ADVANCING ENERGY EFFICIENCY IN DEVELOPING COUNTRIES

Lessons Learned from Low-Income Residential Experiences in Industrialized Countries

Alexandra Aznar, Jeffrey Logan, Douglas Gagne, and Emily Chen
National Renewable Energy Laboratory

April 2019

A product of the USAID-NREL partnership
Contract No. IAG-17-2050

NOTICE

This work was authored, in part, by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the United States Agency for International Development (USAID) under Contract No. Contract No. IAG-17-2050. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government or any agency thereof, including the United States Agency for International Development.

Cover photo from iStock 145903143.

NREL prints on paper that contains recycled content.

Acknowledgments

The authors thank Monica Bansal from the U.S. Agency for International Development's Office of Energy and Infrastructure for her vision and guidance, which drove the production of this report. We also thank the following staff members from the National Renewable Energy Laboratory for their contributions to this study: Dan Bilello, Jennifer Daw, Otto VanGeet, Sheila Hayter, Chuck Kutscher, James Salasovich, Chuck Kurnik, and Shanti Pless. We also thank Katie Wensuc, Britton Marchese and Stacy Buchanan from the National Renewable Energy Laboratory for their editorial support. Finally, we thank the following individuals for providing review comments on the report: Juliana Williams (National Renewable Energy Laboratory), Ariel Drehobl (American Council for an Energy-Efficient Economy), and Stephane de la Rue du Can (Lawrence Berkeley National Laboratory).

Any remaining mistakes, oversights, or errors are the sole responsibility of the authors.

List of Acronyms

ACEEE	American Council for an Energy-Efficient Economy
CAA	Community action agency
CFL	Compact fluorescent lamps
DOE	U.S. Department of Energy
EM&V	Evaluation, measurement, and verification
ESCO	Energy service company
HVAC	Heating, ventilating, and air-conditioning
IEA	International Energy Agency
LED	Light-emitting diode
LIHEAP	Low-Income Home Energy Assistance Program
LMI	Low- and moderate-income
NGO	Nongovernmental organization
NTL	Nontechnical losses
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
SIR	Savings-to-investment ratio
USAID	United States Agency for International Development
WAP	Weatherization Assistance Program

Executive Summary

The potential for energy efficiency to simultaneously address economic development, energy security, and environmental protection in countries around the world is well known. Energy efficiency can have even more pronounced impacts in developing countries, where citizens need increased access to energy, utilities might struggle to keep up with demand, and public and private capital to expand availability of energy and improve quality of service is scarce. Especially among low-income residents, energy efficiency has a host of beneficial attributes that can help achieve the United Nations' Sustainable Development Goals, including those associated with economic opportunity, improved health, gender equity, and better environmental and climate-related outcomes. Although energy efficiency faces barriers even in the most favorable environments, the time to consider energy-efficiency programs for low-income households might never be stronger.

This report presents lessons learned in delivering energy-efficiency programs for low-income households that are taken from experiences in the United States and other member countries of the Organisation for Economic Co-operation and Development (OECD). In this report, we summarize lessons learned in delivering energy-efficiency programs to low-income households of industrial countries from the perspectives of program design, program delivery, and institutions. The intent is to provide best practices from experiences in industrial countries that are applicable to each stage of a developing country's deployment cycle with a focus on urban environments that are already electrified. This report discusses:

- Who to target (Section 2)
- How to reduce energy burden (Section 3)
- Coordinating institutional stakeholders (Section 4)
- Which efficiency tools to use (Section 5)
- How to fund low-income energy-efficiency programs (Section 6)
- Screening tools to prioritize projects (Section 7)
- Outreach strategies (Section 8)
- Evaluation methods (Section 9)

In industrial countries, low-income households typically shoulder energy burdens (the percentage of income devoted to energy bills) at a rate three times higher than wealthier households, as illustrated for the United States in Table ES-1. As a result, these households often face trade-offs between paying energy bills and forgoing heat, medicine, food, or other basic needs.

Table ES-1. Metrics Associated with Energy Burden for U.S. Metropolitan Residents

	Household Type	Median Annual Income ($)	Median Energy Burden (%)
Income Type	Low-income (≤80% area median income)	24,998	7.2
	Non-low-income	90,000	2.3
	Low-income multifamily (≤80% area median income, 5 or more units)	21,996	5.0
	Non-low-income multifamily	71,982	1.5

Source: Adopted from Drehobl and Ross 2016

OECD countries have addressed these competing needs through a variety of approaches that fall under two broad umbrellas: (1) electricity subsidization that provides low-income customers with bill assistance, and (2) energy-efficiency investments that provide a long-term reduction in customer energy bills. In the United States, significant learning has emerged from decades of experience with the U.S. Department of Energy's Weatherization Assistance Program, the U.S. Department of Health and Human Services' Low-Income Home Energy Assistance Program, and utility ratepayer-funded programs.

Among the two stated approaches to decrease energy burden, energy-efficiency investments have long-term advantages by addressing the underlying energy use issue while minimizing economic distortions and complementing short-term bill assistance. Political will and/or sufficient resources to rapidly improve low- and moderate-income (LMI) household energy efficiency might be lacking, however, so a staged transition from subsidization to increased efficiency might be a suitable option. Other measures (such as bill assistance) can be introduced to help LMI households with their energy bills while minimizing economic distortions until efficiency measures can be completed. There has also been increasing interest among jurisdictions around the world in combining energy-efficiency measures with distributed solar photovoltaics to further reduce household energy burden.

Key lessons learned from industrial country experiences that might be beneficial for developing countries include:

- **Define the target audience.** The definition of *low-income* can vary by jurisdiction, so program designers need to choose eligibility guidelines that will serve those who are most in need. Inadequate targeting can lead to misdirected energy subsidies in developing countries, leading to disproportionate benefits to higher income households. Program designers should also consider (1) if a program will target deep interventions that affect fewer households or provide a "light touch" for more widespread impact and (2) how to develop appropriate prioritization metrics (e.g., cost-benefit tests) to identify the most suitable investments. Once defined, engage that audience in the program development from the beginning. See Section 2 and Section 7 for more information.
- **Use energy-efficiency investments to reduce the long-term energy burden, but recognize the need for maintaining and potentially phasing out subsidies such as bill assistance over time.** Electricity subsidies might still be needed on humanitarian grounds, particularly when energy-efficiency policies and programs do not reach all needy consumers. Energy-efficiency investments should be explored in tandem with subsidies to address long-term energy use concerns in an economically efficient way. See Section 3 for more information.
- **Assess and engage partners across sectors to support low-income energy-efficiency program design, implementation, and assessment.** Utilities are logical partners, and nonprofits often excel at outreach and implementation. See Section 4 for more information.
- **Find a sustainable funding source.** A dedicated, sustainable funding stream is often essential to support enduring, high-impact programs. Consider using a combination of strategies, such as government programs, utility wires charges or ratepayer funds, private financing, and donor/nonprofit support. See Section 6 for more information.
- **Start simple and grow with implementation.** Decentralized approaches are also effective because local communities are more likely to know and trust the local partner organizations. Learning by doing can help expand knowledge, evolve programs, and build capacity. Leverage local knowledge and partnerships for effective implementation. See Section 5 for more information.
- **Provide multiple financing approaches because low-income households typically do not have the capital to make energy-efficiency investments.** In some cases, private sector energy service companies can help finance multifamily building upgrades. See Section 5 for more information.

- **Create a tailored, flexible, multidimensional outreach strategy that accounts for diverse low-income household participation.** Employ trusted partners to deliver the message. See Section 8 for more information.
- **Evaluate your program to understand if it is targeting the right audience and achieving desired results.** How can it be improved? Choose a level of evaluation complexity and rigor that makes sense given institutional capacity. See Section 9 for more information.

As stakeholders learn by doing and share lessons among participating groups, program design and delivery can mature. As institutional capacity expands, more sophisticated and impactful programs can follow that build on stakeholder ability and deployment approach (Figure ES-1).

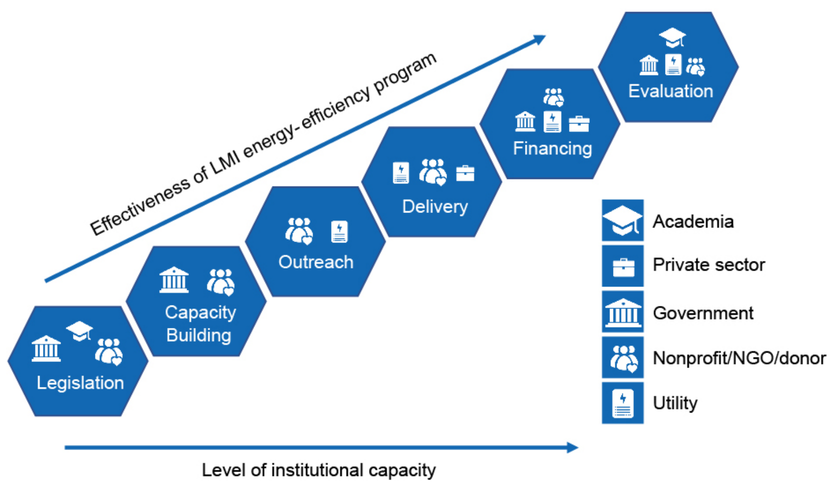


Figure ES-1. Illustrative example of how institutional capacity results in increasing sophistication of LMI energy-efficiency delivery

In developing countries, providing energy efficiency to low-income households might be more acute because of:

- Limited household capital available for new equipment or fuels
- Financially strapped utilities that might be struggling to deliver even basic services
- Limited institutional capacity required to plan, execute, and evaluate programs.

Regulatory and utility reforms to address issues such as cost-reflective tariffs and losses associated with electricity theft and subsidies might be essential for maximizing the impacts of energy efficiency and require strong leadership. Utilities are critical partners in delivering and even financing energy-efficiency programs; therefore, without a financially solvent utility that results from consumers paying their energy bills and effective corporate management, rate-based energy-efficiency programs might remain limited. Nevertheless, LMI efficiency offers can come from other sources. Examples of nonutility partnerships that can achieve success include bulk purchasing and deployment of high-efficiency lighting or improved appliance standards.

Deciding how and where to start implementing programs requires careful planning and prioritization. Methods of outreach and evaluation, for example, have important roles to play. In jurisdictions with limited capacity and basic energy services, a focus on relatively simple administrative interventions, such as improving the efficiency of lighting or sealing building envelopes, might be the highest priority, with bulk purchasing programs in partnership with utilities or nongovernmental organizations a potential delivery mechanism. Figure ES-2 illustrates how measures can target different subsectors, although a variety of institutional capacity, political willpower, and resources might be needed at each step. Some subsectors shown in the outer bands of the figure, such as markets, do not necessarily require increased institutional capacity, but they might take longer to achieve desired results or require strong political willpower. Each country will need to ascertain where it falls within the framework and which priorities to tackle first.

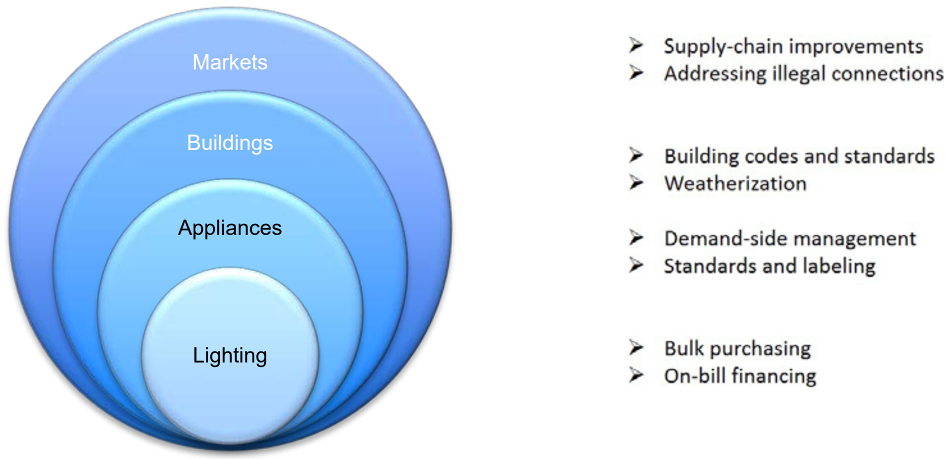


Figure ES-2. Increasing levels of energy-efficiency intervention

For each level—lighting, appliances, buildings, and overall market—Section 10 outlines how program implementers can initiate efforts and the associated best practices for each. Planning and sequencing efforts are location specific and depend on local climate, economic development trends, the capacity of stakeholders, cultural norms, the local policy environment, and other factors.

Establishing energy-efficiency programs for LMI households can empower local communities and make significant impacts on the lives of individual families. Although complex and challenging, emulating the best practices and experiences globally can build institutional capacity and confidence for deeper and broader impacts down the road.

Table of Contents

1 Introduction: The Importance of Addressing Energy Efficiency in Low-Income Households 1
1.1 The Unmet Potential for Energy Efficiency in Households..1
1.2 Benefits and Costs 2
1.3 Energy Burden 2
1.4 Demand Growth in the Developing World 4
2 Who to Target 6
2.1 Classifying "Low-Income": Measure and Prioritize..6
2.2 Targeting Households: Deep Versus Wide Program Design 7
2.3 Key Takeaways for Developing Countries 8
3 How to Reduce Energy Burden 9
3.1 Shifting from Bill Assistance to Energy Efficiency..10
3.2 Key Takeaways for Developing Countries 12
4 Which Institutions and Stakeholders Are Needed and What Are Their Roles? 13
4.1 U.S. Experience 13
4.2 Other OECD Experience...14
4.3 Building Institutional Capacity Enables Impact and Replication 14
4.4 Key Takeaways for Developing Countries 15
5 What Tools Are in the Toolbox? 17
5.1 Overview of Targeted Low-income Energy-Efficiency Tools 17
5.1.1 No-Cost or Discounted Weatherization Programs 17
5.1.2 Traditional and Low-Cost Loans 18
5.1.3 On-Bill Financing 20
5.1.4 Bulk Purchasing 20
5.1.5 Utility Rebates for Efficient Appliances 20
5.1.6 Education and Outreach Programs.. 21
5.1.7 Energy Efficiency and Distributed Photovoltaics 21
5.2 Additional Energy-Efficiency Tools for LMI Households 21
5.2.1 Evaluation, Measurement, and Verification Guidelines 22
5.2.2 Energy-Efficiency Resource Standards.. 22
5.2.3 Building Codes and Standards 22
5.2.4 Appliance Standards and Labeling.. 23
5.2.5 Market Transformation 23
5.2.6 Integrated District Development.. 23
5.3 Key Takeaways for Developing Countries 25
6 How to Fund It.. 26
6.1 Funding Sources 26
6.1.1 Government-Directed Funds.. 26
6.1.2 ESCOs... 26
6.1.3 Utility Ratepayer Funds 27
6.2 Key Takeaways for Developing Countries 27
7 How to Prioritize Action: Design and Implementation of Benefit-to-Cost Tests 28
7.1 Savings-to-Investment Ratios 28
7.2 Other Cost-Benefit Tests...29
7.3 Key Takeaways for Developing Countries 29
8 How to Conduct Outreach 30
8.1 Outreach Measures..30
8.2 Key Players 30
8.3 Challenges..31
8.4 Key Takeaways for Developing Countries 31
9 How to Evaluate LMI Energy-Efficiency Programs 32

9.1 Types of Evaluations....32
9.2 Evaluation in Practice 33
9.3 Key Takeaways for Developing Countries 33
10 Roadmap to Action.... 35
10.1 Core Elements 35
10.2 Roadmap for Energy-Efficiency Interventions....35
10.2.1 Impact Level 1 and Level 2: Lighting and Appliances 36
10.2.2 Impact Level 3: Buildings.... 38
10.2.3 Impact Level 4: Markets 40
References 42

List of Figures

Figure ES-1. Illustrative example of how institutional capacity results in increasing sophistication of LMI energy-efficiency delivery vii
Figure ES-2. Increasing levels of energy-efficiency intervention viii
Figure 1. Potential for energy efficiency by sector 1
Figure 2. Electricity demand by end-use and region in the New Policies scenarios (2017–2040) of IEA's *World Energy Outlook 2018* 5
Figure 3. U.S. low-income funding breakdown for measures targeting efficiency (boxed) and bill assistance 9
Figure 4. Number of European Union countries using energy-efficiency and social policies to address low-income needs. 10
Figure 5. Institutions and functions to deliver LMI household energy efficiency 13
Figure 6. Illustrative example of institutional building blocks and how institutional capacity results in increasing sophistication of LMI energy-efficiency delivery 15
Figure 7. Frequency of energy-efficiency measures installed in homes in program year 2008 17
Figure 8. The Pena Station Next project will demonstrate a new model for smart city design. 24
Figure 9. Diversity in ownership (left) and electricity consumption (right) among U.S. low-income households 31
Figure 10. Increasing impact levels of energy-efficiency intervention 36

List of Tables

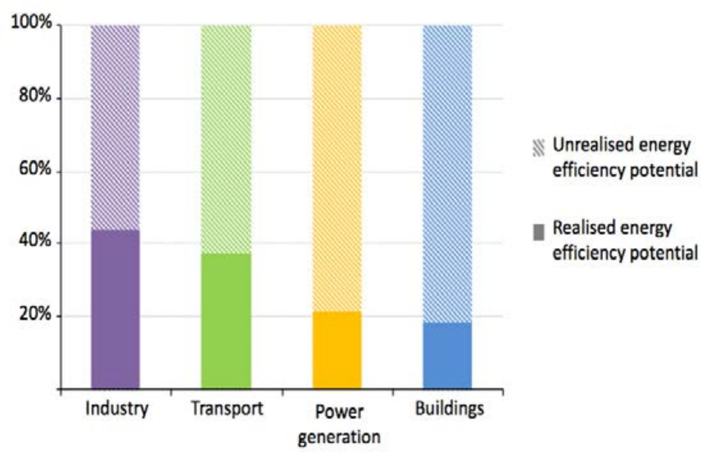
Table ES-1. Metrics Associated with Energy Burden for U.S. Metropolitan Residents v
Table 1. Metrics Associated with Energy Burden for U.S. Metropolitan Residents 4
Table 2. Eligibility Criteria for Low-Income Energy-Efficiency Services and Programs in European Union Member States 6
Table 3. Characteristics of Evaluation Methods for Nonenergy Benefits 32

1 Introduction: The Importance of Addressing Energy Efficiency in Low-Income Households

This report presents lessons learned in low-income energy-efficiency program delivery in the United States and other Organisation for Economic Co-operation and Development (OECD) countries, and it provides a high-level roadmap to establishing such programs in developing countries. The report provides a macro understanding of how to assess needs and then how to design, implement, and evaluate energy-efficiency programs in developing countries. Although efficient electricity use is the primary focus, the information might also provide lessons for other energy sources, such as natural gas or bioenergy and potentially water (de Laski and Mauer 2017). The report focuses mainly on lessons learned from the long history of establishing low-income programs in industrial countries, but it also includes lessons from developing countries where available.

1.1 The Unmet Potential for Energy Efficiency in Households

Energy efficiency is one of the lowest cost options for providing consumers with electricity services as well as addressing energy security, economic development, and environmental protection goals (The World Bank 2017; International Energy Agency [IEA] 2018a; Molina 2014; McKinsey and Company 2010). Efficiency can underpin important segments of the economy by boosting local job creation, trade, innovation, and commercial opportunities (U.S. Department of Energy [DOE] 2017b; American Council for an Energy-Efficient Economy [ACEEE] 2017). Although some regions and sectors of the world have advanced energy-efficiency technologies and savings, the IEA reports that as of 2012, more than 80% of the global economic potential for energy efficiency in buildings remains untapped; see Figure 1 (IEA 2012b).



Source: IEA 2012b

Figure 1. Potential for energy efficiency by sector

Low-income communities have a high potential for energy savings. More than 30% of households in the United States qualify for low-income energy assistance, but utility spending in that segment comprises only 17% of overall efficiency spending (Hoffman, Leventis, and Goldman 2017). A 2017 report from the Consortium for Energy Efficiency suggests that U.S. electric utility spending on low-income customers might be even less, only 5% of total expenditures (Consortium for Energy Efficiency 2017). In many developing countries, low-income households might receive even fewer efficiency resources. As a result, many households in developing countries do not have access to energy-efficiency investments and are therefore unable to capture the economic, social, and environmental benefits of these energy-efficiency measures.

Energy efficiency targeted at low-income households aligns well with many of the United Nations' Sustainable Development Goals.[1] For residential households, energy efficiency can help achieve goals of energy access, cleaner economic development, gender equity, water savings, and public health improvements. Efficiency investments also allow for more services (e.g., refrigeration, lighting) to be provided to the poor while using the same amount of energy or less, which can increase standards of living and quality of life.

1.2 Benefits and Costs

Successful efficiency interventions result in both energy benefits (savings on energy bills) and other nonenergy[2] benefits, such as healthier and safer homes, reduced pollution, job creation, and increased energy security. The costs of efficiency programs involve the direct costs of installing energy-efficiency upgrades and measures, but other indirect costs might also be included. These could include needed health and safety investments to prepare a home for certain energy-efficiency investments, such as weatherization. Additional costs could also include program administration and workforce development investments.

Energy-efficiency measures not only deliver electricity savings to low-income beneficiaries that enhance energy affordability for these households but also make homes more comfortable and safer. Investments in energy efficiency in low-income households include benefits to utilities as well. For example, late payments or nonpayment of utility bills (arrearage) occur more frequently among low-income households, resulting in lost revenue for utilities, especially when disconnection is required (Hernández and Bird 2010). Energy efficiency can help households reduce their energy burden and reduce their arrearages, which lead to increased revenue collected by the utility.

Multiple benefits around comfort, health, and safety also produce major benefits for low-income households. Homes with inadequate insulation and air sealing lead to more expensive energy bills as well as difficulty in maintaining a safe and comfortable home temperature. Low-income households are also more likely to house vulnerable populations, including elderly, disabled, young children, or single parents, populations that are more susceptible to health impacts from improperly heated and cooled homes (Anderson, White, and Finney 2012; Poortinga et al. 2017). Children raised in homes that are cold, for example, have increased incidences of asthma and other health problems (Heyman et al 2011; Hernández and Bird 2010; Liddell and Morris 2010) than children who reside in properly heated homes. Energy efficiency can also reduce morbidity related to hot and cold temperatures, particularly among vulnerable populations in urban areas, through investments such as insulation, ventilation, efficient windows, and passive building design.

More information on quantifying the benefits and costs of residential efficiency measures is provided in Section 7.

1.3 Energy Burden

Energy burden is the percentage of a household's income spent on energy bills. It provides a measure of energy affordability.

Energy burden tends to include electricity and heating fuel expenses, and it could also include water and transportation costs. Studies have found that energy burdens tend to be higher for low-income households and that low-income households pay more per square foot for their energy bills (Drehobl and Ross 2016). Researchers often identify 6% as a high or unaffordable energy burden in the United States, and the aim is to keep burdens at or less than this threshold (Fisher Sheehan & Colton Public Finance & General

[1] See https://sustainabledevelopment.un.org.
[2] Often referred to as "multiple benefits" by practitioners.

Economics 2017). Moreover, qualitative research indicates that energy burden is not experienced equally among low-income households; households with similar energy burdens might feel different levels of energy insecurity. For example, households with children often feel more energy insecure than those with elderly inhabitants (Berry, Hronis, and Woodward 2018).

High energy burdens for low-income households result not only from lower incomes but also because lower-income families typically inhabit older, less efficient homes that have older appliances (Center for Climate and Energy Solutions 2017; Cluett, Amann, and Ou 2016). These households might face difficult decisions between paying monthly utility bills or buying other necessities, such as food or medicine. These choices lead to increased stress from economic insecurity, and they can perpetuate the cycle of poverty (Drehobl and Ross 2016).

In Europe, *fuel poverty* might be the more common terminology, and it is defined as the level at which energy burden is significantly cost-prohibitive. A typical definition of fuel poverty is when a household spends more than 10% of its income on energy (Boardman 1991). Definitions of fuel poverty in Europe have evolved over time, from the general, such as “where a household finds it difficult or impossible to ensure adequate heating in the dwelling at an affordable price,” to the more specific and recent definition: “twice the median fuel expenditure as a proportion of income” (Heffner and Campbell 2011; Alpheeis n.d.).

For aggregate measures of energy burden, the median annual income, size of the unit, and median annual utility spending are used to calculate the median energy burden. According to a recent study by Drehobl and Ross (2016), the average non-low-income household in the United States, including single and multifamily residences, spent 2.3% of annual income on energy bills in 2011 and 2013, whereas those who qualified as low-income (defined as 80% of the area median income), paid 7.2%. This is more than three times the level of non-low-income households (Table 1). Also, these median energy burdens mask the increased burdens that certain regions experience. Low-income households in Memphis, Birmingham, and Atlanta had energy burdens that exceeded 10%, whereas some individual households spent nearly 20% of their income on energy (Drehobl and Ross 2016). Additionally, low-income households in the United States pay approximately 20% more per square foot of living space on energy bills than their non-low-income peers, demonstrating that these homes are generally less efficient. Finally, nonwhite households, renters, and low-income multifamily building residents pay disproportionally more than other households (Ross, Drehobl, and Stickles 2018).

Table 1. Metrics Associated with Energy Burden for U.S. Metropolitan Residents

	Household Type	Median Annual Income ($)	Median Energy Burden[a] (%)
Income Type	Low-income[b]	24,998	7.2
	Non-low-income	90,000	2.3
	Low-income multifamily	21,996	5.0
	Non-low-income multifamily	71,982	1.5

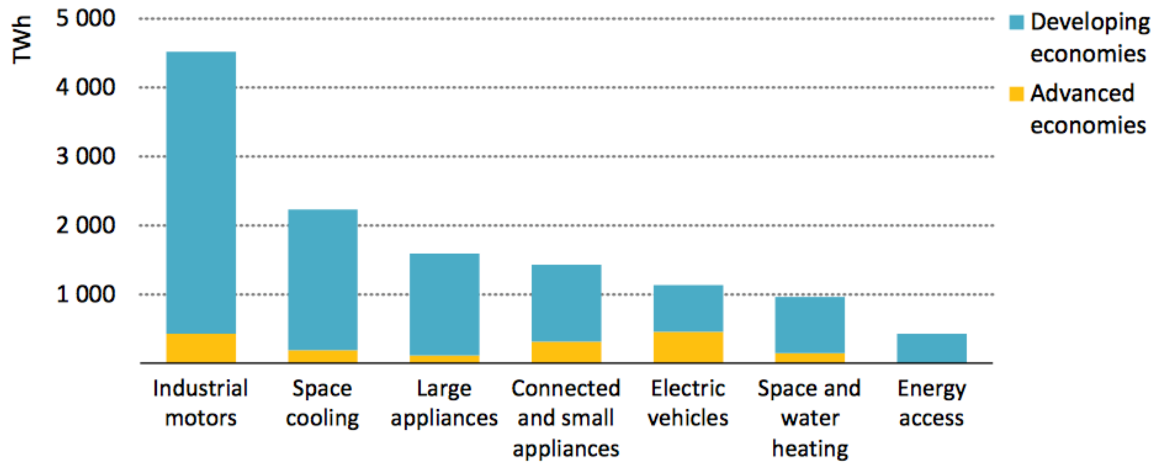
Source: Adopted from Drehobl and Ross 2016

[a] Derived by calculating the energy burden for all households and then taking the median. This is different from calculating the median annual utility spending divided by income.

[b] Low-income includes both single-family and multifamily (a building with five or more units) households, and it is less than or equal to 80% of the area median income (see Section 2.1). All data are from the U.S. Census Bureau and U.S. Department of Housing and Urban Development's American Housing Survey in 2011 and 2013.

1.4 Demand Growth in the Developing World

Most major energy studies expect that future electricity demand growth will occur fastest in developing countries. For example, the IEA estimates that 90% of electricity demand growth between now and 2040 will occur in developing countries. Researchers predict that China will have twice the electricity demand as the United States, with India falling closely behind. Electricity demand is expected to grow by 3% per year through 2040, led by China, India, Southeast Asia, Central and South America, and Africa (IEA 2018a). Industrial countries, on the other hand, face largely flat load growth primarily because of energy-efficiency investments (IEA 2018b). This projection emphasizes the importance of focusing energy-efficiency efforts on developing countries and low- and moderate-income (LMI) households in particular. Although demand growth in the developing world might still focus on industrial applications, such as electric motors, strong residential demand growth in large appliances, space cooling, and small appliances, including lighting, will also advance energy demand (Figure 2). Providing electricity access to approximately 700 million additional people represents a small fraction (3%) of global electricity demand (IEA 2018b). The trend of increasing end-use electrification (e.g., electric vehicles and heat pumps) could significantly alter these projections. Other recent research points to the potential for significant demand in space cooling around the world as temperatures (and incomes) increase (O'Grady and Narsipur 2018).



Source: IEA 2018b

Figure 2. Electricity demand by end-use and region in the New Policies scenarios (2017–2040) of IEA's *World Energy Outlook 2018*

Overall, the IEA estimates that the building sector will drive global electricity demand (nearly 55% of growth by 2040).The residential sector in particular is estimated to contribute 70% to overall buildings electricity demand growth between 2025–2040 (IEA 2018b). These sectors and end uses are ripe targets for low-income, energy-efficiency programs. Energy efficiency enables low-income households to jump tiers of productive, efficient energy consumption. Because low-income households might have limited economic capital, they might therefore experience high energy burdens and face barriers to investing in energy-efficient solutions to achieve energy affordability. Energy efficiency allows for more services (e.g., lighting, heating, cooling) to be accessed for the same (or minimal increases in) amount of electricity consumption and cost.

2 Who to Target

Section 1 discussed the benefits of investing in energy efficiency in low-income communities. Properly identifying and targeting specific households for assistance is the first step toward designing an efficient and equitable low-income, energy-efficiency program.

2.1 Classifying "Low-Income": Measure and Prioritize

Definitions of LMI populations vary across jurisdictions and programs but are generally determined as a percentage of area median income for a given location or are based on federal poverty levels. In the United States, the U.S. Department of Housing and Urban Development, for example, defines very low-income households as having 50% of an area's median income and low-income households as having 80% of an area's median income (U.S. Department of Housing and Urban Development 2016). Moderate-income families, by definition, fall at 100% of the area's median income level. These are examples of measuring poverty in relative terms.

Other programs might rely on poverty guideline levels that use absolute metrics. In 2017, for example, a family of four residing in the continental United States with an income of $24,600 or less met the poverty guideline level defined by the U.S. Department of Health and Human Services (U.S. Department of Health and Human Services 2018). Many low-income energy assistance programs in the United States use a threshold of either 150% or 200% of the federal poverty level as a qualification threshold. These levels equate to income levels of $36,900 ($24,600 x 1.5) and $49,200 ($24,600 x 2.0), respectively. Moderate-income families typically fall in a range of 200%–300% of the federal poverty level (State and Local Energy Efficiency Action Network 2017). Often in the United States low-income eligibility requirements for energy efficiency are streamlined across other social programs, so someone who is already enrolled in one program can be automatically enrolled in another.

In the United States, federal, state, and local entities all have control over eligibility requirements for low-income efficiency programs, whereas the European Union tends to use national definitions for low-income households. Recent European Union directives between 2009–2012 call for member states to more explicitly address energy poverty and energy efficiency for low-income residents. As of 2015, most European member states have determined eligibility criteria for low-income energy-efficiency services and programs (Table 2). Some countries, such as Ireland, more specifically prioritize energy-efficiency delivery by focusing on a subset of the most vulnerable low-income residents (elderly, families with children, renters, etc.) (Ugarte et al. 2016).

Table 2. Eligibility Criteria for Low-Income Energy-Efficiency Services and Programs in European Union Member States

Leading Factor	Member States[a]
Energy affordability (low income/high expenditure)[b]	FR, IT, SE
Eligibility for social welfare	BG, CY, DE, DK, EE, FI, HR, HU, LT, LU, MT, PL, PT, SI
Disability/health[c]	CZ, NL, SK, IE
Range of socioeconomic groups	AT, BE, ES, GR, RO, UK

[a] Abbreviations: AT: Austria, BE: Belgium, BG: Bulgaria, CY: Cyprus, CZ: Czech Republic, DE: Germany, EE: Estonia, ES: Spain, FI: Finland, FR: France, GR: Greenland, HR: Croatia, HU: Hungary, IE: Ireland, IT: Italy, LU: Lithuania, LV: Latvia, MT: Malta, NL: The Netherlands, PL: Poland, PT: Portugal, RO: Romania, SE: Sweden, SI: Slovenia, SK: Slovakia, UK: United Kingdom. Adapted from (Ugarte et al. 2016)
[b] Interchangeable with energy burden in this context
[c] Often a factor used to describe vulnerability, but often considered with age and income (Ugarte et al. 2016)

In other countries, such as India, poverty (synonymous with low-income in this respect) is measured in absolute terms (e.g., $1/day), as in a minimum income required to meet basic needs (e.g., food, water, shelter, clothing, transportation, education). Those who are below this poverty line might be eligible for government assistance; however, those who are below this poverty line might have limited use of energy, relying mostly on biomass (which is not the focus of this report), so different criteria for low-income households might be more appropriate for specific energy-efficiency interventions. A low-income definition couched in absolute terms will vary by jurisdiction depending on the income required to provide for necessities. Moreover, developing countries might find it useful to further distinguish among low-income definitions and eligibility according to urban, rural, and slum contexts. Each country or jurisdiction will need to determine low-income eligibility criteria that make the most sense for their given context.

Designing programs to target certain low-income households can naturally evolve over time as lessons are absorbed and best practices are established. For example, in 2002, Brazil's regulatory agency, ANEEL, originally defined low-income eligibility for social tariffs (i.e., reduced electricity rates) based on consumption levels and connection type but later revised these parameters after learning that they often included higher income consumers with specific connection types and excluded lower income consumers with high energy consumption. Now social tariff eligibility is aligned with customer registration in other social programs designed for low-income residents. This adjustment better targets low-income customers and reduces electricity subsidies paid by ratepayers (Herreros Garcia and Broc n.d.). In developing countries, where metering infrastructure might not be robust, it is also critical to take a first step to ensure that households have individual meters to measure electricity usage and enable proper targeting (Kojima and Trimble 2016).

2.2 Targeting Households: Deep Versus Wide Program Design

A key choice associated with targeting low-income households is whether to seek deeper and more comprehensive (and more expensive) improvements among a smaller subset of potential recipients or to seek more limited improvements among a larger proportion of potential recipients. This trade-off is often pronounced in deciding to target low-income, multifamily households (often rentals) or single-family residences, given that more residents can benefit from improvements in multifamily housing compared to those of single-family housing. In multifamily rental households, energy-efficiency providers must overcome the split-incentive barrier[3] that exists where the building owner might be different from the energy bill payer. Programs that offer some financial support to landlords to make energy-efficient improvements can expand the impact of the program beyond low-income homeowners to renters who typically have little control over their homes. Targeting multifamily households, however, can achieve better economies of scale and uniformity that reduce per-unit intervention costs.

[3] Split incentives result when the tenants are responsible for paying utility bills but the landlord must pay for the efficiency upgrades. In this case, the landlord does not have an incentive to invest in efficiency to reduce the bills. The split incentive also arises when the landlord pays the utility bill and then the tenants do not feel motivated to save energy. Although the building owner can see benefits for investing in efficiency, the tenants are the primary beneficiaries in terms of reduced monthly energy bills and other nonenergy benefits, and the same goes for tenants who see the benefits of efficient behavior.

Two examples typify the trade-offs of the deep-versus-wide approach: (1) energy audit-based interventions that target whole-house efficiency renovations; and (2) "top five" energy kits, or other prepackaged measures, that attempt to address the least-cost options for as many households as possible. In the United States, energy audits alone can cost program implementers between $100–$600 before any improvements are made, and typically they include a list of prioritized measures that can cost an additional $1,000–$15,000, depending on needs (Fixr 2018). These types of whole-house retrofits can lead to deep energy savings (40% or more), but the cost might be prohibitive for low-income households unless funded through ratepayer, federal, or state funds (Leinartas and Stephens 2015). At the other end of the spectrum, prepackaged measures offer low-cost saving opportunities that can be deployed at scale but might offer less energy savings. These packaged measures might include light-emitting diode (LED) bulbs, low-flow faucets and showerheads, "smart" power strips that households install themselves, and informational brochures on how to save more energy. Utilities can often make bulk purchases for the items contained in the kits and might distribute them for free or very low cost to targeted households. Wide approaches, such as prepackaged measures, might cost less, be less administratively burdensome, and can help stimulate local supply chains. Ultimately, when designing a low-income energy-efficiency program, implementers must decide between reaching many people with fewer resources per intervention or a few people with many resources for each.

2.3 Key Takeaways for Developing Countries

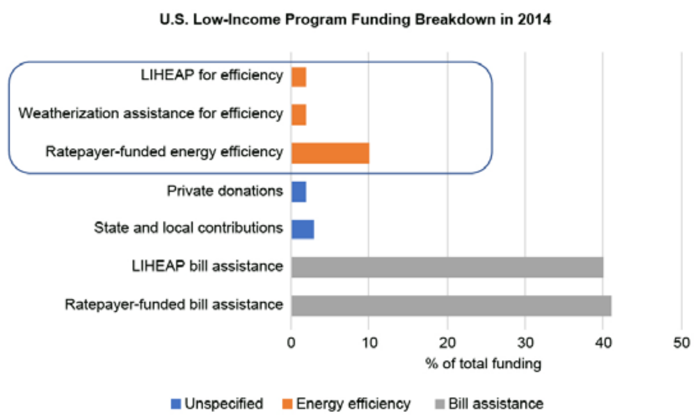
Clearly define your target. *Low income* can be defined in relative or absolute terms and will vary by context. Clear, consistent, appropriate, and transparent guidelines for "low-income" eligibility help focus a program's target demographic and allow prospective recipients to easily understand their potential eligibility. Energy-efficiency interventions range in price and type, and they should be carefully evaluated with respect to the costs, benefits, barriers, and applicability for a given context.

Consider "wide" rather than "deep" to start. As governments and utilities begin the process of developing efficiency programs for LMI households, they might start with low-cost, packaged measures for a wide audience to keep administrative costs low and ensure increased equity. As program implementers collect data on program impacts, they can consider shifting to more tailored approaches that deliver increased savings per intervention, although typically at increased individual costs.

3 How to Reduce Energy Burden

Economic approaches to reducing energy burden that target energy use and bills can either (1) reduce the amount that consumers pay for electricity, often through subsidy programs; or (2) provide assistance to reduce the amount of electricity consumers use. Many countries attempt to make energy more affordable for consumers through subsidy programs, also known as bill assistance. These programs relieve an individual's energy burden by covering a part of their energy bill using government or other ratepayer funds, reducing the amount that the individual pays. These subsidies can be directed at all members of society or targeted to certain demographic groups, such as the elderly, disabled, or low income. The second approach—helping reduce consumer electricity use—might also rely on subsidies in some form (e.g., subsidized LEDs or financing mechanisms), but it focuses on providing long-term solutions to reducing high energy burdens.

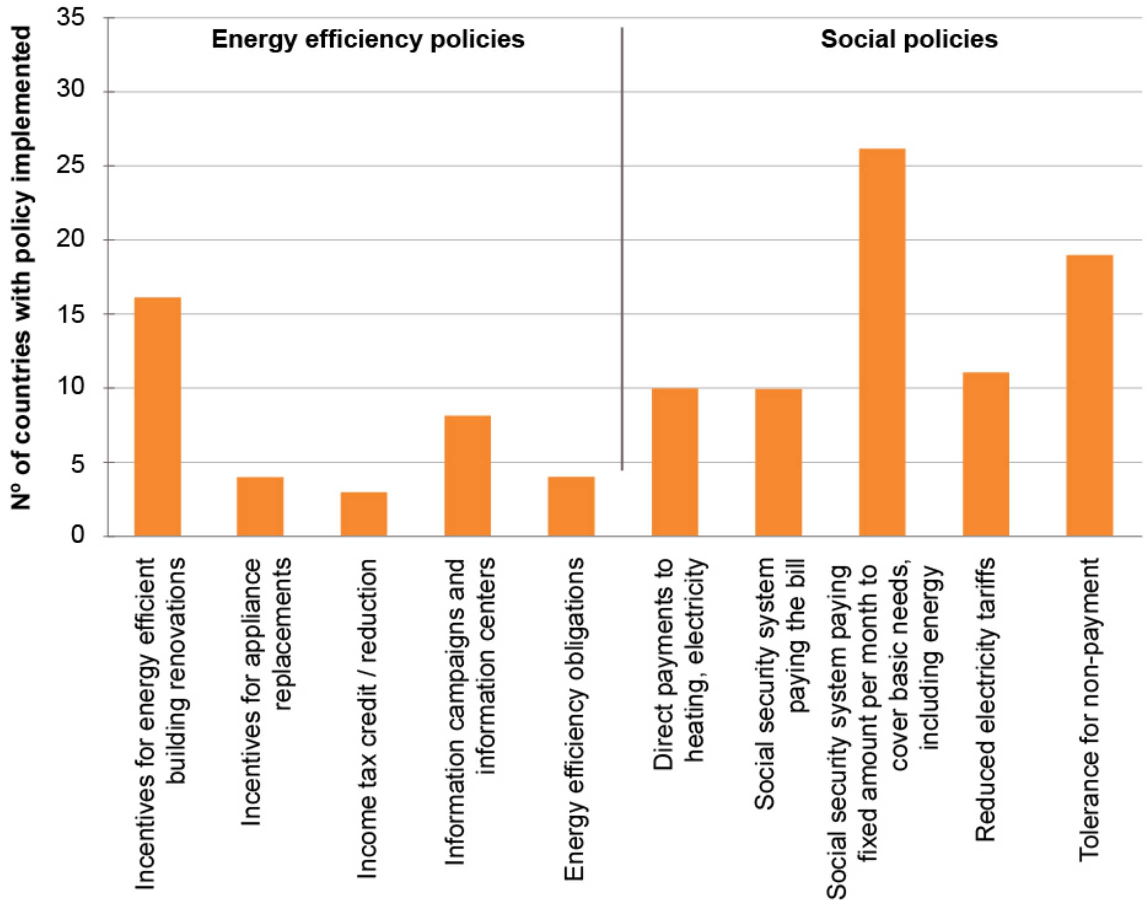
The United States uses both approaches to reduce high energy burdens. Bill assistance, through the U.S. Department of Health and Human Services' Low-Income Home Energy Assistance Program (LIHEAP) and ratepayer-funded programs, accounts for more than 80% of total spending on low-income energy assistance (Figure 3). In California, for example, the California Alternate Rates for Energy program provides electricity bill discounts of 30%–35% for eligible households (California Public Utilities Commission 2018). Two main programs to reduce low-income energy burdens include (1) DOE's Weatherization Assistance Program (WAP) and (2) state and utility (ratepayer-funded) programs.



Source: Adopted from Ross 2017. Underlying data from Cluett, Amann, and Ou 2016

Figure 3. U.S. low-income funding breakdown for measures targeting efficiency (boxed) and bill assistance

European Union member states use a combination of energy-efficiency and social policies (i.e., subsidies/bill assistance) to address energy poverty (Figure 4), but social policies such as bill assistance are more common (Ugarte et al. 2016).



Source: Adapted from Ugarte et al. 2016. Compiled from National Energy Efficiency Action Plans national documents ODYSSEE-MURE 2016; Insight Observatory n.d.; Agency for the Cooperation of Energy Regulators 2015)

Figure 4. Number of European Union countries using energy-efficiency and social policies to address low-income needs.

3.1 Shifting from Bill Assistance to Energy Efficiency

Although helpful or even essential for vulnerable communities, subsidies (i.e., bill assistance) could economically incentivize wasteful energy use or prevent benefits from reaching those who need it most (IEA, OECD and The World Bank 2010; Komives et al. 2005). Without appropriate price signals to guide energy behavior, subsidies can prevent consumers and businesses from making efficient choices, standing in the way of efficient economic development. Excessive energy subsidies can erode utilities' revenue base, leading to slow expansion of electricity networks, poor grid reliability, and limited capacity to provide reliable service (The World Bank 2016). A different type of illegal and unintentional "subsidy" is provided to some customers who steal electricity. Addressing electricity theft or nonpayment is one opportunity to break the cycle between unintentional subsidies and poor utility financial health, as described in Text Box 1.

Moreover, electricity subsidies in many countries might not properly target intended populations. In all countries of Central America, researchers found that electricity subsidies are inefficiently targeted. Less than 40 cents of every dollar spent were to the poorest 40% of the population primarily because of misaligned household eligibility thresholds (Oré et al. 2018). Brazil has taken steps to increasingly refine eligibility criteria for subsidized "social tariffs" among citizens, for example, by disallowing qualification by second homeowners (Herreros Garcia and Broc n.d.). Limiting subsidies to targeted households is a priority first step for jurisdictions seeking to rationalize LMI energy assistance.

Incentivizing energy-efficient behaviors while meeting the primary needs of vulnerable communities is enabled by strong political will, good corporate governance, effective communication programs, and transparent evaluations. Implementing programs that support long-term efficiency improvements in LMI households can, over time, result in reduced net outlays by governments, utilities, and ratepayers compared to regular subsidies, especially when all benefits are included (U.S. Environmental Protection Agency 2011; Hernández and Bird 2010). Bill assistance and energy efficiency might be complementary approaches to reducing energy burden for periods of time because of (1) unmet, immediate, often severe energy burden among low-income households; (2) insufficient funds for comprehensive, deep energy-efficiency impacts; (3) a delay in the effect of energy-efficiency improvements; or (4) all of the these.

Text Box 1: Addressing Nontechnical Losses

Distribution utilities in developing countries have historically suffered from high levels of "nontechnical losses" (NTLs), which generally refer to theft of electricity through illegal connections, tampering with meters, or nonpayment of bills. Utilities that do not address NTLs might not be in a position to initiate programs on energy efficiency let alone more basic functions such as proper billing, collection, and offering reliable service. Although some jurisdictions have taken successful steps to reduce lost revenue associated with NTLs during the past two decades, a significant number remain severely handicapped from functioning effectively as a result of revenue shortfalls (The World Bank 2009). A recent estimate put the global annual value of NTLs at nearly $100 billion (Foster 2017).

An NTL—whether illegal, tolerated, or encouraged—is a form of subsidy that distorts electricity markets. Utilities can attempt to recover the lost revenue by adding onto the entire rate base or they can seek direct cost recovery from the government. The former can lead to a snowball effect, with unsatisfied customers refusing to pay for their electricity, especially if the service is unreliable, and it can further erode utility revenue. Illegal connections might often occur in dense urban areas where utilities have little ability to see and rectify what is occurring on their distribution network or where corruption allows them to endure. These are not restricted to residential users, however; commercial and industrial entities are also caught making illegal connections (International Center for Research on Environment and Development 2017).

Some jurisdictions are experimenting with privately owned distribution networks, where the companies have a stricter policy of patrolling infrastructure, removing illegal connections and shutting off power to users that do not pay. Privatized companies, especially if they charge higher tariffs, are expected to be able to offer significantly increased reliability and a better value proposition for consumers to pay their monthly bills regularly. The World Bank, the U.S. Agency for International Development, and the International Center for Research on Environment and Development have published multiple case studies outlining how NTLs have been significantly reduced in key regions of the world through a variety of measures, only some of which involve the privatization of distribution companies (World Bank 2009; Lawaetz 2018; International Center for Research on Environment and Development 2017).

Special incentives can also be created that allow consumers to "see" and pay the real price of energy but then receive other payments (dividends or grants) that account for their specific situation. For example, a jurisdiction can use market-based energy pricing for everyone and then provide tax relief, grants, or annual dividends to targeted populations to help offset the relatively high energy prices. Keeping administrative costs low in a developing country by streamlining application processes and standardizing evaluations can help ensure that valuable bill assistance funding is directed to target populations for the most impact.

3.2 Key Takeaways for Developing Countries

Gradually prioritize efficiency over subsidies when possible. Although subsidies might reduce energy burden, they can prevent or slow the effective development of energy systems (through economic distortions), depending on their design and use. Instead, developing countries could (1) ensure that subsidies go only to the neediest, (2) focus at least some financial assistance on increasing energy efficiency to complement direct subsidies, and (3) offer dividends, grants, or refunds ex post to minimize distortions while protecting the most vulnerable (GIZ 2009). Minimizing nontechnical losses (NTLs) at distribution utilities, though challenging from a political perspective, can empower utilities to improve services, including planning and operational support for energy efficiency as well as overall reliability.

4 Which Institutions and Stakeholders Are Needed and What Are Their Roles?

Delivering any energy-efficiency service to LMI households requires institutional capacity. Experience in the United States and OECD countries demonstrates that five main institutions or stakeholders tend to play a role in LMI efficiency programs: government, utilities, nonprofits/nongovernmental organizations (NGOs), academia, and the private sector (Figure 5). Each stakeholder has a unique role in contributing to the measures needed to carry out LMI efficiency projects: legislating policy, building capacity, conducting outreach, delivering efficiency services, financing upgrades, and evaluating results. Institutional capacity varies by jurisdiction and changes over time as experience is gained—a pattern developing countries will likely follow as well.

4.1 U.S. Experience

The United States takes a decentralized approach to low-income energy-efficiency delivery that relies on the federal and state governments, local agencies and organizations, utilities, and private sector contractors. Although federal LIHEAP funding does support energy efficiency, the premier federal low-income energy-efficiency program in the United States is WAP, which was established in 1976 to help low-income households better meet their energy needs through improved efficiency measures in their homes. The goal of WAP is not only to save low-income households money on energy bills but also to improve the health and safety of their residences, especially in homes that have elderly, disabled, young children, and single-parent populations.

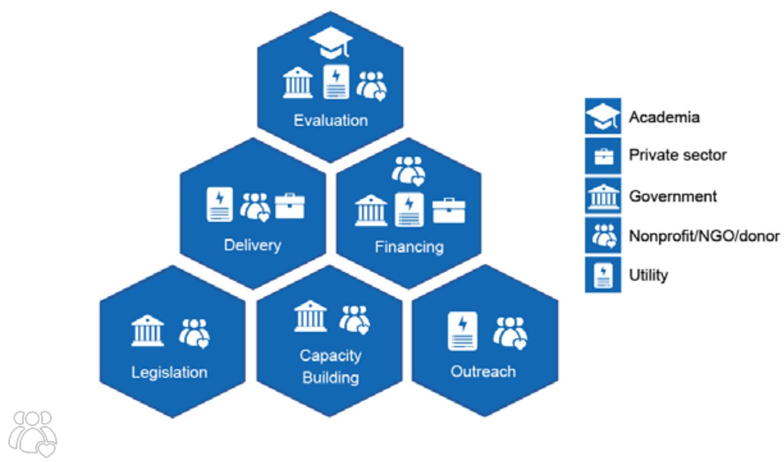


Figure 5. Institutions and functions to deliver LMI household energy efficiency

WAP is managed by DOE's Office of Energy Efficiency and Renewable Energy and directs congressionally-appropriated funds to states, territories, and Washington, D.C., via state-level grantees through a formula-based mechanism. Grantees then distribute funding to subgrantees, often through agencies that are responsible for coordinating all low-income energy-assistance efforts for a state through a network of stakeholders. Recipients of subgrantee funding are often referred to as community action agencies (CAAs) or community action partnerships. These network partners, typically not-for-profit NGOs, either do the efficiency upgrades themselves or hire approved private sector contractors for specialty work, such as replacing or repairing boilers and furnaces. In many states, these CAAs serve as a central coordinator for other federal, state, and utility-funded low-income programs as well as many other social programs. To increase the effectiveness of efficiency delivery, WAP also funds the Weatherization Leveraged Partnerships Project, which provides training programs to local partners. These training programs include weatherization program design, public utility commission (state regulator) advocacy, and strategies for gathering state funding (Community Action Partnership 2018). DOE has also engaged academia to evaluate the impacts of WAP (Tonn et al. 2014). Engaging academia, research organizations, or third-party evaluations is common among state or utility-run energy-efficiency programs as well.

Utilities are also instrumental to low-income energy-efficiency delivery in the United States. Policymakers and regulators have typically instructed utilities to collect and dedicate specific customer charges to low-income energy-efficiency programs through the regulatory process. Utility-led, ratepayer-funded efficiency programs emerged in the United States during the 1980s and grew rapidly, largely in the form of demand-side management (DSM)[4] programs. These programs collect charges from ratepaying customers and use these funds for energy-efficiency programs. Today, utility-driven programs for low-income households are the single largest source of funding targeting energy efficiency in that market segment (see Figure 3 in Section 3).

Although the federal and state governments play a critical role in terms of funding and coordination, CAAs and private sector contractors are the primary institutions on the ground delivering energy-efficiency measures and conducting outreach in communities. Ongoing capacity building and training for local organizations and the private sector ensure that these institutions are familiar with emerging technologies and methods. For example, DOE's Guidelines for Home Energy Professionals project has developed standard work specifications for home energy upgrades with an online, interactive tool with trainings and checklists as well as standard job task and credentials to support the private sector energy-efficiency workforce in the United States (DOE 2014).

4.2 Other OECD Experience

Although not as longstanding as those in the United States, low-income energy-efficiency programs in many other industrial countries share the decentralized approach and a reliance on local partners, typically nonprofit entities. France's two main low-income energy-efficiency programs—Les Fonds Sociaux d'Aide aux Travaux de Maîtrise de l'Energie (FSATME) and Habiter Mieux (Live Better)— for example, are highly decentralized programs implemented at the department[5] level in partnerships with local institutions (Alpheeis n.d.; Dubois 2012). Ireland's Better Energy Warmer Homes Scheme applies a "social employment delivery model" whereby regional community-based organizations are engaged and trained to deliver the efficiency services[6] to their communities and networks must identify eligible homes (IEA 2012a; IEA 2014a; Ugarte et al. 2016; Department of Communications, Energy, and Natural Resources 2011). As part of Australia's Low-Income Energy Efficiency Program, a consortia of community organizations, energy companies, local or regional governments, energy-efficiency technology manufacturers, financial institutions, and research institutions compete for competitive merit-based grants. Various state governments in Australia have also instituted energy-efficiency initiatives in parallel with federal initiatives, such as the New South Wales Home Power Savings Program (Australian Government Department of Climate Change and Energy Efficiency 2012; IEA 2017a; Ugarte et al. 2016). Funding for these and other OECD programs comes largely from federal budgets and appropriations.

4.3 Building Institutional Capacity Enables Impact and Replication

In developing countries, institutions might assume responsibilities similar to those in industrial nations, but in other cases, institutions might face unique barriers and challenges that limit or prohibit the

[4] *DSM* is defined by the U.S. Energy Information Administration as energy and load-shape modifying activities undertaken by utilities (U.S. Energy Information Administration 2018).

[5] A geographical administrative division in France.

[6] Measures include attic insulation, draught proofing, lagging jackets, CFL bulbs, and cavity wall insulation (Department of Communications, Energy, and Natural Resources 2011).

execution of activities critical to LMI energy-efficiency delivery. Utilities will have a unique role in developing countries. Because they are a direct, existing interface with the customer, they might serve as an optimal point of entry to working with low-income populations, many of whom can be difficult to reach. For example, Brazil's Sao Paulo distribution utility, AES Eletropaulo, opened a local office in the Paraisópolis favela (an informal slum) that was the target of a pilot slum electrification and loss reduction program to better target and serve low-income, hard-to-reach customers (Herreros Garcia and Broc n.d.).

Generally speaking, the quantity and quality of low-income energy-efficiency programs will increase as institutional capacity grows. Figure 6 illustrates this dynamic. As the level of institutional capacity matures, programs can become more sophisticated, resulting in increased replicability and impact.

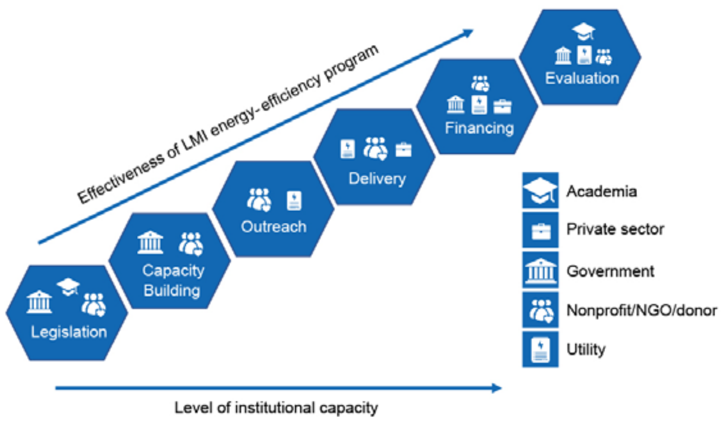


Figure 6. Illustrative example of institutional building blocks and how institutional capacity results in increasing sophistication of LMI energy-efficiency delivery

4.4 Key Takeaways for Developing Countries

Decentralized approaches leverage local knowledge and capacity. Effective low-income energy-efficiency programs are often decentralized so that local partners more familiar with their community needs and with appropriate outreach capabilities can deliver services effectively. Target populations should also be included in program design through implementation to ensure that the program will meet the needs of the community. In this decentralized structure, an overseeing federal, regional, or state government can experiment with different approaches to service delivery and identify best practices. Such an approach, however, can mean inconsistency in service delivery across regions, which should be mitigated by the evaluation of best practices and peer exchange among programs and communities.

Utilities are a logical program partner. Utilities play an important role in low-income energy-efficiency programs in OECD countries in terms of service delivery and funding programs (e.g., surcharges or fees dedicated to funding low-income energy-efficiency programs). Because of their unique technical expertise and existing knowledge and relationships with customers, utilities might serve as a trusted low-income energy-efficiency partner in developing countries.

To be effective at energy-efficiency delivery, utilities must be generally adept at customer billing, education and outreach, and evaluation. Developing these institutional skills should be initial goals in developing countries where utilities face challenges to delivering basic energy services that might compromise their ability or willingness to participate in low-income energy-efficiency programs.

Private sector engagement can be critical. The private sector has played an integral role in the United States and other developed countries' low-income energy-efficiency program delivery. In developing countries where energy-efficiency knowledge might be nascent, programs should consider dedicating resources to workforce training and creating certificates or designations to distinguish trained, skilled, and experienced professionals and entrepreneurs. In more mature markets, energy service companies (ESCOs) can deliver efficiency improvements with no up-front costs, but a relatively large-scale project (commercial or industrial scale) is required to guarantee savings. When there is not a well-developed private sector capable of delivering efficiency services, starting with easy-to-administrate, prepackaged efficiency programs (e.g., bulk purchasing of LEDs) can be an effective means to create a domestic market.

Academia can evaluate programs and inform decision-makers. Industrial countries frequently engage universities, research organizations, and third-party evaluators to evaluate low-income energy-efficiency programs because of their expertise and status as objective, neutral third parties. Academia can also support capacity-building to inform early stages of policymaking and program design. For more information on program evaluation, see Section 9.

5 What Tools Are in the Toolbox?

With a program population target, an energy burden reduction approach, and key institutions engaged, the next step to advancing low-income energy efficiency is understanding and selecting delivery measures and financing mechanisms for program implementation. OECD experience points to various tried and true options, so-called "tools in the toolbox." As mentioned in Section 4, the tools outlined in this section have often been implemented (in OECD countries and others) in a decentralized manner with different levels of government, local organizations, private sector, and utility involvement. Often, program implementers apply multiple measures and financing mechanisms concurrently.

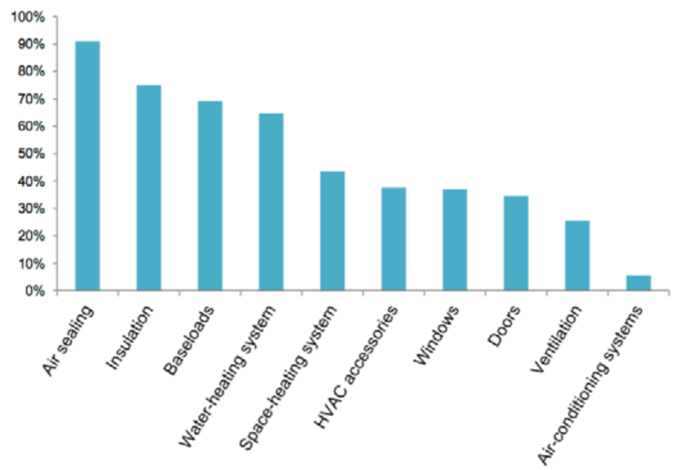
5.1 Overview of Targeted Low-income Energy-Efficiency Tools

5.1.1 No-Cost or Discounted Weatherization Programs

Weatherization is the central focus of the United States' main low-income energy-efficiency program: WAP. Typical measures offered at no or low cost to households include:

- Sealing gaps with caulking and weather stripping to prevent air intrusion
- Adding insulation to roofs and crawl spaces
- Addressing baseload electricity consumption by improving the efficiency of lighting, refrigeration, hot water flow rates, and other major energy-consuming household devices
- Repairing or replacing heating, ventilating, and air-conditioning (HVAC) equipment
- Repairing or replacing inefficient windows and doors.

The frequency at which energy-efficiency measures were installed in homes through WAP in the year 2008 are shown in Figure 7.



Source: Tonn et al. 2014

Figure 7. Frequency of energy-efficiency measures installed in homes in program year 2008

Evaluations determine that households save around 35% on annual energy consumption after weatherization (DOE 2011). The degree of energy savings varies based on the measures installed (e.g., insulation, lighting, and HVAC equipment), type of climate, resident behavior, and the rebound effect.[7] An evaluation of WAP recognized that weatherization investments in colder climates are more cost-effective than those in warmer ones (Tonn et al. 2014).

Weatherization measures are widely employed throughout other OECD countries as well. The United Kingdom provides energy audits and low-cost financing for energy-efficiency improvements for citizens, including low-income residents. From 2010–2015, the U.K. Department of Energy and Climate Change estimates that low-income energy-efficiency programs delivered more than 525,000 heater measures (boiler replacements and communal heating) and more than 1.28 million insulation measures (loft cavity and solid wall) (Department of Energy and Climate Change 2015).

France's two low-income energy-efficiency programs subsidize or finance thermal improvements for low-income households in low-income housing, particularly for the elderly (Alpheeis n.d.; Dubois 2012).

Since 2001, Ireland has improved energy efficiency in low-income households through no-cost retrofits under its Better Energy Warmer Homes Scheme (IEA 2012a; IEA 2014a; Ugarte et al. 2016; Department of Communications, Energy, and Natural Resources 2011). With a budget of 60 million euros, the scheme has assisted 65,000 households in Ireland (Department of Communications, Energy, and Natural Resources 2011).

Germany's Caritas-Stromspar Check program installs energy-efficient appliances at no cost within days of a free energy audit. The program invests an average of 70 euros per household and has resulted in savings (per household) of 16% annual electricity consumption (~98 euros/year); 17% annual water consumption (~31 euros/year), and 216 kWh in heating (~11 euros/year). As of 2016, the program had delivered services to 226,150 households. Moreover, the program recruits unemployed residents of low-income households and trains them to deliver free energy audits to low-income households (Ugarte et al. 2016).

New Zealand's marquee Warm Up New Zealand energy-efficiency programs have targeted insulation improvements, heat, and other retrofits. Landlords are eligible for substantial subsidies to cover improvement costs, and low-income residents can receive 100% cost coverage. As of 2016, 139,000 low-income households participated in the program and received insulation measures. Participants report increased levels of comfort and improved health (Ugarte et al. 2016; Heffner and Campbell 2011).

Ugarate et al. (2016), in their comparative evaluation of low-income energy-efficiency programs across Europe and other OECD, notes that programs in Ireland, France, and New Zealand provided cost-effective financial incentives for building renovations that are attributed to the use of targeted energy audits focused on high-impact projects such as wall and roof insulation and boiler replacements as well as a multistep approach to financial aid (education, audits, and retrofit subsidies).

5.1.2 Traditional and Low-Cost Loans

Utilities and other federal and state organizations can offer a variety of traditional and innovative loan products to help finance energy-efficiency upgrades for low-income communities. Loans might be

[7] The rebound effect posits that consumers might use more energy after an efficiency upgrade because they are then paying less for that energy service. Despite the potential for rebound effects to impact energy bills, anecdotal evidence points to relatively minor impacts. See, for example, Gillingham, Rapson, and Wagner (2016). For low-income households, particularly in the developing world, the rebound effect might actually be an indication of achieving development objectives because energy efficiency allows households to make well-being improvements (e.g., purchase time-saving appliances) and be more productive than they otherwise would have been.

secured by the property or they might be unsecured. These are generally modest, although the United States' Fannie Mae's Green Financing for multifamily homes has recently grown rapidly (Fannie Mae 2018). Property Assessed Clean Energy financing and Energy Savings Performance Contracting[8] are two other financing models that could be used in certain low-income household situations. Some states have created "green banks," financial institutions specifically focused on bringing low-cost capital to clean energy projects. Green banks offer financial products to a variety of end users, including low-income populations (National Renewable Energy Laboratory 2018).

In another unique approach, in Vermont, funders now incorporate Efficiency Vermont's energy performance requirements into the underwriting criteria for affordable housing projects (Nowak et al. 2013). Energy performance requirements include efficiency specifications for heating systems, domestic hot water, air-conditioning, ventilation, the thermal building shell, air leakage, ENERGY STAR®[9] certification, lighting, and common in-unit appliances. These requirements are intended to keep energy use low, energy operating budgets stable at affordable housing projects, and also result in access to low-interest 30-year financing. To demonstrate compliance, the Vermont Housing Finance Agency requires developers to provide (1) certification of substantial completion from the project architect and (2) a completed checklist and evidence from the housing credit sponsor (Vermont Housing Finance Agency 2012). Efficiency Vermont, or approved contractors, is required to conduct on-site inspections to verify compliance.

In 2012, the Washington State Housing Finance Commission established a revolving loan fund for multifamily and nonprofit retrofits. Loans from the Sustainable Energy Trust allow borrowers to fund measures up to $1 million that might not necessarily be cost-effective from the utility's perspective (and therefore do not have associated rebates) but still generate savings. Projects are required to generate at least 10% savings, and the interest rate is tied to the degree of savings achieved, with average interest rates between 2%–3%, and loan terms up to 10 years (Washington State Housing Finance Commission 2018).

In another example, Utah's Housing and Community Development Division created a $2 million loan fund using underwriting from the state housing trust fund. Under this approach, low-income households could apply for 15-year, 2.75% interest loans to fund efficiency measures and then use the savings to repay the loan interest. This approach navigated statutory constraints with borrowing from private lenders and underwriting loans with public funds (Tonn, Rose, and Hawkins 2017).

Microfinance institutions in the developing world can also provide energy-efficiency lending. As one example, in Bosnia, the EKI, a microfinance organization that was created after the Bosnian War, received 600,000 euros from the International Finance Corporation to create a home energy-efficiency lending program and develop a radio and television marketing campaign. Housing loans provided by this program focused on thermal insulation and improved boilers, and they had an average term of 17 months and a maximum term of 36 months (Moyo 2006).

Last, international financing institution and commercial financing can support energy efficiency in the developing world and demonstrate cost-effectiveness and profitability through different projects. For

---

[8] Property Assessed Clean Energy allows property owners the chance to finance the up-front portions of an efficiency or renewable energy investment through an assessment that is tied to the property and not the individual (DOE 2018a). Energy Savings Performance Contracting is another approach to making building energy-saving improvements with no up-front costs: an energy service company finances the upgrades and agrees to split the monthly energy savings with the property owner in an agreed-upon fashion (National Association of Energy Service Companies n.d.).

[9] Energy Star is a voluntary labeling program administered by the U.S. Environmental Protection Agency that informs consumers about highly efficient products: https://www.energystar.gov.

example, under the Morocco Sustainable Energy Financing Facility, the European Bank for Reconstruction and Development has lent more than 40 million euros to provide efficiency and supply improvements for more than 80 projects. The focus of the program has been on industry and commercial clients, including hotels, agribusinesses, equipment manufacturers, and others. By attaching international financing institution lending and targeted technical assistance to the local finance institutions already engaged in making capital loans to these clients, use of the financing facility has been rapid. Results have also been impressive, with payback periods as low as 2 years (European Bank for Reconstruction and Development SEFF 2015).

5.1.3 On-Bill Financing

Proposed as a more sustainable approach to reach large communities of low-income households, utilities pay for energy-efficiency upgrades at households and then recover a portion of the saved energy on each month's bill. On-bill financing works like a revolving fund to support low-income households (and others) in a sustainable manner. For example, one rural cooperative in Arkansas, Ouachita Electric, has implemented a tariffed on-bill finance program called the Home Energy Loan Program Pay As You Save. Under this program, the utility pays for a home energy assessment and efficiency improvements, and then the customer simply pays a monthly cost-recovery charge that totals less than the estimate (Harvell 2017). The program includes renters in multifamily housing but does require that participants have a solid payment history with the utility.

On-bill financing can be effective because it allows the utility to simplify the interface for households by using an existing partnership and fits with the "nudge theory" in the behavioral economics of making it easier for people to do a new thing or adopt a new behavior (Henderson 2013). In countries where utilities do not have adequate billing and collections procedures or a functional customer management system, on-bill financing might not be possible in the short term without first addressing these core operational issues (see Text Box 1 for more on utility NTLs).

5.1.4 Bulk Purchasing

A key element of most utility DSM programs, bulk purchasing allows utilities to distribute free or very low-cost devices or informational packages that can result in significant electricity savings. Efficient lighting (LEDs and compact fluorescent lamps [CFLs]) and low-flow showerheads are typical examples. For example, the Vermont Energy Investment Corporation through its Efficiency Vermont program leverages relationships with local food bank distribution centers to order high volumes of CFLs or LEDs at low cost. Efficiency Vermont purchases bulbs directly from the manufacturers, cutting out retail middlemen. The bulbs are another item low-income residents can receive when visiting their local food bank (Nowak et al. 2013). Internationally, India's state-run LED program has also implemented a bulk purchasing program at scale, selling more than 230 million LED bulbs in 3 years, reducing LED prices by 90% and reducing India's entire residential electricity consumption by an estimated 13% in 2016. This program does not require any subsidy, but instead it provides a benefit by selling the LEDs at the government's bulk cost to households (Chunekar, Mulay, and Kelkar 2017).

5.1.5 Utility Rebates for Efficient Appliances

Many utilities offer rebates for large, energy-efficient appliances, such as air conditioners, dishwashers, refrigerators, and washing machines. These programs are widely prevalent and also relatively easy to administer. Utilities will generally provide a rebate to customers who purchase a qualifying efficient appliance, and occasionally they might also specify the use of certified participating contractors for installation as well. In the United States, Xcel Energy has a well-developed cooling rebate program, including tiered rebates based on the equipment's expected energy savings and allowing trade-in rebates for system upgrades. Interested customers must first find a participating contractor to ensure installation quality, and then choose equipment that meets the Air Conditioning, Heating & Refrigeration Institute's efficiency standard. Contractors must provide customers with the rebate application, which a customer in turn fills out and submits to Xcel. A check reimbursement from Xcel arrives within several business days (Xcel Energy 2018). For investor-owned utilities such as Xcel Energy, these programs are generally required by the regulator to be net cost-saving or cost-neutral and are funded by ratepayers. Municipal utilities and cooperatives also invest in rebate programs to reduce their customers' consumption, and often they have more flexibility in program design because they are not generally bound by the same public utility commission limitations.

Appliance exchanges are an iteration of appliance rebates whereby customers can exchange an older, inefficient appliance for a newer model or receive funding or financing to do so. Some examples of this practice can be found in Latin America. In 2009, Mexico developed a Cash for Coolers program[10] where residents exchanged refrigerators and air conditioners that were more than 10 years old for direct payments and subsidized financing to purchase newer appliances that exceeded Mexico's energy-efficiency minimum standards (Ugarte et al. 2016). Brazil used funds from a utility wires charge to fund a refrigerator replacement program administered by local utilities. The program replaced 1 million old, inefficient units with newer models during a period of 10 years (IEA 2007).

5.1.6 Education and Outreach Programs

Demonstrating the potential for cost savings to low-income households is a key goal of this measure and widely considered an essential element of successful improvements to low-income households. Many U.S. states offer awareness and educational outreach programs to low-income households, some of whom might need special targeting because of language barriers, lack of direct access to information, an increased chance of having health problems or disabilities, or other hurdles. States might delegate this role to nonprofit agencies with expertise in this area, such as Energy Outreach Colorado. These agencies generally work with LIHEAP or WAP agencies to promote efficiency programs at shelters, food banks, schools, and multifamily housing units. Energy Outreach Colorado has seen about 5%–7% energy savings (from behavior change) from households as a result of education, even before any energy-efficiency measures were implemented (DOE 2017a).

5.1.7 Energy Efficiency and Distributed Photovoltaics

The first step to reducing energy burden for low-income households is to institute energy-efficiency measures. Distributed photovoltaic (PV) systems play an important role in potentially reducing energy bills further, or in the developing world by enabling or improving access to electricity. Recently, WAP also began considering applications for renewable energy, mainly PV, in requests for weatherization assistance (Rinebolt 2017). Although this option was legally available for more than a decade, solar PV has only recently been able to begin passing the cost-benefit test (see Section 7) required in many jurisdictions because of the rapid decline in PV prices. PV is not an efficiency measure per se, although it does allow low-income households to significantly reduce their electricity bills and can be a cost-effective option for households even when heating fuel (natural gas, propane, distillate oil) burdens have been addressed through weatherization. Implementing energy efficiency in tandem with distributed PV can enable lower cost solar installations, maximizing affordability for low-income households.

5.2 Additional Energy-Efficiency Tools for LMI Households

Other available tools target wider household energy-efficiency improvements and impact low-income communities, although indirectly. This is not meant to be an exhaustive list but instead describe some of the other tools that can impact low-income households.

[10] Initiated in 2009, Mexico's Cash for Coolers program allowed residents exchanged refrigerators and air conditioners that were more than 10 years old for direct payments and subsidized financing to purchase newer appliances that exceeded Mexico's energy-efficiency minimum standards (Ugarte et al. 2016).

5.2.1 Evaluation, Measurement, and Verification Guidelines

Whereas cost-benefit tests attempt to prioritize the most cost-effective efficiency investments, evaluation, measurement, and verification (EM&V) guidelines are the tools and processes used to evaluate an energy-efficiency project after it has been implemented. EM&V is critical to understanding whether energy-efficiency measures meet expected energy savings and what can be done to improve performance going forward (ACEEE 2010b). The U.S. Environmental Protection Agency's EM&V protocols report[11] summarizes some of the most common federal and state protocols and guidelines for EM&V (U.S. Environmental Protection Agency n.d.).

5.2.2 Energy-Efficiency Resource Standards

These resource standards set time-based energy-saving targets that utilities in a given jurisdiction must meet. Targets might differ, but typically they require that a percentage reduction in energy sales be achieved by customer energy-efficiency measures by a specific date or on an annual basis. Twenty-seven states in the United States have energy-efficiency resource standards, and similar utility obligations are mandated throughout Europe (Berg et al. 2018; Ugarte et al. 2016).

5.2.3 Building Codes and Standards

Codes and standards aim to set performance levels for new building envelopes and some of the energy-consuming devices within them, especially HVAC equipment. They can also be enforced for renovations at existing buildings. These can be important for low-income households when new multifamily residences are being planned or during the longer term as lower income populations migrate to newer housing (Laustsen 2008; Northeast Energy Efficiency Partnerships 2018; ACEEE 2010a). At the planning stage, governments can mandate that low-income housing developments meet or exceed particular building codes (i.e., mandating specific technologies or building-use energy intensity thresholds). The United Kingdom, for example, requires that all eligible privately rented properties meet a minimum energy-efficiency standard[12] prior to being rented. It also requires increasing energy-efficiency standards for new buildings (Department of Energy and Climate Change 2015). Similarly, a U.S.-based nonprofit, Enterprise Community Partners, has developed a green building standard for low-income housing in the United States that is adopted at the state level (Enterprise Community Partners 2018).

In developing countries, there might be additional challenges to creating standards that reduce consumption that are also enforceable and do not price low-income home buyers out of the market. In India, building codes are still largely voluntary, and there are significant gaps in enforcement. In OECD countries, building codes are generally enforced through permitting processes, but in India, there is currently limited capacity in this part of the process (Evans et al. 2014). Similar to approaches with appliance standards, market transformation efforts that focus on voluntary standards with large building developers is a potential avenue for moving codes and enforcement forward, such as through Leadership in Energy and Environmental Design, International Finance Corporation's Excellence in Design for Greater Efficiency, and others.

Enforcement of building codes in the developing world can be accomplished by the use of accredited, third-party inspectors. In China, third-party inspectors, regulated and monitored by local authorities, have contributed to building code compliance (Yu, Evans, and Kumar 2013). Although this approach will add

[11] https://19january2017snapshot.epa.gov/sites/production/files/2015-08/documents/epa_lbe_appendixi.pdf

[12] A minimum of an "E" Energy Performance Certificate rating is required. The Energy Performance Certificate rating system is A (most efficient) through G (least efficient). Property owners must install measures to reach this E rating, but the owners are exempted from this standard if they can prove that the cost of the improvements, including financing costs, exceeds the expected energy savings. Local authorities are empowered to enforce the regulation by following up on a tenant complaint or their own investigation and imposing a civil penalty, but specific guidance on enforcement is still in development (Department of Energy and Climate Change 2014).

to the cost of construction and is subject to potential conflicts of interest, it might be superior to not conducting any permitting evaluation. Notably, contractors, builders, and other professionals in the private sector must also have sufficient knowledge of building codes and training to be able to meet the requirements effectively.

5.2.4 Appliance Standards and Labeling

Usually set at the federal level, appliance standards and labeling set performance levels for select types of appliances (televisions, refrigerators, air conditioners, etc.). Combined with programs such as ENERGY STAR, these can be important tools to engage low-income households in better understanding life-cycle appliance costs and why buying a slightly more expensive though more efficient appliance might save money during the long term. Appliance standards allow utilities to objectively determine energy savings and issue rebates to low-income households under certain circumstances, such as when the appliance exceeds a mandatory efficiency level.

Government leadership at the national level and industry buy-in are key determinants to the success of both appliance standards and labeling in developed countries. Standards and labeling should be consistent across regions, hence the need for national-level leadership. Where governments do not have sufficient capacity to design standards themselves, programs such as the Collaborative Labeling and Appliance Standards Program (CLASP) can connect policymakers to an international network of standards and labeling experts.[13]

5.2.5 Market Transformation

Market transformation is a strategic, coordinated approach to remove barriers to the adoption of energy efficiency. Activities can include supply chain improvements, standards and labeling, and education and outreach, and they depend largely on private sector participation. Often there can be a substantial (e.g., 5–10 years) lag between market transformation activities and impact because of the complexity of the undertaking (York et al. 2017). Although aimed at all consumers, market transformation also directly impacts low-income consumers and activities and can be done in tandem with targeted low-income energy-efficiency programs.

One example of market transformation is strengthening local supply chains. Adequate supply chains for energy-efficient goods and services are important to ensure the delivery of technology, so it might behoove governments and the private sector to form public-private partnerships aimed at boosting local manufacturing and supply chain sufficiency. Government procurement can stimulate the private sector, creating a market for these new technologies. Local suppliers of energy-efficient goods and services might not exist in some jurisdictions but can be encouraged to grow and expand offerings to low-income households through coordinated public-private partnerships. International suppliers might serve to fill the initial void until local suppliers are established, potentially with specific in-country manufacturing requirements.

5.2.6 Integrated District Development

District or neighborhood development projects that include residential housing, commercial businesses, transportation infrastructure, and other energy- or water-intensive services are common in many moderate- to rapidly growing economies. Urban planners are beginning to work on integrated approaches to building design and neighborhood layout to maximize the efficiency of energy, water, telecommunications, and transportation services. Advanced modeling techniques can aid in these designs. In many rapidly growing jurisdictions, these approaches could help promote zero energy districts with low water usage and efficient mobility services.

[13] See https://clasp.ngo.

One such example is under development in Denver, Colorado, through a partnership between Panasonic Enterprise Solutions, the National Renewable Energy Laboratory, the local utility, the city and airport of Denver, real estate developers, and other organizations. The Pena Station Next district includes offices, homes, hotels, retail dining, and parks, all operating as a zero energy microgrid (Figure 8). New software tools are allowing the integrated planning of building layout, heating and cooling needs, varying levels of PV and efficiency targets, and overall interaction with the local distribution grid.

Source: National Renewable Energy Laboratory 2017

Figure 8. The Pena Station Next project will demonstrate a new model for smart city design.

District development projects benefit the residents in specific locations. Such an approach can target low-income households more specifically if completed in low-income regions or slums that require investment or where developments have a requirement to rent to low-income tenants. The Argentinian government, for example, in partnership with the World Bank, has taken an interdisciplinary approach with a strong emphasis on energy efficiency to redeveloping a famous Buenos Aires slum, Villa 31 (Bosi 2017). Although financing district development projects will always be a challenge, some cities, particularly in India, have created successful public-private partnerships for slum redevelopment to fulfill national development goals (Nallathiga 2012). Efficient, integrated energy use could be a potential overlay these projects could consider.

5.3 Key Takeaways for Developing Countries

Start simple and grow. Experience from WAP and utility programs show significant learning by doing knowledge that can be gathered from successes and failures. New programs should start with proven and simple measures, as discussed in Section 2.2 and Section 2.3, and expand over time. Post-intervention evaluation studies (see Section 9) can be used to determine if investments have been successful. These data can inform debt financing where energy-efficiency savings are used to repay low-cost loans or utility on-bill financing.

Provide a variety of financing options. Program implementers should consider a variety of programs that have a variety of financing and funding options—including utility rebates, tax credits, low-interest loans, and on-bill financing—because most low-income households do not have the capital to make significant energy-efficiency improvements. More sophisticated financing tools, including products from green banks, ESCOs, and Property Assessed Clean Energy can emerge as institutional capacity grows; however, especially in developing countries, financing might not be available until the efficiency approaches are proven to be cost-effective. Microfinance institutions could be one, albeit limited (in scale) tool for financing energy-efficiency measures.

General energy-efficiency policies can help low-income households at low cost. Setting energy-efficiency targets, establishing and enforcing building codes and standards, and institutionalizing labeling programs have economy-wide impacts but benefit the low-income residential sector as well.

6 How to Fund It

Energy efficiency for low-income households consistently delivers, by design, more direct and indirect benefits than costs, but those benefits cannot be attained without initial program funding.

6.1 Funding Sources

Industrial countries have used a combination of three main funding streams to support low-income energy-efficiency programs: government-directed taxpayer funds, state and utility directed funds, and leveraging private sector investment. Dedicated revenue streams such as WAP and LIHEAP as well as other OECD programs rely on dedicated federal resources. State governments might use general revenue streams to support additional low-income energy-efficiency programs or direct utilities to collect funding through a wires charge or similar type of adder. Federal, state, and utility (i.e., ratepayer) funds can be leveraged with private sector support through ESCOs and other entrepreneurial approaches.

6.1.1 Government-Directed Funds

LIHEAP funds that can be allocated to efficiency might be delivered directly to the network of CAAs that also coordinate WAP disbursement or to state agencies that pool funding for low-income efficiency measures. WAP funding often leverages resources from other federal, state, and local agencies and utilities. For example, typical funding levels for WAP before the economic recession in 2008–2009 were approximately $250 million per year, which often leveraged an additional $500–800 million from other funders (Ross 2017).

Formation of public-private partnerships have allowed WAP to leverage state and private funding. For example, the DOE qualification review board evaluates private firms for the qualified list of ESCOs. If approved, the ESCO is allowed to compete for energy-efficiency project contracts with federal agencies. The development of the ESCO program has created a profitable business model based entirely on retrofitting existing buildings with efficiency measures (DOE 2018b).

Low-income efficiency programs in the European Union are largely funded by government-directed taxpayer funds, with some utility-funded contributions. Taxpayer funds can come from taxes on particular items or services, as is the case in South Korea, which established a tax of approximately 6% on energy-consuming home appliances and directed the revenues toward the purchase of high-efficiency appliances for low-income households (IEA, OECD, and The World Bank 2010). This mechanism is referred to as a "feebate."[14]

6.1.2 ESCOs

ESCOs combine engineering and financial expertise to offer potential packages of energy-efficiency upgrades to customers, and they might be the most widely cited example of the private sector driving energy efficiency in industrial and emerging economies. ESCOs typically serve the industrial and public buildings sectors more than households; however, ESCOs could play a role in delivering increased efficiency to low-income households in developments such as public housing projects, district developments focused on integrated zero energy outcomes, refugee camps, and high-density urban slums.

Utilities and industry also can play a critical role in financing energy-efficiency improvements. For example, the slum electrification and loss-reduction project launched in 2005 in Sao Paulo, Brazil, was supported by the local utility (AES Eletropaulo), the International Copper Association, and U.S. Agency for International Development (USAID). AES Eletropaulo financed distribution network upgrades,

[14] A feebate program is a set of structured rebates and penalties that reward energy-efficient practices and impose fees on those that consume high levels of energy. In the motor vehicle sector, for example, consumers receive a rebate on purchases that are highly efficient and pay extra fees on vehicles that are not.

metering, and appliances (e.g., refrigerators); International Copper Association funded household rewiring and transformers; and USAID led the outreach, audit, and program evaluation activities (Herreros Garcia and Broc n.d.).

6.1.3 Utility Ratepayer Funds

Many utilities implement programs to address residential energy-efficiency measures for low-income households. In many cases, states have directed their utilities to add a surcharge—often called a wires charge, public benefits fee or charge, universal service fee, or system benefits charge—onto all customer bills that is then used to promote energy efficiency in the service territory, with a certain percentage that must be spent on low-income households (Lazar 2016). Funds might be spent directly by utilities in parallel to other WAP and LIHEAP granting, or they might be pooled with those funds.

Many states are often responsible for coordinating funding from utility, WAP, LIHEAP, and state revenues to carry out weatherization activities. State agencies responsible for coordinating low-income energy assistance to a government agency work with a variety of the other federal, state, and local organizations to plan, execute, and evaluate energy-efficiency programs. Implementation differs considerably by state—in California, for example, low-income energy assistance is predominantly funded by ratepayers (90%) and involves state-mandated programs that provide discounts on utility bills and free weatherization services. These programs leverage WAP and LIHEAP funding and provided almost $1.5 billion in services in Fiscal Year 2012.These services are coordinated by a consortium of nonprofits, LIHEAP agencies, and California's regulated utilities.

In contrast, Florida has no ratepayer program and relies entirely on federal funding for programs. Florida CAAs augment federal funding with private donations from utilities and nonprofits such as the Salvation Army and United Way. Florida provided roughly $80 million in services in FY 2012, which included weatherization and bill assistance (Landley and Rzad 2015). Some states, such as Massachusetts, dedicate funding for low-income energy efficiency through more general sources of revenue (Commonwealth of Massachusetts 2016).

Many European countries have energy-efficiency obligations that require utilities to deliver energy savings, but only the United Kingdom, France, and Ireland require that some energy-efficiency savings are directed toward addressing low-income energy efficiency and alleviating fuel poverty (Ugarte et al. 2016). In Latin America, Brazil passed legislation in 2007 mandating that utilities invest 0.5% of their annual net revenue in energy-efficiency and research-and-development programs, half of which must be devoted to low-income households (Herreros Garcia and Broc n.d.).

6.2 Key Takeaways for Developing Countries

Low-income energy-efficiency programs require dedicated funding streams. Funding can be federally (or locally/state/regionally) appropriated or generated through utility measures (e.g., energy-efficiency obligation savings or wires charges) or other ratepayers (e.g., surcharge). Often revenue streams have been comingled and managed by a central agency or organization. The energy offices of developing countries could potentially serve in a similar convening role to that of U.S. state agencies and coordinate funding from private, public, and government sources, assuming that they have sufficient financial oversight.

Funding streams in developing countries might be limited and less reliable. Financially struggling utilities might resist contributing to low-income energy-efficiency programs, and regulators might hesitate to pass low-income energy-efficiency program costs to other ratepayers. Limited and unreliable funding streams point to the need to develop pilot projects that can deliver results with resources available, before scaling up. Moreover, projects funded jointly by multiple institutions within a country help overcome financial barriers that individual institutions might face.

7 How to Prioritize Action: Design and Implementation of Benefit-to-Cost Tests

Given the variety of energy-efficiency measures available and often limited resources, how can a program prioritize investments in low-income energy efficiency? A key yardstick for many government and utility-funded efficiency programs is the cost-benefit test needed to identify or prioritize the most promising investments. Unless estimated benefits exceed costs, the measure can fail to qualify for support. A number of different tests have emerged to evaluate the costs and benefits to different stakeholders, and some perceived values are very difficult to quantify (U.S. Environmental Protection Agency 2008; Lazar and Colburn 2013; Heffner and Campbell 2011; E4TheFuture 2018). Over time, energy-efficiency program cost-benefit tests have evolved to incorporate a broad set of costs and benefits, including those of other ratepayers and society, instead of solely relying on utilities and program participants (Woolf et al. 2012; Daykin, Aiona, and Hedman 2012; Berg and Drehobl 2018).

7.1 Savings-to-Investment Ratios

In the United States, the demand for both WAP and LIHEAP support is much greater than can be accommodated by congressional appropriations, so guidelines and rules—including cost-benefit tests and targeted households (e.g., disabled, elderly, single parents)—attempt to prioritize both where funding is directed and how it is used. Tests used by federal and state government programs—savings-to-investment ratios (SIRs)[15]—require a ratio of 1.0 or greater, which means the investment in the energy-efficiency measure must be at least fully recovered in energy savings. An SIR greater than 1.0 shows that the present value of an energy-efficiency measure during its lifetime is greater than the costs (lifetime savings/cost >1.0). Upon evaluation, some low-income energy-efficiency programs have not exceeded a cost-benefit ratio of 1.0 when accounting solely for energy benefits but far exceed this threshold when nonenergy benefits are also included in the analysis (Lazar and Colburn 2013).

For some states in the United States, the traditional SIR test might be waived for individual projects as long as the aggregate total is more than 1.0 and it can rest on the justification of the nonenergy benefits (e.g., improved health and safety, economic development), which are often greater than those for non-low-income households (Gilleo, Nowak, and Drehobl 2017). Quantifying nonenergy benefits can be complex, so some regions use simple multipliers to estimate the social value of having more efficient low-income households in certain neighborhoods (Woolf and Neme 2017).

Many low-income residences might have structural or safety issues that need to be addressed before the efficiency measures can be initiated.[16] These improvements can be costly and can lead to cost-benefit tests not reaching 1.0 (Raissicharmakani 2018; Wilson and Tohn 2011). DOE does allow some WAP funds to be used for health and safety improvements.[17] States typically establish a health and safety spending cap on their overall weatherization budgets; the level of funding per household is decided at the discretion of the subgrantee. Other financial resources (e.g., U.S. Department of Housing and Urban Development funds) are leveraged to support these essential repairs prior to making energy-efficiency

[15] An SIR is a metric used to measure the ability of a technology or intervention to recover the investment cost through savings from customer utility bill reductions during the lifetime of the technology or intervention. In other words, an SIR is the savings divided by the investment. An SIR greater than 1 indicates that an investment can be fully recovered (i.e., pay for itself).
[16] Examples include dated electrical wiring (knob and tube) that needs to be updated, roofs that need to be replaced or retiled, and failing foundations. In other cases, these homes might have mold, asbestos, and lead paint concerns that need to be mitigated in advance of any energy-efficiency measure.
[17] As of 2011, an average 10% of the weatherization budget for a home was spent on health and safety improvements Wilson and Tohn 2011.

improvements at households. Nonetheless, average deferral rates[18] on home weatherization because of serious and expensive health and safety are 10%–15%, according to 44 state-level WAP agencies and 42 WAP subgrantees (Wilson and Tohn 2011).

7.2 Other Cost-Benefit Tests

Utility-run programs in the United States, on the other hand, use a variety of potential cost-benefit tests from the perspective of utilities, recipients, or society at large. They can include both direct energy (and water) benefits as well as quantifiable nonenergy benefits. Depending on which test is used, stakeholders can have significantly different avenues for pursuing energy efficiency for low-income communities. Examples of other tests that vary on cost-benefit perspectives include the Total Resource Cost Test, Participant Cost Test, Societal Cost Test, Program Administrator Cost Test, and Ratepayer Impact Measure (U.S. Environmental Protection Agency 2008).(For more background on the tests used in the United States and how they are quantified, see U.S. Environmental Protection Agency (2008), Lazar and Colburn (2013), and Energy Efficiency Screening Coalition (2013); and for an international perspective, see IEA (2014b).

7.3 Key Takeaways for Developing Countries

Prioritization metrics should address low-income needs. Creating a system of prioritization is essential to low-income energy-efficiency delivery so that limited resources can be distributed transparently and equitably. Although an SIR test is an analytically sound method for quantifying costs and benefits of energy-efficiency measures, it is also relatively sophisticated and might be challenging to reproduce in some developing country contexts, particularly when data are poor and analytical capacity is limited. Because the nonenergy benefits of low-income energy-efficiency programs (e.g., improvements in health, safety, economic development) are substantial, often outweighing the direct energy benefits, decision-makers might consider accounting for them in cost-benefit tests or other prioritization metrics. Using tests that value the full social benefits might be more appropriate for low-income households compared to the larger population because they are typically more inclusive, even if methodologies can be complex.

[18] Deferral rates refer to the number of homes deemed unqualified for weatherization assistance because of structural or safety shortcomings compared to the total number of applicants.

8 How to Conduct Outreach

8.1 Outreach Measures

A key aspect of any low-income energy-efficiency program is outreach, which might need to be tailored to low-income residents. Methods might include:

- Information and social media campaigns
- Radio and TV announcements
- Connections through other social services
- Door-to-door visits
- Product labeling
- Focus groups
- Community meetings
- Word-of-mouth advertising from satisfied customers.

A multipronged approach is likely to be most effective at reaching the target audience. Germany's Caritas-Stromspar Check program recruits unemployed residents of low-income households and trains them to deliver program services (Ugarte et al. 2016), a peer-to-peer outreach and delivery method.

An evaluation of the slum electrification pilot project in Brazil's Paraisópolis favela revealed that door-to-door visits were essential to reaching customers, but they were best paired with community events in parallel. The timing and sequence of these events also influenced the impact of outreach (Herreros Garcia and Broc n.d.). In another slum electrification and energy-efficiency project in Bahia, Brazil, called Coelba, the program implementers identified existing community organizations and invited them to collaborate on the project to gain legitimacy and community acceptance. These community associations in turn hired and trained local residents to be "community agents" responsible for advertising and identifying and registering eligible customers within their assigned community (AVSI Foundation 2010). The type of outreach methods that most resonate with low-income residents are location- and country-specific, and they are best informed and developed in conjunction with local practitioners.

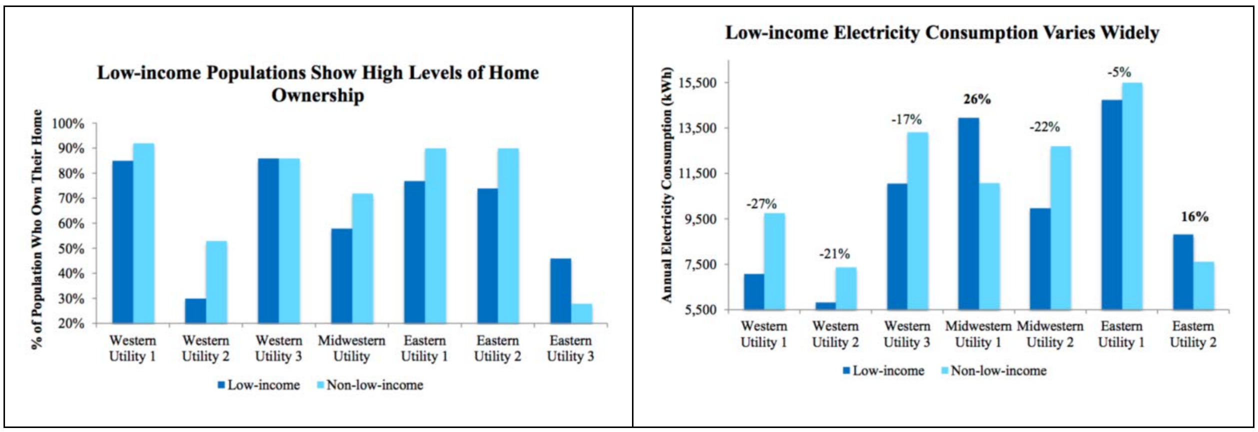
8.2 Key Players

Outreach for low-income energy-efficiency programs is typically undertaken by two sectors: (1) nonprofits/NGOs/donors and (2) utilities. Local organizations (typically nonprofit NGOs) have successfully conducted energy-efficiency program outreach in the United States and other OECD countries because of their intimate knowledge of and deep roots within specific communities. The same has shown to be true in developing countries as well. In the Ahmedabad Slum Electrification Program in Gujarat, India, two local nonprofits (SAATH and Mahila Housing SEWA Trust) supported the implementation of the local utility's project. In addition to going door-to-door, the nonprofits collaborated with local childcare centers to educate residents about the electrification program and organized social events to build rapport among residents (The Energy and Resources Institute 2011).

Utilities also commonly conduct outreach for energy-efficiency programs in large part because they often manage energy-efficiency programs. Their deep knowledge of customer energy use and established infrastructure (e.g., metering, billing) makes them a natural fit for efficiency outreach to low-income residents. In many developing countries, however, utilities face a host of challenges (e.g., financial uncertainty, skilled staff shortages) that might compromise their ability or willingness to add an additional responsibility of program outreach. In these cases, an additional layer of outreach to the utility to demonstrate the utility benefits of low-income efficiency programs will likely be necessary.

8.3 Challenges

According to ACEEE (2014), low-income populations in the United States are far from uniform, and therefore it can be challenging to use one unified method or message to reach out to these populations. This is likely true in the developing country context as well. Households exhibit significant variation in size, number of occupants, energy usage patterns, and ownership/rental status across regions (Figure 9). Large families might live in an urban multifamily residence, or a single elderly person might inhabit a rural home. Languages spoken might be equally diverse. Literacy rates can also vary significantly, especially in developing countries. Figure 9 reflects some of this diversity. Given the diversity of low-income households, it is important to understand the demographic characteristics of these populations akin to market research, which might be difficult where data are scarce. Based on demographic analysis, different outreach methods are needed to ensure that the target audience is aware of assistance programs and appropriate communication tools are used to engage them (LIHEAP Clearing House 2016).



Source: Berelson 2014

Figure 9. Diversity in ownership (left) and electricity consumption (right) among U.S. low-income households

8.4 Key Takeaways for Developing Countries

Provide coordinated service and a single point of contact for customers. Low-income households are widely considered hard-to-reach populations for energy-efficiency upgrades. Minimizing red tape and bureaucratic barriers can help ensure successful interventions. A trusted local partner is often best to serve as the single point of contact for programs that combine federal, state, and local government programs with nongovernmental assistance. In developing countries, this should ideally be an entity that already interacts with low-income households, such as a local development agency or potentially the utility service provider. Outreach can be more successful when low-income communities have been engaged in a program from the beginning—the design phase.

Flexible and varied outreach methods are needed. Low-income households are diverse, and different outreach methods are needed to successfully engage them. Factors such as housing quality, language barriers, level of education, involuntary transience, health, and types of vulnerable people (e.g., children, elderly) might all vary much more among those with low-incomes than other demographics. Low-income households can also vary dramatically from one jurisdiction to the next (e.g., rural, suburban, urban). A wide variety of outreach materials—including brochures, verbal messaging, videos, and case studies—can help reach a diverse audience with different capacities to absorb messaging. All efficiency measures and investments should include an outreach focus to educate households.

9 How to Evaluate LMI Energy-Efficiency Programs

Evaluation provides an understanding of program performance and provides insight into needed changes to ensure that program goals are met. Effective evaluation is not an afterthought but an important component of project planning and goal-setting from the start. The pronounced need for safe, reliable, and affordable energy in developing countries combined with the paucity of financial and institutional resources available to meet that need underscore the importance of program evaluation. Resources, simply put, cannot afford to be wasted.

9.1 Types of Evaluations

To support an evaluation, the program's objectives must be clearly defined. Objectives might include not only a specific change in energy demand for a given cost but also goals regarding program participation and energy-efficiency education. Evaluations can assess direct and indirect benefits of a low-income energy-efficiency program. Evaluation methods (i.e., survey or direct measurement) should be carefully chosen to assess the program objectives with consideration for the budget, data quality, and technical capacity available.

Although U.S. federal programs use the SIR test, program implementers might use claimed savings, which are internal estimates of savings, or evaluated savings by an independent party, to determine the effect (ex post) of energy-efficiency programs (State and Local Energy Efficiency Action Network 2012). For direct energy savings, baseline energy use is compared to post-treatment energy use. Before beginning EM&V, it is important to ensure that there is adequate infrastructure to collect the data necessary to measure energy use and cost.

Beyond the direct energy benefit evaluation, inclusion of nonenergy benefits is critical for low-income populations because of their high energy burdens. As noted in previous sections, it might be difficult to estimate nonenergy benefits, which might include additional economic benefits with a reduced energy burden and environmental benefits of reduced air emissions, water pollution, or other health benefits. Both survey and site evaluation methods might be used to estimate the value of nonenergy benefits. New York State Energy Research and Development Authority has implemented a number of these methods, as illustrated in Table 3.

Table 3. Characteristics of Evaluation Methods for Nonenergy Benefits

	Method Type	Approach	Outcome Pro/Cons
Contingent valuation	Survey	Ask respondents to estimate willingness to pay for a good (i.e., clean air)	- Large range of values
Direct query	Survey	Ask respondents to value nonenergy benefits relative to a reference	+ Consistent values
Conjoint analysis	Survey	Ask respondents to rank among different levels of nonenergy benefits	- Large range of values
Direct estimates	Impact evaluation estimates	Estimate nonenergy savings (i.e., water, labor)	- Accounts for only quantifiable nonenergy benefits

Source: Adapted from State and Local Energy Efficiency Action Network 2012

Because direct estimates require technical capability and cost, these methods are more suited for advanced energy-efficiency programs. Survey methods address nonenergy benefits at reduced cost. As evaluation resources increase, multiple survey methods might be integrated to improve evaluation.

In addition to impact evaluations, process evaluations assess a program's effectiveness in its operations, typically through surveys. A program's operational model depends on its goals—for example, a program that prioritizes deep savings from few participants would be structured quite differently than one that prioritizes equity and high program participation. Because programs vary in their approaches to delivering energy efficiency, the questions used in a process evaluation depend on the program's stated objectives. For low-income populations, surveys should consider data such as the number of low-income residents contacted, number of residents who choose to implement an efficiency action, and how valuable participants find the information or resources provided in an energy-efficiency program

9.2 Evaluation in Practice

Low-income energy-efficiency program evaluation can be approached with different levels of sophistication. Utilities and nonprofits might be required to report periodically on key metrics (e.g., costs, energy saved, number of program recipients). Governments might conduct or hire others to conduct more robust ex post program evaluation, such as those mentioned previously.

Ideally, the results of low-income energy-efficiency program evaluations inform and improve program design and delivery. For example, New Zealand quantified the nonenergy health benefits of warmer homes (reduction in respiratory hospitalizations after insulation was installed). This evaluation resulted in the New Zealand Heat Smart program including these health benefits in their cost-benefit justification for projects (Grimes et al. 2011). Similarly, academics in Brazil have conducted evaluations of energy access and energy-efficiency measures in some of its poorest favelas, and the results were used to modify future program delivery (Souza e Silva, Oliveira, and Tostes 2017). An ex post evaluation of Mexico's Cash for Coolers program found that less energy was saved than expected because of a rebound effect that occurred among customers who purchased new air conditioners (Ugarte et al. 2016).[19] These insights can help inform midcourse adjustments to program design and identify where successful measures could be scaled or replicated in other communities.

Nonprofits and NGOs in developing countries are likely familiar with the concept of, and approaches to, program evaluation because it is considered a best practice regardless of an organization's mission. The extent to which utilities in developing countries would be able and willing to conduct low-income energy-efficiency evaluations is less certain given competing priorities (e.g., avoiding rolling blackouts, maximizing sales) and challenges. Other barriers to program evaluation include (1) the lack of high-quality data (because of inadequate technology, collection methods, customer behavior, etc.), (2) insufficient knowledge and capacity to conduct robust evaluations, (3) limited financial resources to conduct evaluations, and (4) a tendency (not unique to the developing world), politically motivated or otherwise, to emphasize action and implementation over evaluation. Academia is well positioned to conduct evaluations and could be good partners.

9.3 Key Takeaways for Developing Countries

Evaluation of low-income energy-efficiency programs can provide heightened value. Evaluation adds value to a program by providing a framework to define objectives and assessing how effectively a program delivers energy-efficiency improvements, either in terms of energy savings or in a program's operations. No matter the type of evaluation chosen, program administrators should integrate program

[19] Davis et al. (2012) argue that this rebound effect is likely caused by a combination of factors, including improperly functioning air conditioners, appliances that exceeded size requirements, and additional features (e.g., ice makers) that were included with some air conditioners.

evaluation early in the process of program design. When this is done, evaluators can communicate their data needs to provide the most valuable recommendations for improvement or justify the expansion of pilot projects. In developing countries, early steps can be taken to engage universities and the research community to support the analysis, outreach, and evaluation of low-income energy-efficiency programs.

10 Roadmap to Action

So far, this report has explored the architecture of low-income energy-efficiency programs in OECD countries to date and the rationale for addressing these issues in developing countries. Best practices and lessons learned from the industrial world can inform the design and implementation of similar programs in developing countries, but prescriptive applications might fail to account for the unique context of each developing country. Instead, we offer a roadmap to action that (1) explores elements broadly common to numerous energy-efficiency interventions and (2) provides a framework for prioritizing specific energy interventions.

10.1 Core Elements

Whether providing basic energy education to low-income households, installing LEDs, or conducting energy audits, some common programmatic steps and best practices are broadly applicable to all interventions. These include:

1. **Define the target audience.** The definition of *low-income* can vary by jurisdiction, so eligibility guidelines that will serve those in need and avoid misdirected aid are essential. By defining a target audience, two additional issues will need to be determined: (1) if a program will target deep interventions that affect fewer people or provide a "light touch" for more widespread impact and (2) if there are other evaluation tools a program will use to prioritize investments when demand is greater than available resources. Once defined, engage that audience from the beginning in program development.
2. **Use energy-efficiency approaches to reduce energy burden but recognize the need for maintaining and ideally phasing out subsidies.** Electricity subsidies might be needed on humanitarian grounds, but they do not address the root causes of energy burden. Energy-efficiency approaches are more economically efficient and should be explored in tandem to subsidies.
3. **Assess and engage partners across sectors to support low-income energy-efficiency program design, implementation, and assessment.** Utilities are logical partners, and nonprofits often excel at outreach and implementation.
4. **Find a sustainable funding source**. A dedicated, sustainable funding stream is often essential for program impact. Consider using a combination of strategies, such as government revenues, utility wires charges, revolving loan funds, and donor support.
5. **When it comes to implementation, start simple and grow**. **Decentralized approaches are also effective.** Learn by doing to gain knowledge, evolve programs, and build capacity. Leverage local knowledge and partnerships for effective implementation.
6. **Provide multiple financing approaches because low-income households typically do not have the capital to make energy-efficiency investments.**
7. **Create a tailored, flexible, multidimensional outreach strategy that accounts for diverse low-income household participation.** Employ trusted partners to deliver the message.
8. **Evaluate your program to understand if it is targeting the right audience and how it can be improved.** Choose a level of evaluation complexity and rigor that makes sense given institutional capacity.

10.2 Roadmap for Energy-Efficiency Interventions

Some developing countries might need to start at quite targeted levels of low-income energy-efficiency intervention and progress toward broader interventions as institutional capacity and secure funding streams develop. Others might be ready to take on broader interventions quickly, such as market transformation, and then focus on targeted interventions. Some interventions will be concurrent. Figure 10 presents a framework for thinking about the different levels of low-income efficiency interventions. Simpler and targeted interventions that focus on either one or a small subset of improvements often require less institutional capacity and are nested within larger levels of intervention that might require more capacity, political will, and have broader market impacts. Some subsectors in the outer bands of the figure, such as markets, do not necessarily require greater institutional capacity, but they might take longer to achieve desired results or require strong political willpower. Each country will need to ascertain where it falls within the framework and which priorities to tackle first.

This section synthesizes top opportunities for low-income energy efficiency in these different levels of intervention and explores how best practices from industrial countries can be applied to these opportunities. Many of these interventions (e.g., lighting) are already the focus of efficiency programs writ large, but the low-income lens and best practices from industrial countries illuminate innovative strategies to help low-income households. We categorize interventions by expected level of market impact, institutional capacity, and program participation to support the prioritization process. Note that this framework is intended to provide high-level guidance and does not replace the need for additional analytics to determine typical energy use patterns and meaningful energy-efficiency improvements for a specific population in a specific jurisdiction.

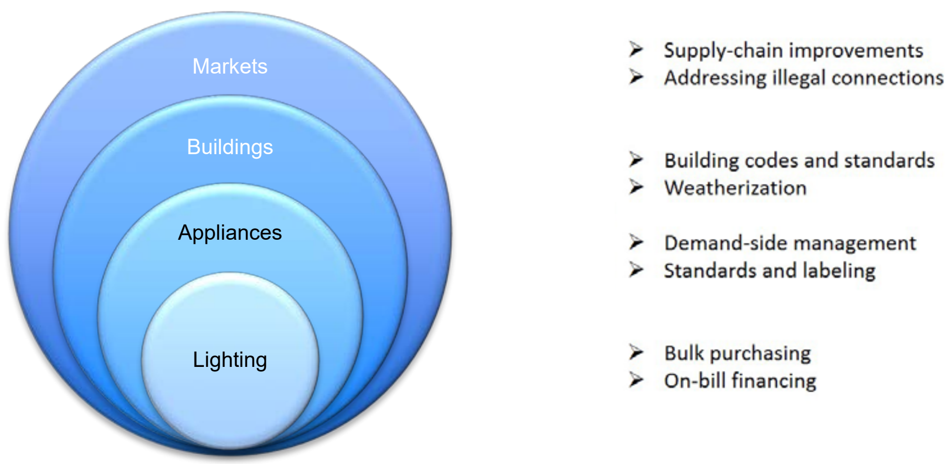


Figure 10. Increasing impact levels of energy-efficiency intervention

10.2.1 Impact Level 1 and Level 2: Lighting and Appliances

Lighting serves basic human needs, enabling education, health, and commerce. As access to electricity increases, household demand for more energy-intensive domestic appliances can follow suit if households can afford the appliance and increased electricity required. These domestic appliances deliver important services, such as refrigeration, cooking, and space cooling along with time savings and convenience. Although lighting typically uses less electricity than other large appliances, its prevalence in the residential sector (across housing types, population densities, and urban forms) makes it a prime efficiency target.

- **Lighting:** *Low financial cost, high program participation*
  Efficient lighting is relatively low-tech, not requiring extensive capacity building or staff training. Nonprofits and NGOs are well positioned to deliver lighting through bulk purchasing programs because of their local knowledge. The Efficiency Vermont program is an example in the United States that leverages relationships with food bank distribution centers to increase access to customers in need. Similar models could be employed in developing countries, pairing delivery of efficient lighting with other services (e.g., food, education/training, health care) for low-income residents

provided by myriad organizations and institutions. Utilities can also engage in bulk purchasing programs for efficient lighting, but their ability to participate is context-specific, potentially constrained by financial viability.

- **Other electrical appliances**: *High financial cost, limited program participation*
  Although donor support could be pursued, the impact of a no-cost energy-efficient appliance program will likely be limited to a smaller subset of households because of the high cost of domestic appliances. Governments can play decisive roles in soliciting a tender for the bulk procurement of appliances at reduced costs. Under budget constraints, government and nonprofits can work jointly to comingle funds for such bulk procurement. Some industrial country programs (e.g., Germany's Caritas-Stromspar Check) deliver efficient appliances at little to no cost for low-income households; however, this is funded primarily by legislative mandate, meaning that government funding can be a key constraint.

Low-income energy-efficiency approaches for lighting and appliances include:

1. **Bulk purchasing programs**: *Low capacity needs, high program participation*

   Efficient lighting and appliances can be delivered to low-income customers for free or at low cost if supported with a funding stream. Purchasing high volumes of appliances can reduce transaction costs, enable the program to move large quantities, and achieve greater access to customers in need. There are several steps and considerations for new bulk purchasing programs:

   A. **Identify technical specifications for procurement.** These help ensure safety and quality for customers and send a clear signal to manufacturers about which products can qualify for the program.

   B. **Consider the role of the utility.** Some financing options such as on-bill financing will require utility participation.

   C. **Consider competitive bidding** for bulk procurement. Strive for clarity and transparency in the bidding process.

   D. **Consider multiple marketing materials and messengers**. For example, India's bulk purchasing LED program had an online dashboard that displayed the number of bulbs sold around the country in real time—something that became a talking point of community leaders (Chunekar, Mulay, and Kelkar 2017).

   E. **Craft a distribution strategy** that relies on networks of nonprofits, vendors, utilities, and other relevant stakeholders for a wide reach.

   F. When designing a bulk purchasing program for lighting or other appliances, **thought should be given to how older, less efficient equipment is treated** to avoid two negative outcomes: (1) equipment is disposed of in a manner harmful to human health and the environment, and (2) equipment continues to be used. For example, an evaluation of India's bulk purchasing LED program estimates that 40% of customers disposed of old CFLs, which contain mercury, in landfills where mercury likely leaches into soil (Chunekar, Mulay, and Kelkar 2017).

2. **Combining bulk purchasing with financing programs**: *Medium capacity needs, high program participation.*

   These programs offer low-cost loans or on-bill financing options for low-income residents to increase program impact. Because low-income customers are unique, financing programs might need to be structured differently to account for those who might not use banks, have no or poor credit history, or otherwise struggle to qualify for more traditional financing services. For example, India's LED bulk purchasing program offered customers the option of either paying upfront for a maximum of 10 bulbs per household or paying monthly installments (for up to 4 bulbs per household) via electricity bills. Around 40% of customers in Maharashtra purchased LEDs using this method (Chunekar, Mulay, and Kelkar 2017). Such programs, however, do have additional transaction costs, and new program implementers should consider (1) if utilities are willing and able to adapt billing systems and recover dues from customers and (2) how customers will be vetted—two potential stumbling blocks to smooth on-bill financing programs.

Governments, nonprofits, and utilities can also provide funding for appliance financing programs or cost-share funds with one another to stretch project impact. Nonprofits and other on-the-ground organizations are best suited to conduct outreach for financing programs because of their existing relationship with low-income households, even if they do not directly financially back them.

3. **DSM**: *Medium capacity needs, medium to high program participation*

   In the United States, utilities have historically taken the lead on DSM programs after receiving regulatory approval from their governing public utilities commissions. In developing countries, however, where utility capacity might be limited, government energy offices could also potentially fill this role. Although utilities stand to benefit most from implementing DSM by gaining more control over the commensurate peak demand reduction, other agencies, such as nonprofits, can also implement this approach if they have support from government and the private sector. For example, in the United States, Energy Outreach Colorado, a nonprofit, uses a DSM approach to address low-income energy-efficiency holistically. First, they conduct education and outreach at both multifamily and single-family housing and have experienced an approximate 5%–7% energy savings from households because of education alone, even before any efficiency measures (DOE 2017a). Then, they act as the "one-stop shop" for households and multifamily building owners, connecting them with vendors and existing rebates and incentives for appliances and energy controls, and ultimately prime them for high-impact weatherization measures in the future. This approach has resulted in a cumulative $10.6 million in lifetime savings for 40,000 multifamily and single-family units since 1989 (DOE 2017a).

4. **Appliance standards and labeling**: *Medium capacity needs, medium program participation*

   Appliance standards set energy performance levels for appliance categories. Labeling can help customers understand and reduce energy use. Both appliance standards and labeling benefit a broad demographic, not only low-income households.

Government leadership at the national level and industry buy-in are key determinants to the success of both appliance standards and labeling. Standards and labeling should be consistent across states and provinces, hence the need for national-level leadership. Where governments do not have sufficient capacity to design standards themselves, there are existing programs, such as Collaborative Labeling and Appliance Standards Program.

10.2.2 Impact Level 3: Buildings

As of 2018, buildings accounted for 31% of total final energy consumption worldwide. Demand is expected to increase by ~1% annually through 2050 (IEA 2018b). Within buildings, space cooling and heating can typically represent a significant portion of a household's energy consumption. Low-income residents might have less access to electricity and natural gas to serve heating and cooling needs, relying largely on biomass (e.g., wood, dung), but fuel sources change as household income increases. Moreover, IEA estimates substantial growth in electricity demand from space cooling in developing economies through 2040 (IEA 2017c). Space heating demands are larger in cooler climates (e.g., Central Asia and

Eastern Europe, or mountainous regions), so they are a more appropriate efficiency target in those climates. Low-income energy-efficiency approaches for buildings include:

1. **Weatherization**: *High capacity needs, low to medium program participation*

   Weatherization measures can support energy-efficient space heating and cooling. As demonstrated in the prior examples, comprehensive whole-house approaches that offer no-cost multiple measures and follow-up inspections to measure performance deliver the best results for low-income residents. There are additional steps and considerations in addition to selecting the most relevant, cost-effective, and impactful weatherization measures available:

   A. **Identify a funding method.** Like electrical appliances, certain weatherization measures have significant upfront costs. If these high costs prohibit programs from offering no-cost appliances, providing financing for customers for part or all of the cost is another strategy. Low-cost loans and on-bill financing are two approaches that industrial countries have used to meet the financing need of low-income customers. Notably, financing eligibility criteria might need to be modified to ensure that low-income customers are not penalized or excluded.

   B. **Develop the workforce to deliver services.** Delivery of comprehensive weatherization measures requires skilled labor, typically provided by the private sector in the industrial world. To develop this capacity, developing countries could consider establishing a network of weatherization training centers, such as those established under WAP. Although the private sector can be developed to meet this need, based on OECD experience, weatherization programs will likely need to be developed and promoted by government, utility, or nonprofit organizations to reach low-income households. Funding for weatherization projects could either come from legislative appropriations, utility ratepayers, or potentially on-bill financing by the utility (particularly if weatherization efforts will demonstrably reduce system peak demand).

2. **Building codes:** *High capacity needs, high participation*

Building codes affect the built environment of all residents. They must be established, enforced (a common shortcoming), assessed, and updated over time. Their purpose is to achieve sector energy-efficiency improvements by setting performance standards for building envelopes and devices within them. The IEA estimates that 34% of building energy consumption worldwide in 2017 was covered by codes and standards (IEA 2018a)—there is clearly space for improvement. As part of the general population, low-income residents might enjoy the benefits of building codes indirectly. Building codes also benefit low-income residents over the longer term as these populations migrate to newer or different housing. Key steps and considerations for developing building codes include:

   A. The appropriate level of government (e.g., local, regional, federal) will need to **formally adopt a specific vintage of building code** and determine types of structures that must comply. For example, India developed its Energy Conservation Building Code for Residential Buildings, and Mexico updated its code for existing residential buildings (IEA 2018a). ASHRAE can provide capacity building to assist in building code development (Walter 2015).

   B. At the planning stage, **governments can mandate that low-income housing developments meet particular building codes** or go above and beyond to ensure that targeted residents enjoy the benefits of energy-efficiency (i.e., mandating specific technologies or building use energy intensity thresholds in energy use/square foot/year).

   C. Most importantly, and more of a challenge, is **enforcement of building codes** by government entities. This generally requires dedicated personnel to administer and enforce these programs. If the government is unable to carry out the enforcement function, NGOs or the private sector can potentially be recruited to conduct building code inspection, but proper government oversight of these private sector inspectors is still essential. Jurisdictions need to think creatively about how to overcome barriers to enforcing building code requirements.

D. **Outreach and training for the private sector** are critical. Contractors, builders, and other professionals in the private sector must also have sufficient knowledge of building codes and training to be able to meet the requirements effectively.

10.2.3 Impact Level 4: Markets

Market transformation can target myriad technologies, includes different types of interventions, and requires participation of actors from across different sectors (e.g., manufacturers, utilities, regulators). Interventions can include supply chain improvements, standards and labeling, and education and outreach, and they depend largely on private sector participation. Market transformation can target specific customer types, such as low-income customers, or be broader in nature (York et al. 2017). Some of the approaches noted here have relatively low institutional capacity needs, but the overall effort might take longer to achieve desired impacts, or they might require greater political willpower. Approaches include:

1. **Supply chain improvements**: *Medium capacity, high participation*

   Adequate supply chains for energy-efficiency products (e.g., lighting, appliances) is important to ensure delivery of these technologies. Although government procurement can stimulate markets for these technologies through bulk procurement, additional private-public sector partnerships might be needed to boost local manufacturing and supply chain efficiency as the market evolves.

   Market transformation requires coordination among government, nonprofits, utilities, and the private sector. Sufficient engineering and financial expertise in the private sector is necessary to produce high-quality efficiency products and services to customers. Government, utilities, and nonprofits can reduce barriers customers face to adoption of efficiency through financing and education and outreach.

   Where governments are unable to act as a catalyst for market transformation, industry associations can also serve to set examples of best practices among manufacturers, distributors, and retailers. In the United States, the Association of Energy Services Professionals is one example of a member-based energy-efficiency services organization that promotes the transfer of knowledge to members and acts as an industry network. One potential way to bridge the gap in capacity is to enable knowledge transfer from OECD institutions to developing countries. For example, conducting executive exchanges between utility representatives or other private sector companies can accelerate market transformation in developing countries (USAID and U.S. Energy Association 2014).

2. **Addressing illegal connections**: *Low to moderate utility capacity, high political willpower*

   Low-income households in some countries might have higher instances of illegal connections, electricity theft, and nonpayment. These are dangerous to individuals who establish the illegal interconnections and to utility line workers who might disconnect them, can cause outages, and impact utility financial health. In at least some cases, commercial and industrial users also steal electricity, and they should be the first priority to address given the amount of electricity consumed per connection. Low-income households with illegal connections might be a secondary priority. Addressing illegal interconnections can help ensure utility fiscal health and improve overall reliability for all consumers. To do so, key steps are needed:

A. Government legislation and funding for proper law enforcement is an important first step toward reducing NTLs.

B. Utility involvement in any program designed to address illegal connections will also be essential. Their knowledge of areas of high theft and the ability to install "clean" distribution systems will be required, once industries and neighborhoods causing NTLs are identified.

C. Once NTLs have been addressed in a location, the prior interventions discussed in this report should ideally be administered to low-income households to reduce the economic attractiveness of reinstalling illegal taps.

3. **Integrated district development**: *High capacity, high utility capacity*

District or neighborhood development projects that work on integrated approaches to building design and neighborhood layout to maximize the efficiency of energy, water, telecommunications, and transportation services might be an appropriate approach for countries seeing rapid population growth, particularly in urban areas. Integrated district development requires:

A. **Government leadership:** Municipal governments often lead the charge in projects like this, but they also require participation of land developers, the local grid operator, original equipment manufacturers, research organizations, and NGOs. The municipal government plays the key role in defining how the public interest will be best served through the project and how costs will be allocated to different stakeholders.

B. **Sustainable funding:** Municipal planners can use green bonds—rapidly growing sources of funding for local development projects—to finance such projects, although other funding sources are also feasible.

C. **Modeling and design:** Sophisticated modeling can help maximize benefits of properly orienting buildings, sharing heating or cooling sources among buildings, and locating charging infrastructure for electric vehicle fleets. Properly designed integrated development zones can minimize energy and water use and have far-reaching impacts on distribution system planning and operations, utility business models, and smart city design. Successful models can be rapidly replicated in other regions.

Energy efficiency remains an underused resource for delivering energy services in many regions of the world, particularly those with increasing residential energy demand and large low-income populations. Moreover, energy efficiency provides multiple benefits that align with sustainable development goals. The interventions outlined in this roadmap showcase numerous low-income energy-efficiency interventions that demand varying levels of capacity, time, participation, willpower, and impact. There is no need to start from scratch—developing countries can use this guide to identify strategies most appropriate for their given context and then benefit from lessons learned of OECD countries to make a meaningful impact in the lives of their low-income residents.

References

Agency for the Cooperation of Energy Regulators. 2015. *ACER Market Monitoring Report 2015*. Ljubljana, Slovenia. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2015.pdf.

Alpheeis. n.d. *EPEE Project: European Fuel Poverty and Energy Efficiency*. Valbonne, France. https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/epee_european_fuel_poverty_and_energy_efficiency_en.pdf

American Council for an Energy-Efficient Economy (ACEEE). 2010a. "Building Codes." June 30, 2010. https://aceee.org/topics/building-codes.

———. 2010b. "Evaluation, Measurement & Verification." November 8, 2010. https://aceee.org/sector/state-policy/toolkit/emv.

———. 2014. "Energy Efficiency Resource Standard (EERS)." December 9, 2014. https://aceee.org/topics/energy-efficiency-resource-standard-eers.

———. 2017. "Energy Efficiency—Jobs and Investment." Fact Sheet. http://aceee.org/sites/default/files/ee-jobs-money-web.pdf.

Anderson, Will, Vicki White, and Andrea Finney. 2012. "Coping with Low Incomes and Cold Homes." *Energy Policy* 49: 40–52.

Australian Government Department of Climate Change and Energy Efficiency. 2012. *Low Income Energy Efficiency Program Round Two Guidelines*. Canberra, Australia. https://industry.gov.au/Energy/EnergyEfficiency/Documents/05_2013/LIEEP-Guidelines-RoundTwo.pdf.

AVSI Foundation. 2010. *Case Study: COELBA Community Agent Program for Slum Electrification and Energy Efficiency in Salvador, Bahia, Brazil*. Milan, Italy. https://pdfs.semanticscholar.org/233e/db9c0b840e268d7d2438d858b0c822a00fcc.pdf.

Berelson, Serj. 2014. "Myths of Low-Income Energy Efficiency Programs: Implications for Outreach." Presented at the 2014 ACEEE Summer Study on Energy Efficiency in Buildings. American Council for an Energy-Efficient Economy (ACEEE). https://aceee.org/files/proceedings/2014/data/papers/7-287.pdf.

Berg, Weston, and Ariel Drehobl. 2018. "State-Level Strategies for Tackling the Energy Burden: A Review of Policies Extending State- and Ratepayer-Funded Energy Efficiency to Low-Income Households." Presented at the 2018 ACEEE Summer Study on Energy Efficiency in Buildings. https://aceee.org/files/proceedings/2018/node_modules/pdfjs-dist-viewer-min/build/minified/web/viewer.html?file=../../../../../assets/attachments/0194_0286_000404.pdf#search=%22Berg%22.

Berg, Weston, Seth Nowak, Grace Relf, Shruti Vaidyanathan, Eric Junga, Marianne DiMascio, and Emma Cooper. 2018. *The 2018 State Energy Efficiency Scorecard* (U1808). Washington, D.C.: American Council for an Energy-Efficient Economy. https://aceee.org/research-report/u1808.

Berry, Chip, Carolyn Hronis, and Maggie Woodward. 2018. "Who's Energy Insecure? You Might Be Surprised." Presented at the 2018 ACEEE Summer Study on Energy Efficiency in Buildings. https://aceee.org/files/proceedings/2018/node_modules/pdfjs-dist-viewer-min/build/minified/web/viewer.html?file=../../../../../assets/attachments/0194_0286_000167.pdf#search=%22berry%22.

Boardman, Brenda. 1991. *Fuel Poverty: From Cold Homes to Affordable Warmth*. United Kingdom: John Wiley & Sons Ltd.

Bosi, Martina. 2017. "From Slums to Neighborhoods: How Energy Efficiency Can Transform the Lives of the Urban Poor." *Sustainable Energy for All*, May 25, 2017. http://blogs.worldbank.org/energy/slums-neighborhoods-how-energy-efficiency-can-transform-lives-urban-poor.

California Public Utilities Commission. 2018. "CARE/FERA Programs." 2018. http://consumers.cpuc.ca.gov/lowincomerates/.

Center for Climate and Energy Solutions. 2017. "Strengthening Energy Efficiency Programs for Low-Income Communities." Fact Sheet. https://www.c2es.org/site/assets/uploads/2017/07/strengthening-energy-efficiency-programs-low-income-communities.pdf.

Chunekar, Aditya, Sanjana Mulay, and Mrudula Kelkar. 2017. *Understanding the Impacts of India's LED Bulb Programme, "UJALA."* Pune, India. http://www.prayaspune.org/peg/publications/item/354.

Cluett, Rachel, Jennifer Amann, and Sodavy Ou. 2016. *Building Better Energy Efficiency Programs for Low-Income Households*. Washington, D.C.: American Council for an Energy-Efficient Economy. https://aceee.org/research-report/a1601.

Commonwealth of Massachusetts. 2016. "The Commonwealth of Massachusetts, Department of Public Utilities, Energy Efficiency Three Year Plan Order." http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Energy-Efficiency-Three-Year-Plan-Order.pdf.

Community Action Partnership. 2018. "Energy Partnerships." 2018. https://communityactionpartnership.com/energy-partnerships/.

Consortium for Energy Efficiency. 2017. "CEE Annual Industry Report: 2017 State of the Efficiency Program Industry—Budgets, Expenditures, and Impacts." Boston, MA. https://library.cee1.org/system/files/library/13561/CEE_2017_AnnualIndustryReport.pdf.

Davis, Lucas W., Alan Fuchs, and Paul J. Gertler. 2012. *Cash for Coolers*. Berkeley, CA: University of California, Center for Effective Global Action. https://escholarship.org/uc/item/3fw2s899.

Daykin, Elizabeth, Jessica Aiona, and Brian Hedman. 2012. "Whose Perspective? The Impact of the Utility Cost Test." Presented by the Cadmus Group. http://www.cadmusgroup.com/wp-content/uploads/2012/11/TRC_UCT-Paper_12DEC11.pdf.

de Laski, Andrew, and Joanna Mauer. 2017. *Energy-Saving States of America: How Every State Benefits from National Appliance Standards*. Appliance Standards Awareness Project and American Council for an Energy-Efficient Economy. Washington, D.C. https://appliance-standards.org/sites/default/files/Appliances%20standards%20white%20paper%202%202-14-17.pdf.

Department of Communications, Energy, and Natural Resources. 2011. *Warmer Homes. A Strategy for Affordable Energy in Ireland*. Dublin, Ireland. https://www.dccae.gov.ie/documents/Warmer%20Homes.%20A%20strategy%20for%20Affordable%20Energy%20in%20Ireland.pdf.

Department of Energy and Climate Change. 2015. "Cutting the Cost of Keeping Warm." Policy paper presented by GOV.UK. https://www.gov.uk/government/publications/cutting-the-cost-of-keeping-warm.

Drehobl, Ariel, and Lauren Ross. 2016. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities* (U102). Washington, D.C. American Council for an Energy-Efficient Economy. http://aceee.org/sites/default/files/publications/researchreports/u1602.pdf.

Dubois, Ute. 2012. "Implementing Fuel Poverty Policy: The Challenge of Identification of Fuel Poor Households." Presented at the 12th IAEE European Energy Conference, Venice, Italy.

E4TheFuture. 2018. N*ational Standard Practice Manual*. National Efficiency Screening Project. https://nationalefficiencyscreening.org/national-standard-practice-manual/.

Energy Efficiency Screening Coalition. 2013. *Recommendations of Reforming Energy Efficiency Cost-Effectiveness Screening in the United States: Using the Resource Value Framework to Identify Those Efficiency Programs That Are in the Public Interest*. Washington, D.C. http://www.synapse-energy.com/sites/default/files/SynapseReport.2013-11.NHPC_.Efficiency-Screening.13-101-Report.pdf.

Enterprise Community Partners. 2018. "Green Communities." https://www.enterprisecommunity.org/solutions-and-innovation/green-communities.

European Bank for Reconstruction and Development SEFF. 2015. "Energy Efficient Hotels in Marrakech." http://seff.ebrd.com/cs/Satellite?c=Content&cid=1395251113019&pagename=SEFF%2FContent%2FSEFF_Content.

Evans, Meredydd, Mark Halverson, Alison Delgado, and Sha Yu. 2014. "Building Energy Code Compliance in Developing Countries: The Potential Role of Outcomes-Based Codes in India." Presented at the 2014 ACEEE Summer Study on Energy Efficiency in Buildings. https://aceee.org/files/proceedings/2014/data/papers/8-283.pdf.

Fannie Mae. 2018. "Multifamily Green Financing." https://www.fanniemae.com/multifamily/green-initiative.

Fisher Sheehan & Colton Public Finance & General Economics. 2017. "Home Energy Affordability Gap." http://www.homeenergyaffordabilitygap.com/.

Fixr. 2018. "Energy Audit Cost." https://www.fixr.com/costs/energy-audit.

Foster, Scott. 2017. "Non-Technical Losses: A $96 Billion Global Opportunity for Electrical Utilities." *Oil & Gas Journal*. http://www.pennenergy.com/articles/pennenergy/2017/11/non-technical-losses-a-96-billion-global-opportunity-for-electrical-utilities.html.

Gilleo, Annie, Seth Nowak, and Ariel Drehobl. 2017. *Making a Difference: Strategies for Successful Low-Income Energy Efficiency Programs* (U1713). Washington, D.C.: American Council for an Energy-Efficient Economy. http://aceee.org/sites/default/files/publications/researchreports/u1713.pdf.

Gillingham, Kenneth, David Rapson, and Gernot Wagner. 2016. "The Rebound Effect and Energy Efficiency Policy." *Review of Environmental Economics and Policy* 10 (1): 68–88. https://doi.org/10.1093/reep/rev017.

GIZ. 2009. *Energy Subsidies: Why, When and How?* Bonn, Germany: Federal Ministry for Economic Cooperation and Development. https://www.giz.de/expertise/downloads/gtz2009-en-energy-subsidies-a-think-piece.pdf.

Grimes, Arthur, Tim Denne, Philippa Howden-Chapman, Richard Arnold, Lucy Telfar-Barnard, Nicholas Preval, and Chris Young. 2011. *Cost Benefit Analysis of the Warm Up New Zealand: Heat Smart Programme*. Wellington, New Zealand: Ministry of Economic Development. http://www.motu.org.nz/assets/Documents/our-work/urban-and-regional/housing/Cost-Benefit-Analysis-of-the-Warm-Up-New-Zealand-Heat-Smart-Programme.pdf.

Harvell, Elizabeth. 2017. "How an Arkansas Electric Co-Op Tripled Efficiency Program Participation." *Environmental Finance Blog*, August 15, 2017. http://efc.web.unc.edu/2017/08/15/arkansas-electric-co-op-tripled-efficiency-program-participation/.

Heffner, Grayson, and Nina Campbell. 2011. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes*. Paris, France: International Energy Agency. https://www.iea.org/publications/freepublications/publication/low_income_energy_efficiency.pdf.

Henderson, Philip. 2013. "On-bill Financing: Overview and Key Considerations for Program Design." *NRDC Issue Brief*, July 2013. https://www.nrdc.org/sites/default/files/on-bill-financing-IB.pdf.

Hernández, Diana, and Stephen Bird. 2010. "Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy." *Poverty & Public Policy* 2 (4): 5–25. https://doi.org/10.2202/1944-2858.1095.

Herreros Garcia, Santiago, and Jean Sebastien Broc. n.d. "Energy Efficiency Programs Targeted to Low-Income Households within the Brazilian Electricity Public Benefits Fund." Presented by the World Energy Council. https://wec-policies.enerdata.net/Documents/cases-studies/BR_low_income.pdf.

Heyman, Bob, Barbara Harrington, Anna Heyman, and The National Energy Action Research Group. 2011. "A Randomised Controlled Trial of an Energy Efficiency Intervention for Families Living in Fuel Poverty." *Journal of Housing Studies* 26 (1). https://www.tandfonline.com/. doi: abs/10.1080/02673037.2010.512787.

Hoffman, Ian M., Greg Leventis, and Charles A Goldman. 2017. *Trends in the Program Administrator Cost of Saving Electricity for Utility Customer-Funded Energy Efficiency Programs* (LBNL-1007009). Berkeley, CA: Lawrence Berkeley National Laboratory.

Insight Observatory. n.d. "About InsightE." n.d. Accessed November 9, 2018. http://www.insightenergy.org/.

International Center for Research on Environment and Development. 2017. *Reduction of Technical and Non-Technical Losses in Distribution Networks*. Paris, France: Working Group on Losses Reduction. www.cired.net.

International Energy Agency (IEA), Organisation for Economic Co-operation (OECD), and The World Bank. 2010. *Analysis of the Scope of Energy Subsidies and Suggestions for the G-20 Initiative*." Paris, France. https://www.oecd.org/env/45575666.pdf.

International Energy Agency (IEA). 2007. "National Policy on Energy Efficiency." Brazil. https://www.iea.org/policiesandmeasures/pams/brazil/name-30826-en.php?s=dHlwZT1lZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9lbmVyZ3llZmZpY2llbmN5LyI-RW5lcmd5IEVmZmljaWVuY3k8L2E-PC9uYXY-.

———. 2012a. *Energy Policies of IEA Countries: Ireland 2012 Review*. Paris, France. https://www.iea.org/publications/freepublications/publication/IRELAND2012_free.pdf.

———. 2012b. *World Energy Outlook*. Paris, France. https://www.iea.org/publications/freepublications/publication/WEO2012_free.pdf

———. 2014a. "Warmer Homes Scheme (Low Income Housing Programme)." Ireland. Accessed January 12, 2018. https://www.iea.org/policiesandmeasures/pams/ireland/name-22171-en.php.

———. 2014b. *Capturing the Multiple Benefits of Energy Efficiency*. Paris, France. http://www.iea.org/publications/freepublications/publication/Multiple_Benefits_of_Energy_Efficiency.pdf.

———. 2017a. "Low Income Energy Efficiency Program." Australia. Accessed January 11, 2018. https://www.iea.org/policiesandmeasures/pams/australia/name-31030-en.php?s=dHlwZT1jYyZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9jbGltYXRlY2hhbmdlLyI-Q2xpbWF0ZSBDaGFuZ2U8L2E-PC9uYXY-.

———. 2017b. *Market Report Series: Energy Efficiency 2017*. Paris, France. https://www.iea.org/publications/freepublications/publication/Energy_Efficiency_2017.pdf.

———. 2017c. *World Energy Outlook 2017*. Paris, France.

———. 2018a. *Market Report Series: Energy Efficiency 2018—Analysis and Outlooks to 2040*. Paris, France. https://webstore.iea.org/market-report-series-energy-efficiency-2018.

———. 2018b. *World Energy Outlook 2018*. Paris, France. http://splunk01.nrel.gov/store/IEA/IEA2017/IEA_WEO2017.pdf.

Kojima, Masami, and Chris Trimble. 2016. *Making Power Affordable for Africa and Viable for Its Utilities*. Washington, D.C.: The World Bank. http://www.worldbank.org/en/topic/energy/publication/making-power-work-for-africa.

Komives, Kristin, Vivien Foster, Jonathan Halpern, Quentin Wodon, and Roohi Abdullah. 2005. *Water, Electricity, and the Poor: Who Benefits from Utility Subsidies?* (34334). Washington, D.C.: The World Bank. http://documents.worldbank.org/curated/en/606521468136796984/Water-electricity-and-the-poor-who-benefits-from-utility-subsidies.

Landley, A., and Y. Rzad. 2015. *Approaches to Low-Income Energy Assistance Funding in Selected States*. Washington, D.C.: U.S. Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation: June 13, 2015. https://aspe.hhs.gov/basic-report/approaches-low-income-energy-assistance-funding-selected-states.

Laustsen, Jens. 2008. "Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings," IEA Information Paper.

Lawaetz, Simone. 2018. "Advancing Power Sectors' Self-Reliance Through Electricity System Loss Reduction." U.S. Agency for International Development. https://www.usaid.gov/sites/default/files/documents/1865/Technical-Note_Loss-Reduction_0.pdf.

Lazar, Jim, and Ken Colburn. 2013. "Recognizing the Full Value of Energy Efficiency." *Regulatory Assistance Project. Knowledge Center*, September 9, 2013. http://www.raponline.org/wp-content/uploads/2016/05/rap-lazarcolburn-layercakepaper-2013-sept-9.pdf.

Lazar, Jim. 2016. *Electricity Regulation In the U.S.: A Guide*. Montpelier, VT: The Regulatory Assistance Project. http://www.raponline.org/wp-content/uploads/2016/07/rap-lazar-electricity-regulation-US-june-2016.pdf.

Leinartas, Aguilar, and Brent Stephens. 2015. "Optimizing Whole House Deep Energy Retrofit Packages: A Case Study of Existing Chicago-Area Homes." *Buildings* 5: 323–53. https://doi.org/doi:10.3390/buildings5020323.

Liddell, Christine, and Chris Morris. 2010. "Fuel Poverty and Human Health: A Review of Recent Evidence. *Energy Policy* 38 (6). https://www.sciencedirect.com/science/article/pii/S0301421510000625.

LIHEAP Clearing House. 2016. "Engaging Hard-to-Reach Clients." *Issue Brief*, November 2016. https://liheapch.acf.hhs.gov/sites/default/files/webfiles/docs/HardtoReachClients.pdf.

McKinsey and Company. 2010. *Energy Efficiency: A Compelling Global Resource*. New York, NY. https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/Sustainability/PDFs/A_Compelling_Global_Resource.ashx.

Molina, Maggie. 2014. *The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs* (U1402). Washington, D.C. American Council for an Energy-Efficient Economy. http://aceee.org/sites/default/files/publications/researchreports/u1402.pdf.

Moyo, Thoko. 2006. "IFC Supports Increased Lending to Small Business Owners in Bosnia through Loan to Micro-Credit Organization." *News*, July 28, 2006. https://ifcext.ifc.org/ifcext/pressroom/ifcpressroom.nsf/bbbbed9e2807e7ef85256a5b0078814d/bec21c32f0963fcf852571b9004dd24d.

Nallathiga, Ramakrishna. 2012. *Slum Redevelopment in Cities: Current Approaches and Alternate Models* (SSRN Scholarly Paper ID 2251779). Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=2251779.

National Association of Energy Service Companies. n.d. "What Is an ESPC?" Accessed November 8, 2018. https://naesco.org/what-is-an-espc.

National Renewable Energy Laboratory. 2018. "Green Banks." State, Local, & Tribal Governments. Accessed December 18, 2018. https://www.nrel.gov/state-local-tribal/basics-green-banks.html.

Northeast Energy Efficiency Partnerships. 2018. "Energy Codes." http://www.neep.org/initiatives/energy-efficient-buildings/energy-codes.

Nowak, Seth, Martin Kushler, Patti Witte, and Dan York. 2013. *Leaders of the Pack: ACEEE's Third National Review of Exemplary Energy Efficiency Programs* (U132). Washington, D.C.: American Council for an Energy-Efficient Economy. http://aceee.org/sites/default/files/publications/researchreports/u132.pdf.

ODYSSEE-MURE. 2016. "About the MURE Database." http://www.measures-odyssee-mure.eu/.

O'Grady, Elizabeth, and Saarthak Narsipur. 2018. "The AC Industry Conundrum: Cooling Is Warming the Planet, but Market Failures Are Preventing the AC Industry from Innovating." *Rocky Mountain Institute Blog*, September 17, 2018. https://rmi.org/ac-industry-conundrum/.

Oré, Marco Antonio Hernández, Liliana D. Sousa, Leopoldo Tornarolli, and Luis Sanchez. 2018. *Fiscal and Welfare Impacts of Electricity Subsidies in Central America*. Washington, D.C.: The World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/28504/9781464811043.pdf?sequence=2&isAllowed=y.

Poortinga, Wouter, Shiyu Jiang, Charlotte Grey, and Chris Tweed. 2017. "Impacts of Energy-Efficiency Investments on Internal Conditions in Low-Income Households." *Building Research and Information* 46 (6): 653–57.

Raissicharmakani, Shiva. 2018. "A Programmatic Assessment of the U.S. Department of Energy Low-Income Weatherization Assistance Program." Master thesis, University of Michigan. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/143155/RaissiCharmakani_Shiva_Thesis.pdf?sequence=1&isAllowed=y.

Rinebolt, David. 2017. "WAP Memorandum 024 1.17.17.Pdf," January 17, 2017. https://nascsp.org/wp-content/uploads/2018/02/wapmemo20024201.17.17-1.pdf.

Ross, Lauren, Ariel Drehobl, and Brian Stickles. 2018. T*he High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency* (U1806). Washington, D.C. American Council for An Energy-Efficient Economy. https://aceee.org/research-report/u1806.

Ross, Lauren. 2017. "Best Practices for Implementing Low-Income and Multifamily Energy Efficiency Programs." Presented by the American Council for an Energy-Efficient Economy on February 23, 2017. https://www.energy.gov/sites/prod/files/2017/03/f34/bbrn_Summary_Low-IncomePrograms_022317.pdf.

Souza e Silva, Rogerio Diogne, Rosana Cavalcante Oliveira, and Maria Emilia de Lima Tostes. 2017. "Analysis of the Brazilian Energy Efficiency Program for Electricity Distribution Systems." *Energies* 10. https://doi.org/doi:10.3390/en10091391.

State and Local Energy Efficiency Action Network. 2012. *Energy Efficiency Program Impact Evaluation Guide: Evaluation, Measurement, and Verification Working Group*. Washington, D.C.: U.S. Department of Energy. https://www4.eere.energy.gov/seeaction/system/files/documents/emv_ee_program_impact_guide_0.pdf.

———. 2017. *Energy Efficiency Financing for Low- and Moderate-Income Households: Current State of the Market, Issues, and Opportunities* (DOE/EE-1634). Washington, D.C.: U.S. Department of Energy. https://emp.lbl.gov/sites/default/files/news/lmi-final0811.pdf.

The Energy and Resources Institute. 2011. *Improving Energy Access to the Urban Poor in Developing Countries*. Washington, D.C.: The World Bank, Energy Sector Management and Assistance Program. http://www.avsi-usa.org/uploads/6/7/4/2/67429199/avsi___coelba2.pdf.

The World Bank. 2009. *Reducing Technical and Non-Technical Losses in the Power Sector*. Washington, D.C. https://openknowledge.worldbank.org/bitstream/handle/10986/20786/926390WP0Box3800in0the0power0sector.pdf?sequence=1&isAllowed=y.

———. 2016. "Financial Viability of the Electricity Sector in Developing Countries: Recent Trends and Effectiveness of World Bank Interventions." https://ieg.worldbankgroup.org/evaluations/financial-viability-electricity-sector-developing-countries-recent-trends-and.

———. 2017. "Energy Efficiency." http://www.worldbank.org/en/results/2017/12/01/energy-efficiency.

Tonn, Bruce Edward, Erin M. Rose, and Beth A. Hawkins. 2017. *Evaluation of the US Department of Energy Weatherization Innovation Pilot Program (2010-2014)* (ORNL/TM-2017/245). Oak Ridge, TN: Oak Ridge National Laboratory. https://doi.org/10.2172/1394313.

Tonn, Bruce, David Carroll, Scott Pigg, Michael Blasnik, Greg Dalhoff, Jaqueline Berger, Erin Rose et al. 2014. *Weatherization Works - Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program* (ORNL/TM-2014/338). Oak Ridge, TN: Oak Ridge National Laboratory. http://weatherization.ornl.gov/Retrospectivepdfs/ORNL_TM-2014_338.pdf.

U.S. Agency for International Development (USAID) and U.S. Energy Association. 2014. "Tanzanian Utilities Review Best Practices in Customer Relations, Communications and Loss Reduction." https://www.usea.org/sites/default/files/event-/TANESCO-Philippines%20article.pdf.

U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy. 2018a. "Property Assessed Clean Energy Programs." https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs.

———. 2018b. "DOE Qualified Energy Service Companies." https://www.energy.gov/eere/femp/doe-qualified-energy-service-companies.

———. 2011. "Weatherization Assistance Program: Saving Money by Saving Energy." https://www.nrel.gov/docs/fy11osti/51242.pdf.

———. 2014. "Guidelines for Home Energy Professionals Project." https://www.nrel.gov/docs/fy14osti/61414.pdf.

———. 2017a. "Better Buildings Residential Network Peer Exchange Call Series: Making an Impact: Low-Income Energy Efficiency Programs." Presented on February 23, 2017. https://www.energy.gov/sites/prod/files/2017/03/f34/bbrn_Summary_Low-IncomePrograms_022317.pdf.

———. 2017b. *U.S. Energy and Employment Report*. Washington, D.C. https://www.energy.gov/sites/prod/files/2017/01/f34/us-energy-employment-report-2017.pdf.

U.S. Department of Health and Human Services. 2018. "Poverty Guidelines." Office of the Assistant Secretary for Planning and Evaluation. https://aspe.hhs.gov/poverty-guidelines.

U.S. Department of Housing and Urban Development. 2016. "FY 2016 Income Limits Documentation System, FY 2016 Income Limits Summary." https://www.huduser.gov/portal/datasets/il/il2016/2016summary.odn?inputname=STTLT*2799999999%2BMinnesota&selection_type=county&stname=Minnesota&statefp=27.0&year=2016.

U.S. Energy Information Administration. 2018. "Electricity-Electric Utility Demand Side Management." https://www.eia.gov/electricity/data/eia861/dsm/.

U.S. Environmental Protection Agency. n.d. "Appendix I: EM&V Protocols and Guidance." https://19january2017snapshot.epa.gov/sites/production/files/2015-08/documents/epa_lbe_appendixi.pdf.

———. 2008. *Understanding Cost-Effectiveness of Energy Efficiency Programs: Best Practices, Technical Methods, and Emerging Issues for Policy-Makers*. Washington, D.C. https://www.epa.gov/sites/production/files/2017-06/documents/understanding_cost-effectiveness_of_energy_efficiency_programs_best_practices_technical_methods_and_emerging_issues_for_policy-makers.pdf.

———. 2011. *Energy Efficiency in Affordable Housing: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs*. Washington, D.C. https://www.epa.gov/sites/production/files/2015-08/documents/affordable_housing.pdf.

Ugarte, Sergio, Bart van der Ree, Monique Voogt, Wolfgang Eichhammer, José Antonio Ordoñez, Matthias Reuter, Barbara Schlomann, Pau Lloret Gallego, and Roberto Villafafila Robles. 2016. *Energy Efficiency for Low-Income Households*. Brussesl, Belgium: European Parliament. http://www.europarl.europa.eu/RegData/etudes/STUD/2016/595339/IPOL_STU(2016)595339_EN.pdf.

Vermont Housing Finance Agency. 2012. "Vermont Housing Finance Agency Green Building and Design Standards." https://www.vhfa.org/documents/developers/gbs.pdf.

Walter, William. 2015. "ASHRAE International Standards Activities." Presented on April 29, 2015. https://www.ashrae.org/File%20Library/Technical%20Resources/Standards%20and%20Guidelines/Training/Intl-Stds-presentation-2015.pdf.

Washington State Housing Finance Commission. 2018. "Sustainable Energy Trust." http://wshfc.org/energy/.

Wilson, Jonathan, and Ellen Tohn. 2011. *Healthy Housing Opportunities During Weatherization Work: June 2010–February 2011* (NREL/SR-7A20-49947). Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy11osti/49947.pdf.

Woolf, Tim, and Chris Neme. 2017. "National Standard Practice Manual for Energy Efficiency Cost-Effectiveness." Presented on November 1, 2017, by the National Efficiency Screening Project. https://nationalefficiencyscreening.org/wp-content/uploads/2017/11/NSPM-ACEEE-EE-as-a-resource-2017.pdf.

Woolf, Tim, William Steinhurst, Erin Malone, and Kenji Takahashi. 2012. *Energy Efficiency Cost-Effectiveness Screening: How to Properly Account for 'Other Program Impacts' and Environmental Compliance Costs*." Synapse Energy Economics, Inc. http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-11.RAP_.EE-Cost-Effectiveness-Screening.12-014.pdf. Montpelier, VT: The Regulatory Assistance Project.

Xcel Energy. 2018. "Cooling Rebates." 2018. https://www.xcelenergy.com/programs_and_rebates/residential_programs_and_rebates/heating_and_cooling/cooling.

York, Dan, Hannah Bastian, Grace Relf, and Jennifer Amann. 2017. *Transforming Energy Efficiency Markets: Lessons Learned and Next Steps*. Washington, D.C.: American Council for an Energy-Efficient Economy. https://aceee.org/sites/default/files/publications/researchreports/u1715.pdf.

Yu, Sha, Meredydd Evans, and Pradeep Kumar. 2013. *Using Third-Party Inspectors in Building Energy Codes Enforcement in India* (PNNL-22155). Richland, WA: Pacific Northwest National Laboratory. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22155.pdf.

www.nrel.gov/usaid-partnership

United States Agency for International Development
1300 Pennsylvania Avenue NW • Washington, DC 20523
+1-202-712-0000
www.usaid.gov

Jennifer E. Leisch, Ph.D.
USAID-NREL Partnership Manager
U.S. Agency for International Development
Tel: +1-303-913-0103
Email: jleisch@usaid.gov

National Renewable Energy Laboratory
15013 Denver West Parkway • Golden, CO 80401
+1-303-275-3000
www.nrel.gov

Andrea Watson
USAID Portfolio Manager
National Renewable Energy Laboratory (NREL)
Tel: +1-303-275-4234
Email: andrea.watson@nrel.gov

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL/TP-7A40-71915 • March 2019