

Exploiting the Potential of Energy Efficiency in Residential Buildings

The bottom line. The residential sector makes up about 70 percent of building energy demand. This demand is expected to grow rapidly over the next decade. Although the sector offers huge potential for energy efficiency gains, a range of barriers impede the realization of these benefits. Fortunately, a wealth of global experience shows how these challenges can be overcome through a combination of sound planning, strong policy and regulatory frameworks, well-designed financing and incentives, robust institutional and market development, and accessible information to scale up residential energy efficiency.

Over the past 20 years, the world has made impressive progress in using energy more efficiently. The rate of improvement in energy efficiency has more than doubled, rising from 0.8 percent per year in the early 2000s to about 1.8 percent per year in the past decade. There is still a long way to go, however: Nearly two-thirds of the energy produced from fossil fuels is wasted rather than put to productive use. As global energy demand is expected to grow by 30 percent in middle- and low-income countries over the next decade, the world needs to triple its current annual investments in energy efficiency to \$1.8–1.9 trillion. While this is a large sum, the benefits are even greater, for improving energy efficiency can strengthen energy security, boost economic growth, and support other key development goals.

Why does the residential sector matter?

Because it makes up nearly three-quarters of building energy demand and nearly a third of global energy use

The residential sector—housing—makes up about 70 percent of building energy demand and accounts for nearly 30 percent of global energy use and 27 percent of global greenhouse gas emissions. Much of this demand is for cooling and heating—in the form of space heating, water heating and cooking—with the rest for lighting, household appliances, and entertainment (e.g., radios, TVs). Over the next decade, energy consumption in residential buildings is expected to grow faster than in the rest of the building sector as population, incomes, and urbanization increase. Cooling, in particular, is expected to rise, more than tripling in the next 25 years (box 1). Such growth will place a huge strain on energy infrastructure and resources.



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Box 1. Sustainable cooling and heating

Sustainable cooling will be critical in the next decade to meet growing energy demand. Technologies and strategies exist that can deliver today's space cooling needs with less than half the energy use at a lower lifecycle cost to users and consumers. A recommended approach to sustainable cooling involves (i) reducing cooling loads through passive building designs (e.g., wall/roof insulation, efficient windows, reflective roofs, shading); (ii) ensuring efficient cooling appliances (e.g., high-efficiency fans, air conditioners, chillers); and (iii) optimizing cooling systems and user behaviors to minimize loads. Supportive policies and regulations (e.g., building codes, equipment standards), accessible and innovative financing (such as cooling as a service), consumer awareness, and enhanced professional capabilities can all help drive this important transition.

Today's *space heating* practices are not sustainable. Fossil fuels and unsustainable biomass (mostly firewood) have overwhelmingly met this energy need, leading to air pollution, particularly in urban areas, which causes 302,000 deaths and incurs a welfare cost of 7 percent of GDP annually. Governments are advised to develop *sustainable heating* strategies to include (i) reducing heating demand through efficient building designs and retrofits and changing user behaviors; (ii) bolstering and decarbonizing centralized district heating where possible; and (iii) promoting clean building-level heating systems, such as heat pumps or biomass pellet boilers, where centralized heating is not economic. Public sector planning and regulations, new programs that include incentives and financing (notably for poorer households), inclusive communications and outreach, and training are all important elements of a holistic government response.

Source: World Bank 2020, 2023.

Investments in energy efficiency (EE) can help households lower their energy costs, while improving their overall comfort and enhancing property values. A household that invests in common EE measures—insulation, better windows, efficient lighting and appliances—can save 10–50 percent or more on its energy bills. Where energy prices are below their supply costs, EE can lower fiscal outlays for energy subsidies and facilitate tariff reforms. Such investments can also ease energy demand, improve air quality and health benefits, support resilience, and spur economic development. Because the residential sector in many countries is so large, residential EE can stimulate local economies by creating jobs in areas like energy auditing, installation of efficient equipment, and manufacturing and retailing of energy-efficient products.

Residential EE programs can also be designed to help address broader sectoral goals. In the Europe and Central Asia region, for example, studies have found that implementing essential reforms to transition to cost-reflective electricity, district heating, and fuel pricing using targeted social assistance

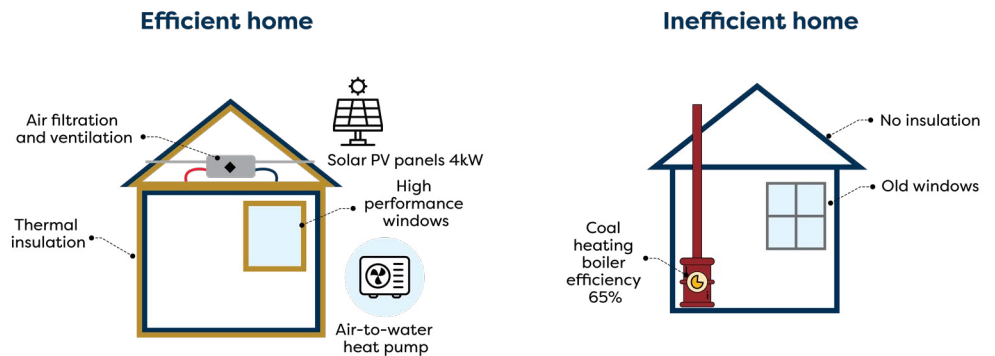
and residential EE investments could generate fiscal savings of 0.5–1.0 percent of GDP on average (World Bank 2012). In Sao Paulo, Brazil, a slum program promoted energy-efficient appliances that reduced nonpayment by 67 percent and energy use by 40 percent for poor households (USAID 2009).

Even though most EE improvements are cost-effective, more than 80 percent of the global economic potential for EE in buildings remains unexploited. This is due to a range of market failures, policy and regulatory barriers, institutional constraints, shortages of financing, and ineffective efforts to change consumers' behavior. Affordability, poor infrastructure and access to credit pose acute challenges in low- and middle-income countries. The good news is that such barriers have been successfully overcome in many countries using a range of approaches. Annex 1 details barriers and solutions based on global experience.

Addressing the needs of the poor is critical. The poor are stuck in a vicious cycle of high energy bills and constraints to

Figure 1. Energy-efficient homes vs. inefficient homes: Why the poor pay more

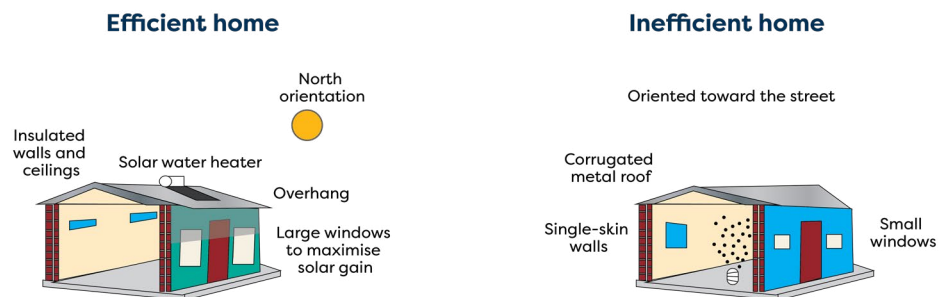
Case 1: Cold climate



Annual energy bill	\$0-461	\$2,501
Investment and payback period	\$35,398 (14.2 years)	N/A

Note: The analysis is based on a 130 m² single-family home in Poland.
Source: World Bank 2023.

Case 2: Tropical climate



Annual energy consumption and energy bill	6,288 kWh \$503	9,488 kWh \$759
Investment and payback period	\$2,022 (7.9 years)	N/A

Note: The analysis is based on a 30 m² standard housing units under the government development program for low-income housing in South Africa. The U.S. dollar amount for the energy bill is calculated as kWh × average revenue (USD 0.08/kWh, derived from revenue ÷ billed energy amount) for 2022, based on the World Bank's latest UPBEAT database.
Sources: Climate Strategies 2009; ESMAP 2011.

investing in EE. While the consumption of poorer households is modest, they typically spend a larger share of their income on energy. The poor are more likely to live in uninsulated, leaky buildings with older appliances and exposure to more polluting fuels for cooking and space heating (figure 1). They often lack the means to obtain credit to invest in energy-efficient

homes or to purchase appliances with higher upfront costs, resulting in chronic inefficiencies that result in higher energy bills and lower quality of energy services (e.g., undercooling, underheating). This situation also strains energy systems, government budgets, and the environment.

As shown in figure 1, the homes on the right side in both cases are typical low-income, inefficient homes. Because the poor tend to live in older, sometimes informal, housing without insulation and with older appliances, their energy bills are likely to be much higher (34–82 percent or more) than those on the left, and their service quality is much worse.

At present, lower-income families simply cannot afford many EE investments or more efficient appliances, creating a vicious cycle. However, when allowed to invest in EE with affordable options, many opt to do so. Energy bills can be substantially reduced as a result.

Many EE investments also lead to greater indoor comfort, lower indoor air pollution, better health outcomes, and enhanced safety (e.g., reduced fire hazards), while stimulating economic activity in their communities.

What has worked so far?

Many governments have been successful when adopting a comprehensive approach to policies and programs, with special attention to low-income homeowners, changing behaviors, and offering incentives

Because the residential sector contains so many small, heterogeneous owners and investments, developing effective and efficient government interventions and implementation arrangements can be a challenge.

Most of the governments that have been able to make a substantial impact on household energy have deployed policy and regulatory changes, information campaigns, government-sponsored programs (e.g., financing schemes, incentives, bulk purchases, utility programs), and collaborative partnerships with appliance manufacturers and others. The most important of these are discussed below.

Policy and regulatory changes generally center on energy price reforms (to make EE investments more attractive), codes and standards, testing protocols and enforcement regimes, homeowner association (HOA) legislation (to facilitate collective decision-making and financing), and measures to regulate demand-side management (DSM) by utilities. Appliance standards may also involve banning some of the least-efficient equipment in the market (e.g., incandescent lamps, coal boilers).

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Informational and behavioral campaigns can help raise awareness. Building certificates and appliance labels provide data on typical annual energy use and costs. Tools like energy calculators, guidebooks, and benchmarking help homeowners better understand their energy use and savings potential.

Government-sponsored programs support the financing and implementation of residential EE projects through banks, utilities, manufacturer partnerships, or other schemes. Financing and incentives can take many forms, such as guarantees, credit lines, on-bill financing, and grants or rebates. For simple, homogenous appliances such as light bulbs or fans, appliance replacement or bulk-purchase schemes can help stimulate the market and bring down the initial purchase price.¹ For others, more comprehensive home renovations—including appliances such as lighting and heating—are needed. While impactful, such programs require more customized approaches, often with individual energy audits, making technical oversight and verification of program resources significantly more complex.

Governments or utilities can also enter into partnerships with manufacturers and suppliers for joint marketing and distribution, incentives or coupons, or information dissemination to encourage households to adopt high-efficiency models.²

In terms of implementation arrangements, dedicated government agencies or utilities are often the preferred option (table 1). But utilities often emerge as a strong candidate

1 An example is the India Energy Efficiency Scale Up Program, which supported a public super-ESCO (energy service company), Energy Efficiency Services Ltd., to support household lighting schemes that included bulk purchase of LEDs and utility on-bill financing.

2 An example is Japan's Top Runner Program, which targets high-penetration, high-consumption products (e.g., room air-conditioners, refrigerators, lighting, TVs), sets efficiency benchmarks based on the best available models, and updates minimum standards.

Table 1. Implementation options for residential energy efficiency

Financing and implementation mechanism	Description	Examples
Bulk purchase and distribution	Large quantities of energy-efficient products (e.g., light-emitting diodes or LEDs) are procured and distributed to consumers, often by a utility or dedicated government agency.	Bangladesh, Ethiopia, India, Mexico, Mozambique, Philippines, Viet Nam
Utility demand-side management	Utilities are required by regulation to finance and implement EE programs for their customers. Utilities can also outsource program implementation to energy service companies, program agents, or other external entities.	Belgium, Brazil, Canada, Thailand, Viet Nam, United States
Energy efficiency obligations	Energy suppliers are required by regulation to achieve savings targets by financing and implementing EE programs for their customers.	Australia, Denmark, France, Ireland, Italy, United Kingdom
Appliance replacements	Government agencies may provide a combination of financing, incentives, and technical support to help homeowners replace individual appliances (e.g., refrigerators, heat pumps)	Bosnia & Herzegovina, China, France, Germany, Kyrgyz Republic, Mexico, Poland, Switzerland, United Kingdom
Home renovation schemes	Government agencies may provide a combination of financing, incentives, and technical support to help homeowners (single- and multi-family) carry out EE renovations.	Belarus, Bulgaria, Canada, Finland, France, Germany, Lithuania, Mexico, Poland, Romania, Serbia, Slovenia
Manufacturer or supplier partnerships	Manufacturers, in cooperation with the government or utility, offer incentives (e.g., coupons) and cooperate on marketing and distribution.	Brazil, Canada, India, EU, Republic of Korea, United States

Source: Adapted from World Bank (2025).

given their existing customer relationships, access to energy use data, and active billing systems.³ In such cases, governments need to explore regulatory options to incentivize or oblige utilities to offer EE programs to their customers, as in many DSM or EE obligation schemes managed by utilities. Once incentives are in place, utilities can implement bulk-purchase and distribution programs (e.g., for efficient lighting products) and offer rebates, on-bill financing for efficient appliances, low-cost energy audits, and many other services.

³ Utilities can also benefit by using demand response schemes to reduce energy demand during peak times in high demand centers, thus allowing them to defer transmission and distribution investments and to minimize supply to subsidized, low-tariff consumers. Utilities in low-income countries may also see value in financing efficient appliances for new household connections as part of energy access programs to help ensure customer affordability and sustainability of utility payments.

Where utility incentives are not possible or preferred, governments can appoint other public institutions (e.g., EE agencies, EE funds, public energy service companies) to carry out bulk procurement and distribution, issue appliance rebates or coupons, and facilitate single or multifamily home renovations, among other measures. These programs are typically complemented with financing schemes, such as revolving funds, credit lines (e.g., green loans/mortgages, Property-assessed clean energy (PACE) loans,⁴ retailer credit) or guarantees. Early pilots can test these financing and delivery

⁴ *Green mortgages* can offer preferential mortgage terms to support the purchase of new, energy-efficient homes (or renovation of existing ones) and the purchase of energy-efficient appliances (e.g., in Australia, Germany, Mexico, the Netherlands, United States). PACE loans are another tool that allows homeowners to finance renovations, procurement of new energy-efficient appliances, and rooftop solar installations while applying repayments to their property tax bills. If the homeowner sells the home, the repayment obligations transfer (along with the future cost savings) to the new owner.

systems, develop case studies, develop technical standards, and so on—but in such cases plans must be put in place to transition to national-level programs with robust and scalable institutional and financing arrangements.

Low-income homeowners. Low-income populations are disproportionately vulnerable to energy poverty. As noted earlier, they often reside in older, poorly constructed homes with low thermal efficiency and older, less efficient appliances. Therefore, many governments have responded with programs targeted to the most vulnerable. Market studies, household surveys, and other tools can help identify current income levels, practices, and constraints so that suitable programs can be designed to address their needs. Because the upfront investment cost of more efficient homes and products can be prohibitively high, suitable financing schemes, coupled with higher grant levels, may be necessary. Many programs have also used bulk-purchase schemes (often giveaways of LEDs) and utility on-bill financing to help make it easier for low-income consumers to participate.

More governments are realizing the benefits of incorporating behavior change into their outreach efforts.

The World Bank also supports low-income housing by deepening and expanding affordable housing finance markets through investment and advisory services, promoting public-private partnerships, developing specialized housing finance products, and providing financial assistance to client countries to reduce costs and increase access for low-income and informal households.⁵ Ensuring that such low-income housing is energy efficient can save governments substantial

5 An example is the Argentina Metropolitan Buenos Aires Urban Transformation Project, where the city government acquired and prepared a site, installing trunk infrastructure (water, sewerage, stormwater drainage, paved roads, public lighting, electricity, gas) and constructing about 1,200 new housing units for residents in poor living conditions. The new units met EE standards; electricity networks were upgraded to reduce losses; and public lighting was shifted to LEDs. By incorporating EE measures, the project delivered assorted benefits, including improved residential comfort, lower energy use and electricity bills, reduced government spending on electricity subsidies, more local jobs, and reductions in greenhouse gas emissions. Another example is the Mexico Improving Access to Affordable Housing Project, which supported a green mortgage product that incorporated energy-efficient designs and appliances, leading to a 20 percent reduction in energy and resource consumption.

resources if these families are in a position to receive energy assistance.⁶

Changing behaviors. More governments are realizing the benefits of incorporating behavior change into their outreach efforts. Behavioral insights can often lead to lower-cost interventions that help overcome barriers associated with the uptake of EE programs.⁷ Well-designed behavioral interventions can lead to increased participation in EE financing programs and enhance the level of energy savings for a given program. As a good practice, EE behavior change programs should be conceived and designed in light of local contexts, social norms, customs, and behavioral habits. They should rely on the most accurate data about consumers' energy use to provide innovative, usually inexpensive, solutions that often complement traditional policy approaches. The application of behavior change programs usually starts with defining the problem, diagnosing any barriers preventing people from adopting the desired behavior, and then designing interventions (e.g., approaches, messaging, information channels, etc.) to address them (ESMAP 2020). It is important to note that different segments of the market (e.g., single-family homeowners, HOAs, apartment building owners, low-income residents) are likely to have different behaviors and priorities, so programs and messaging likely need to be appropriately tailored.

More on incentives. Although EE investments generally pay for themselves over time, the payback period, as well as the upfront costs, can be higher than many households are able to afford. So many governments also offer incentives, which can help overcome the higher incremental cost of more-efficient construction, building materials, and appliances, especially for the poor. Such mechanisms can also help improve program participation rates, which in turn can bring in new suppliers and thus more competition. In such cases, governments will need to (i) assess the potential for incentives to encourage households to adopt more-efficient homes and appliances, and (ii) determine the levels of and eligibility for such incentives and ensure that higher incentives are targeted to those most in need.

6 For more information on the World Bank's support for new, low-income housing, see *Brief on Housing Finance*.

7 This has been the experience of utilities in the United States and Canada (Fitzjarrald 2019). Only 2 percent of their overall DSM expenditures, on average, goes to residential behavioral interventions, but these interventions generate 10 percent of the energy savings achieved.

Incentives come in many forms: fiscal incentives (e.g., tax credits or rebates; import tariff waivers); grants, subsidies or rebates; coupons; or even nonfinancial incentives (e.g., lottery tickets, awards, public recognition). Governments should identify potential sources of funding for such incentives to ensure they are sustainable over time, targeted, and short term (such as during promotional periods). Governments also need to ensure that incentives are easy to access (with clear, transparent rules and eligibility criteria), temporary, targeted (e.g., based on investments with the highest energy-saving potential, aimed at the lowest-income consumers), and bundled with financing options to simplify transactions. Over time, as competition increases and costs decline, these incentives could be scaled down or even phased out. While the World Bank and other donors may provide the initial capital for such schemes through grants and concessional financing, incentives may eventually be secured through local sources such as EE or environmental taxes (on electricity or petroleum sales), general tax revenues, revenues from fees or penalties (e.g., license fees, privatization proceeds, environmental fees), and carbon market revenues. Some examples follow.

- ✓ In 2012, Ghana launched a “rebate and turn in” scheme for refrigerators, which allowed households to turn in their old appliance for a new, efficient model at a discounted price. This was coupled with a massive TV and radio campaign on energy efficient appliances, standards, and labels. About 20,000 units were replaced (UNDP 2021).
- ✓ The ASEAN Energy Awards (AEA) provide a prestigious, regionwide nonfinancial incentive: Public recognition for excellence in EE across buildings and energy management. Annual AEA cycles elevate best-practice examples, boost developer and municipal reputations, and spur imitation—an important complement to cash incentives, especially for multifamily and mixed-use residential developments seeking brand value.
- ✓ Carbon market revenues (carbon credits) are tradable certificates representing verified reductions in greenhouse gas emissions. Among the international mechanisms designed to generate such credits, the Clean Development Mechanism (CDM) plays a particularly significant role. Through the CDM, emission reductions achieved in developing countries are certified as Certified

Emission Reductions, a form of carbon credit that can be traded in global markets which generates revenue. For example, the Mexico Efficient Lighting and Appliances Project implemented a large-scale program to distribute millions of compact fluorescent lamps to low-income households, using revenues from Certified Emission Reductions to help reduce upfront costs and make efficient lighting more affordable.

Incentives come in many forms: fiscal incentives; grants, subsidies or rebates; coupons; or even nonfinancial incentives.

Monitoring and evaluation. Because residential EE programs are generally broad and dispersed, proper program monitoring and evaluation is critically important to determine if a program is working as intended. This usually starts with developing strong M&E plans that should include a baseline study, in addition to mechanisms to capture consumers’ baseline behaviors and expected changes under the program—e.g., energy saved, reduced emissions, longer periods of nighttime illumination in homes, more comfortable indoor temperatures, and job creation, along with measures to track and discount for program leakage, rebound effect, and free riders.⁸

In terms of the rebound effect, while it is true that lower operating costs could result in more consumption, energy use in many low- and middle-income countries is characterized by suppressed demand, whereby consumers use less energy than they need because they cannot afford it. Some argue that such improvements in the level of service provide additional socioeconomic benefits and quality-of-life improvements that should be encouraged as part of broader economic development, in contrast to the rebound effects observed in developed countries (World Bank 2021).

⁸ Program leakage refers to the percentage of participants who receive an incentive from the program but then install the appliance outside the program boundaries. Rebound effect refers to participants who increase consumption of energy services with more efficient appliances since they now have lower operating costs. Free riders are participants who would have made the change anyway, even without the program incentives or other support.

What has been the World Bank's role?

The World Bank has provided about \$1.3 billion to support EE in the residential and housing sector in the past decade (FY15–25)

The World Bank's projects in the period between FY15 and FY25 are concentrated in four main areas: (i) multifamily apartment and single-family building renovations (mostly in Europe and Central Asia); (ii) new and low-income housing; (iii) appliance replacement schemes; and (iv) policy reforms. Often, operations are linked to energy access, district heating upgrades, tariff reforms, and metering. Some programs have also sought to address power shortages, peak demand, air quality, utility nonpayment and other issues.

Financing has been concentrated in the Europe and Central Asia region (\$594 million, 47 percent), followed by Latin America and the Caribbean (\$351 million, 28 percent) and South Asia (\$175 million, 14 percent). Major recipient countries of operations include Argentina, Belarus, Ethiopia, India, Jordan, Peru, Poland, Romania, and Serbia.

A summary of common project target areas and activities appears in table 2. A detailed presentation of the World Bank's residential EE portfolio makes up Annex 2.

Across all sectors, the World Bank's EE portfolio has been cost-effective, at just US¢ 0.63 per kilowatt-hour (kWh) saved—much lower than the US¢ 3–8 per kWh produced typically required for new clean energy generation alternatives.

Table 2. World Bank financing for residential energy efficiency

Target area	Actions	Country examples
New or low-income housing	Provide partial grants and blended finance (including green mortgages) to integrate EE designs and systems into new residential construction. Adopt and enforce building codes and building energy certificates.	Argentina, Armenia, Bangladesh, Kazakhstan, Kosovo, Mexico
Retrofitting housing	Provide partial grants and blended finance (including green mortgages) for building retrofits (e.g., windows/doors, roof/ceiling/wall insulation, heating/cooling). Adopt and enforce building energy certificates.	Armenia, Belarus, Bosnia & Herzegovina, Kosovo, Mexico, Moldova, Poland, Romania, Serbia, Tuvalu, Ukraine
Equipment and appliances	Modernize district heating systems and install building-level substations with controls and consumption-based metering. Replace heating/cooling systems and other appliances—lighting, fans, refrigerators, pellet stoves, heat pumps, solar water heaters, etc.—through bulk procurement, utility DSM, partial grants, and concessional finance. Adopt and enforce appliance labelling and minimum energy performance standards.	Argentina, Belarus, Benin, Bosnia & Herzegovina, Cambodia, Dominican Republic, Ecuador, India, Kyrgyz Republic, Malawi, Mexico, Mozambique, Panama, Poland, Sao Tome and Principe, Serbia, Ukraine, Viet Nam
Efficient, clean cooking	Scale access to efficient/clean cookstoves and fuels through partial grants, concessional finance, and leasing. Support local production of efficient clean cookstoves, technical training, market demos, small grants, and results-based incentives. Adopt and enforce clean cooking performance standards.	Ethiopia, Federated States of Micronesia, Lao PDR, Mozambique, Tajikistan
Rooftop solar	Provide grants and blended/concessional finance for rooftop solar photovoltaic in housing. Pair rooftop solar photovoltaic with energy-efficiency upgrade packages (e.g., insulation, heating and cooling upgrades, LEDs).	Mozambique, Serbia, Tajikistan, Ukraine

What's needed to scale things up?

To come close to exploiting the potential of energy efficiency in residential buildings, a programmatic approach will be needed

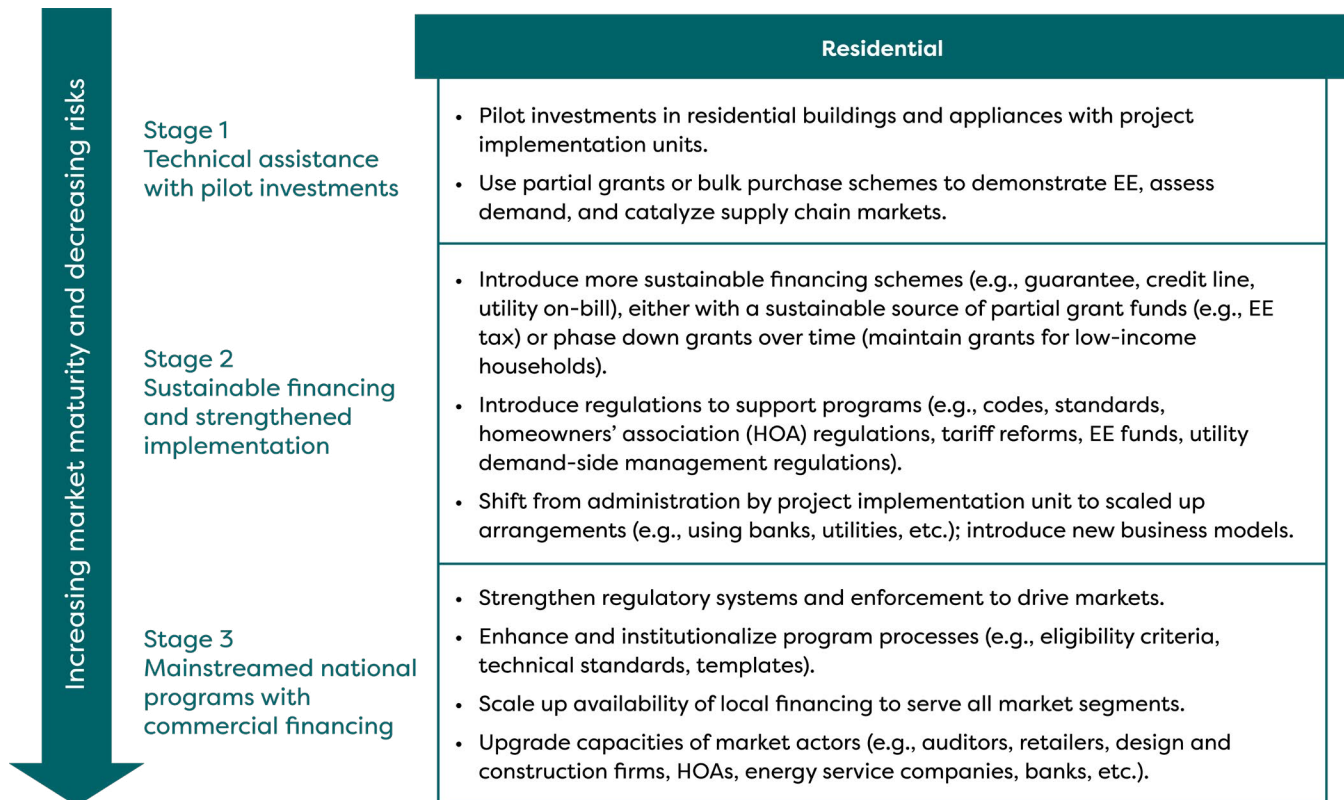
Government leadership is pivotal to set EE targets and mandates, build capable institutions, and launch bankable programs. To double EE outcomes and triple investments, countries must scale policies and programs through ambitious planning, aggressive regulations, continued reforms, stronger institutions, and improved mobilization of commercial finance and donor coordination.

Too often, however, small, grant-dependent pilots often prove non-scalable or are discontinued. This results in substantial upfront investments in developing systems, capacity building, and market development that are then lost once the project ends. But implementing pilots with a clear pathway to scale, through the adoption of a programmatic approach, can significantly improve impacts.

A program for renovation of multifamily apartment buildings in Bulgaria (2015–18) was successful in renovating about 2,000 buildings over 4–5 years. Yet national statistics indicated about 41,858 buildings remained to be renovated. Analysis showed that renovations at a rate of 400 buildings/year would take 105 years to complete. However, at the rate of 500 per year, plus an increase of 10 percent/year, completion would take about 23.5 years, which would be within the timeline of full building stock renovation by mid-century (World Bank 2018).

A programmatic approach (figure 2)—anchored in a medium-term vision and structured interventions that address known barriers to private investment—can help speed the transition from pilots to national programs that leverage commercial financing while advancing key reforms and introducing risk mitigation measures.

Figure 2. Framework for scaling up energy efficiency in the residential sector



Stage 1 uses public funding to attract early participants and to test financing and implementation modalities, while documenting experience of costs and benefits, the stringency of technical specifications, and qualified supplier capacity. It is also important to assess financing and implementation options for transitioning to Stage 2, and to identify needed policy, regulatory, and institutional reforms (e.g., setting up EE funds, improving HOA or utility DSM regulations, reforming tariffs, and adopting rooftop solar regulations) to facilitate this transition. Stage 2 introduces more sustainable financing schemes, together with banks, and puts in place conditions for sustainability and scalability. Public financing (e.g., EE revolving funds) may still be needed for less creditworthy segments, with more targeted grants for the poor. By Stage 3, the market functions largely with commercial financing and greater standardization, with lower levels of government program support (e.g., templates, training, guides, low-income schemes) to reduce transaction costs. Early upstream engagement with partners and market actors can inform strategies for successive stages and enable joint or coordinated national programs, including pooled funding.

What have we learned?

Future programmatic approaches should build in the valuable lessons learned in recent years

Global experience shows that implementing residential EE programs at scale can be resource-intensive and requires parallel sector reforms to create a favorable enabling environment.

Fortunately, common barriers have been overcome through a combination of sound planning, strong policy and regulatory frameworks, well-designed financing and incentives, robust institutional and market development, and accessible information

In addition, important technological and digital innovations, such as heat pumps, near-zero-energy buildings, geospatial planning, smart AI-enabled thermostats, and smart windows, among other innovations, have created new opportunities for countries to leapfrog to high-efficiency systems and practices. These developments provide opportunities for countries to scale up EE while boosting market demand for efficient services, products, and financing—which can bring

in new suppliers, help lower costs, and channel the massive inflow of private capital needed to realize the vast EE potential and drive job growth. Harmonizing policies, technical standards, documents, and templates will help create more predictability for equipment suppliers, commercial banks, service providers and others—leading to more-resilient supply chains, greater interregional trade, and further economies of scale.

Near-zero-energy buildings, geospatial planning, smart AI-enabled thermostats, and smart windows, among other innovations, have created new opportunities for countries to leapfrog to high-efficiency systems.

Residential programs should be designed with attention to broader government development and sector goals and challenges, such as tariff reforms, peak load reductions, affordability, and access. Programs should be tailored to prevailing market conditions, barriers, and opportunities in the country, drawing on international experiences and good practices and informed by market studies, household surveys, and related diagnostics to understand current income levels, practices, and constraints.

A comprehensive program design is recommended, with a combination of financing mechanisms and incentive schemes, along with parallel technical and informational components. Technical assistance can include energy audits, guides, and training to help homeowners make more informed choices and lower their transaction costs. Effective awareness and information campaigns should disseminate information about the costs and benefits of EE measures, coupled with behavior change approaches, to nudge consumers to make informed purchasing decisions.

Programs should also be designed to be inclusive and to support vulnerable and poor households, with specific financing and information tailored to their needs. However, grants should not inadvertently encourage overconsumption or discourage private service providers from serving poor

neighborhoods. It is also important to ensure that the application process and access to information are customized for the poor in a way that is easy for them to understand and act on.

Stringent building codes and appliance standards are important to ensure technical quality and persistent energy savings; these norms should be updated over time. Programs should also encourage the adoption of high-efficiency appliances through higher subsidy levels or labels and certificates informing consumers about energy consumption and operating costs. Systems also need to be put in place for disposal or recycling of old materials and equipment.

A centralized institutional approach, such as a utility or EE fund, has the advantage that, if appropriately resourced, the entity can serve as a one-stop shop for financing, incentives, information, and technical expertise for residential EE programs. For programs supporting full home renovations, proper oversight is critical, along with strong technical standards, standard scopes of work, technical guides, and proper documentation of use of program funds.

Recommendations for program implementation include the following:

- ✓ Support robust technical monitoring and oversight early on to ensure competency and quality, with documentation of deficiencies for future training programs. Ensure proper oversight of grants.
- ✓ Use pilots to test financing and delivery systems, develop case studies, and develop technical standards—but put plans in place to transition to national-level programs with sufficiently robust and scalable institutional and financing arrangements.
- ✓ Consider the use of program agents or other schemes to support program marketing, assistance with household applications, advice on selecting contractors, and support with technical oversight (especially for home renovation programs). Help desks, websites, and certified contractor lists can also support households.

- ✓ Deploy monitoring and evaluation systems to track implementation progress and impacts, thereby furnishing feedback for periodic adjustments and informing the design of future, scaled up programs. Monitoring of impacts must consider changes in household behaviors and practices following participation in the program.
- ✓ Develop mechanisms for coordination across government agencies, program partners, and market actors to address policy and program issues and emerging challenges, and seek proactive measures to address them.
- ✓ For bulk-purchase or utility programs, where a central institution may be purchasing large shares of appliances, ensure proper management of inventories and efficient and effective distribution channels. Take pains to work with local distributors and retailers to ensure that existing distribution channels are not adversely affected by the programs. There must be a clear exit strategy to allow the private sector to step in and sustain the delivery of efficient models.
- ✓ Consider harmonizing technical specifications and standards to support greater regional trade and promote greater competition to bring down prices over time.
- ✓ Report on program impacts and publicize results to show accountability for the program and help gain public and political support for future funding and support.

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Annex 1. Residential energy efficiency barriers and global practices to overcome them

Barrier	Solution
Policy and regulatory	
Low energy pricing	<ul style="list-style-type: none"> • Implement tariff reforms • Provide government incentives/subsidies for EE investments • Promote other benefits of EE (e.g., environment, health, comfort, improved property value) • Offer guarantees to support longer loan durations
Split incentives (for owners/tenants, developers/owners)	<ul style="list-style-type: none"> • Develop building codes, minimum certificate levels (e.g., Class B or higher) and enforce them • Introduce appliance standards (MEPS) with suitable enforcement mechanisms
Lack of metering or consumption-based billing (common for apartments with district heating)	<ul style="list-style-type: none"> • Promote universal metering alongside incentives for EE investments • Encourage use of heat cost allocators or similar technologies
Lack of policies around HOAs to enable them to implement EE investments	<ul style="list-style-type: none"> • Strengthen HOA regulations (to sign contracts, take out loans, open bank accounts, enforce dues collections) • Facilitate third-party service providers (e.g., maintenance/facility management companies) where HOAs do not exist
No regulations to allow or mandate utilities to provide EE services	<ul style="list-style-type: none"> • Introduce DSM by utility/energy supplier; EE obligation regulations to save help customers save energy • Provide incentives for utilities to undertake DSM programs (e.g., decouple energy sales from profits)
Limited availability of competitively priced energy-efficiency products and services	<ul style="list-style-type: none"> • Launch of public procurement or bulk-purchase schemes for energy-efficient equipment to bring in new suppliers • Introduce building codes/MEPS and/or certificates/labels with energy consumption data to build demand
Low or inconsistent quality materials and/or appliances in the market	<ul style="list-style-type: none"> • Introduce building codes/material or appliance standards (with stringent testing) and enforce them • Where technical standards are not possible, develop robust program standards
Institutional and market	
Small, disaggregated investments across many households with different income levels, needs, and levels of awareness about EE	<ul style="list-style-type: none"> • Develop building codes, minimum certificate levels (e.g., Class B or higher) and enforce them • Introduce appliance standards (MEPS) with suitable enforcement mechanisms • Develop financing and implementation schemes that can bundle and standardize investments, such as through utility DSM programs, bulk-purchase schemes, appliance retail credit, etc.
Multiple energy bills (e.g., electricity, gas, oil, coal, firewood) which complicate tracking of energy spending	<ul style="list-style-type: none"> • Develop tools (e.g., energy calculators) to help homeowners track energy spending • Provide support for home energy audits • Provide home benchmarking data and allow for comparisons to neighbors, etc.

(continued)

Annex 1. Continued

Barrier	Solution
Collective decision-making for multifamily apartment buildings (HOAs)	<ul style="list-style-type: none"> • Reduce homeowner threshold to make investment decisions (usually from 100 percent to 51-75 percent) • Provide government incentives to encourage homeowners to proceed with EE investments • Provide information on EE benefits, impacts for homeowners
Disaggregated market (energy auditors, construction firms, equipment suppliers) with conflicting incentives	<ul style="list-style-type: none"> • Introduce third-party service providers (e.g., maintenance or facility management companies) to provide integrated services to homeowners/apartment buildings • Develop dedicated websites with pre-qualified firms, online quotations, consumer reviews, etc.

Low-income consumers

Low baseline energy use, suppressed demand (e.g., undercooling, heating)	<ul style="list-style-type: none"> • Ensure that tariff reforms include social safety nets for basic energy services • Provide government incentives for EE investments, especially thermal renovations to lower heating/cooling losses • Ensure that EE programs are designed to allow for EE investments alongside improvements in service quality
Need for capital repairs before EE measures may be viable	<ul style="list-style-type: none"> • Offer parallel subsidies or loan programs to cover capital renovations, roof replacement, seismic safety, etc. • Allow part of the funding for EE renovation programs to be used for parallel capital renovation investments (non-EE) • Mandate structural safety of homes when purchased/rented or when applying for loans/grants for EE upgrades
Low incomes, limited disposable income to invest in EE, competing or short-term priorities	<ul style="list-style-type: none"> • Provide government incentives/subsidies for EE investments • Promote information on benefits of EE (e.g., environment, health, comfort, improved property value) • Offer guarantees to provide dedicated, longer term, more affordable financing options • Introduce utility DSM or other pay-as-you-save schemes

Financing

High upfront costs for energy-efficient homes, renovations, and appliances	<ul style="list-style-type: none"> • Provide government incentives/subsidies for EE investments • Offer guarantees or credit lines/green mortgages to provide longer term, more affordable financing options • Encourage appliance supplier credit, leasing options • Implement bulk-purchase schemes for common equipment (e.g., light bulbs, fans) or partnerships with manufacturers
Lack of access to affordable financing owing to high interest rates, inconvenience of bank loans for smaller appliance purchases	<ul style="list-style-type: none"> • Provide government incentives/subsidies for EE investments • Offer guarantees or credit lines to provide longer-term, more-affordable financing options, green mortgages • Introduce utility DSM or other pay-as-you-save schemes

(continued)

Annex 1. Continued

Barrier	Solution
Lack of creditworthiness or collateral, risk of owner selling before EE measures are fully paid back	<ul style="list-style-type: none"> • Offer guarantees to facilitate accessible, affordable financing • Provide government incentives/subsidies for EE investments (paid once loan repayment has been completed) • Introduce on-bill financing for utility DSM • Develop PACE financing product
Bank reluctance to lend for EE, uncertainty about actual cost savings, perceived risks	<ul style="list-style-type: none"> • Provide bank training and information/case studies about past EE project performance • Provide government incentives/subsidies for EE investments (paid once loans are repaid)
Bank preference for short-term loans	Offer guarantees to facilitate accessible, affordable, longer-term financing
Awareness, information and behavior	
Lack of awareness about building/appliance performance, energy saving opportunities, energy-efficient equipment	<ul style="list-style-type: none"> • Provide informational materials with case studies (e.g., actual EE costs and savings, payback periods) • Introduce labels with energy consumption data (e.g., building certificates, appliance labels) • Develop tools (e.g., energy calculators) to help track energy spending and compare homes to neighbors' • Provide support for home energy audits • Provide government incentives for EE investments for a short, promotional period
Lack of knowledge about how to identify viable EE measures, how to implement them, which materials to use (e.g., for windows, insulation) and equipment to purchase	<ul style="list-style-type: none"> • Provide informational materials with case studies and results • Introduce building codes/MEPS and/or certificates/labels with energy consumption data • Provide support for home energy audits • Prepare EE project guidebooks and templates • Develop websites with prequalified firms, simple on-line quotations, consumer reviews, etc. • Introduce utility DSM programs
Behavioral inertia as homeowners follow set routines/habits and can be unmotivated to try new things, social pressures for status, preference for convenience over EE	<ul style="list-style-type: none"> • Simplify processes, options, and transaction costs (e.g., preselected/default choices, one-stop shops) • Leverage behavior-change strategies (e.g., testimonials from influential citizens, benchmarking) • Design and provide tailored education campaigns with customized messaging
Underestimation of the impacts of collective actions (i.e., feeling that individuals can't make a difference)	<ul style="list-style-type: none"> • Provide educational materials with case studies and results • Share inspirational stories of others who made the change and the impacts of collective actions

EE = energy efficiency; DSM = demand-side management; HOA = homeowners' association; MEPS = minimum energy performance standards; PACE = property-assessed clean energy.

Annex 2. Continued

Country	Project ID	Project name	Lending Instrument	Targets low-income?	Pilot?	Subsector					Implementation approach					
						New housing	Housing retrofits	Efficient appliances	Clean cooking	Rooftop solar/Solar water heating	Codes and standards	Pricing reforms and incentives	Utility DSM	Bulk procurement	Financing and grants	Capacity building/Surveys
Dominican Republic	P175874	Electricity Reform for Sustainable Growth DPL	DPF					•			•	•				
Armenia	P176278	Green, Resilient & Inclusive DPO	DPF				•				•			•		
Benin	P176513	First Unlocking Human and Productive Potential DPO series	DPF					•			•					
Colombia	P176788	Equitable and Green Recovery DPL	DPF								•					
Ecuador	P176983	Green and Resilient Recovery (EGARR) DPF	DPF					•			•					
Serbia	P177410	First Green Transition Programmatic DPL	DPF								•					
Peru	P177765	Enabling a Green and Resilient Development DPF	DPF								•					
Benin	P178042	Second Unlocking Human and Productive Potential DPF series	DPF					•			•	•			•	•
Kazakhstan	P178303	Inclusive and Sustainable Economic Growth	DPF			•					•	•				
India	P178329	Second Tamil Nadu Housing Sector Strengthening Program	DPF					•			•					
Mozambique	P178668	Second Institutions and Economic Transformation DPF	DPF	•							•					
Romania	P178912	Inclusive and Green Growth DPL	DPF				•				•					
Grenada	P178930	Second Recovery and Resilience Programmatic DPC	DPF								•					
Moldova	P179086	Emergency Response DPO2	DPF				•				•					
Panama	P179817	Climate Resilience and Green Growth DPL	DPF					•			•					
Armenia	P179849	Second Green, Resilient & Inclusive DPO	DPF			•	•				•					
Kosovo	P179944	Fiscal Effectiveness, Competitiveness & Green Growth DPL	DPF			•	•				•					
Cambodia	P180749	Second Cambodia Growth and Resilience DPF	DPF					•			•					
Panama	P181306	Second Climate Resilience and Green Growth DPL	DPF					•			•					
Moldova	P181479	Supporting Growth and Resilience DPO	DPF				•				•					

Note: IPF = Investment Project Financing; PforR = Program-for-Results; DPF = Development Policy Financing.