupied single-family homes. Because of the time constraints of the 2 year grant cycle, DHCD decided to market its performance-based loan opportunity for weatherization to the multifamily housing sector. In an effort to weatherize multifamily buildings within the WIPP grant cycle, DHCD conducted surveys and moved forward with energy audits for two "loan program-ready" properties. Unfortunately, Utah did not have a state DOE-approved *multifamily* energy auditing tool as required under WAP rules. When the audit data were received by DHCD, they revealed that the SIR for the work completed on the first property was less than 1.0. This meant that no WIPP funds could be expended to weatherize the property. Thus, the project was funded at $1.96 million using the housing trust fund and GE Capital (CRA-based) loan funds. Although the second multifamily property identified and audited produced a cost-effective scope of work, the weatherization agency was unable to complete the work before the end of the grant cycle.

3.2 WORKFORCE DEVELOPMENT AND VOLUNTEER ENGAGEMENT

3.2.1 Habitat for Humanity International

HFHI, based in Atlanta,[21] proposed a model that consisted of mobilizing volunteer labor to weatherize owner-occupied single-family homes, obtaining in-kind donations from the private sector and technical assistance providers, and fundraising efforts. HFHI's project intended to use local affiliates/chapters across the country to deliver weatherization services and assist with the development of a nationally coordinated system that would include access to technical assistance and training.

This overview focuses on key findings from eight affiliates that participated in in-person interviews and one site visit with ORNL evaluators.[22] Quantitative data presented are at an aggregate level for 13 of the 26 affiliates that submitted completed evaluation data forms.[23] Based on the data provided, it was

[21] http://www.habitat.org/
[22] HFHI did not provide energy usage data, so it was not possible to conduct an impact analysis.
[23] Data received included housing characteristics for 158 weatherized units, installed measures, and project costs at the household level.

concluded that HFHI headquarters and its affiliates did not demonstrate a capability to implement weatherization equal to the WAP formula grant in terms of training, oversight, quality installations, and reporting.

The administration and training required to successfully develop a national-scale WAP delivery business model from scratch proved to be too challenging for HFHI to accomplish in the time allotted. During interviews conducted with affiliate staff, it was stated that full compliance with the reporting requirements associated with completed training, monitoring, project implementation, and quality control measures was not regulated by HFHI. Several incomplete records were provided to ORNL for review. Technical support was to be coordinated using HFHI's online portal or "national affiliate network"; some affiliates stated they were unaware that this online resource even existed. Staff also suggested that HFHI was frequently unable to provide the technical assistance required for project implementation (e.g., familiarity with Hancock's Home Energy Audit Tool and DOE reporting requirements was a major obstacle for most affiliates). In response to these statements made by affiliates, HFHI replied that the affiliates' collective level of experience in administrative and auditing skills was "very low." HFHI and the affiliates noted that this lack of experience and familiarity with audit tools[24] was a causative factor for both slow and low levels of production.

The use of volunteer labor was significantly less than the intended average of 12 volunteers per project. Because of unexpected challenges, some affiliates reported they did not use volunteers for weatherization at all. It was reported that some of the units were completed by WAP providers hired by local affiliates. During in-field evaluation interviews with volunteers, many indicated a preference to contribute to new construction efforts and/or assist with "clean" work (i.e., minor improvements and structural repairs), rather than be involved with the weatherization tasks. Interviews with crew members revealed that repeat volunteers for weatherization were rare, and training required for volunteers to correctly install weatherization measures became "too time consuming if they were only going to work one day." Based on HFHI's final quarterly report in September 2014 found in PAGE, for work completed in 436 homes, a reported 2,660 volunteers were used for a total of 22,666 hours (an average of about 52 hours of volunteer labor per home and 8.5 hours per volunteer). The data support the information gleaned from interviews that volunteers, on average, tended to work on the projects only once. Household-level evaluation data forms completed by HFHI revealed that of 158 homes, volunteers worked on only 96. The data forms did not detail whether volunteers performed weatherization or home repairs.

Some HFHI affiliates reported requiring homeowners to financially contribute to overall costs, which could include both charging homeowners market value for donated materials and charging for crew labor. Because of a lack of transparency, it was unclear if financial contributions were requested for home rehabilitation services, or if homeowners were charged for weatherization-related materials or services. In some models, interest-free loan options were available, or monthly payments were tacked on to the mortgage if the lien was held by HFHI. Payments were in some instances quite high. In one project, the total cost to the homeowner was $17,874 (which in this case did include housing rehabilitation), with monthly payments of $212. For the WAP population, payments in such amounts can be a significant financial burden. Although HFHI neither confirmed nor denied that homeowner contributions were required, they were reported by two of the eight affiliates interviewed. Another model required homeowners to pay 5% of the total cost; another required an up-front one-time payment of $500; and, yet another required the homeowner to pay 25% of the total cost. Three affiliates required only "sweat equity" as a homeowner contribution. The level of sweat equity varied in the number and type of hours,

[24] HFHI expressed that DOE delayed the approval of HFHI's chosen audit tool (Home Energy Audit Tool) for a prolonged amount of time. However, during ORNL conversations with DOE project officers, it was stated that each affiliate was given the green light early in the grant cycle to use the audit tool already approved for its state.

based on the affiliate model and a homeowner's physical capabilities. None of the affiliates reported an estimated value of in-kind donated materials per job on evaluation data forms.

Habitat deobligated 59% of its original grant award and reached 32% of its leveraging goal. HFHI reported outlays in three categories: federal (~$1.19 million), private sector (~$1.77 million), and leveraged funds ($2.86 million), with the participating Habitat affiliates listed as the source of leveraged funds.[25] The federal outlays were broken down into administration ($142,000), training and technical assistance ($89,000), and program operations ($953,000). Program operations consisted of the weatherization costs and delivery for 436 completed homes at an average cost of $2,187 per home.[26] It is unclear if the remaining $4.6 million in private-sector and leveraged funds were used for home rehabilitation, because line items by function for these outlays were not provided. The quarterly reports lack the information necessary to determine where costs were charged to homeowners for materials and labor.

Through the national evaluation, WAP providers showed reduced deferral rates through bundling home rehabilitation and weatherization practices. Survey findings revealed 66% of Habitat WIPP homes received some type of health and safety measure and 42% of homes were reported to have incurred costs associated with general repair and rehabilitation work. Through the use of donations, contributions of materials, and volunteers, HFHI could potentially decrease deferral rates by focusing on critical home repairs and health and safety measures while partnering with traditional WAP providers.

3.2.2 People Working Cooperatively

PWC, located in Cincinnati, Ohio,[27] intended to use a sophisticated model for recruiting and training volunteers to assist crew members with the implementation of its WIPP project, incorporate a client education strategy into the traditional WAP to increase energy savings, and develop a whole-house service model to lead to better outcomes in terms of health and safety and non-energy benefits.

PWC has delivered weatherization, home repair, home maintenance, and mobility modification services to low-income, elderly, and disabled clients for several decades, and has a long history of mobilizing volunteers to assist with these services.[28] Historically, PWC has conducted annual recruiting efforts, such as the Repair-a-Fair and other small community engagement events. Through WIPP, ongoing volunteer support was necessary and it became apparent it was more challenging to recruit willing participants, as weatherization work is seen as "dirty and more difficult." To assist with recruitment, PWC formed partnerships with a variety of organizations that embark on similar philanthropic and green-building endeavors. Partners included the Cincinnati Zoo, University of Cincinnati, Xavier University, Greater Cincinnati Energy Alliance, AmeriCorps, Job Corps, and Cincinnati State. These partnerships improved the level of participation.

A group training session, conducted by two PWC weatherization staff, was observed by ORNL evaluation staff. The training lasted 1.5 hours and consisted of a short video, "What is WAP," followed by an overview of a typical project, with an emphasis on worker safety issues. PWC found most volunteers preferred to work for one half-day stint, whereas others were willing to take on more. Training volunteers was determined to be cost-prohibitive.

[25] These data were retrieved from PAGE in August 2015.
[26] These data was retrieved from PAGE in August 2015. Based on data forms provided to the ORNL evaluation team (from 13 affiliates), DOE WIPP expenditures were slightly lower—an average of $1,850 per home (n=158); leveraged funds were $471 (n= 158).
[27] http://www.pwchomerepairs.org/ohio.aspx
[28] PWC became a WAP subgrantee during the period of the American Recovery and Reinvestment Act in Ohio and Indiana.

In-field observations of volunteers were conducted, and crews were debriefed. It was difficult to determine if volunteers reduced the cost of weatherization delivery through the displacement of paid staff labor time. The following observations were made:

- The volunteers reported that the orientation discussing the WAP goals and mission, as well as basic safety training, was beneficial.
- Volunteers need training on installing weatherization materials since they have varying backgrounds and existing skill sets. Providing this training in a classroom environment takes time and is expensive.
- On-the-job training, oversight, and quality assurance creates a burden on crews, which can have a negative impact on production.

Overall, PWC provided WIPP services to 324 households—48% of the projected number of units[29] and used 100% of its WIPP grant. PWC intended to leverage funds used for weatherization services provided by Duke Energy and WAP. Through WIPP, it reached 43% of its leveraging goal of $4.2 million. However, non-DOE sources comprised 58% of PWC's total costs per source, compared with an average of 13% for all of the WIPP projects (those that provided such data) combined at an aggregate level (Table 3.8).

Table 3.8. Comparison of all WIPP Grants combined and PWC costs per unit by funding source

Costs (mean) per job per source [a]	All WIPP combined	PWC's WIPP (n=269)
DOE WIPP	$3,965	$3,249
Non-DOE	$574	$4,441
Non-DOE %	13%	58%
TOTAL	**$4,539**	**$7,690**

[a] This table shows DOE WIPP and non-DOE costs only. Zero homes reported cost values for DOE non-WIPP costs.

On average, PWC per-unit costs totaled $7,690 (Table 3.9). The health and safety and renovation costs (non-ECM) were 10% of the total costs.

Table 3.9. PWC costs per unit by category (ECM and non-ECM)

Costs (mean) per job per type	PWC
ECM	$6,909
Non-ECM	$782
Health and safety	*($512)*
Renovation	*($270)*
Non-ECM %	10%
TOTAL[a]	**$7,691**

[a] Total values differ slightly from those in Table 3.8, as units reported for data analysis with missing ECM data are excluded.

[29] Projected number of units cited from original grant proposal.

An energy bill analysis[30] estimated that the mean gas heat savings from PWC's WIPP projects was 12%, the mean electric heat savings was 10%, and the mean electric baseload savings was 9%. The occupant survey revealed that 93% of households were satisfied or very satisfied with the energy savings in their homes after the PWC work was completed. Through WIPP, PWC aimed to improve health and safety outcomes; however, only 43% of PWC's clients claimed they received information on ways to improve health and safety, and only 23% claimed they were satisfied or very satisfied with the information received on this subject. Through both the occupant survey data and cost analysis, it is difficult to establish whether or not PWC successfully advanced outcomes through the installation of health and safety measures or through education.

3.2.3 YouthBuild USA

YouthBuild USA. Inc., [31] based in Somerset, Massachusetts, coordinated with six YouthBuild affiliates[32] across the country to implement its WIPP project. YouthBuild's goal was to use a workforce pool from the graduates of the YouthBuild program and implement a train-the-trainer model for new hires. Instructors with each affiliate were to be trained and then train YouthBuild students and graduates for entry-level employment, as well as prepare them for certification exams.

Organic Think Inc., a consulting and training organization, partnered with YouthBuild to develop a standard curriculum and provide training for affiliate staff and graduates of the program. Several on-site training sessions were conducted for each affiliate; webinars were provided as well. The weatherization curriculum was reported to include ~75% hands-on instruction. The introductory level auditing aspects of the training used curriculum suggestions provided by International Builder's Show advisors.[33]

In YouthBuild's original proposal, the trained workforce pool was to be YouthBuild graduates; however, YouthBuild USA later reported that the training was also provided to the general population. A trainee survey was administered by the evaluation team to characterize the perceived quality and comprehensiveness of the training model.[34] All participants reported they were graduates of the YouthBuild program. An unexpected finding was that these trainees were not recent graduates, as the average age was 32 years old. Following are some summary descriptions drawn from the survey:

- Close to half of the respondents had attended some college, and the other half had a high school diploma or equivalent.

- Of those responding, 46% reported they learned most of the weatherization skills they had as YouthBuild students, 36% through on-the-job training after being employed in weatherization, and 9% through formal weatherization training classes or workshops provided by their weatherization employers.

[30] Sample sizes, after attrition, were as follows: gas heat (n=73); electric heat (n=20); and electric baseload (n=48).
[31] The YouthBuild program serves at-risk youth between the ages of 18 and 24 who have barriers to employment, by providing academic and vocational training, social service support and stipends. https://www.youthbuild.org/
[32] Community Renewal Team Inc. in Hartford, CT; United Way of Long Island, NY; Civic Works Inc. in Baltimore; Southern Appalachian Labor School in Kincaid, WV; Red Lake Nation in MN; and Pathways Inc. in Petersburg, VA
[33] Information regarding training and curriculum was provided during personal correspondence with Rob Moody, a consultant/trainer with Organic Think Inc.
[34] Despite repeated requests for contact information for recent trainees to administer the trainee/staff survey, only one of the six affiliates complied; therefore, the resulting sample size was quite small at n=11.

- After being employed in weatherization, 55% reported receiving formal training at a center, 73% reported receiving quite a bit to a great deal of on-the-job training or mentoring, and 18% received some training through webinars.[35]

- 82% received training in health and safety topics and 82% learned a great deal about energy savings.

- 80% reported there was not any training they felt they still needed (but were unable to get) to deliver entry-level weatherization.

- Job titles held by respondents, at the time of the survey were crew member (27%), crew leader (18%), and auditor (9%).[36]

Through WIPP, YouthBuild created (or retained) 370 jobs (PAGE 2015) and 925 graduates attained some type of credential.[37] YouthBuild stated in its original proposal that it planned to "employ 74 graduates that [after undergoing the provided training] would be certified for OSHA-10, Residential Energy Services Network's (RESNET) Home Energy Rating System (HERS) Professional, or Building Performance Institute's (BPI's) new air leakage control installer and dense pack insulation installer credentials. The credentials and number received were successful completion of the OSHA-10 Construction Safety course—306, entry-level BPI certifications—13; BPI Building Analyst—7, and RESNET's HERS Professional—42.

Each affiliate adopted its own approach to recruitment and training. Each also faced unique challenges, with some reporting more favorable outcomes than others.[38] One of the affiliates was reported to have positioned itself to transition its model into a fee-for-service division—hiring trained graduates and leveraging weatherization services for further training programs.

3.3 NEW TECHNOLOGIES AND TECHNIQUES

3.3.1 Commission on Economic Opportunity[39]

CEO operates both as a traditional WAP provider and as a weatherization contractor for the Pennsylvania Power and Light (PPL) Electric Utilities Winter Relief Assistance Program (WRAP). For the purposes of this grant, CEO installed in-home displays (IHDs) and coordinated energy education and outreach delivered by Energy Corps AmeriCorps[40] volunteers in concert with the PPL contract. This strategic move allowed CEO WIPP and PPL program staff the opportunity to explore electricity savings and attribute them to the energy information monitors and to the education received from the trained Energy Corps volunteers. CEO provided IHDs and energy education to 2,501 low-SES households in Pennsylvania. It used experts in weatherization and consumer energy education to train the Energy Corps volunteers on the use of transformative dialogue and the most effective ways to reduce baseload electricity consumption. The study also employed electricians to install the IHD technology during the

[35] These results are not mutually exclusive.
[36] The remaining responses were "not applicable" (18%) and "not answered" (27%).
[37] Data reported on October 29, 2015, through personal communication with Eva Blake, YouthBuild's WIPP project manager.
[38] Three affiliates did not comply with ORNL data collection requirements, requests for project reports, and requests to host a site visit. Therefore, anecdotal data associated with project implementation are limited in scope and were provided through conversations from one participating affiliate and with YouthBuild USA, whose role was to provide oversight for the affiliates.
[39] http://www.ceopeoplehelpingpeople.org/
[40] The Energy Corps AmeriCorps is "an initiative of the National Center for Appropriate Technology (NCAT) in cooperation with The Corporation for National and Community Service. The Energy Corps was created to address unmet community energy needs by promoting sustainable energy consumption and education, fostering community sustainability and helping to mitigate the effects of global climate change." For more information on this initiative, see http://www.energycorps.org/.

education sessions. The project was initially designed to test different brands and types of IHDs to best meet the needs of its diverse customers.

As a traditional WAP provider, CEO was able to efficiently navigate the reporting requirements and regulations set by DOE. This afforded it the opportunity to move swiftly into the production phase of the grant. Additionally, no part of the project design was overly complex or required significant policy or programmatic changes. CEO was successful in meeting both its production target and 3:1 leveraging goal.[41] The project expended nearly $6.5 million: $1.6 million from DOE and $4.9 million from PPL.

The CEO WIPP project was unique as it offered a comparison group derived from PPL data sets for net energy impact results to be calculated. The only difference between the treatment and comparison groups was the addition of IHDs and energy education. The vast majority of the CEO WIPP homes on which the ORNL-led evaluation team received information (1,850 out of 2,075, or 89%) were single-family homes. All CEO WIPP clients were weatherized by PPL or were in the queue for PPL weatherization services. Approximately half of the households included in the sample reported electricity as their primary heating fuel; 70% had electric water heating equipment.

Evaluators received electricity usage information for 417 WIPP jobs, 288 of which had enough pre- and post-weatherization usage for analysis. A comparison sample of 287 cases was selected from WRAP jobs completed in 2011 that were not CEO WIPP clients. After applying the gross savings generated from the comparison group that did not receive WIPP technology or education, the net savings from the CEO grant resulted in a mean 4.0% reduction in baseload electricity consumption across all households (Table 3.10). This savings result is comparable to the savings of the VEIC grant, which also included the installation of IHDs (Section 3.3.5). The savings realized in a high-energy-use group of homes in the pilot (i.e., mean pre-intervention electricity consumption of 26,349 kWh) resulted in an average net savings of 1,896 kWh (7.2%). These homes, found in one particular region within the PPL/CEO service territory, were also described as having received "full-cost" weatherization (i.e., comprehensive weatherization versus baseload-only treatment) through WRAP. The group of homes with the lowest results for energy savings from IHDs (<1%) tended to be households that received "baseload only" weatherization retrofits from PPL.

Table 3.10. Mean gross and net electricity savings generated from the WIPP CEO data by job type

Normalization method: PRISM (after attrition)						
Group	**Analysis group**	**N**	**Normalized annual consumption pre-weatherization (kWh)**	**Gross savings (kWh)**	**Net savings (kWh)**	**Net savings (%) of pre-weatherization consumption**
All jobs	WIPP	191	19,286	1,134	766 (±690)	4.0% (±3.6%)
	Comparison	195	19,095	368		
Full-cost jobs in one region	WIPP	52	26,349	2,372	1896 (±2344)	7.2% (±8.9%)
	Comparison	84	23,361	476		
Baseload-only jobs	WIPP	56	12,433	88	67 (±944)	0.5% (±7.6%)
	Comparison	58	12,233	21		

Note: 95% confidence intervals shown for net savings.

[41] The project was initially awarded $2.5 million but expended only $1.6 million (while still meeting production goals).

3.3.2 Community Environmental Center

CEC, a traditional WAP provider located in Long Island City, New York,[42] planned to leverage financial and in-kind resources from a range of stakeholders—including contributions from multifamily property owners—to implement its WIPP project. CEC's project had several components, most of which did not proceed as planned or faced insurmountable obstacles.[43] Because of these challenges, CEC experienced significant delays in production.[44] Almost 2 years into the grant cycle, and past ORNL data collection deadlines, CEC had treated fewer than 10 units; therefore, an energy impact analysis could not be conducted. This overview focuses on anecdotal findings collected through site visits and correspondence with CEC's WIPP project managers and DOE project officers.

In New York State, there has been a wide variance in multifamily owner contribution requirements over the years (anywhere from 0 to 50% since 2000). This variance has led to program inconsistency and unrealistic expectations from owners. CEC developed a procedure that calculates the portion of monetary savings from weatherization that will benefit the owner over a 5 year period; this savings determines the owner's contribution. It was reported by CEC's WIPP management that building owners did not want to participate in WIPP projects that, by design, required a significant financial contribution, even after being informed of the projected savings. Instead they chose to pursue weatherization provided through WAP (or other energy efficiency programs) as those were "better deals." The American Reinvestment and Recovery Act (ARRA), which funded WIPP, also resulted in an influx of funding to WAP over a multiyear period which was atypical. WAP traditionally does few multifamily projects because funding was and is a fraction of the ARRA level and is available in single year increments making it difficult to schedule and implement large projects.

CEC's goal of leveraging financial and in-kind resources from local stakeholders at a 3:1 match was not accomplished. CEC achieved only 3% of its original leveraging goal. However, CEC reported that it developed internal procedures and financing mechanisms to allow multiple streams of funding through state energy efficiency incentive programs to be deployed in single buildings. CEC staff indicated that this process allows it to regularly supplement WAP funding with New York State Energy Research and Development Authority programs for increased benefits.

CEC also intended to explore monetizing the reduction of carbon emissions and quantify the societal benefits using a software model, the Societal Externality Assessment Mechanism (SEAM),[45] as an SIR buy-down mechanism. However, because of the low cost of carbon, the modeling with SEAM showed the impact was not significant; therefore, CEC was unable to justify the inclusion of more "deep" energy savings measures to the extent intended because of WAP's SIR requirements.[46] CEC stated it would like to develop the tool further to incorporate societal benefits beyond simply carbon mitigation, including improved health from air pollution mitigation and a decreased urban heat island effect from "cool" roofs to fully reflect the benefits of low-income weatherization.

[42] http://www.cecenter.org/

[43] This grantee was assigned by DOE to the new technologies and techniques category, based on its original project objectives. As its project progressed and modifications were made, innovative financing became a major component.

[44] Hurricane Sandy hit the CEC service territory during the WIPP performance period. CEC should be commended for persevering despite the serious setbacks encountered that greatly disrupted the infrastructure and housing market in New York City.

[45] SEAM was developed by Forsyth Street Advisors.

[46] It was also reported that DOE informed CEC that, according to regulations, CEC could not incorporate carbon emission reductions into the SIR, even though this objective was included in the original grant proposal and was approved.

3.3.3 New Hampshire Community Loan Fund

The cornerstone of NHCLF's WIPP project was to maximize the cost-effectiveness (SIR) of weatherization by purchasing material in bulk and working within densely populated, single-family manufactured-home communities. NHCLF also proposed to hire and train two residents within each community to serve as energy efficiency advocates and assist with outreach. The main purpose of this component was to facilitate these processes and to obtain applications from a large number of homeowners in close proximity.

Findings show that the close-proximity production model required applications within each resident-owned community (ROC) to be processed as a group. This requirement could inadvertently target households that are not categorized as high-priority. In the NHCLF project, approved applicants may have been moved up the waiting list, in turn bypassing higher-priority households, according to the WAP purpose and scope.[47] However, 42% of households served in the sample were reported to have a high energy burden which is one of five priorities under WAP.[48]

Anecdotal findings revealed that close-proximity production increased the number of homes served by minimizing travel times and increasing crew collaboration and sharing of materials. NHCLF estimated that an auditor could save 33–50% in labor costs by increasing the number of homes inspected in one day; however, additional factors could impact the accuracy of these cost savings estimates:

- If weatherization providers use a contractor model, productivity gains and efficiencies from labor/travel time reductions may accrue to the contractor rather than the agency. There was no decrease in contractor pricing per unit or reduction in material costs.

- Of the 38 ROCs served by NHCLF's participating WAP subgrantees, the percentage of homes within each ROC that received weatherization through WIPP ranged from 1 to 70%. Only 29 of the 38 ROCs had a sufficient number of homes weatherized to gain any potential benefits from clustering the houses by targeting neighborhoods.

WIPP project managers stated that the Energy Advocate project component was found to be unnecessary —crew visibility within these dense neighborhoods and word-of-mouth from a trusted source through social networks proved more successful. Findings from the Occupant Survey (n=60) showed that 53% of the WIPP program recipients had conversations with a member of their ROC about weatherization and 61% learned about ways to save energy in their home. When asked, *"How important was your community's support of this weatherization program to your decision to apply?"* 72% of the respondents stated it was very important.

The mean bulk fuel savings[49] through NHCLF's WIPP was found to be 12.5 MMBtu/year [50]. On average, NHCLF achieved 1,028 cfm reductions in air leakage rates. Duct sealing was completed in 84% of

[47] The WAP purpose and scope as stated in the Code of Federal Regulations 10 Part 440.1 is "to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high energy burden." (Code of Federal Regulations 2011) When ARRA funding is not available, virtually 100 percent of the households served fit into one of these priority categories.
[48] Defined as those with the lowest income and highest energy use (accounting for household size).
[49] The majority, 81%, of NHCLF's WIPP mobile homes were heated by fuel oil, with 14% heated by propane (referred to in combination as "delivered fuels").
[50] NHCLF completed weatherization of a total of 382 homes. ORNL received data for 137 of those jobs. Owing to attrition and lack of sufficient pre- and post-weatherization usage data, the sample size for the energy impact analysis was eight homes.

NHCLF's WIPP mobile homes. The client satisfaction survey revealed that 85% were satisfied or very satisfied with the energy savings achieved after the NHCLF weatherization.

Leveraging through the Regional Greenhouse Gas Initiative and electric utility funds [51] allowed NHCLF to install additional non-ECMs (Table 3.11). The flexibility of these funds allowed for more opportunities for home rehabilitation, in turn decreasing rates of deferrals. Non-DOE funds constituted 67% of the mean costs per job for NHCLF's WIPP (Table 3.12).

Table 3.11. NHCLF WIPP costs by category for the same climate zone and housing type

Costs (mean) per unit per type	NHCLF's WIPP
ECM	$4,923
Non-ECM	$2,422
Health and safety	*$375*
Renovation	*$2,047*
Non-ECM %	33%
TOTAL[a]	**$7,345**

[a] Total values differ slightly from those in Table 3.12, as units reported for data analysis with missing ECM data are excluded.

Table 3.12. Comparison of all WIPP grants combined and NHCLF WIPP costs per unit by funding source

Costs (mean) per job per source [a]	NHCLF's WIPP (n=137)
DOE WIPP	$2,424
Non-DOE	$4,900
Non-DOE %	67%
TOTAL	**$7,324**

[a] This table shows DOE WIPP and non-DOE costs only. Zero homes reported cost values for DOE non-WIPP costs.

3.3.4 University of North Carolina Charlotte

Under UNCC's pilot project, "Streamlined Weatherization Improvements for Tomorrow" (SWIFT), project managers planned to install weatherization measures in 800 owner-occupied HFHI houses using an innovative financing mechanism through a home energy loan pool (HELP), with the goal of developing a low-income weatherization program less dependent on government funding. The HELP loan was financed through the North Carolina Housing Finance Agency (NCHFA) charged with distributing a finite Duke Energy–funded loan pool to income-eligible households as zero-percent-interest forgivable loans of up to $10,000. Through the recruitment of homeowners by local HFHI chapters in North Carolina, the project intended to test the use of volunteer labor, partnerships with national retailers of weatherization materials, and the installation of innovative technologies alongside traditional measures (i.e., ductless heat pumps, in-home energy monitors and occupant education, and automated whole-house fans that bring in fresh air through the HVAC system in lieu of using the central air conditioning when appropriate). During the 3-year grant cycle, this DOE-funded project resulted in 95 homes being weatherized at an average program cost per unit of just over $16,000.

[51] Leveraged funds and sources include Regional Greenhouse Gas Initiative funds, $1,997,132.49; utility funds, $1,008,619.83.

The UNCC project team opted to develop a new model for the application of low-income weatherization with new partnerships and protocols instead of expanding upon or modifying the existing DOE WAP model. SWIFT project managers—highly qualified in architecture and electrical engineering—stated that although they focused on the development and implementation of the new model, little time was left during the grant cycle to develop and apply the innovative technologies slated for the project: ductless heat pumps, in-home energy monitoring devices, and whole-house fans. No ductless heat pumps and only two whole-house fans were installed during the project. The pilot installed 45 IHD energy monitors along with "commissioning" (i.e., consumer energy education). However, evaluators were unable to determine the cost-effectiveness (e.g., the SIR) for these devices, as the data required to do so were not delivered by the grantee in time for an energy impact analysis.

The UNCC SWIFT project was awarded approximately $2 million and spent $1.7 million. Of the approximately $798,000 leveraged (13% of its goal), $767,000 was delivered through the forgivable loan pool.

After only a few weatherization installations, UNCC recognized challenges associated with using volunteer labor (university students) and abandoned this component of the project. SWIFT managers reported engaging 95 volunteers, who completed a total of 112 hours of work. It was noted that the term "engaged" indicated that students had signed up to volunteer but may not have actually performed any work. Reported difficulties in using university student labor included volunteers showing up late to the work site (if at all); time spent by the contractor training the volunteers on-site; high volunteer turnover rates; and, most important, time spent correcting the work completed by volunteers after homes failed inspections by the third-party auditor, Advanced Energy. Advanced Energy is the Home Performance with Energy Star program sponsor for North Carolina and helped develop the standards for the HELP loans distributed by NCHFA. Final inspections conducted by Advanced Energy were a condition of accessing HELP. SWIFT project managers reported the units that failed inspections did so because of poor duct and air sealing. On-site inspections conducted through this evaluation indicated a need for increased technical expertise and auditor training.

NCHFA is the same loan company that the HFHI owners used to finance the construction of their new homes, so they had some familiarity with the loan process, which often is intimidating. Offering home visits by family specialists, and an attorney, as part of the NCHFA loan agreement further accommodated the clients. The average loan amount for a unit without a heating system replacement ranged from $6,000 to $7,500. With a new heat pump the loan was approximately equal to or less than $10,000. All the loans were guaranteed to have no monthly payments, and $1,000 per year was forgiven for 10 years, as long as the homeowner remained in the home.

It seems clear that WAP as a grant program requires less commitment on the part of the client than a program in which clients are obligated to remain in a home for the life of the loan to avoid any penalties. Although this alternative financing option and its delivery through SWIFT offered "free" weatherization to income-eligible HFHI homeowners through an efficient and client-centric process, the project was not sustainable. WIPP funds were necessary for project administration, program operations, and training and technical assistance. Additionally, the HELP established by Duke Energy was a finite loan pool. Finally, the demographics of the homeowners who participated in this study seemingly matched only two categories of vulnerable persons explicitly described as high-priority in WAP statute: households with children and those with high energy burdens.

3.3.5 Vermont Energy Investment Corporation[52]

VEIC is an administrator of three energy efficiency utilities, including Efficiency Vermont. Therefore, it has investments and access to a wide range of residential energy efficiency targets, programs, and data. The VEIC WIPP project was designed as a companion study to another DOE grant in which VEIC was participating, the Smart Grid Infrastructure Grant (SGIG). The $66 million SGIG project endeavored to deploy automated metering infrastructure (AMI), grid automation, and security technologies across the state of Vermont (Donovan, Bleything, and Enterline 2014). The VEIC WIPP grant was characterized as a consumer behavior study with the aims to (1) "determine the technological factors that put low-income households in a stronger position to reap the benefits of smart grid technologies they are helping to pay for," and (2) "demonstrate the benefits of well-established integration of the WAP provider network, energy efficiency programs, and distribution utility services that otherwise would typically operate alone in assisting low-income households." VEIC planned to install 750 IHDs in WAP-eligible homes to measure incremental electricity savings from efficiency coaching (i.e., consumer education), IHDs, and their subsequent feedback. Feedback on household energy use was delivered through both the IHD interface and a web-based portal. Two groups within the study were distinct from one another, and the impacts of the services they received were compared and analyzed by the VEIC project team (Donovan, Bleything, and Enterline 2014). One group received energy coaching with Proactive Customer Service via telephone; the other received on-site energy coaching from a weatherization expert through a local WAP provider.

The study ran for 12 months within the 3-year grant cycle and expended approximately $817,000: $617,000 from DOE (86% of the requested grant amount) and $200,000 (the full amount of the proposed leveraged funding) from utility, ratepayer, or system benefits rebates. The intent of the study was to learn how best to engage and prepare low-SES households AMI and smart-grid technologies. -

Implementation challenges became evident early in the grant cycle. Dependence on new technology yet to be deployed impacted the project's timeline and posed unforeseen challenges with recruitment. It was observed that the web-based portal available for households to track energy usage in the home was not consistently used as expected. A survey of study participants administered through the ORNL evaluation indicated that 22% found the web portal influential in how they use electricity, compared with 58% influenced by the IHD. This is consistent with the results derived from the VEIC survey (conducted internally) of participants, in which 70% reported checking the IHD weekly, compared with 17% who reported logging into their web-portal (Donovan, Bleything, and Enterline 2014). This knowledge of consumer behavior is critical, considering that study participants were required to have broadband internet for the technology to work. Energy usage data were collected using a current transformer clamp, which then communicated the data to the web portal for household access to real-time usage. Strict criteria for study inclusion (e.g., broadband internet, home ownership) resulted in a need for extensive recruitment efforts to secure eligible households, using multiple data sets to search for eligible households (i.e., WAP, Low Income Home Energy Assistance Program [LIHEAP], and utility). This difficulty was believed to have restricted the study to a small percentage of WAP homes, which then impacted the sample size (116 actual compared with a planned 750 households), ultimately limiting the defensibility and usefulness of results. According to project staff interviews, multiple visits to homes to complete the audit, installations, and technical support resulted in participant fatigue and instances of noncompliance.

Of those participants with completed survey information, 84% resided in single-family site-built homes and 16% resided in mobile homes; all were homeowners. Of the households served by VEIC, 59% contained children, and fewer elderly persons (10%) were served. Of those homes with completed heating

[52] https://www.veic.org/

characteristic information, the majority (56%) were heated with fuel oil, followed by natural gas (17%), propane and other fuel (12% each), and electricity (3%). Of those homes in the VEIC sample with documented heating system types, the majority were equipped with central forced-air systems (68%), followed by boiler systems (18%), wall/room heaters (12%), and electric baseboard heat (2%). No homes were documented to have central air conditioning; 59% reported the use of window or wall air-conditioning units, and 41% reported no air-conditioning equipment. Most of the water heating equipment was reported to be electric (37%), followed by propane and natural gas at 22 and 19%, respectively.

Electricity usage data were received for 107 of the 116 VEIC recipients of an IHD. The data were processed and energy savings were estimated using PRISM. The WIPP IHD install date was used to define the pre- and post-weatherization periods. Of the 107 homes with usage data, 21 remained after attrition and were used to evaluate the electricity baseload impact. The analysis conducted and presented herein combined the two study groups that received two different forms of energy coaching. The mean normalized annual consumption pre-intervention was 9,710 kWh and the gross savings was 636 (±689), resulting in a mean 6.6% savings (±7.1%) across households included in the analysis. It is interesting that the VEIC study team found that Proactive Customer Service telephone coaching "yields up to 5% energy savings" compared with households that received on-site coaching, in which savings were observed to be negligible despite the IHDs provided to both groups (Donovan, Bleything, and Enterline 2014).

Because the VEIC WIPP grant completed projects in only 15% of its planned number of units, the lessons learned from this study further illuminate the challenges associated with innovative technologies and behavioral strategies for use by and applied to low-SES households. Further research is needed to determine actual savings attributable to IHDs and energy coaching with more precision.

3.4 GREEN AND HEALTHY HOMES

3.4.1 Coalition to End Childhood Lead Poisoning[53]

The CECLP WIPP grant was funded to better integrate weatherization into the organization's Green & Healthy Housing Initiative (GHHI) operating nationally as an evidence-based healthy housing program. GHHI was designed to

> streamline programs that address health, safety, lead hazard reduction, energy efficiency, and weatherization into an integrated, comprehensive "whole house" approach to better serve low and moderate income populations at the local level.

This integrated service delivery strategy ideally results in energy and non-energy benefits (e.g., improved health and education outcomes) achieved through improved energy efficiency and IEQ for low-SES households disproportionately burdened by health disparities and other psychosocial stressors (e.g., fuel poverty, missed days of work and school). Within the spirit of the GHHI mission, the CECLP WIPP grant sought to use the existing service integration model as a platform for comprehensive weatherization work in Baltimore City to produce "healthy, green and safe units." Additionally, this grant offered an opportunity to weatherize units that might have otherwise been deferred because of health and safety hazards in the home.

The CECLP grant was leveraged by numerous third parties from both the nonprofit sector (i.e., Civic Works, Open Society Foundation, Annie E. Casey Foundation, and United Way of Central Maryland) and the government (i.e., Maryland Energy Administration and both Baltimore City and Maryland

[53] http://www.greenandhealthyhomes.org/

Departments of Housing and Community Development). This leveraged amount totaled nearly $350,000. This amount was substantially lower than planned in part owing to the inability to count grant funding secured by HUD as "leveraged" because HUD is another federal agency. CECLP expended approximately $1.1 million of the awarded $1.3 million in DOE WIPP funds.

CECLP completed interventions in 212 units, having planned to complete 210. The ORNL-led evaluation team received housing characteristic information on 66 units. Of those units, 61 were single-family attached homes, and the rest were single-family detached buildings. Of those units with collected data, all had basements, and all but one unit were heated with natural gas. Of the units served by CECLP, 93% had natural gas water heating, and 51% of the homes with housing characteristic data had window or wall air-conditioning units.

Billing histories for gas usage were received for 49 households. After attrition, only 32 cases were analyzed for energy savings. Nineteen of the 55 cases with usable electricity data were analyzed. There was no comparison group. Through the energy impacts analysis led by APPRISE (Applied Public Policy Research Institute for Study and Evaluation), it was estimated that the CECLP WIPP project resulted in an average estimated energy savings of 11.8% in natural gas–heated homes and zero savings in electric baseload. The average job cost was $5,206, with the DOE WIPP portion contributing $1,883 (36%) on average.

Characteristics of the CECLP grant that diverged from the WAP national program related to the types of measures installed. CECLP used the approved priority list as its diagnostic approach for determining ECMs for all of its homes. Four percent of the housing units received furnace replacements, and 38% received duct insulation under the CECLP grant. Of the cases with data for the installation of programmable thermostats, 71% received this type of thermostat under the grant. No refrigerators were reported to be replaced during the CECLP project.

Of high importance is that 96% of those households served by the CECLP WIPP grant, where demographic information was attained, self-identified as black, non-Hispanic. This is critical when considering the intent of CECLP and the GHHI program to reduce health disparities associated with pediatric asthma, which disproportionately burdens communities of color (Centers for Disease Control and Prevention 2014).

3.4.2 The United Illuminating Company[54]

The primary objective of the UI WIPP project was to develop a "one-touch" approach for better integration and streamlining of programs that provide housing-related services to low-SES households in the state of Connecticut. Under the WIPP grant, and in partnership with Connecticut Light and Power (CL&P) and the Connecticut Energy Efficiency Fund, UI led the Connecticut Efficient Healthy Homes Initiative (CTEHHI). The CTEHHI developed into a partnership network[55] to address the health, housing and energy needs extending beyond the scope of its utility weatherization program, Home Energy Solution-Income Eligible. The UI WIPP project expended the total $3 million awarded by DOE and leveraged just over $3.5 million in utility ratepayer or system benefits funding from UI and CL&P. The project completed 968 of the 2,285 planned units (42%).

[54] https://www.uinet.com/

[55] The Connecticut Children's Medical Center's Lead Action for Medicaid Primary Prevention (LAMPP) was an integral partner in shaping the initiative. Other partners included Bridgeport Neighborhood Trust, the city of New Haven, the city of Bridgeport, Connecticut Department of Public Health, Connecticut Housing Finance Authority, L. Wagner & Associates, NauVEL, NeighborWorks New Horizons, and Yale–New Haven Hospital.

An important deliverable of this project was the Healthy Homes Assessment Checklist[56] developed from WAP's Weatherization Health and Safety Guidance (i.e., Weatherization Program Notice [WPN] 11-6[57]) as an instrument for assessing health and safety issues in a home. The delivery of this "Weatherization Plus Health" model adhered to the major principles of healthy housing as established by the National Center for Healthy Housing. Results from the checklist were then integrated into the scopes of work to allow for a more comprehensive retrofit while remaining in compliance with WAP rules. The partnership network established through the WIPP grant provided an approach for securing resources in instances where the needs of the households extended beyond the scope of CTEHHI, or conversely, when the needs extended beyond the scope of the agency referring the household to CTEHHI.

The APPRISE-led energy impact team received data for 171 homes from the UI project managers. Of the homes represented, 75% were reportedly single-family site-built homes (1–4 units) and the remaining 25% were large multifamily buildings (>5 units). 97% of the recipients served rented their homes. The majority of homes were heated with electricity (76%). The remaining19% and 5% of homes were heated by natural gas and fuel oil, respectively. Fifty-nine percent of homes were equipped with central air conditioning. All of the homes included in this characterization analysis received an energy audit. The UI project, on average, reduced the leakiness of a home (measured in cubic feet per minute of airflow from the building under 50 pascals of air pressure) by 183 CFM 50. Blower door tests were not always conducted before weatherization–auditors cited health and safety concerns as the primary reason–and were conducted during the inspection only "if needed." Insulation was typically installed only in the attic. Under the UI WIPP grant, 59% of furnaces and 65% of air-conditioning units were replaced as ECMs. Finally, 66% of units received new refrigerators. Only 1% of UI WIPP units received more than two major ECM measures.

Of the 171 homes for which data were received by the evaluation team, electric usage information was collected for 167 homes and natural gas usage information for 21 homes. The usage data covered billing through March of 2013. Because most jobs were not completed until the second half of 2012, few homes had enough post-weatherization usage data beyond the final job completion date. Many of the homes for this grantee experienced lengthy delays between the work start dates and the final inspections, in part because of employee turnover at the management level. As an alternate approach to estimating savings, APPRISE defined the post-weatherization period as the billing history after the weatherization start date. These results likely underestimated savings: 4.1% for natural gas, 2.1% for electric baseload, and 7.9% for electric heating.

The average job cost across the UI WIPP homes was estimated to be $5,149: $4,458 for ECM costs and $692 for non-ECM costs. This does not include costs to other partner programs, as those data were not available. On average, the DOE WIPP grant contributed $2,029 per unit, and the two utility programs contributed the remaining $3,121.

Challenges to meeting the planned level of production are attributed to the need for approval for the proposed energy auditing tool and the healthy homes checklist,[58] project management turnover, the inherent complexities of completing multifamily weatherization, and a lack of control in collaborating with multiple partners. Also, additional training was required to better equip staff with (1) the adoption of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62-2 standard for adequate ventilation[59] and improved IEQ and (2) the use of the Healthy Housing Assessment

[56] Retrieved from http://www.waptac.org/data/files/website_docs/healthy_homes/healthy-homes-checklist.pdf.
[57] Retrieved from http://waptac.org/data/files/website_docs/government/guidance/2011/wpn%2011-6.pdf.
[58] The healthy homes checklist was developed with guidance from WIPO staff.
[59] The percentage of homes that received mechanical ventilation was not provided by UI.

Checklist and best practices for engaging occupants about the health and safety needs of the home.[60] Unfortunately, tracking data related to the number and types of referrals made to partners within the resource network developed under the CTEHHI were not received by the ORNL-led evaluation team. These data would have allowed further assessment of the impact(s) of the grant.

[60] Ellen Tohn of Tohn Environmental Strategies provided on-site training. Staff also completed the Essentials for Healthy Homes Practitioners course developed by the National Center for Healthy Housing.

4. CONCLUSIONS

The DOE WIPP grant resulted in a better understanding of the challenges associated with innovative technologies and features, the use of volunteers, financing approaches, and implementation strategies to be considered for adoption by WAP. This evaluation underscores the importance of piloting these innovations before they are included alongside or in replacement of standard WAP mechanisms, to ensure compatibility and alignment with WAP goals and mission.

WIPP Project Advantages, Challenges, and Apprehensions

Grantees that applied innovative, but not overly complex, features to well-established programs founded on evidence-based practice seemed to prove better able to fully realize the potential of the piloted idea within the grant cycle. These grantees experienced fewer challenges than pilots requiring major policy amendments (e.g., US Department of Housing and Urban Development rules related to misaligned incentives for tenants and property owners), projects with multiple innovations (e.g., alternative financing, new technologies and approaches, and volunteer labor piloted in combination), innovations that were not market ready (e.g., carbon credits, new technology not yet deployed), and those that sought to replace traditional WAP providers with workforce development strategies reliant on volunteer labor lacking in building science experience and training.

Uncertainties inherent in innovation resulted in unexpected inabilities to perform the proposed tasks for a myriad of reasons. The initial 2-year grant cycle proved challenging for grantees not ready for work to begin. Approval of contracts (e.g., new legal considerations for innovative financing mechanisms) and energy auditing tools not previously approved at the state level resulted in delayed weatherization work and expanded timeframes. Innovations that required changes or waivers to establish new policy or protocols also resulted in delayed production and reductions in planned leveraged funding and total outlay. Grantees characterized as traditional WAP providers were reportedly and observably not challenged by the DOE regulations, reporting requirements, or evaluation tasks. These advantages provided these projects the means to move forward with their innovation and production goals without delay.

In most cases, WIPP grantees operating as, or in partnership with, public utilities had several advantages. These grantees had privileged access to household energy usage data. Access to these data allowed for targeted implementation and guidance of weatherization and energy education programs, as well as internal monitoring and evaluation of electricity impacts from IHDs. Additionally, public utility partnerships made it feasible to examine an on-bill financing pilot and for a home energy retrofit loan forgiveness program. Finally, well-established utility energy efficiency programs provide platforms for add-on features (e.g., HHIs) to be delivered alongside or after weatherization.

It was also observed that nontraditional WAP providers do not always serve, or serve at the same scale, the WAP-targeted, high-priority populations designated by statute (i.e., persons of elderly or disability status, households with children, and high energy users).

Innovative Financing Approaches

WAP functions to provide federal grants to states (based on a funding allocation formula) and its services are delivered to income-eligible households at no cost to them. The WIPP grant allowed DOE to explore alternative financing mechanisms to potentially assist WAP in terms of cost and reach. The mission of the organizations that chose to explore alternative financing mechanisms is to secure affordable housing for low-SES households, which is similar to the mission of traditional WAP agencies, such as those in New

York City that aim to improve energy efficiency and preserve affordable housing by securing building contribution.[61]

Under this grant, on-bill utility financing proved effective in negotiating and finalizing nearly 200 loan agreements. However, these transactions were time- and resource-intensive, as were most of the projects performed under the WIPP innovative financing umbrella.

ESCOs provide a means for energy retrofits, such as weatherization, to occur in situations in which the building or property owners are unable to pay cash for the endeavor. ESCOs offer ESPCs to ensure the projected cost savings from the installed ECMs perform as expected. This is critical, as the ESCO is repaid through these cost savings. However, the use of ESCOs for improved energy efficiency in weatherizing multifamily properties proved resource-intensive for all parties involved in the transactions (i.e., owners, investors, ESCOs, and project managers).

Two projects revealed that generating carbon credits through low-income weatherization has potential for inclusion in WAP. However, using CIFs to leverage weatherization costs also proved to be resource-intensive. The administrative costs to navigate all the processes and requirements for carbon credit validation could be higher than the expected revenue produced by selling the carbon credits. However, it does appear that once the processes and costs required for carbon credit validation are achieved, CIFs could be replicated as an effective model.

In the end, it must be determined whether the financing mechanisms being explored are attractive complements to WAP's current operations and whether they are truly cost-effective and sustainable.

Workforce Development and Volunteer Engagement

Organizations that have an established history in securing leveraged and in-kind resources through private sector investments, donations, and volunteer engagement offer valuable avenues for home rehabilitation (e.g., roof repairs) and healthy-homes work (e.g., door ramps) to be completed while partnering with traditional WAP providers or as a means to ensure deferred homes are eventually weatherized. Despite the efforts of these nontraditional providers to perform at the same caliber as WAP subgrantees in weatherizing homes, volunteers and persons in workforce development programs too often lacked building science expertise and experience possessed by the trained and traditional WAP workforce. Volunteer labor was observed to impede and decrease the installation and quality of weatherization measures. WIPP project managers and evaluators linked failed work quality inspections to work completed by volunteers. On-site organization and training of volunteer labor was determined by project managers to be undependable and time consuming, even for tasks requiring minimal skill levels, making the process inefficient. The evaluation indicated that weatherization delivered through WAP as an evidence-based intervention for the improvement of energy efficiency will remain so only with a dependable, skilled, and trained workforce dedicated to its mission.

The evaluation did find, however, that well-established volunteer programs that target energy efficiency education were able to effectively deliver residential energy coaching alongside WAP that resulted in validated energy savings.

[61] In NYC, building owner contribution can be waived *if* the owners are a nonprofit and as long as the savings-to-investment ratio is 1.0 without the contribution.

New Technologies and Techniques

Grantees that aimed to incorporate new technologies that were not market ready, or were still in the research and development stages, were faced with unforeseen challenges and production delays. For example, exploring the application of a newly developed savings-to-investment ratio buy-down tool, based on the value of carbon emission reductions and societal benefits, was ambitious within the timeframe of the grant cycle.

However, the approach of integrating new techniques or technologies into established weatherization programs encountered fewer obstacles (e.g., the installation of IHDs alongside a utility weatherization program). As a result, traditional weatherization providers proved capable of integrating innovation into or alongside their programs, provided the innovation was not overly complex.

IHDs were studied by several grantees and were found to offer incremental electricity savings on top of weatherization energy savings. The benefits of such devices, alongside household consumer energy education, are more fully realized by high-energy user households. Both of the grantees that produced enough work to be evaluated during the grant cycle offer existing programs as sturdy platforms for incorporating IHDs and transformative education approaches into previously established utility (CEO project) and WAP (VEIC project) services. It is interesting that CEO (characterized as a traditional WAP provider and Community Action Agency) piloted its innovative technology and approach alongside its PPL *utility* weatherization contract, whereas VEIC (an energy efficiency utility) piloted its technology and approach alongside a local *WAP* provider. In both scenarios, the availability of billing history data for the household coaching component proved useful in tailoring the education to the current energy usage, demand, and circumstances of the households. Although this billing history information did not include or exclude eligible households, it could prove beneficial in the future for programs interested in achieving greater energy savings results. Households in the VEIC sample did not appear to use the real-time data and suggestions on their computers via the web portal. Further research is necessary to determine whether the costs and challenges associated with this type of feedback are worth the resources and effort, considering the low level of customer participation.

The evaluation found that NHCLF's approach to close-proximity production resulted in an increased number of homes served because it minimized travel times. However, the resulting savings seemed to accrue to contractors rather than to WAP. The potential benefits of this innovative approach need further exploration.

Green and Healthy Homes

Opportunity exists for comprehensive healthy housing measures to be completed in concert with WAP. When combined, the core missions of energy efficiency programs and healthy housing programs have the potential to produce complementary and synergistic benefits at both the household (e.g., improved health and safety) and societal (e.g., improved health care outcomes) levels. The two pilots performed under the WIPP grant offer two different but effective Weatherization Plus Health[62] models promoted by the National Association for State Community Services Programs.

It was observed through this evaluation that the experience and quality of cross-training for both agency and contract staff are instrumental for meaningful engagement with occupants, and for advancing energy and healthy housing outcomes. The effectiveness of cross-training traditional weatherization auditors and crews to complete health impact assessments requires further investigation. Although weatherization

[62] https://www.wxplushealth.org/

providers are capable of delivering HHIs in concert with their energy efficiency programs, traditional HHI providers appeared to be better equipped to understand and address place-based drivers for health disparities than were traditional weatherization providers. Observations made early in the grant cycle revealed that even cross-trained weatherization providers displayed more difficulty in engaging occupants on health status and assessing home hazards compared with traditional HHI providers. Conversely, the traditional HHI provider operating under this grant was able to deliver effective home energy efficiency services (i.e., energy saving impacts).

Research in this area suggests that HHIs (i.e., including community health workers to help engage residents and complete health impact assessments) is an effective strategy for improving indoor environmental quality and health outcomes. However, the evaluation was unable to measure the health impacts of either green-and-healthy-homes grant because of a lack of the necessary metrics to do so.

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APPENDIX A. ENERGY PIONEER SOLUTIONS

Table A.1. Building type and primary heating fuel for 171 buildings under EPS grant

	Primary heating fuel		
Building type	**EL**	**NG**	**Total**
Single-family detached	6	138	144
Mobile home	0	6	6
Shelter	0	2	2
Small multifamily	0	19	19
Total	6	165	171

Table A.2. EPS job costs by DOE and non-DOE funding source

	Mean cost	**Median cost**
DOE	$1,968	$1,423
Non-DOE (client costs)	$1,085	$929
Total	$3,053	$2,775

Table A.3. EPS gross energy impacts for electric and natural gas heated homes by calculation method

Gas heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (therms)	74	857	816
Gross savings (therms)	74	173 (±42)	157
Gross savings (percent)	74	20.2% (±4.9%)	19.2%
Electric baseload	**PRISM (after attrition)**		
	N	*Mean*	*Median*
Normalized annual consumption pre (kWh)	59	12,456	11,670
Gross savings (kWh)	59	1,579 (±699)	895
Gross savings (percent)	59	12.7% (±5.6%)	7.7%

APPENDIX B. LOCAL ENERGY ALLIANCE PROGRAM

Table B.1. Building type and primary heating fuel for 26 buildings with 2-8 units per building under LEAP grant

Building type	Primary heating fuel		
	EL	NG	Total
Small multifamily	18	0	18
Large multifamily	114	0	114
Total	132	0	132

APPENDIX C. PEOPLE WORKING COOPERATIVELY

Table C.1. Program year (PY) 2010 clients—clients by housing unit type

Housing unit type	Clients	Percent of clients
Single-family site built (1-4 units)	244	89%
Mobile home	28	10%
Large multifamily (5+ units)	1	<1%
TOTAL	273	100%

Table C.2. PY 2010 clients in single-family homes—household characteristics

Statistic	National	Cold climate	PWC
Income and poverty			
Median income	$15,607	$15,937	$15,127
Median % of poverty	109%	113%	106%
% < 100% of poverty	44%	42%	44%
Vulnerability status			
% w/elderly individual	41%	38%	27%
% w/disabled individual	30%	24%	12%
% w/children	33%	28%	44%
Household status			
% homeowner	82%	82%	84%
Mean household size	2.46	2.48	2.74
% Single parent	20%	22%	–
% Single elderly	23%	22%	15%
Race/ethnicity			
% white non-Hispanic	59%	76%	58%
% Black non-Hispanic	28%	17%	41%
% Hispanic	11%	6%	0%
% Asian	1%	1%	1%
% Native American	1%	<1%	0%
% Other	<1%	<1%	0%

Table C.3. PY 2010 clients in single-family homes—home ownership by demographic group

	PWC WIPP	
Demographic group	**Owners**	**Renters**
Elderly households	92%	8%
Disabled households	81%	19%
Households with children	77%	23%
Single-parent households	–	–
Single elderly households	90%	10%
ALL	84%	16%

Table C.4 PY 2010 PWC WIPP clients in single-family homes—mean and median cost per job

	Mean job cost	**Median job cost**
PWC WIPP	$7,690	$7,331

Table C.5. Estimated savings results for PWC WIPP for each method

Gas heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (therms)	73	1,089	912
Gross savings (therms)	73	137 (±68)	160
Gross savings (percent)	73	12.6% (±6.2%)	17.5%
Electric baseload	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	48	12,711	12,021
Gross savings (kWh)	48	1124 (±846)	867
Gross savings (percent)	48	8.8% (±6.7%)	7.2%
Electric heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	20	21,805	21,002
Gross savings (kWh)	20	2118 (±2,286)	2,404
Gross savings (percent)	20	9.7% (±10.5%)	11.4%

APPENDIX D. COMMISSION ON ECONOMIC OPPORTUNITY

Table D.1. Building type and primary heating fuel for 2075 buildings under CEO grant

Building type	Primary heating fuel							Total
	EL	NG	LP	FO	Wood	Other	Unknown	
Single-family	746	379	59	430	10	38	188	1850
Mobile home	20	2	8	17	0	0	4	51
Large multifamily	167	2	0	1	0	1	3	174
Total	933	383	67	448	10	39	195	2,075

Table D.2. CEO job costs by type of PPL utility weatherization category

PPL WRAP job type	Mean PPL cost	Median PPL cost
Full cost	$3,173	$3,021
Low cost	$1,505	$1,340
Baseload	$978	$1,019

Table D.3. CEO gross electricity impacts by calculation method for WIPP and comparison group

WIPP	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	191	19,286	18,759
Gross savings (kWh)	191	1,134 (±558)	461
Gross savings (percent)	191	5.9% (±2.9%)	2.5%

Comparison sample	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	195	19,095	18,249
Gross savings (kWh)	195	368 (±412)	182
Gross savings (percent)	195	1.9% (±2.2%)	1.0%

Table D.4. CEO net electricity impacts by calculation method

Normalization method	Analysis group	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP comparison	191 195	19,286 19,095	1,134 368	766 (±690)	4.0% (±3.6%)

Table D.5. CEO gross electricity impacts for full cost jobs by calculation method for WIPP and comparison groups

WIPP (full cost jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	122	22,823	22,419
Gross savings (kWh)	122	1,641	1,168
Gross savings (percent)	122	7.2%	5.2%
Comparison sample (full cost jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	121	23,075	21,695
Gross savings (kWh)	121	553	515
Gross savings (percent)	121	2.4%	2.4%

Table D.6. CEO net electricity impacts for full cost jobs by calculation method for WIPP and comparison groups

Normalization method	Full cost jobs	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP comparison	122 121	22,823 23,075	1,641 553	1,088 (±965)	4.8% (±4.2%)

Table D.7. CEO gross electricity impacts for low cost jobs by calculation method for WIPP and comparison groups

WIPP (low cost jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	13	15,609	15,119
Gross savings (kWh)	13	878	195
Gross savings (percent)	13	5.6%	1.3%
Comparison sample (low cost jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	16	13,871	12,666
Gross savings (kWh)	16	229	-97
Gross savings (percent)	16	1.7%	-0.8%

Table D.8. CEO net electricity impacts for low cost jobs by calculation method for WIPP and comparison groups

Normalization method	Low cost jobs	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP	13	15,609	878	649 (±2,161)	4.2% (±13.8%)
	comparison	16	13,871	229		

Table D.9. CEO gross electricity impacts for baseload jobs by calculation method for WIPP and comparison groups

WIPP (baseload jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	56	12,433	10,326
Gross savings (kWh)	56	88	206
Gross savings (percent)	56	0.7%	2.0%
Comparison sample (baseload jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	58	12,233	11,198
Gross savings (kWh)	58	21	159
Gross savings (percent)	58	0.2%	1.4%

Table D.10. CEO net electricity impacts for baseload jobs by calculation method for WIPP and comparison groups

Normalization method	Baseload jobs	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP	56	12,433	88	67 (±944)	0.5% (±7.6%)
	comparison	58	12,233	21		

Table D.11. CEO gross electricity impacts for full cost jobs in Northeast region by calculation method for WIPP and comparison groups

WIPP–Northeast (full cost jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	69	20,291	19,661
Gross savings (kWh)	69	1,131	855
Gross savings (percent)	69	5.6%	4.3%
Comparison sample–Northeast (full cost jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	37	22,426	21,125
Gross savings (kWh)	37	727	910
Gross savings (percent)	37	3.2%	4.3%

Table D.12. CEO net electricity impacts for full cost jobs in Northeast region by calculation method for WIPP and comparison groups

Normalization method	Northeast region—full cost jobs	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP	69	20,291	1,131	404 (±1,344)	2.0% (±6.6%)
	comparison	37	22,426	727		

Table D.13. CEO gross electricity impacts for full cost jobs in Susquehanna region by calculation method for WIPP and comparison groups

WIPP—Susquehanna (full cost jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	52	26,349	25,414
Gross savings (kWh)	52	2,372	1,620
Gross savings (percent)	52	9.0%	6.4%
Comparison sample—Susquehanna (full cost jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	84	23,361	23,077
Gross savings (kWh)	84	476	233
Gross savings (percent)	84	2.0%	1.0%

Table D.14. CEO net electricity impacts for full cost jobs in Susquehanna region by calculation method for WIPP and comparison groups

Normalization method	Susquehanna region—full cost jobs	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP	52	26,349	2,372	1896 (±2,344)	7.2% (±8.9%)
	comparison	84	23,361	476		

Table D.15. CEO gross electricity impacts for baseload jobs in Northeast region by calculation method for WIPP and comparison groups

WIPP—Northeast (baseload jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	47	10,901	10,212
Gross savings (kWh)	47	−12	203
Gross savings (percent)	47	−0.1%	2.0%
Comparison sample—Northeast (baseload jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	32	11,938	11,198
Gross savings (kWh)	32	−133	61
Gross savings (percent)	32	−1.1%	0.5%

Table D.16. CEO net electricity impacts for baseload jobs in Northeast region by calculation method for WIPP and comparison groups

Normalization method	Northeast region—baseload jobs	*N*	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP	47	10,901	−12	121 (±952)	1.1% (±8.7%)
	Comparison	32	11,938	−133		

Table D.17. CEO gross electricity impacts for baseload jobs in Susquehanna region by calculation method for WIPP and comparison groups

WIPP—Susquehanna (baseload jobs)	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	9	20,433	24,450
Gross savings (kWh)	9	613	845
Gross savings (percent)	9	3.0%	3.5%
Comparison sample—Susquehanna (baseload jobs)	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	26	12,596	10,536
Gross savings (kWh)	26	210	193
Gross savings (percent)	26	1.7%	1.8%

Table D.18. CEO net electricity impacts for baseload jobs in Susquehanna region by calculation method for WIPP and comparison groups

Normalization method	Susquehanna region—baseload jobs	N	NAC pre (kWh)	Gross savings (kWh)	Net savings (kWh)	Net savings (% of pre)
PRISM (after attrition)	WIPP	9	20,433	613	403 (±2,686)	2.0% (±13.1%)
	Comparison	26	12,596	210		

APPENDIX E. NEW HAMPSHIRE COMMUNITY LOAN FUND

Table E.1. PY 2010 clients in mobile homes—clients by housing unit type under NHCLF grant

Housing unit type	Clients	Percentage of clients
Mobile homes	137	100%
TOTAL	137	100%

Table E.2. PY 2010 NHCLF WIPP clients in mobile homes—household characteristics

Statistic	NHCLF
Income and poverty	
Median income	$18,019
Median % of poverty	137%
% < 100% of poverty	23%
Vulnerability status	
% w/elderly individual	37%
% w/disabled individual	37%
% w/children	34%
Household status	
% Homeowner	99%
Mean household size	2.2
% Single parent	16%
% Single elderly	25%
Race/ethnicity	
% White non-Hispanic	99%
% Black non-Hispanic	0%
% Hispanic	1%
% Asian	0%
% Native American	0%
% Other	0%

Table E.3. PY 2010 NHCLF WIPP clients in mobile homes—housing unit characteristics

Statistic	NHCLF
Housing unit	
Median heated space	924
Mean heated space	928
Housing vintage	
% pre-1940	0%
% 1940–1969	14%
% 1970 or later	86%
Pre-weatherization status	
Mean CFM 50	2,313

Table E.4. PY 2010 NHCLF WIPP clients in mobile homes—diagnostics approach

Statistic	NHCLF
Diagnostic approach	
% Priority list	0%
% Calculation procedure	100%
% Other	0%

Table E.5. PY 2010 NHCLF WIPP clients in mobile homes—air sealing and shell measures

Statistic	NHCLF
Air sealing*	
<500	26%
500 to <1,000	31%
1,000+	39%
No data	4%
Any air sealing	91%
Attic insulation	
% Installed	75%
Wall insulation	
% Installed	5%
Other insulation	
% Floor insulation	89%
% Rim/band joist insulation	0%
% Foundation insulation	0%
% Any installed	89%
Mean CFM reduction	1,028
% Installed mechanical ventilation	91%

*Pre minus post CFM50 reduction

Table E.6. PY 2010 NHCLF WIPP clients in mobile homes—heating and water heating equipment measures

Statistic	NHCLF
Heating equipment replacements	
Furnace (non-ECM)	11%
Furnace (ECM)	7%
Furnace (unknown)	2%
Any furnace	20%
Heating ducts (% of systems with ducts)	
Duct sealing	84%
Duct insulation	0%
Water heating equipment	
Heater (non-ECM)	2%
Heater (ECM)	1%
Heater (unknown)	1%
Any water heater	4%

*Issues for Table E.6:
In the single-family and mobile home reports, the heating duct statistics are only for homes with central heat and heat pump main heat. NHCLF cases did not have the primary heating information, so the duct statistics are from all homes.

Table E.7. PY 2010 NHCLF WIPP clients in mobile homes—other measures

Statistic	NHCLF
Windows	
Window (non-ECM)	8%
Window (ECM)	2%
Window (unknown)	5%
Window (any reason)	16%
Storm window	2%
Air conditioner (AC)	
AC unit (non-ECM)	0%
AC unit (ECM)	0%
AC unit (unknown)	0%
Any AC unit	0%
Other equipment	
Programmable thermostat	29%
Lighting	95%
Refrigerator	44%

Table E.8. PY 2010 NHCLF WIPP clients in mobile homes—mean and median cost per job

	Mean job cost	Median job cost
NHCLF	$7,454	$6,901

Table E.9. PY 2010 NHCLF WIPP clients in mobile homes—ECM and non-ECM costs

Statistic	NHCLF
Costs per job	
Mean ECM costs	$4,923
Mean Non-ECM costs	$2,422
Health and safety	*$375*
renovation	*$2,047*
Mean non-ECM %	33%
Mean TOTAL costs*	$7,345

*Non-ECM costs for the agency include general repairs and rehab (work not done specifically for energy savings or health and safety), rather than including these in ECM costs.

Table E.10. PY 2010 NHCLF WIPP clients in mobile homes—DOE WIPP and non-DOE costs

Statistic	NHCLF
Costs per job	
Mean DOE WIPP costs	$2,424
Mean Non-DOE costs	$4,900
Mean non-DOE %	67%
Mean TOTAL costs*	$7,324

*Issues for Table E.10:
The single-family and mobile home reports show DOE vs. non-DOE costs. This table shows DOE WIPP and non-DOE costs because no homes had a cost value for DOE non-WIPP.

Billing Analysis/Energy Savings Results

We obtained electric usage information for 34 jobs and bulk fuel (propane or fuel oil) usage information for 75 jobs. These data were processed and energy savings were estimated using PRISM and a degree-day method approach to weather normalization. Results are summarized in Tables E.11 to E.13.

Table E.11. Breakdown of electric utilities serving the NHCLF WIPP clients

Electric utility	Subgrantee				Total
	Strafford	BMCAP	SNHS	Tri-CAP	
PSNH	0	39	10	22	71
UNITIL	0	18	23	0	41
New Hampshire Electric Cooperative	0	4	0	14	18
Other	0	0	3	1	4
Unknown	3	0	0	0	3
Total	3	61	36	37	137

*The electricity results are limited because only one NH electric utility, UNITIL, was willing to provide usage data. In addition, UNITIL was able to provide only 2 years of usage history, which did not provide enough pre-WAP coverage. We had obtained pre-WAP usage data whenever they were available in agency records. Only one WAP subgrantee, SNHS, had usable pre-WAP electric data for any clients served by UNITIL. Therefore, the electricity results below include only clients that are UNITIL customers and were weatherized by SNHS.

Table E.12. Cases in the NHCLF WIPP data file

Account group	Accounts in cleaned usage data	Enough pre- and post-WAP usage data	Survived attrition in degree-day method	Survived attrition in PRISM
Bulk fuel heat	75	49	47	8
Electric baseload	33	11	11	5
Electric heat	1	1	1	1

Table E.13. Estimated savings results for NHCLF WIPP

Bulk fuel heat	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (therms)	8	602	576
Gross savings (therms)	8	124 (±81)	110
Gross savings (percent)	8	20.7% (±13.5%)	19.1%
Electric baseload	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	5	9,774	11,253
Gross savings (kWh)	5	37 (±913)	136
Gross savings (percent)	5	0.4% (±9.3%)	1.2%

APPENDIX F. VERMONT ENERGY INVESTMENT CORPORATION

Table F.1. Building type and primary heating fuel for 119 cases under VEIC WIPP grant

Building type	Primary heating fuel						Total
	EL	NG	LP	FO	WO	Unknown	
SFA	0	1	0	0	0	0	1
SFD	3	16	10	47	12	10	98
SFU	0	0	0	0	0	1	1
SMF	0	0	0	0	0	0	0
MH	0	1	3	13	1	1	19
LMF	0	0	0	0	0	0	0
Total	3	18	13	60	13	12	119

SFA = single-family attached, SFD = single-family detached, SFU = single-family unknown
SMF = small multifamily, MH = mobile home, LMF = large multifamily
EL = electricity, LP = liquid propane, FO = fuel oil, WO = wood

Table F.2. VEIC WIPP electricity impacts

Electric baseload	PRISM (after attrition)		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	21	9,710	9,577
Gross savings (kWh)	21	636 (±689)	268
Gross savings (percent)	21	6.6% (±7.1%)	2.8%
Electric heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	0	NA	NA
Gross savings (kWh)	0	NA	NA
Gross savings (percent)	0	NA	NA
Electric unknown	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	1	4,583	NA
Gross savings (kWh)	1	−64	NA
Gross savings (percent)	1	−1.4%	NA

APPENDIX G. COALITION TO END CHILDHOOD LEAD POISONING

Table G.1. Building type and primary heating fuel for 66 homes under CECLP grant

	Primary heating fuel			
Building type	**EL**	**NG**	**FO**	**Total**
Single-family attached	1	56	4	61
Single-family detached	0	4	1	5
Total	1	60	5	66

Table G.2. CECLP job costs by DOE and non-DOE funding source

	Mean cost	**Median cost**
DOE WIPP	$1,883	$1,552
Non-DOE	$3,323	$495
Total	$5,206	$2,386

Table G.3. CECLP gross energy impacts by for natural gas–heated homes and for electric baseload by calculation method

Gas heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (therms)	32	1,002	942
Gross savings (therms)	32	118 (±57)	102
Gross savings (percent)	32	11.8% (±5.7%)	10.9%
Electric baseload	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	19	9,766	9,348
Gross savings (kWh)	19	−7 (±719)	83
Gross savings (percent)	19	−0.1% (±7.4%)	0.9%

APPENDIX H. UNITED ILLUMINATING

Table H.1. Building type and primary heating fuel for 171 buildings under UI WIPP grant

	Primary heating fuel			
Building type	**EL**	**NG**	**FO**	**Total**
Single-family attached	99	0	0	99
Single-family detached	0	9	7	16
Small multifamily	0	13	1	14
Large multifamily	31	11	0	42
Total	130	33	8	171

Table H.2. UI job costs by DOE and non-DOE funding source

	Mean cost	**Median cost**
DOE WIPP	$2,029	$2,550
Non-DOE	$3,121	$4,120
Total	$5,149	$6,677

Table H.3. UI gross energy impacts for electric and natural gas heated homes and for electric baseload by calculation method

Gas heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (therms)	17	961	797
Gross savings (therms)	17	39 (±84)	27
Gross savings (percent)	17	4.1% (±8.8%)	3.4%
Electric baseload	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	11	5,026	3,904
Gross savings (kWh)	11	107 (±374)	201
Gross savings (percent)	11	2.1% (±7.4%)	5.2%
Electric heat	**PRISM (after attrition)**		
	N	***Mean***	***Median***
Normalized annual consumption pre (kWh)	87	10,987	11,350
Gross savings (kWh)	87	872 (±385)	651
Gross savings (percent)	87	7.9% (±3.5%)	5.7%