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LESSONS LEARNED FROM INCENTIVE PROGRAMS FOR EFFICIENT AIR CONDITIONERS: A REVIEW

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Abstract

One of the largest drivers of growing global energy demand is the increasing market penetration of air conditioners (ACs). Global sales of room ACs were up 9% in 2013 compared to 2012, and that growth is expected to accelerate in coming decades, particularly in large metropolitan areas with hot climates. This report focuses on financial incentive programs that aim to mitigate the energy consumption attributable to the growing stock of ACs. Financial incentives leverage private investments to pull higher-efficiency technologies into the market. Through detailed case studies of AC energy-efficiency incentive programs, we show the significance and diversity of these programs and describe and share lessons learned from their design and implementation. The report also describes how incentive programs can be designed to address other pressing concerns related to growing AC use, such as challenges to power supply reliability resulting from increased peak demand and the global warming potential (GWP) of AC refrigerants.

For policy makers and program administrators interested in addressing AC energy efficiency through incentive schemes, the report provides examples of past and present programs and highlights challenges that need to be considered when making program design and implementation decisions. The report begins with an overview of AC markets, highlighting their growth and savings potential, recent achievements from minimum energy performance standards, and typical barriers to the penetration of more efficient AC models. Next, we examine six AC incentive programs in depth, based on evaluation reports and/or interviews with program administrators. Finally, we outline program design features that could a) increase penetration of energy-efficient ACs, b) increase utility and customer participation in demand response programs targeted at reducing peak-load impacts, and c) phase out the use of high-GWP refrigerants in ACs. We find that incentive programs are particularly effective when they target emerging technologies that have still a low penetration in the market.

Acronyms

AC	air conditioner
BUENAS	Bottom-Up Energy Analysis System
CAC	central air conditioner
CFC	chlorofluorocarbon
CFE	Comisión Federal de Electricidad (Federal Electricity Commission, Mexico)
CLASP	Collaborative Labeling and Appliance Standards Program
CO2	carbon dioxide
ConEd	Consolidated Edison
CTF	Clean Technology Fund
DISCOM	distribution company
DR	demand response
DSIRE	Database of State Incentives for Renewable Energy
DSM	demand-side management
EEPS	energy-efficiency portfolio standard
EER	energy-efficiency ratio
ESEER	European seasonal energy-efficiency ratio
EU	European Union
FIDE	Fideicomiso para el Ahorro de Energía Eléctrica (Trust Fund for Energy Savings, Mexico)
FS	fixed-speed
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GWh	gigawatt hours
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HPMP	HCFC phase-out management plan
HVAC	heating, ventilating, and air conditioning
IBRD	International Bank for Reconstruction and Development
IPL	Indianapolis Power and Light (USA)
kW	kilowatt

LBNL	Lawrence Berkeley National Laboratory
LEERA	LBNL Energy Efficiency Revenue Analysis model
MEPS	minimum energy performance standard
MERC	Maharashtra Electricity Regulatory Commission
METI	Ministry of Economy, Trade, and Industry (Japan)
MLF	Multi-lateral Fund
MW	megawatt
MWh	megawatt hour
NAFIN	Nacional Financiera (National Finance Bank, Mexico)
NYSERDA	New York State Energy Research and Development Authority
ODS	ozone-depleting substance
PACT	program administrator cost test
PEERAC	Promoting Energy-Efficient Room Air Conditioners (China)
PENHRA	Promoting Energy-Efficiency for Non-HCFC Refrigeration and Air Conditioning
PNSEE	Programa Nacional de Sustitución de Equipos Electrodomésticos ((National Program for the Substitution of Household Electrical Appliances, Mexico)
PSC	public service commission
RI	Reliance Infrastructure (India)
RIM	ratepayer impact measure
RMB	renminbi
SCT	societal cost test
SEAD	Super-efficient Equipment and Appliance Deployment
SEER	seasonal energy-efficiency ratio
SENER	Secretaría de Energía de México (Secretary of Energy, Mexico)
tCO2E	tonnes of carbon dioxide equivalent
TWh	terawatt hour
UAE	United Arab Emirates
UC	University of California
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
U.S.	United States
VS	variable-speed

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EXECUTIVE SUMMARY

Problem Statement

Air-conditioner (AC) sales are increasing rapidly as the standard of living increases in regions with hot climates. The Lawrence Berkeley National Laboratory (LBNL) Bottom-Up Energy Analysis System (BUENAS) model projects that operation of residential ACs purchased between 2010 and 2020 will consume more than half of all solar and wind generation projected to be added globally during the same period. Because AC usage is concentrated during the summer months, it not only increases overall electricity demand but also contributes significantly to peak demand. On very hot days when AC units are typically set to maximum cooling, electricity demand spikes, and additional generation capacity is required to meet this demand. In addition, ACs use refrigerants that have a high global warming potential (GWP) and damage the ozone layer. Although the 1987 Montreal protocol allowed a gradual transition to refrigerants that do not damage the ozone layer, the most recent generation of refrigerants still has hundreds to thousands of times the greenhouse potency of carbon dioxide (CO_2). According to a recent forecast (Velders et al.2012), increased use of hydrofluorocarbons (HFCs) will result in a 14 to 27% increase in CO_2 emissions under the range of Intergovernmental Panel on Climate Change (IPCC) business-as-usual scenarios for 2010 to 2050.

Increase in AC penetration poses a serious challenge for policy makers who must balance meeting consumer demand for cooling against limiting the negative environment impacts of AC. To help address these challenges, policies and programs are needed to transform the market toward energy-efficient ACs that minimize energy and peak demand and reduce the global warming and ozone impacts of AC refrigerants.

Market Transformation Policies

A number of policy interventions can help transform the market toward higher efficiency ACs. Standards and labeling (S&L) programs transform the market by removing inefficient technologies and empowering consumers to make informed purchasing choices based on product efficiency rankings. Incentive programs target the "top" of the market, accelerating transformation by encouraging the production and/or purchase of AC products that are more efficient than standard products. Incentive programs generally offer a financial stimulus (subsidized loan, cash rebate, grants, etc.) to motivate private investment in energy-efficient equipment. Typically, incentives are implemented through downstream programs (i.e., provided directly to customers), midstream programs (directed at distributors or retailers), or upstream programs (targeting manufacturers).

The goal of this report is to analyze AC incentive programs in different countries to increase our understanding of the type, scope, and mix of economic instruments best suited to target the top of the market and help transform the AC market.

Case Studies

Globally, a limited number of incentive programs target ACs. The U.S. has implemented, by far, the largest number of these programs. U.S. programs are typically ratepayer funded – i.e., their costs are recovered by a small electricity rate surcharge – and these programs are part of integrating energy efficiency into least-cost resource planning. Their main objective is to reduce energy consumption and peak load in order to reduce the need to construct new generation capacity. Although energy-efficiency incentive programs for ACs have been developed more recently in China, these programs have the largest impact among programs worldwide because of the national scope of China's efforts and the budget allocated to them. The Chinese program example studied in this report illustrates how government funding can leverage very large amounts of capital: US$1.85 billion over 18 months (June 2009 to May 2011) was allocated to the transformation of the Chinese AC market. International institutions have also helped national governments to implement incentive programs, for example Mexico's national replacement program for ACs that are 10 years old or older was partly funded by a loan from the World Bank. In India, a few power distribution companies (DISCOMs) have recently launched incentive programs with support from state electricity commissions. An example is Reliance Infrastructure (RI) in the State of Maharashtra, which operates an upstream incentive program for efficient ACs. A United Nations Development Programme (UNDP) project in Indonesia with co-financing from the Global Environment Facility (GEF) has been submitted to GEF with the goal of mobilizing resources to maximize climate benefits of the phase-out of hydrochlorofluorocarbons (HCFCs) in ACs. Implementation has started yet but the description of the program is available from project description.

We identified incentive programs targeting AC market transformation around the world and then selected six case studies to be analyzed in detail in this report. These programs are not supposed to be model programs but, rather, example programs that could possibly be very general examples of how to promote efficient ACs. The six case studies are:

- **China**: Promoting Energy-Efficient Products for the Benefit of the People
- **Mumbai, India**: Reliance Infrastructure Ltd. Five-Star Split AC Pilot Program
- **Mexico**: National Appliance Replacement Program
- **New York, USA**: Consolidated Edison Residential Appliance Replacement Program
- **Indonesia**: Promoting Energy Efficiency for Non-HCFC Refrigeration and Air Conditioning (PENHRA)
- **Indianapolis, USA**: Indianapolis Power And Light (IPL) CoolCents Demand Response Program

For each case study, we collected information on the program's goals, strategies, mode of intervention in the market, administration, source of funding, reported impacts, and evaluation results if available. Table ES- 1 summarizes the key characteristics of each program.

Table ES- 1. Summary of Case Study Characteristics

	Goals	Intervention	Administration	Funding	Impacts
China	- Boost the economy - Transform the market to more efficient products - Increase awareness of energy-efficient products	Upstream	Government	US$2.4 billion total, AC only: US$1.85 billion over 18 months (Round 1)	- 34 million energy-efficient AC units sold - Energy savings of 80 - 100 billion kWh* over the lifetime of the ACs - Revision of MEPS
Mumbai, India	- Conserve energy - Increase consumer awareness	Upstream	Utility	Approximately US$330,000	No impact yet
Mexico	- Boost the economy - Reduce poverty - Reduce GHG* emissions	Downstream	Government	US$600 million for appliance replacements (approximately 10% were air conditioners)	More than 150,000 participants for ACs
New York, USA	- Save energy to meet regulatory energy-reduction targets	Downstream	Utility	Approximately US$1.1 million, budget from New York's System Benefits Fund	- 59,193 units in 2 years - 1,210 MWh* of net savings, - 758 kW* net peak demand savings
Indonesia	- Reduce GHG emissions - Save energy	Upstream	Government	US$5M GEF, US$25M co-financing	Project not yet started- waiting for final GEF approval
Indianapolis, USA	- Peak-demand savings - Economic savings from reducing energy use when it is most expensive (at peak- demand hours)	Downstream	Utility	US$1.3 million in 2013 (though only 83% was spent to realize 99% of the goals)	IPL's demand-response resources are equal to approximately 1% of installed generation capacity; in 2013, nearly 20% of eligible customers participated in the program.

*kWh – kilowatt hours; GHG - greenhouse gas; kW – kilowatts; MWh- megawatt-hours

Discussion and Lessons Learned

Incentive programs vary widely in their goals, scope, funding source, and impacts. No single model can apply universally. Program designs are based on specific local market barriers and reflect local conditions. However, a few lessons can be generalized from programs that have already been implemented.

1- Target low-penetration efficiency level

Incentive programs are particularly effective in transforming markets for new technologies that have a low penetration. By increasing their market penetration, incentive programs help to streamline the production process and allow manufacturers to take advantage of economies of scale and learning effects. The China case study in this report shows that a large national program rapidly changed the penetration of energy-efficient products from 5% to 70% in less than two years, at a cost well below the cost of new energy supply. By contrast, the second round of China's program reveals the impact of targeting products with an energy efficiency that already have a high market penetration. The result of this choice of target was that a large portion of ACs was eligible for the subsidy, which increased the risk of free ridership (the share of customers who benefited from the subsidy but would have purchased the product without it). This finding also emerges from the New York case study, where free ridership was estimated at 53%, reducing net savings by the same percentage. Recommendations from the evaluation of that program included the need to target higher efficiency levels to reduce the free ridership percentage. In the case studies, incentives are generally offered to both variable speed and fixed speed ACs. This stems from the fact that standard and labeling programs are not technology neutral in many countries and have performance rating for both technologies which can be misleading for consumers (Li et al, 2013). Ideally, from an energy efficiency perspective, incentive programs should be technology-neutral and only target the most efficient technology.

Program administrators need to balance program cost against targeting highly efficient products that have a low penetration. As the efficiency level required by a program increases, the program cost also increases because more efficient products tend to be more expensive. Justification of a program from an utility perspective generally requires that the program cost be lower than the cost of adding new generation. Monetary incentives provided in the case studies analyzed in this report range from US$29 to $127, and most programs aimed to eliminate the price gap between products that meet minimum standards and more efficient products.

2- Choose program type according to market conditions and barriers

Incentives can be directed at different points in the supply chain depending on the technology's maturity, market penetration, market barriers, and the nature of the supply chain. Upstream incentives are effective for influencing a large portion of the market through fewer actors and therefore have lower transaction costs. This is one of the main reasons that the Chinese government used an upstream program for its very large market. Upstream program are most successful when a local industry exists. However, the main challenge with upstream programs is to design it carefully and put in place a robust monitoring and verification scheme to make sure that the financial incentive is used to address the goal of the program. Downstream incentives have the advantage of raising consumer awareness of the benefits of highly efficient products, which has positive spillover effects on other energy-efficiency purchases. The existence of a rebate is a signal in itself and may be even more important than the cash amount in some cases. Moreover, downstream programs have the flexibility to be directed at selected populations, such as low-income households, as in the Mexican case study. The type of market barrier being addressed also ought to dictate the type of program chosen.

3- Consider additional program features customized to specific goals and local market conditions

Additional features can be considered depending on the program's objective and local market conditions. Table ES-2 shows the main program features for each case study.

Table ES-2. Program Features

Features	Description	Case Study
Replacement requirement	The eligibility criteria for a few programs, including the Mexican and Mumbai programs analyzed in this report, require that participants surrender old units to be eligible for the incentive. This feature accelerates the rate at which the old appliance stock is replaced and prevents that subsidized sales increase the stock. The programs aim to reduce electricity use by both encouraging the deployment of efficient ACs and ensuring that older, less-efficient ACs are removed from the stock.	- Mexico - Mumbai
Recycling	Recycling old units and properly disposing of their refrigerant gases reduces impacts on the ozone layer and climate-change impacts	- Mexico - Mumbai
Marketing	Marketing is an important program design feature. For example, upstream programs tend to be invisible to consumers, but the Chinese program developed an endorsement label to encourage consumers to buy the discounted efficient products. However, this process achieves best results when the bidding offer can attract interest from a large enough pool of manufacturers to drive down the price.	- China - Mumbai - New York
Bidding process	The Mumbai case study shows that it is possible to use a competitive bidding process to buy down the price of efficient models targeted by the program. However, this process achieves best results when the bidding offer can interest a large enough pool of manufacturers to drive down the price.	- Mumbai
On-bill financing	The Mexican case study features a financing option that allows participants to pay for efficient units through their electricity bills.	- Mexico
Combining ozone-depleting substances and global warming potential	The Montreal Protocol's Multi-lateral Fund (MLF) HCFC phase-out funding could be leveraged to achieve climate co-benefits by enhancing manufacturing of energy-efficient equipment and use of low-GWP refrigerants. Currently the MLF only funds the incremental costs of transition to non-ozone depleting refrigerants, and encourages the maximizing of climate benefits. This may change in the future as many countries are supporting amendments of the Montreal Protocol to target low-GWP refrigerants.	- Indonesia
Load control devices	In the IPL program, adaptive load control switches are installed on ACs to manage participants' AC use during demand-response program events (i.e., when certain criteria have been met, such as the marginal price of generation rising above a certain amount)	- Indianapolis

4- Consider multiple benefits when designing program goals

The most common goal of an AC incentive program is to save energy, but some programs have additional goals, such as reducing climate-change impacts, increasing economic activity, and reducing poverty. In the China and Mumbai programs, raising public awareness is one overarching goal. In Indonesia, where the program is funded in part with international climate monies, the main goal is the reduction of greenhouse gas (GHG) emissions through energy efficiency. In China and Mexico, goals include economic recovery. Furthermore, the Mexican program aims to reduce poverty.

An evaluation by Davis et al. (2013) determined that the Mexican program experienced a significant rebound (or take back) effect that had a net impact of slightly increasing energy consumption. Rebound effects are behaviors that increase energy use in response to the lower energy bills that result from energy-efficiency improvements. Rebound effects are a positive effect from increasing energy efficiency which reflects that consumers are taking advantage of the energy efficiency improvements realized. Indeed, rebound effects need to be considered in the context of the policy objective, especially in developing countries where demand for basic energy services such as lighting, heating, cooling, and food refrigeration is not fully met. Improving energy efficiency reduces the amount of energy needed to produce one unit of energy service output (for example an hour of cooling at 21^{o}C delivered for X vs. Y kWh). As a result of the decrease in energy costs, energy efficiency increases access to more energy services.

The value of energy-efficiency policies should be measured by their overall social, economic, and environmental benefits. In some places, the largest benefit of energy-efficiency policies may be to increase access to energy services rather than to decrease overall energy consumption. Policymakers should analyze these trade-offs from different stakeholder perspectives and from the perspective of society as a whole in order to choose energy-efficiency measures and programs that will increase the country's overall welfare.

5- Evaluation, monitoring, and verification should be part of program design

Third-party evaluations were available for four out of the six programs studied in this report. The two U.S. programs (New York and Indianapolis) have regulatory obligations to retain third parties to evaluate their programs. In these cases, the evaluations helped the program administrators modify the programs to optimize impacts. Two other programs had evaluations sponsored by independent organizations.

Evaluation of energy savings is necessary to estimate the net savings resulting from a program, i.e., the energy savings strictly attributable to the program. Net savings include spillover effects but exclude free ridership, and rebound and other program effects. Program goals need to be clearly stated so that metrics can be developed to evaluate progress toward those goals. Evaluations should be planned at the design stage, and pilot programs and periodic evaluations should be considered to test key assumptions and verify the realism of estimated program results so that program design can be modified if outcomes do not meet goals.

Conclusion

Incentive programs have a significant role to play in transforming the market to more efficient ACs. These programs can also help reduce peak load and move the market toward ACs that have low GWP. Incentive programs can also help remove old inefficient equipment from the stock faster and allow recycling of ACs' environmentally damaging refrigerants.

Global experience with AC incentive program designs shows that programs are very diverse, and there is no single model that is universally applicable. Programs should be designed taking into account the specific barriers that hinder the penetration of more efficient products in the local market.

Although global experience is encouraging, and results are positive, more efforts are needed to move the market faster toward efficient and innovative technologies that better answer the challenges posed by growing demand for cooling services. Moreover, a program has yet to be designed that combines multiple objectives, e.g., refrigerant transition, efficiency improvement, and demand-response participation. Policy makers and program administrators are encouraged to develop innovative designs to achieve these multiple inter-related goals.

1. INTRODUCTION AND METHODOLOGY

Much of the world's economic growth is occurring in the hottest climates. As these economies become wealthier, demand for air conditioning is expected to grow rapidly (Davis and Gertler, 2015). For example, in 2010 alone, Chinese consumers bought 50 million air conditioners (ACs) (China Daily, 2012). An explosion in the uptake and use of ACs can profoundly impact energy consumption, electricity grids, and the environment.

ACs are very energy intensive and account for a major share of household's electricity bills when used. Demand for cooling tends to be simultaneous among all users during the hottest days and therefore contributes significantly to peak electricity demand. In countries where the power supply is constrained by capacity shortage, AC demand exacerbates gaps in power availability and undermines system reliability. ACs also use hydrochlorofluorocarbon (HCFC) or hydrofluorocarbon (HFC) refrigerants (R22 or R410A) that have a global warming potential thousands of times greater than carbon dioxide (CO_2). For all of the reasons outlined here, increased AC penetration presents significant challenges and opportunities for policy makers desiring to support sustainable development.

Opportunities for deep, cost-effective savings from AC efficiency improvements remain under exploited because of a number of barriers to their uptake. New, and stronger policy interventions are needed to overcome these barriers and mitigate impacts from increased AC penetration. Policies such as minimum energy performance standards (MEPS) are improving AC efficiency by removing the least-energy-efficient products from the market. Labeling programs empower consumers to make informed purchasing choices. Incentives, also referred to as economic instruments, can complement these policy initiatives by accelerating market penetration of products that are more energy efficient than required by existing standards. Although standards and labeling programs dominate the current policy framework for ACs, the need for increased market action and enhanced private-sector involvement is necessary to push energy efficient AC technology even further.

This report addresses the following questions:

- What role can incentive programs play in accelerating transformation of the AC market?
- Can incentive programs successfully leverage private investment to pull highly efficient technologies into the market?
- What has the experience been so far with AC incentive programs?
- What program designs have addressed the market barriers that hinder investment in energy efficiency?
- Are these programs successfully addressing the overall environmental challenges posed by increasing numbers of ACs?
- Are there incentive program designs that successfully combine multiple objectives e.g. refrigerant transition and efficiency improvement, or efficiency improvement and demand response participation?

Despite current interest in market transformation programs, there are few reports on incentive programs globally, and even fewer focusing specifically on appliance incentive programs. This report aims to fill this gap. Using detailed case studies, we show the significance and diversity of AC energy-efficiency incentive programs, describe their program designs, and share lessons learned from their implementation. We also cover emerging approaches to addressing growing cooling loads, particularly demand response (DR) programs, and approaches to addressing the global warming potential (GWP) of AC's refrigerants through the use of alternative refrigerants. This report offers multiple strategies to address the multiple challenges that rapid adoption of ACs will present globally and looks at the key factors that decision makers should weigh when considering incentive program design.

Methodology

This report considers all types of programs that provide a financial stimulus to help move the AC market toward more efficient products. Incentives under these programs can be offered to various actors in the supply chain. Often, incentives are offered directly to customers through what are known as downstream programs. In this case, incentive programs stimulate the purchase of new efficient products and can also be designed to dispose of old, inefficient appliances. By contrast, upstream incentives target manufacturers, encouraging them to produce more efficient equipment and accelerate technology upgrades.

After a first screening based on a literature search, we organized by program type the incentive programs that we had identified. Case studies were then selected to represent a diverse set of program types and participating countries. We selected programs based on the availability of documents that described them in detail. There are few national programs in emerging economies, and, for many programs, comprehensive information is not available. We ultimately chose six programs to examine in depth and conducted interviews with program administrators to complement the information collected and to help us understand the implementation process for the programs. These programs are not supposed to be model programs but, rather, example programs that could possibly be very general examples of how to promote efficient ACs.

Table 1 lists the types of programs considered, their general objectives, and the corresponding case studies.

Table 1. Program Types and Country Case Studies Selected

	Name	Goals	Implementing Agency	Program Type and main features
China	Promoting Energy-Efficient Products for the Benefit of the People	- Economic development - Market transformation	Government	- Upstream - Label Scheme
India (Mumbai)	Reliance Infrastructure Ltd. Five- Star Split AC Pilot Program	- Energy savings - Increased public awareness	Utility	- Upstream replacement - Competitive bidding process
Mexico	National Appliance Replacement Program	- Economic development - Poverty reduction - Energy savings	World Bank and Government	- Downstream - Early replacement - On bill financing - ODS recycling
U.S. (New York)	Consolidated Edison Residential Appliance Replacement Program	- Energy savings	Utility	Downstream
Indonesia	Promoting Energy-Efficiency for Non-HCFC Refrigeration and Air Conditioning (PENHRA)	- Transition from HCFCs to non-ozone-depleting low-GWP refrigerants - Energy savings	United Nations Development Programme and Government	- Upstream - Resource mobilization with HPMP
U.S. (Indianapolis)	Indiana Power & Light CoolCents Demand Response Program	- Demand response	Utility	Demand response

The body of this report begins with an overview of AC markets, highlighting their growth, the potential for reducing AC energy consumption, and the typical barriers to the penetration of efficient AC models. Next, we examine six AC incentive programs in depth based on evaluation reports and/or interviews with program administrators. Finally, we outline program design features that effectively a) increase penetration of energy-efficient ACs, b) increase utility and customer participation in DR programs targeted at reducing peak-load impacts, and c) phase out high-GWP refrigerants in ACs. Finally, we discuss some lessons learned and recommendations for policymakers.

2. AIR CONDITIONER PRODUCT OVERVIEW

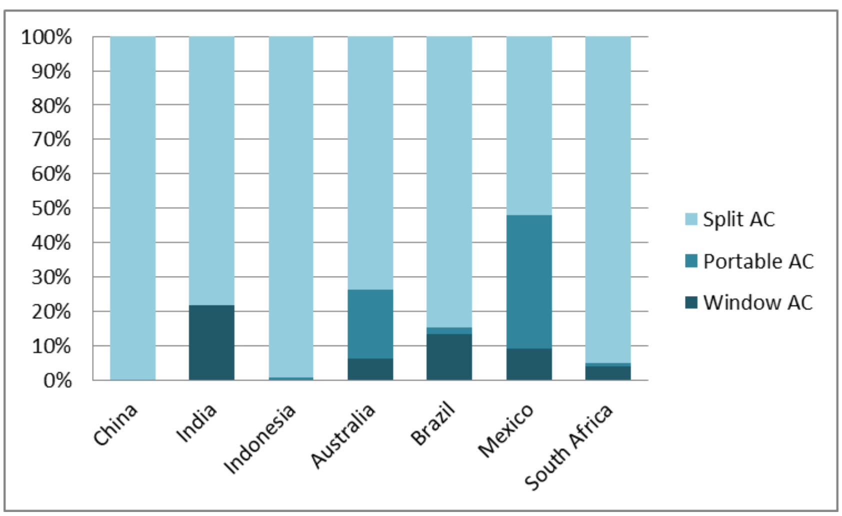
2.1 MARKET TRENDS

The residential AC market includes a variety of types of units, [1] ranging from central ACs (CACs), which use ducts to distribute cooled air to more than one room, to unit ACs, which cool the air for a single room and are often referred to as unit ACs. Room ACs can be further disaggregated into different types, the most common being:

- Window ACs
- Unducted split-packaged (known in the U.S. as mini-split[2]) ACs, consisting of two packaged units (one indoor and one outdoor unit) connected by a pipe that transports the refrigerant
- Portable ACs

Central air systems are most common in the U.S., found in 90% of single-family homes built since 2000 (US EIA, 2009). However, room ACs are still common in some places, notably cities in the Northeast such as New York where the building stock is older and consists of multi-family dwellings. In other countries, room ACs dominate the market, with mini-split ACs increasingly replacing window units. Figure 1 shows the market shares of various types of ACs sold primarily to residential and small commercial customers in key countries. A significant majority of these ACs are split ACs, and the share of split ACs is growing in most markets.

Figure 1. 2010 Market Share of room AC products by type



Source: Euromonitor International, 2014.

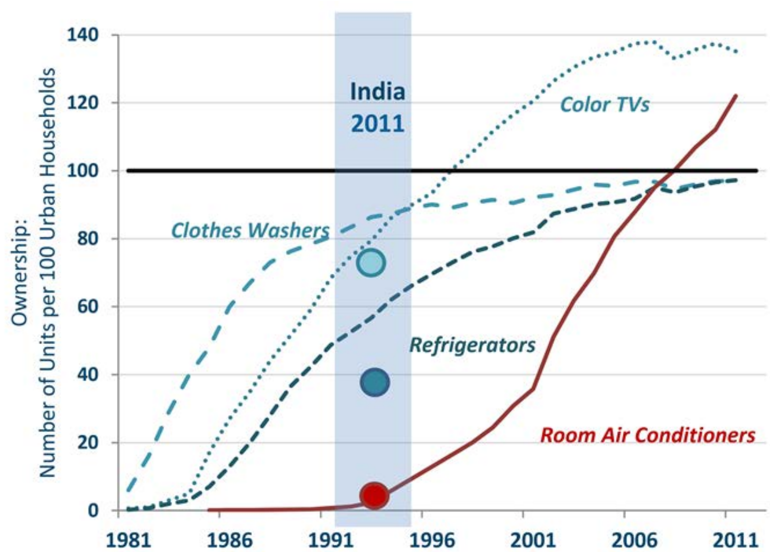
[1] For a more comprehensive discussion of different types of ACs see the preparatory study for the EU Ecodesign program (EuP, 2009).
[2] In North America, mini-split ACs are considered to be a type of CAC both for testing and within energy-efficiency regulations.

China consumers currently purchase 60% of the world's global sales of unit air conditioners, and demand has increased at double-digit rates during most of the past two decades. There are currently an estimated 275 enterprises operating in the Chinese room-AC industry, generating $83.8 billion in revenue and employing about 321,500 people (IBIS, 2014). The concentration of low-cost room-AC manufacturing in China offers a major opportunity to improve energy efficiency and reduce greenhouse gas (GHG) emissions, not only in the domestic realm but also in an international context.

2.2 ENERGY DEMAND AND PEAK LOAD

Global sales of room ACs were up 9% in 2013 compared to 2012, and that growth is expected to accelerate in coming decades, particularly in large metropolitan areas with hot climates. Although the market in the U.S. is approaching saturation, with 87% of households having some type of AC (EIA, 2009), in most other countries in the world, including India, Mexico, Indonesia and Brazil, ACs have a much lower market penetration, under 15% of households. Urban China is a notable exception, with room AC penetration in urban households increasing from ~5% to 127% from the mid 1990s to 2012. Figure 2 shows the actual penetration of major households equipment in urban Indian households in 2011 compared to the evolution of the penetration in Chinese urban households. India is at the bottom of the curve and penetration of AC is expected to increase fast as income increases.

Figure 2. Comparison of Relative Rates of Appliance Ownership in Urban China and India



Source: China NBS, 2014; India NSSO, 2012, Fridley et al, 2012

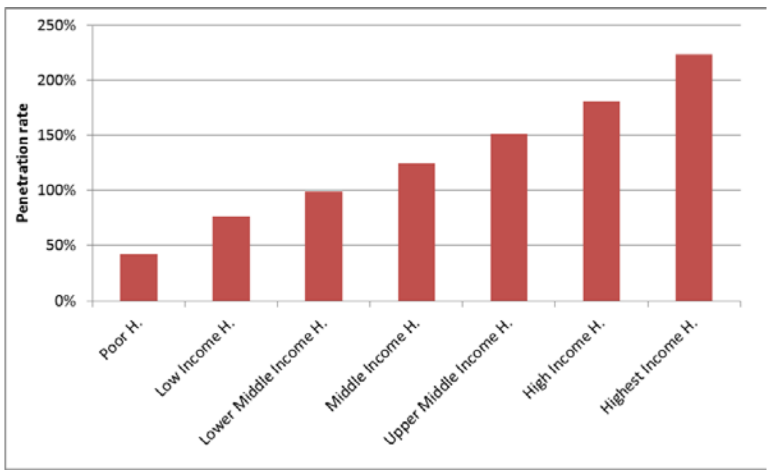
AC sales are driven by rising income levels and increasing urbanization, particularly in countries with warm climates. These trends and characteristics are typical in the major emerging economies, e.g., India, China, Mexico, Brazil, and Indonesia (McNeil et al, 2012). The penetration of ACs is increasing much more rapidly in urban than in rural areas. For example, the penetration of ACs is 127% in Chinese cities whereas it is 25% in rural areas (China NBS, 2014).

ACs are often considered luxury goods because they do not provide basic essential functions (like cooking or food preservation). However, the idea of what constitutes a luxury rather than a necessity changes with income level

(Matsuyama, 2002). As income increases, the ownership of ACs increases in all classes because ACs improve comfort just as space heating does. In China, the penetration of ACs in the lowest-income urban households was nearly 50% in 2012 (Figure 3). This rate continues to increase with higher levels of income, indicating that wealthier households own more than one AC unit (Figure 3).

The combination of rapid urbanization and rising living standards creates a serious challenge for cities to provide the energy necessary to power ACs.

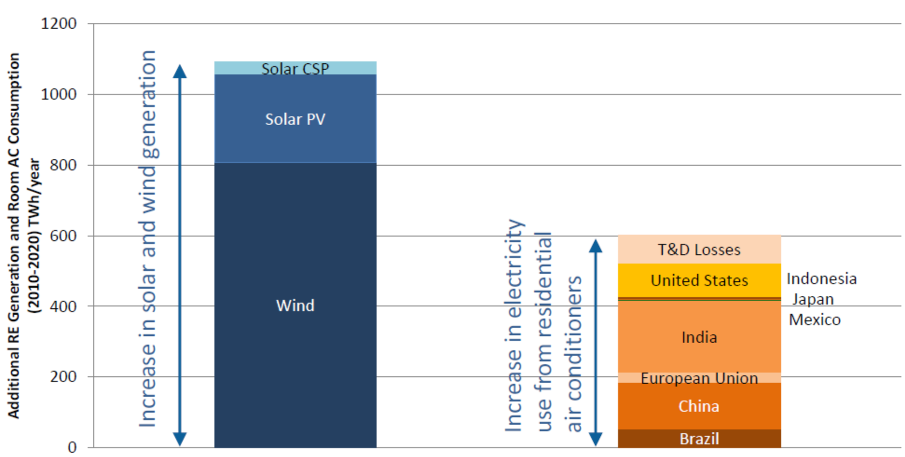
Figure 3. Ownership of ACs Per 100 Urban Chinese Households by Level of Income (2012)



Source: China NBS, 2014. H = households

China, India, Brazil, Mexico and Indonesia purchased 70% of the estimated 108 million room ACs sold in 2013, and this share is expected to increase to 76% by 2020. The additional ACs sold in these countries between 2015 and 2020 are expected to consume an addition 590 terawatt-hours (TWh) of electricity in 2020 in a business-as-usual scenario (McNeil et al., 2012). This electricity demand needed to power residential ACs purchased during 2010-2020 could consume more than half of all solar and wind generation projected to be added globally over the same period.

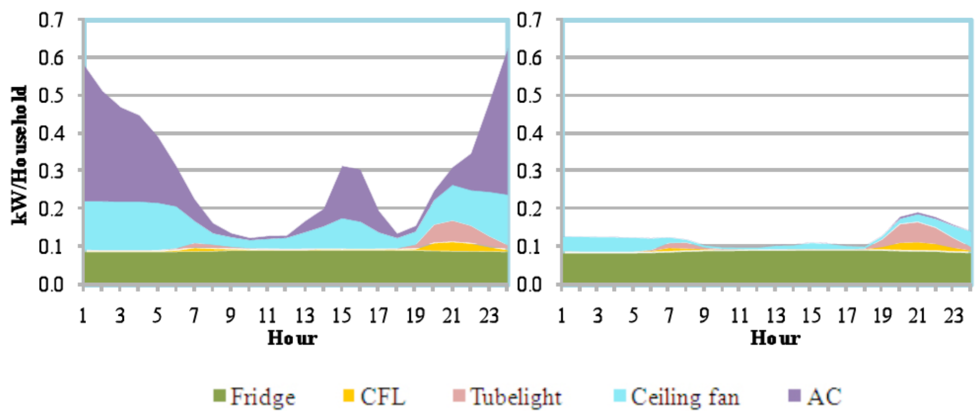
Figure 4. Growth in Renewable Generation and Cooling Energy, 2010–2020



Source: Renewable energy generation: IEA World Energy Outlook 2012 (Current Policies scenario). Residential air conditioning consumption: LBNL's BUENAS model (McNeil et al., 2012).

The energy consumed by air conditioning not only increases overall demand for electricity, it also contributes significantly to peak demand. Indeed, usage of ACs is concentrated in time, generally in the summer months. On very hot days, many air-conditioning units are set to a maximum position, and as a consequence demand for electricity spikes, requiring that power capacity be added to meet this peak demand. A study in the Indian state of Gujarat showed that ACs contributed about 60% of summer peak demand, as shown in Figure 5.

Figure 5. Gujarat Appliance Load Curve in "Summer" and "Winter"



Source: USAID ECO III, 2010.

The additional electricity demand resulting from new sales of ACs puts tremendous pressure on countries to supply power to meet this demand. Supplying this power is challenging because a significant portion of AC electricity demand coincides with peak demand. Meeting greater peak demand attributable to ACs requires costly investments in power plants and transmission and distribution infrastructure even though the demand might arise only during a short period of time each year. In the long term, if it is not possible to manage peak demand, capacity will have to be added to the electricity generation, transmission, and distribution system. This will impose significant costs on all electricity consumers (not just the users of ACs) because the low capacity utilization factor of peak generators will increase the marginal cost of peak power for all customers.

Moreover, many emerging economies are already running on thin reserve generation capacity margins and experiencing rolling blackouts and brownouts. In some cases, peak consumption is met with inefficient, carbon-intensive back-up diesel generation. Countries need to plan ahead for additional capacity to meet the rapid expected growth in demand attributable to increasing penetration of ACs.

Because of the costs of meeting added electricity demand to operate growing numbers of ACs, the opportunity to save peak energy by means of AC energy-efficiency improvements has a higher value than most efficiency measures. This is one of the drivers of incentive programs focused on ACs. Section 2.6. describes the costs and benefits of AC incentive programs.

2.3 SAVINGS POTENTIAL

AC energy efficiency can be improved by optimizing AC components and improving the thermodynamic cycle. A recent study by Lawrence Berkeley National Laboratory (LBNL) for the Super-efficient Equipment and Appliance Deployment Initiative (SEAD) detailed the commercially available options for producing more efficient ACs, describing how efficient compressors, improved fan blade design, improved heat exchangers, and efficient motors can significantly reduce overall AC energy consumption (Shah et al., 2013).

Shah et al. studied the energy efficiency of unducted mini-split ACs (a subset of split packaged ACs), which form the majority of global residential air conditioners in every country except the U.S. That study found a range of efficiencies, from a minimum energy efficiency ratio (EER) of 2.14 in the United Arab Emirates (UAE) to a maximum EER of 6.67 in Japan. This range indicates that there is significant opportunity to improve the energy efficiency of commercially available ACs. Shah et al. developed a base case for each country and then simulated the cost and energy efficiency of successive design changes for a total of up to 1,728 possible, mutually exclusive, efficiency improvement options for each economy. Labor costs, supply chain markups, installation and maintenance costs, energy costs, and capital costs were all adjusted for the local economy based on a combination of sources including literature, estimated factory gate costs, retail prices, expert contacts, and official statistics. The study generated cost-versus-efficiency curves for each economy, including manufacturer (or factory gate) costs, and costs to the end user for each level of efficiency and corresponding design change. The efficiency levels were calculated using climate-specific, local hours of use data.

Table 2 summarizes the results from Shah et al.'s study. Column B of the table shows the approximate market average European seasonal energy-efficiency ratio (ESEER) (the efficiency metric used in Europe) of each economy, and columns C and D show the economic (or cost-effective) efficiency improvement levels and the technical (or best available) levels; these data illustrate the significant potential for efficiency improvements. Columns E and F in Table 2 show the annual energy savings potential in 2020 from room AC efficiency improvement in TWh/year, assuming that the corresponding market transformation program goes into effect at the efficiency level corresponding to columns C and D, respectively, and that the program transforms 100% of the market to the specified level (i.e., the program achieves 100% potential).

Table 2. Efficiency and Energy Savings in 2020 for Each Country's Economic and Technical Potential

A	B	C	D	E	F
Country	**Market Average ESEER**	**Economic Potential ESEER**	**Technical Potential Max ESEER**	**2020 Energy Savings @ Economic Potential**	**2020 Energy Savings @ Technical Potential**
	(W/W)	**(W/W)**	**(W/W)**	**(TWh/year)**	**(TWh/year)**
Australia	**4.03**	**4.48**	**8.55**	**1.05**	**6**
Brazil	**4.05**	**5.67**	**8.83**	**18**	**30**
China	**4.11**	**5.19**	**7.3**	**48**	**99**
EU	**4.09**	**5**	**8.33**	**33**	**90**
India	**3.56**	**5.55**	**7.91**	**57**	**87**
Japan	**5.21**	**7.44**	**7.85**	**24**	**27**
Korea	**4.8**	**5.33**	**8.45**	**3**	**12**
Mexico	**3.71**	**4.45**	**9.74**	**0.45**	**3**
Russia	**4.2**	**4.2**	**10.23**	**0**	**12**
UAE	**3.46**	**6.24**	**7.64**	**6**	**6**
USA	**3.87**	**6.8**	**8**	**0.6**	**0.72**
Total				**192**	**373**

Source: Shah et al, 2013

The total 2020 energy savings potential that is cost effective from a consumer perspective was found to be about 64 Rosenfelds[3], i.e., the equivalent of 64 medium-sized power plants (or 192 TWh/year), and the total technical potential is about 123 Rosenfelds, i.e., about 123 medium-sized power plants (or 373 TWh/year). Because of the high peak coincidence of room AC use, we could also include the costs of peak power, backup generation, or power outages in the analysis of cost effectiveness. Including these costs would result in cost-effective ESEER levels even higher than those shown in column D and correspondingly greater savings. Further, because of falling AC prices and increasing efficiency levels, the numbers shown in Table 2 are conservative estimates of cost effective efficiency.

This huge potential for improved AC efficiency remains untapped today. A combination of energy efficiency policies, including incentive programs, is needed to realize these savings and the associated benefits to consumers. Section 2.5 describes relevant policy interventions and the role of incentive programs.

2.4 REFRIGERANTS

GHG impacts from ACs can be broadly divided into two categories: "direct" impacts from leakage or loss of refrigerants, and "indirect" impacts attributable to fossil fuels emitted during generation of the electricity consumed by ACs. This section describes the direct impacts from ACs on GHG emissions.

ACs use refrigerants as working fluids in the vapor compression cycle to cool air. These refrigerants, when eventually released into the atmosphere contribute to ozone-layer depletion. The Montreal Protocol, signed in 1987, regulates these ozone-depleting substances (ODSs) and established a schedule to gradually phase out production and consumption of ODSs. This schedule differs for developing countries (a.k.a. article 5 countries) and developed countries (non-article 5 countries), as can be seen in Table 3.

Table 3. ODS Phase-out Schedule under the Montreal Protocol

	Non-article 5 countries	**Article 5 countries**
CFCs	January 1, 1996	January 1, 2010
HCFCs	January 1, 1996: freeze at Baseline	January 1, 2013: freeze at Baseline
	January 1, 2004: cut by 35%	January 1, 2015: cut by 10%
	January 1, 2010: cut by 75%	January 1, 2020: cut by 35%
	January 1, 2015: cut by 90%	January 1, 2026: cut by 67.5%
	January 1, 2020: cut by 99.5%	January 1, 2030: cut by 97.5%
	January 1, 2030: full phase-out	January 1, 2040: full phase-out

Source: UNIDO, 2014.

Chlorofluorocarbons (CFCs) were the first gases targeted by the protocol and were phased out by all countries by 2010. These gases have largely been replaced by HCFCs, which has a much lower ODS potential but are still detrimental to the atmosphere (Table 4). Therefore, HCFCs are also targeted by the Montreal protocol with a gradual phase-out started in 1996 for developed countries and in 2013 for developing countries. HFCs are the third generation of refrigerants, replacing HCFCs and CFCs.

However, most ODSs are also potent global-warming gases as can be seen in Table 4. While the Montreal Protocol has eliminated about 10 million tonnes of carbon dioxide equivalent (tCO_2e) per year in 2010, which is about five

[3] In line with Koomey et al. 2010, we use the unit of Rosenfeld for denoting energy savings. One Rosenfeld=3TWh/year, or approximately one 500-megawatt (i.e., medium-size) power plant.

times the annual target of the Kyoto Protocol on GHGs between 2008 and 2012 (Velders et al., 2012), it also had the unintended effect of significantly increasing the production of HFCs, which contribute to global warming. Today, ACs around the world mostly use the high-GWP[4] refrigerants R22 (HCFC 22) and R410A (HFC-410A), which have GWPs of 1,760 and 1,924 respectively (IPCC, 2014). ACs also make limited use of R32 (GWP= 675).

Table 4. AC Refrigerant GWP and ODSs

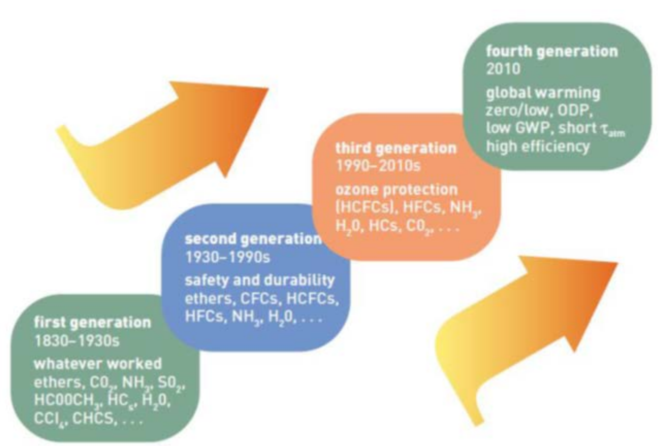
	GWP	ODS
CFCs	4,740 to 14,400	0.8 to 1
HCFC-22 (R-22)	1,760	0.055
HFC-410A (R410A)	1,924	0
HFC-32 (R32)	675	0

Source: IPCC, 2014.

2.4.1 MARKET TRANSFORMATION FOR NET CLIMATE BENEFITS

As discussed by Calm (2008) and shown in Figure 5, the fourth generation of refrigerants is currently being developed with the goals of reducing global warming impacts while ensuring AC safety and durability and preventing ozone damage. In regard to those potential phase-out efforts, it would be useful for policy makers to be able to reflect on lessons learned from previous efforts, particularly AC incentive programs. Policies and programs to increase energy efficiency should take into account any possible effects on the choice of refrigerants, with the objective of safely maximizing net climate benefits at the lowest possible life-cycle cost.

Figure 6. Refrigerant Transitions



Source: Calm, 2008

Incentive programs targeting ACs could help accelerate the transition to fourth-generation low-GWP refrigerants. Incentive programs have been particularly successful in accelerating the U.S. transition to CFC free refrigerators in the mid 1990s. The Super-Efficient Refrigerator Program successfully transformed the market for energy-efficient refrigerators and accelerated the adoption of non-CFC units. This happened at a time when many believed converting refrigerators to non-CFC insulation would lead to reductions in energy efficiency (Gillingham et al., 2004). The program was designed to induce the development of a CFC-free refrigerator that was at least 30% more

[4] GWP is a relative measure of how much heat a greenhouse gas traps in the atmosphere compared to the amount of heat trapped by carbon dioxide for a similar unit of mass.

efficient than the standard unit and that was competitively priced. This program is recognized as having had a profound impact on the market and significantly accelerating the penetration of super-efficient CFC-free refrigerators (Lee et al., 1996). We found no specific examples of incentive programs that encourage a transition to non-CFC or non-HFC refrigerants for ACs, but we identified one program supporting the current transition to non-HCFC AC production in Indonesia. This program is described in detail in the case studies portion (Section 3.6) of this report and shows how a program can be designed to maximize climate benefits through energy efficiency enhancements as part of transitioning to non-HCFC refrigerants.

Environmental regulations have put pressure on the AC industry to move toward low-GWP alternative refrigerants. These regulations include the European Union (EU) F-gas regulation[5] as well as various proposals to amend the Montreal Protocol[6]. In response, the industry has launched a collaborative testing program to evaluate low-GWP refrigerant alternatives.[7] Although alternatives exist for many applications, in some cases these alternatives are flammable/ mildly flammable, lower efficiency, or higher cost. HFC R32, hydrofluoro-olefins such as R1234yf, and blends of these (with each other and with hydrocarbon refrigerants) are among the leading alternatives being considered. These substances have GWPs ranging from 675 for R32 to 3 for R1234yf and 0 for hydrocarbons (Table 5). Table 5 shows the current understanding of the state of the art for these refrigerants.

Table 5. Summary of Alternative Refrigerants for Stationary AC and Heat-pump Applications

	R410A	R32 (HFC)	HFO Blends	Carbon Dioxide	HC (R290)
GWP	2080	675 (<500 Charge Red.)	~ 500	1	<10
Compressor Design & Cost		Heat Mitigation			
Efficiency					Pump+HX Losses
Safety		Mildly Flammable			Highly Flammable
Refrigerant Cost			Higher		
System Cost					Sec. Loop Required

Source: Pham and Rajendran, 2012

In designing AC incentive programs, policy makers need to address cost, safety, and net climate benefit (both energy-efficiency and low-GWP considerations) to avoid locking in sub-optimal outcomes.

[5] Details regarding the EU F-gas regulation are available http://ec.europa.eu/clima/policies/f-gas/index_en.htm.

[6] Proposed amendment to the Montreal Protocol submitted by the Federated States of Micronesia, UNEP/OzL.Pro.WG.1/33/4 (16 April 2013); *and* Proposed amendment to the Montreal Protocol submitted by Canada, Mexico and the United States of America, UNEP/OzL.Pro.WG.1/33/3 (16 April 2013).

[7] See the Air conditioning, Heating and Refrigeration Institute's low-GWP Alternate Refrigerant Evaluation Program. The results are publicly available at http://www.ari.org/site/514/Resources/Research/AHRI-Low-GWP-Alternative-Refrigerants-Evaluation

2.4.2 REPLACEMENT PROGRAMS

Despite the phase-out in production of most ODSs, large amounts of these substances remain in the existing stock of equipment (UNIDO, 2014). These sources of ODSs are commonly referred to as “ODS banks” and defined as “consumption not yet emitted.” Over time, these stocks of ODSs will inevitably leak into the atmosphere unless they are collected and destroyed. A report published in 2005 estimates that the ventilation of one-third of the ODS banks in existence in 2002 would result in emissions of nearly 7 GtCO2e by 2015 (IPCC & TEAP, 2005). This value is approximately equivalent to the 2010 CO_2 emissions from fuel combustion in China.

Refrigerant gases are largely unaddressed, partly because they fall between the Montreal and Kyoto Protocols. The Montreal Protocol addresses the production and consumption of ODSs but not ODS banks, and the Kyoto Protocol excludes GHGs controlled by the Montreal Protocol, i.e., CFC and HCFC. Therefore, mechanisms governed by the Kyoto Protocol, such as the Clean Development Mechanism, do not cover these gases, and ODS destruction projects cannot earn Certified Emission Reductions credits. Other markets exist where destruction projects are credited for their carbon emission reduction. This is the case of the regulatory carbon markets in California and Quebec, and the voluntary carbon market. However, California and Quebec specifically exclude any participation from developing countries. The voluntary carbon market, which is several orders of magnitude smaller, does offer recognition of carbon credits from destruction of ODS stocks in developing countries.

As will be described in Section 4 in the Mexico case study, Mexico’s AC incentive program has allowed the government to recover the refrigerants from old units and stock those gases so that they can be disposed of properly. The government of Mexico is investigating applying for carbon reduction credits, in the voluntary carbon markets, for these retired refrigerants (CAR, 2014).

AC and refrigerator replacement programs can not only provide for proper disposal of old units but also proper disposal of the gases that these units contain. Implementing agencies such as the United Nations Industrial Development Organization (UNIDO), United Nations Environment Programme (UNEP), and the United Nations Development Programme (UNDP) are looking into ways to value these efforts so that countries can recover the cost of recycling and destroying these gas.

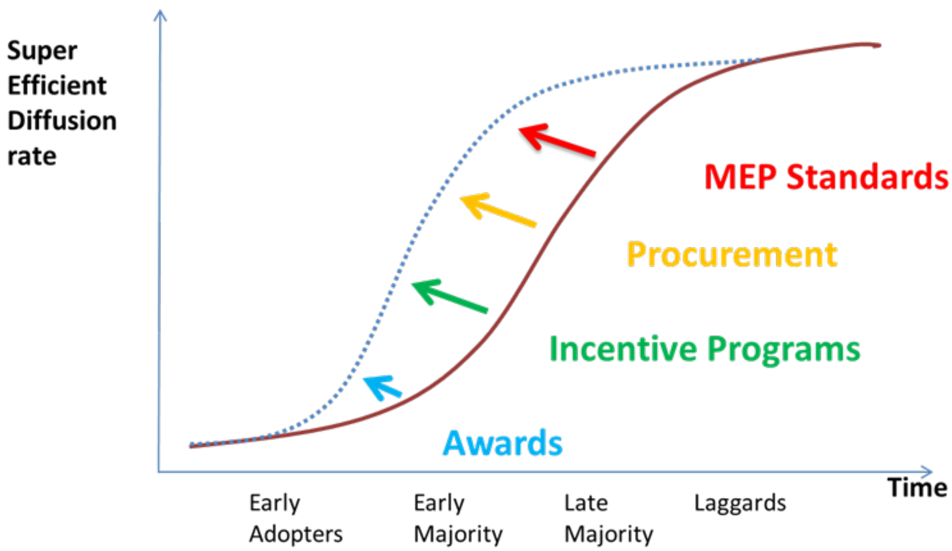
Replacement incentive programs are particularly suited for recycling of refrigerants in the existing equipment stock because these programs ensure that existing AC units are replaced with new units. Other types of incentive programs might not accomplish this goal if replacement is not an explicit requirement.

2.5 POLICY INTERVENTIONS

A number of policy interventions can transform the market towards higher efficiency for specific end-use equipment such as ACs. Labeling programs certify and rank products according to their efficiency and thereby empower consumers to make informed purchasing choices. Incentive programs complement the market transformation process by increasing the penetration of efficient equipment and preparing the market for more stringent MEPS. Both categorical labeling programs and incentive programs target the “top” of the market to increase sales of highly efficient appliances while MEPS target the bottom of the market, removing inefficient technologies and thus raising the efficiency floor. Incentive programs generally offer a financial stimulus (subsidized loan, cash rebate, etc) to motivate private investment in energy-efficient equipment. Typically, incentives are implemented through downstream programs (i.e., provided directly to customers), midstream programs (directed to distributors or retailers), or upstream programs (targeting manufacturers). See de la Rue du Can et al. (2014) for a more complete description.

The diffusion of highly efficient technologies generally follows an "S" curve. At first, only a few early adopters will be willing to risk investing in a new, more expensive technology, so market penetration is small. After some time, when a technology has proven itself, its market penetration rates increase more quickly. Next, market penetration of the tech nology levels off, and only "laggards" are still resistant to adopting the new technology. Figure 7 illustrates how market interventions can help speed the diffusion of highly efficient technologies and can have permanent effects.

Figure 7. Impact of Market Interventions on Highly Efficient Technology Diffusion Rate



Source: de la Rue du Can et al., 2014

Among policy options, implementation of standards typically has the greatest impact on energy savings because standards affect the majority of sales. However, significant barriers prevent MEPS from reaching their cost-effective potential, which is the level at which the benefits from the energy savings equal the incremental cost of efficient equipment from the consumer's perspective. An analysis by SEAD of the energy-saving potential of different scenarios shows that recently implemented MEPS in SEAD economies[8] reached less than half the cost-effective potential for ACs (Letschert et al., 2013). This indicates that additional energy efficiency policies could complement MEPS and accelerate market transformation toward more efficient products.

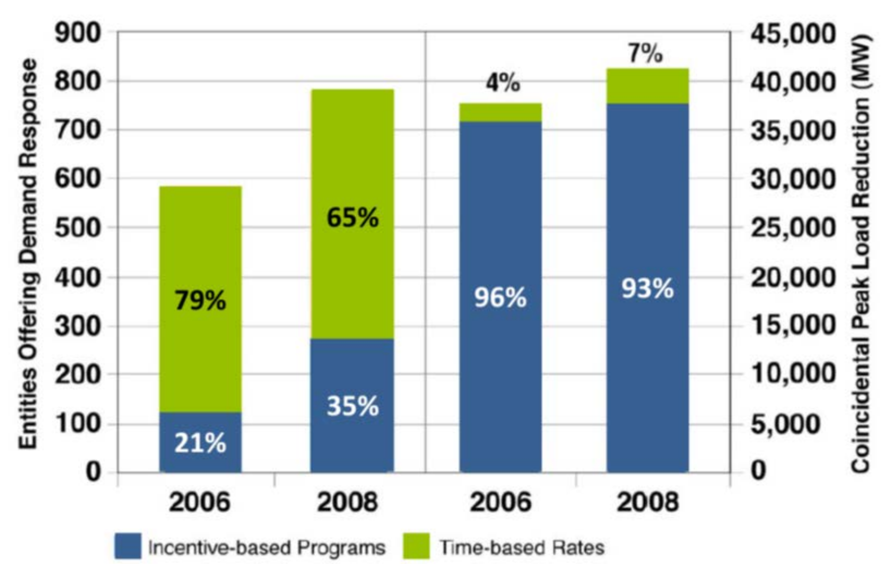
In countries with slow-moving standards and labeling programs or weak standards, incentive programs can help jump-start negotiations to set higher efficiencies. In some cases, incentive programs help make ambitious standards politically acceptable to local manufacturers and the public. In addition, incentive programs influence consumer purchase decisions and, where a labeling program is also in place, they help educate the public about the benefits of the higher-efficiency products in the program. The existence of a consumer rebate is a signal in itself, underscoring the value of the labeling program. Incentive rebates are often linked to high-performance products (i.e., products that are labeled as highly efficient). As the China and India case studies in Section 4 of this report demonstrate, incentive programs have also been used to increase consumers' awareness of the benefits of buying efficient products.

[8] As of October 2014, the SEAD economies included: Australia, Brazil, Canada, the European Union, Germany, India, Indonesia, Japan, Korea, Mexico, Russia, South Africa, Sweden, the United Arab Emirates, the United Kingdom, and the United States. SEAD economies are responsible for about half of global energy demand.

Also, as discussed earlier, replacement incentive programs are likely the only type of policy intervention that affects the stock before the end of the equipment's life. As noted earlier, replacement programs offer a means to recycle or dispose of refrigerants in an environmentally sound way.

Finally, demand response programs are now increasingly being used by utilities in the United States and Australia to reduce the peak load impacts of AC demand, as well as to provide services to the grid such as energy storage (e.g. by precooling), or integration of intermittent renewable energy. Incentive-based programs have been found to be among the most effective DR programs in the US, accounting for about 95% of actual peak load reduction even though incentive-based programs represent only about 20-35% of all DR programs being offered, as shown in Figure 8 and discussed further by Cappers et al 2009.

Figure 8. Types of Demand Response Programs and Corresponding Peak-load Reduction in the United States



Source: Cappers et al., 2009

By increasing the penetration of highly efficient equipment, preparing the market for more stringent MEPS, influencing consumer purchase decisions, AC incentive programs are policy measures worth considering.

2.6 AIR-CONDITIONER COST- BENEFIT ANALYSIS

Among the many justifications for air conditioner market transformation is that efficient ACs reduce the costs of power generation. Because ACs contribute significantly to peak load, reducing their electricity consumption avoids large investments in peaking plants that are used only on a limited basis during the year. Another argument for AC market transformation is the cost effectiveness of the energy savings for the consumer, the utility, and/or society. Finally, other or co-benefits include emissions reduction, increased energy access, improved power system reliability, and job creation. This following subsections review some of these rationales for AC incentive program implementation.

2.6.1 COST EFFECTIVENESS

As part of the rationale for implementing an incentive program, policy makers and program administrators are often asked to compare the costs of the programs to its benefits and conduct cost-benefit analysis (CBA). There are several ways of estimating the costs and benefits of a program depending on the parameters considered and on the perspective taken.

Measuring and quantifying the benefits and cost of a program is challenging. It necessitates to determine the counter-factual, i.e. the energy that would have been consumed and the costs that would have been incurred if the program had not been implemented. While benefits are often evaluated on the basis of the energy savings, significant non-energy benefits exist but are rarely quantified due to the methodological challenges involved. Moreover, benefits and costs arise across multiple stakeholders. CBAs for each perspective bring additional information on the motivation of stakeholders to invest in energy efficiency. Table 6 summarizes costs and benefits from different perspectives.

Table 6. Summary of Cost and Benefit Components

Perspective	Costs	Benefits
Participant	- Incremental equipment costs	- Incentive payments - Bill savings resulting from energy savings
Program Administrator	- Program administration costs - Incentive payments	- Energy- and capacity-related avoided cost of additional power plants - Transmission and distribution avoided costs
Society	- Incremental equipment costs - Program administration costs - Non-energy costs[9]	- Energy savings - GHG emissions reduction - Increased system reliability/ elimination of electricity deficit - Reduced government subsidies on electricity tariff - Other non-energy benefits

Collecting data and assessing the incremental costs of purchasing and producing more energy efficient ACs can also prove to be challenging. To increase public knowledge about the costs and benefits of AC energy efficiency, SEAD's techno-economic analysis for each SEAD economy (Shah et al., 2013) estimates the incremental cost of producing and purchasing more efficient ACs based on engineering analysis. This study can help conduct CBA to show the potential cost and benefits of a program in a country.

From the participant perspective, a program is cost effective if the annualized energy bill savings are greater than the incremental cost of purchasing a more efficient AC (net of the incentive offered).

From a program administrator perspective, an important benefit of energy efficiency is the avoided cost of new supply. Avoided costs are those that would have been necessary if efficiency measures had not been implemented to reduce energy demand (NAPEE, 2007 and 2008). These costs include the energy- and capacity-related costs of new power plants and transmission and distribution infrastructure.

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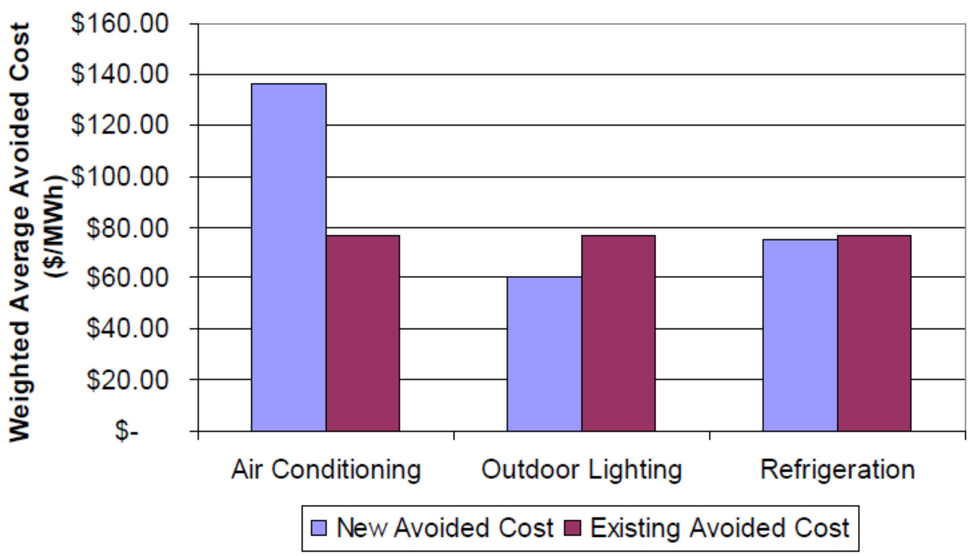
[9] non-energy costs refers to non-energy negative impacts that can have energy efficiency (e.g. diminished customer comfort)

Energy generation is most costly during peak hours when all less-expensive generation has already been dispatched. Measures to reduce energy demand from end uses that have high peak coincidence, such as ACs, can save more expensive kilowatt-hours (kWh) than can be saved by reducing the demand of end uses that have lower peak coincidence. Hourly rather than annual load shapes can, therefore, be used to calculate specific avoided costs for some efficiency measures. Figure 9 shows the avoided costs for three efficiency measures in California – air conditioners, outdoor lighting, and refrigeration – using both avoided-cost calculation methodologies: one that applies hourly averages (new) and the typical calculation that uses annual averages (existing). More efficient air conditioning (here defined as a residential AC unit upgrade from 12 to 13 SEER) has an average avoided cost savings of $138 per megawatt hour (MWh) using the the hourly avoided costs (labeled "new"'[10] in the chart) compared to a savings of approximately $78 per MWh using the annual avoided costs (labeled "existing").

In California, hourly avoided costs are used because air conditioning load has a high peak coincidence and is greatest when electricity is most expensive, because it requires generation capacity to be built that is rarely used outside of peak times. Thus, hourly results fully capture the value of AC energy efficiency.

Figure 9. California End-Use Avoided Costs



Source: Price and Kollman, 2004

CBA can be assessed for society as a whole, integrating the impacts of all actors in society. CBA can include the value of GHG reduction, which can be estimated and added to the benefits of efficiency measures. In countries that provide electricity subsidies to consumers, energy savings resulting from efficiency programs can mean significant cash flow for the government as well as reduced electricity bills for consumers. In Mexico, for example, where electricity tariffs are heavily subsidized, the federal government saves, for each kilowatt hour (kWh) saved by efficiency, the subsidies that would have been spent on that energy. LBNL developed the Energy-Efficiency Revenue Analysis (LEERA) model to calculate the subsidy savings for different levels of efficiency in specific appliances, including ACs (Gopal et al, 2014).

[10] "new Avoided Cost" in the Figure 8 refers to the fact that in 2003 California proposed new avoided costs based on the methodology described in this section.

Table 6 shows the benefits that can be quantified as part of a cost-benefit analysis. Within each of these categories, policy makers must decide which specific benefits are sufficiently known and quantifiable to be included in the assessment.

In the U.S., five cost-effectiveness tests reflect the perspectives of different stakeholders: participant cost test, program administrator cost test, ratepayer impact measure, total resource cost test, and societal cost test (NAPEE, 2008). State legislatures or state energy regulatory commissions decide which tests should be used to assess whether a program is worth being implemented. The selection of test requirement varies by state. However, in many instances, states require that all tests be calculated to assess the multiple perspectives of a program and account for the full range of issues that programs might raise.

The World Bank and other development agencies calculate the economic rate of return (ERR) to determine the efficiency of resource allocation. ERR is a form of CBA that attempts to estimate the net impact of project investments. This is the metric used by the World Bank for the Mexico incentive program described in the case study.

2.6.2 NON-ENERGY BENEFITS

Energy efficiency incentive programs are also implemented for the non-energy benefits that they yield, such as productivity improvements, economic growth stimulation, electricity price reduction, power system reliability improvements, etc. Table 7 summarizes some of the co-benefits of increasing energy efficiency that can be used to argue in favor of implementing an incentive program.

Table 7. Co-benefits of Energy Efficiency

Economic development	- Increases job creation - Increases economic activity (measured through GDP) - Reduces electricity rates - Increases energy security (trade balance) - Increases energy supply reliability/ decreases supply deficit - Enhances technology innovation and leap-frogging
Public budget	- Increases tax revenues through greater economic activity - Reduces electricity subsidy budget
Health and well-being	- Improves occupant health and comfort - Improves air quality - Increases energy access - Reduces negative health impacts from power plant emissions
Environment	- Reduces GHGs - Reduces local pollution - Reduces ODSs

These benefits vary among countries depending on local conditions and have not been assessed systematically, in part because critical data and mature methodologies to measure their scope and scale are lacking (IEA, 2014). Non-energy benefits are particularly important in programs that have an economic development goal, such as economy recovery and/or reduction of poverty, which is the case of a few programs studied. For example, the China promotion program had dual goals of promoting energy-efficient products to “benefit the people” and boosting sales of home appliances to stimulate economic activity in the wake of the 2008 financial crisis. The Mexican program had goals to accelerate growth and reduce poverty, while also reducing GHG emissions from energy consumption. In such instances, the non-energy benefits of the program are central to its success, and should be treated as such.

2.6.3 REBOUND EFFECT

ACs' energy consumption is particularly vulnerable to the rebound effect. ACs are expensive to run and consumers tend to adjust their ACs' energy consumption according to the cost of the cooling service. In countries where consumer energy needs are not fully met due to unaffordability or un-reliable supply, efficiency improvements may increase consumption of energy. This is a result of the rebound (or take-back) effect, which is a behavioral reaction to the more affordable energy services and increased disposable income that result from an efficiency improvement. For example, Davis, et al (2013) found that, in Mexico's AC replacement program, savings from improved efficiency led to an increase in energy consumption.

However, rebound effect is not necessarily a negative outcome. As pointed out in a recent IEA publication, it can be positive thing from the perspective of contributing to economic and social objectives. Improved energy services are important benefits of energy efficiency and are essential for wealth creation and social development. (SE4All, 2014).

Certain regions and consumer segments may be more susceptible to large rebound effects than others. In this case it is important to assess its potential impacts on energy savings but also assess the non-energy benefits that result from this increase in energy service demand.

Policy makers should analyze all the trade-offs from the different stakeholders perspectives and for the society as a whole and choose the energy efficiency measures and programs that have the best comparative advantage for meeting the goals of increasing the welfare for the country.

2.7 MARKET BARRIERS TO EFFICIENT AIR CONDITIONERS

Although cost-effective energy savings are possible, a number of barriers hinder full realization of these savings. Understanding these barriers is fundamental to the success of energy-efficiency incentive programs. Incentive programs need to be designed precisely to address the identified barriers. Matching existing market barriers with effective barrier-removal activities is an effective way to transform markets.

An extensive body of literature describes the typical market barriers to deployment of energy-efficient technology. However, few studies have focused on identifying barriers for specific energy products in individual countries. Barriers vary among countries according to the level of economic development and depending on the actors involved in the supply chain leading to market penetration.

A study on market barriers to efficient ACs in Thailand, described by Wörlen (2011), identified affordability as an important barrier. Energy-efficient ACs can have a higher up-front cost than low-efficiency ACs, which discourages consumers from investing in efficient products even when operation over the unit's lifetime is cost efficient. Wörlen (2011) found that the large number of AC manufacturers and assemblers in Thailand was also a barrier, making it difficult for the industry to reach consensus on regulation of the market. The large number of actors deepened the technology gap for more efficient products.

Table 9 summarizes the findings from our review of studies of barriers to the penetration of efficient ACs.

Table 8. AC Market Barriers

Actors	Barriers	Description
Institutions	Information	Lack of reliable and clear indication of AC energy performance
	Tariff distortion	Subsidized electricity tariffs distort the market, causing energy efficiency to be undervalued
Consumers	Information	- Lack of understanding of energy-efficiency benefits - Lack of information about the value of equipment energy performance - Uncertainties about energy savings; energy savings are not directly measurable but can only be inferred
	Affordability	High up-front costs
	Principal agent problem	This barrier occurs when the people who are purchasing ACs are not the ones paying for the electricity to operate them. This is frequent in rental homes.
Manufacturers /Retailers	Availability of products	- Lack of energy-efficient products available on the market - Lack of available capital for investment in production upgrades
	Financial barriers	Energy-efficiency projects considered high risk by financial institutions
	Technical barriers	- Large gap in technical capacity to produce efficient equipment in developing countries - Little incentive to encourage local manufacturers to produce efficient products

3. AIR-CONDITIONER INCENTIVE PROGRAMS

3.1 GLOBAL OVERVIEW

United States: Globally, the number of incentive programs targeting ACs is limited. The U.S. has implemented, by far, the largest number of these programs. The Database of State Incentives for Renewable Energy (DSIRE) lists about 800 incentive programs across the U.S. that offer some form of rebate for energy-efficient ACs (DSIRE, 2014). Most of these programs are ratepayer-funded energy-efficiency programs; i.e., their costs are recovered by a small rate surcharge and are part of integrating energy efficiency into least-cost resource planning. Because resource energy planning is regulated at the state level and each state may mandate energy savings from several utilities[11], there are numerous incentive programs in the U.S. Many U.S. programs target CACs as part of the heating, ventilating, and air conditioning (HVAC) system. Our case studies include two programs from the U.S. Consolidated Edison (ConEd) in New York operates the first, which is one of the few U.S. programs targeting room ACs. The second program is a DR program implemented by Indianapolis Power and Light.

India: Utilities in India are regulated at the state level. Although the Energy Conservation Act of 2001 requires states to establish Energy Conservation Funds (PACE-D, 2013), implementation of state Clean Energy Funds has been slow. The state of Kerala was the first to establish a fund, the Kerala State Energy Conservation Fund, which facilitates the purchase of efficient refrigerators and air conditioners by providing zero-interest loans through a local financial institution. Reliance Infrastructure (RI), an electric utility, operates a downstream incentive program for efficient air conditioners, which we analyze in detail in the case studies in Section 4.

[11] Public utilities can be privately owned or publicly owned. Publicly owned utilities include cooperative and municipal utilities.

Australia: Appliance incentive programs are also implemented at the state level in Australia. Some states, such as Victoria, require large energy providers to help households save energy by offering energy audits and incentive programs. Because ACs contribute considerably to peak demand, Demand Response (DR) programs are burgeoning, and the government of Australia is considering development of a DR standard for ACs to ensure that they are manufactured with interfaces that allow them to be controlled remotely. However, it will take time for the stock of ACs to turn over. Table 9 shows some programs in Australia.

Japan: Japan has implemented an innovative incentive program to promote low-carbon lifestyles by raising consumer awareness and sense of responsibility. The program awards carbon points to consumers for every energy-efficient appliance they buy, including ACs. These points can be redeemed for product discounts or cash. In addition to encouraging consumers to buy efficient products, the reward points are often exchangeable only for the purchase of local products and services that encourage energy-efficient behavior, such as traveling via public transport. The program was evaluated by the Ministry of Economy, Trade, and Industry (METI), which found that the program increased the sales of ACs with four or more stars from 20 percent to 96 percent (METI, 2010).

Europe: The share of energy used for cooling in the EU is small, representing only about 0.3% of household energy use in 2010 (Odysee, 2014). The majority of energy-efficiency programs for space conditioning in EU countries focus on reducing heat demand and increasing insulation. A few countries in southern Europe, such as Italy, Greece, and Malta, have implemented AC incentive programs, as shown in Table 9.

Others: Governments of developing countries or economies in transition can seek financial support from international financial institutions such as the World Bank, the Clean Technology Fund, and the Global Environment Facility (GEF) to implement market transformation programs. For example, Mexico’s Programa Nacional para la Sustitución de Equipos Electrodomésticos (National Program for the Substitution of Household Electrical Appliances, PNSEE) is supported by loans from the World Bank and capital from the Global Environmental Fund (WB, 2010).

There has been growing interest in combining climate-change and ozone-depletion mitigation objectives. For example, the Mutli-lateral Fund[12] secretariat asked its implementing agencies, the World Bank, UNDP, UNEP, and UNIDO to assess opportunities for mobilizing resources to maximize climate benefits beyond those normally available for funding of HCFC phase-out alone (UNEP, 2013a). Efficiency enhancements are not part of the objective of phasing out HCFCs but can be implemented simultaneously to leverage the HCFC Phase-out Management Plan (HPMP) transition. Following the Multi-lateral Fund’s request, the UNDP proposed two projects relating to ACs: a project for Indonesia with co-financing from GEF and a project in Maldives co-funded by the Climate and Clean Air Coalition Trust fund. We study the Indonesia project in detail in the case studies in Section 4. UNIDO also proposed a project in Russia aimed at phasing-out of HCFCs and promotion of HFC-free, energy-efficient refrigeration and air-conditioning systems.

Table 9 lists all the incentive programs targeting ACs that we identified for our study.

[12] The Fund is dedicated to reversing the deterioration of the Earth's ozone layer. It was established in 1991 to assist developing countries meet their Montreal Protocol commitments.

Table 9. AC Incentive Programs in various regions

GEOGRAPHIC FOCUS	PROGRAM NAME	PROGRAM TYPE	TIMELINE	ADMINISTRATING BODY	SOURCE OF FUNDING	REFERENCE
AUSTRALIA (Victoria)	Energy Saver Incentive	**Downstream**	2013-2015	State government	Rate payer funds	(A.DOI, 2014)
AUSTRALIA (Queensland)	Energex PeakSmart Air-conditioning Program	**Downstream - DR**	2013-present	Utility	Rate payer funds	(A.DOI, 2014)
CHINA	Program of Benefiting the Public through Energy-efficient Products	**Upstream Program**	2009-2013	National Development and Reform Commission	Central government	LBNL, 2012
CHINA	Old-for-New Exchange Program for Household Appliances	**Downstream Replacement**	2009-2011	Provincial government	Central government	LBNL, 2012
CHINA	Home appliances going to countryside	**Downstream**	2007-2011	Provincial government	Central government	LBNL, 2012
CHINA	Promoting Energy-efficient Room Air Conditioners (PEERAC)	**Upstream and Midstream**	2009-2014	Ministry of Environmental Protection and UNDP	UNDP/GEF/Central government/Private sector	UNDP, 2014
GREECE	Changing Air Conditioner Program	**Midstream Replacement**	Jun. 2009 - Aug. 2009	Ministry of Development	Central government	Mure/ Odysee, 2012
INDIA (Kerala)	Energy-efficient Appliance Financing Scheme for Domestic Customers	**Downstream Loan**	Jan 2010 – present	Energy Management Centre, Kerala	Kerala State Energy Conservation Fund	PACE-D, 2013
INDIA (Mumbai)	Tata Power, My Mumbai, Green Mumbai!: 5-Star Split AC program	**Downstream Program**		Utility	Ratepayer funds	Tata Power, 2014
INDIA (Mumbai)	Reliance Infrastructure 5-Star Split AC Program	**Downstream Program**		Utility	Ratepayer funds	Pramod Deo, 2014
INDONESIA	Promoting Energy Efficiency for Non-HCFC Refrigeration and Air Conditioning (PENHRA)	**Upstream**	2015-2017	Ministry of Energy and Mineral Resources and UNDP	UNDP/GEF/Central government/Private sector	GEF, 2015

ITALY	Renewable Energy for Heating and Cooling Support Scheme	**Downstream**	2014	Central Government	Government	GSE, 2014
JAPAN	Eco-Points Scheme for Green Home Appliances	**Eco-points**	May 2009-March 2011	Ministry of Economy, Trade and Industry and Ministry of the Environment	Central government	METI, 2010
MALDIVES	Strengthening Low-Carbon Energy Island Strategies	**- ODS phase-out - Energy-efficiency improvement**	2013 - 2018	Government	UNEP/GEF/Central government/Private sector	GEF, 2012
MALTA	Fiscal Incentives for Energy Savings and Renewables in Households	**Downstream**	Nov. 2006 - Jul. 2008	Government	Government	Malta NAO, 2009
MEXICO	Programa Nacional para la Sustitución de Equipos Electrodomésticos	**Replacement Program**	Jan 2010 - Dec 2013	Government	World Bank/GEF/Central government/Private sector	World Bank, 2010
RUSSIA	Tax exemption for businesses for new efficient assets such as air conditioners (Federal draft law No. 448864-5)	**Downstream**	Jan. 2012 to present	Central Government	Government	KPMG, 2014
RUSSIA	Phase-out of HCFCs and promotion of HFC-free Energy-Efficient Refrigeration and Air-conditioning systems	**- ODS phase-out - Energy efficiency improvement**	2009-2015	Ministry of Ecology and Natural Resources and UNIDO	UNIDO/GEF/Central government/Private sector	GEF, 2009
USA (New York)	ConEd Residential Appliance Replacement Program	**Downstream**	2010 - present	Utility (ConEd))	Ratepayer funds	Coltro, 2014
USA (Indianapolis)	CoolCents Demand Response Program	**DR Incentive**	2002 - present	Utility (Indianapolis Power and Light)	Ratepayer funds	Allen & Willis, 2014
USA	DSIRE records about 800 incentive programs across the U.S. that offer some type of rebate for energy-efficient ACs.					DSIRE, 2014

From this list of incentive programs six case studies were selected and described below. The six case studies, from China, India (Mumbai), Mexico, the U.S. (New York), Indonesia, and the U.S. (Indianapolis), are organized following a standard format: following a brief introduction that describes the incentive program or group of programs, a table summarizes the program features, and subsequent subsections detail the program's goals, mode of intervention in the market, administration, funding, and reported impacts and evaluation results if available.

For each case study, we identify program goals as well as the strategies and tactics used to achieve those goals (referred to as program objectives). The most common goal of an AC incentive program is to save energy, but some programs have additional goals, such as reducing climate change impacts, increasing economic activity and reducing poverty.

A key element of the design of the case study programs is the point or points in the supply chain at which incentives are targeted. As mentioned previously, incentives are implemented through downstream programs, midstream programs, or upstream programs. Different types of incentives address different barriers to adoption of efficient ACs.

Other key elements of the programs include the energy-efficiency level that is targeted – in most cases this is AC units with endorsement labels or the most efficient levels on comparative energy levels – and the inclusion of features such as on-bill financing and recycling of old units and the high-GWP refrigerants in them.

Following the six case studies, we present overall findings and recommendations from our analysis.

3.2 CHINA CASE STUDY: PROMOTING ENERGY-EFFICIENT PRODUCTS FOR THE BENEFIT OF THE PEOPLE

A number of incentive programs have been implemented to tap the significant opportunities to save energy in China. The number of ACs in urban homes in China has increased rapidly, from 8% in 1995 to 128% in 2012 (NBS, 2014). Production of ACs grew rapidly to meet both this demand and demand from other countries. China produces 70% of the world's room ACs; half of this production is exported (The Economist, 2013). Therefore, improving the performance of ACs produced in China offers a unique opportunity to transform the global market.

A fundamental goal of China's central government is to reduce the economy's energy intensity as measured in energy consumption per unit of GDP. During the 11th Five-Year Plan (2006-2010), China targeted a 20-percent reduction in energy intensity by 2010. The 12th Five-Year Plan (2011-2015) builds directly on this objective, with a target of reducing energy intensity by an additional 16% by 2015. Among the key measures implemented to achieve these goals are the extension and strengthening of MEPS for energy-consuming products.

A 2008 survey conducted by the China Household Electrical Appliances Association found that 86% of room ACs sold in the country were in the lowest, tier-5, efficiency category (Raufer et al., 2013). At the same time, China was facing a slowdown in economic growth compared to a double-digit growth rate in the early 2000s. The Chinese government decided to stimulate demand for energy-efficient products to simultaneously boost the economy and mitigate the exponential growth in urban residential energy demand. Within three years, the government implemented three major programs targeting AC production and sales: the "Household Electric Appliance Going to Countryside" program (2007, extended in 2008 and 2009), the "Promotion of Energy-Efficient Products to the Benefit of the People" program (2009), [13] and the "Household Appliance Replacement Program" (2009). The Chinese government also partnered with UNDP in 2010, using funding from the GEF to implement the "Promoting

[13] Also known as "China Energy Savings Programme" (China Energy label, nd-b)

Energy-Efficient Room Air Conditioners" (PEERAC) project, designed to increase the production and sale of energy-efficient room ACs. After gathering information on each of these programs, we chose to describe in detail in this report the "Promotion of Energy-Efficient Products to the Benefit of the People" program for ACs (referred to hereafter as the "China Promotion program"). To support the move to a higher level of efficiency, the National Development and Reform Commission and the Ministry of Finance implemented the Promotion program in June 2009. The goal of this program was to accelerate the penetration of energy-efficient products including ACs, cars, lighting, and three-phase asynchronous motors.

Table 10. China Promotion Program Case Study Summary

Time Frame	- Phase 1: June 2009 to May 2011, - Phase 2: June 2012 to June 2013
Goals	- Boost the economy - Transform the market to more efficient products - Increase awareness of energy-efficient products
Objectives	lowering the up-front price of tier 1 and tier 2 AC products
Mode of intervention	Upstream
Specification	Tier 1 and 2 efficiency levels
Financial Incentive	- Phase 1: From $22 to $127 depending on the efficiency level (tier 1 or 2), size of the equipment, and time period - Phase 2: From $29 to $63 depending on the type (fixed- or variable speed), the efficiency level (tier 1 or 2), and the size of the equipment.
Administration	Ministry of Finance and National Development and Reform Commission
Funding	- Round 1: o Total: 16 billion renminbi (RMB) (US$2.4 billion) o AC only: 11.54 billion (RMB) (US$1.85 billion[14]) over 18 months - Round 2: o Total: 26.5 billion RMB (US$4.2 billion) o ACs only: Not available
Impact	- 34 million energy-efficient AC units sold - Energy savings of 80 - 100 billion kWh over the life time of the ACs - Revision of MEPS

3.2.1 PROGRAM GOALS

The China Promotion program had dual goals: boosting sales of home appliances to help the economy recover from the 2008 financial crisis and promoting energy-efficient products to "the benefit of the people." The program encouraged consumers to buy energy-efficient products by lowering the up-front price of these products. The program also pushed manufacturers to modernize and improve production lines by offering an upstream subsidy. The first round of the promotion program ended on May 31, 2011; the program was then extended to June 1, 2013.

[14] 1 Chinese RMB equals 0.16 U.S. Dollar

3.2.2 MODE OF INTERVENTION

The Promotion program subsidized the price of energy-efficient ACs produced prior to their sale to consumers. Manufacturers were paid refunds by the government on a monthly basis.

Requirements for products and manufacturers included (China Energy label, nd-b and nd-c):

- Manufacturers had to be legally registered in mainland China as independent legal entities.
- Eligible products had to meet national standards for products rated at energy-efficiency tier[15] 1 or 2.
- The volume of promoted products had to be at least 100,000 units.
- The retail price could not exceed the promotional price promised by the manufacturers after the value of the subsidy had been deducted.
- Products and manufacturers qualifying for subsidies had to be made public after being verified.

The subsidies were designed to match the price gap between energy-efficient products and products that met the MEPS. Table 19 and Table 20 show the amount of subsidy given for each AC size and type (fixed or variable speed) for the first and second rounds of the subsidy program, respectively. The tables also specifies the Energy Efficiency Ratio (EER) which is the ratio of cooling output (W) to electrical input (W). The lower the EER, the less efficient the AC is, and therefore, the more electricity it will consume to produce a given amount of cooling. The subsidy was reduced by more than half midway through the first round of the program and then slightly increased for the second round. Subsidies for variable-speed (VS) ACs only started during the second phase and were slightly larger than for fixed-speed (FS) ACs.

Table 11. China's Subsidy Scheme for Fixed-Speed Air Conditioners (2009-2011)

Cooling Capacity	**June 2009 to May 2010**				**June 2010 to May 2011**			
EE Spec	**Tier 2**		**Tier 1**		**Tier 2**		**Tier 1**	
	USD/Unit	EER	USD/Unit	EER	USD/Unit	EER	USD/Unit	EER
CC<=2,800	45	3.2	75	3.4	22	3.4	30	3.6
2800<CC<=4,500	52	3.2	82	3.4	22	3.4	30	3.6
4,500<CC<=7,100	67	3.1	97	3.3	30	3.3	37	3.5
CC>7,100	97	3	127	3.2	/	3.2	/	3.4

Source: adapted from Zheng et al. (2013) using an average exchange rate of 6.69 between 2009 and 2011 (OECD, 2014)

Table 12. China's Subsidy Scheme for Fixed-speed and Variable-speed Air Conditioners (2012)

Cooling Capacity	**Fixed-speed AC**				**Variable-speed AC**			
EE Spec	**Tier 2**		**Tier 1**		**Tier 2**		**Tier 1**	
	USD/Unit	EER	USD/Unit	EER	USD/Unit	EER	USD/Unit	EER
CC<=4,500	29	3.4	38	3.6	38	4.5	48	5.2
4,500<CC<=7,100	32	3.3	44	3.5	44	4.1	55	4.7
CC>7,100	40	3.2	52	3.4	52	3.7	63	4.2

Source: adapted from Zheng et al. (2013) using the 2012 average exchange rate of 6.31 (OECD, 2014)

[15] Tier 1 is the most efficient, and tier 5 corresponds to the mandatory MEPS. For FS ACs, the number of tiers was reduced from 5 to 3 in 2010 during the MEPS revision; similar revision took place in 2013 for VS ACs.

The label for FS ACs was reduced from 5 to 3 tiers during the MEPS revision in 2010. As a result, the subsidy for FS ACs during the second phase of the program affected more than 50% of the market (Li et al., 2013).

Manufacturers had to provide retailers sales receipts to receive the subsidy. This was the only information we found regarding rules and procedures to ensure that the retail prices of tier 1 and 2 ACs were actually reduced by the amount of the manufacturer subsidy.

An interesting aspect of this program is that a specific label was developed for products that received the subsidy. Figure 10 shows the "Promotion of Energy-Efficient Products to the Benefit of the People program" program label. Even though manufacturers received the subsidy, the government developed a label to tell consumers which products were part of the subsidy program.

Figure 10. The "Promotion of Energy-Efficient Products to the Benefit of the People" Program Label

3.2.3 ADMINISTRATION

The Promotion program was developed by the Ministry of Finance and the National Development and Reform Commission.

3.2.4 FUNDING

Over a period of 18 months, from June 2009 to December 2010, the central budget allocated RMB 16 B (US$2.4 billion) to subsidize more than 34 million energy-efficient room AC units, 1 million energy-efficient cars, and 360 million energy-efficient light bulbs (China Energy label, nd-d).

ACs represented 72% of the total budget, RMB 11.54 B (US$1.85 billion). On average, the government spent $50 per tier -1 or -2 AC produced during the first phase of the program.

In June 2012, a new round of subsides started with a larger budget of 26.5 billion RMB (US$4.2 billion). These subsidies also covered a larger range of equipment – flat-panel TVs, air conditioners, refrigerators, washing machines, and water heaters – than the first round (Zheng et al., 2013).

3.2.5 IMPACTS

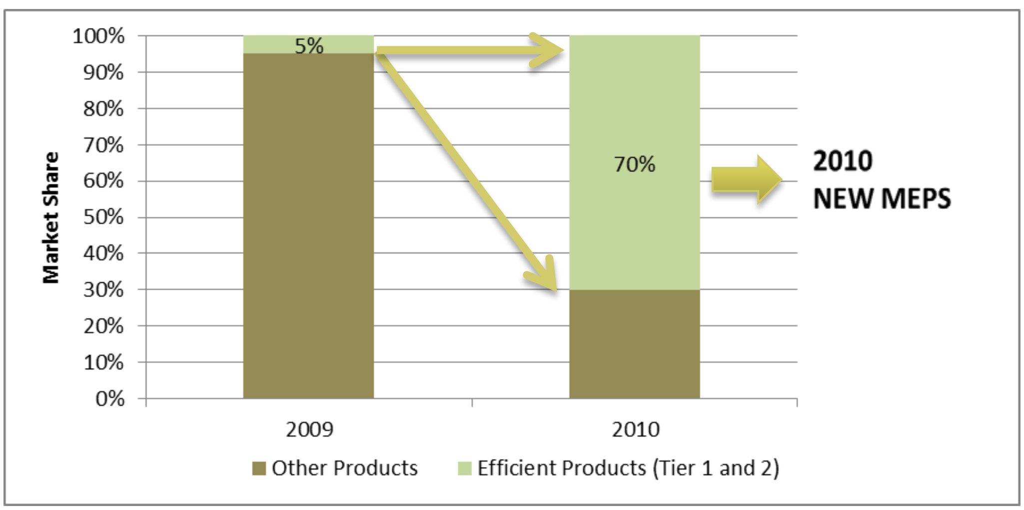
The China Energy label website published official estimates of the impact of the first round of the program (China Energy label, nd-d). According to these estimates, 22.5 TWh of first-year gross energy savings resulted from implementation of the program during the first 18 months (June 2009 to December 2010). This represents a reduction in CO_2 emissions of more than 14 million tons. No details are given about these savings, so we assumed that they were gross savings.[16] Official sources estimate that the program directly stimulated the spending of RMB 120 billion (US$18 billion) on home consumer products.

For ACs only, gross energy savings were estimated at 10 TWh in the first year, representing 80 to 100 TWh of savings over the lifetime of the products (89 TWh with a 5% discount rate and a 12-year equipment lifetime). Summer peak electricity load was reduced by an estimated 30%. Based on these savings estimates and the budget of US$1.85 billion, the cost of conserved energy for ACs was about $0.02 per kWh.

In terms of financial impact on consumers, the first phase of the program resulted in annual electric bill savings of RMB 5 B (US$ 0.75 billion) from improved AC energy efficiency. This is equivalent to RMB 40 – 50 B (USD$5.98 to 7.48 billion) in savings over the product lifetime, from an initial investment of RMB 11.54 B (US$1.85 billion) by the central government.

One of the main goals of this program was to transform the FS AC market because only 5% of market sales were of the most efficient (tier 1 or 2) units. According to official reports, the program helped increase the share of tier-1 and -2 units to 70% by the end of 2010, as shown in Figure 11 (China Energy Label, nd-a; Li, 2014). This increase in the overall energy efficiency in ACs sold in China was codified in the 2010 MEPS revision for FS ACs, which specified a more stringent level, tier 2. Thus, the program successfully accelerated market transformation and enabled new energy-efficiency standards. During the period of the 2010 standard, the number of efficiency tiers was reduced from five to three; production of the least-efficient levels (tiers 3, 4 and 5) stopped, and level 2 became the new standard. The introduction of the new MEPS allowed completing the market transformation realized by the incentive program and ensured that its impact was permanent.

Figure 11. China Market Transformation



Source: adapted from Li, 2014

After 2010, the program resumed, and the new revised tiers 1 and 2 were again subsidized. When the program ended in May 2011, the penetration of tier-1 and -2 units decreased somewhat, so the central government implemented a second phase, from June 2012 to May 31, 2013.

[16] Net savings = gross savings – free ridership + spillover effects. Please refer to Section 4.4 of the report for a definition of net and gross savings.

During the second phase of the program, 65 million home appliance products were subsidized with a total budget of 12.2 billion RMB (US$2 billion) (IHS, 2013; China daily, 2013). Chinese consumers spent 250 billion RMB (US$40.78 billion) on efficient appliances during the second phase. Data on the program for ACs only are currently being developed by the China National Institute of Standardization (Fu and Liu, 2014). The subsidy program was expected to boost consumer spending by 450 billion yuan and to save 11.7 million tons of coal used to produce electricity (top10news, 2012).

No comprehensive independent third-party evaluation has verified the program's net energy savings or performance. However, a few studies have pointed out program limitations, as described below.

3.2.6 EVALUATION

Market Transformation

Evaluation across countries demonstrates that incentive programs tend to be more effective when they target efficiency levels for which penetration is minimal, under 30% as suggested by Lees (2008) in his assessment of a UK incentive scheme. However, the second phase of the China program targeted ACs with an energy efficiency that already had a high penetration according to a market analysis of China's energy-efficient products (Li et al., 2013) conducted by CLASP and Top 10 China in 2012 (Top10, 2012). When the program resumed in July 2012, the penetration of tier-2 FS ACs had already reached 47% market share. Therefore, a large portion of ACs was eligible for the subsidy, which increased the risk of free ridership (the share of customers who benefited from the subsidy but would have purchased tier-2 products without it).

In addition, the program incentivized a technology (FS AC) that was not the most energy-efficient on the market and that had a declining market share; the market share for VS ACs, which save much more energy than FS ACs, increased from 16% in 2009 to 44% in 2012 (Li et al., 2013). The study recommended eliminating subsidies for FS ACs and instead providing larger subsidies to VS ACs only. VS ACs are 40% more expensive up front than FS ACs but are more cost effective over the equipment lifetime (Li et al., 2013). A more effective approach to transforming the market toward a higher level of efficiency would have been offering larger per-unit incentives that targeted only tier-1 and tier-2 VS ACs. Zheng et al. (2013) found that the subsidy offered during phase 2 of the program did not close the price gap between tier 1- or -2 and tier-4 or -5 VS ACs; the price gap was as large as 20% for the largest-size ACs. China's new subsidies average less than 10% of the appliance cost. The study also recommended that subsidies be restricted to small- to average-size equipment to avoid encouraging customers to buy larger appliances. This approach could limit the rebound effect that can occur when customers use a subsidy program to replace small appliances with larger ones.

Price Impacts

According to official estimates, the subsidy scheme led to a significant drop in the retail price of energy-efficient ACs, of RMB 1000 to 2000 (US$163 to $326) (China Energy label, nd-d). However, Zheng et al. analyzed the price of ACs in the second phase of the program and concluded that tier-1 products' prices were made artificially high so that manufacturers could profit from well-off consumers. This raises questions about the effectiveness of the program's design, which was intended to pass the discount from the subsidy to the customers.

In addition, a large number of appliance manufacturers were reported to have illegally obtained hundreds of millions of dollars in energy-saving subsidies (Global Times China, 2013). According to an audit by the National Audit Office (NAO), 348 companies reported fraudulent data that overstated their sales of energy-efficient products in order to obtain extra subsidies from the government. These companies illegally received as much as

1.62 billion yuan (U$264 million) in subsidies from February 2011 to March 2013 (Global Times China, 2013). The report indicated that ACs were particularly subject to fraud because of the long supply chain from manufacturers to consumers, which made it easier to falsify reports. This fraud report points to a lack of government oversight of the program and underscores the need for a robust monitoring and verification system.

Increased Awareness

The program's original, dual intent was to both influence manufacturers to produce more efficient equipment and to increase consumer awareness of the energy-savings benefits of tier-1 and -2 ACs. By creating a label to promote these energy-efficient products, the subsidy program significantly increased consumer awareness of the benefits of energy efficiency.

A survey conducted by Yu (2013) in October 2012, four months after the second round of subsidies began, showed that consumers considered energy savings the most important factor influencing their purchase decisions for large appliances such as ACs and refrigerators. Among the persons interviewed who had purchased an appliance during the previous six months, 87% had chosen an energy-efficient appliance. The survey indicated that the subsidy was not the customers' first motivation for buying an energy-efficient appliance, but the subsidy had a significant influence in their purchase, as they gave a rating of 4 out 5 for the influence of energy efficiency in their purchase decision. Those who did not buy energy-efficient appliances reported that higher up-front cost was the main reason.

Consumer awareness of the subsidy program was reported as moderate (62%). However, because the subsidy program affected consumer purchase decisions in two ways – through lower prices and efficiency labels – some consumers might have been influenced by the reduced price without being aware of the program. Another interesting finding of the survey is that a large majority of consumers (86%) claimed that they were ready to pay an extra 10% for energy-efficient appliances compared to standard products.

Although the survey offers an interesting consumer perspective on the program, it did not estimate the percentage of customers that would have bought an energy-efficient appliance in the absence of the program, i.e., the share of free riders, nor did it attempt to assess spillover or rebound effects.

3.2.7 CONCLUSION

No other country has injected as large an amount of money into boosting the sale of energy-saving appliances as China. The China Promotion program illustrates the difficulties of designing a program that aims to both increase consumer spending and decrease wasteful energy consumption. The first phase of the program was particularly effective at moving the market to a higher efficiency level. The efficiency gains achieved were then cemented by the implementation of the new more stringent standard, resulting in additional savings. The second phase of the program encouraged inefficient technologies by targeting an energy-efficiency level that already had a large share of the market. It is thought that more energy savings could have been achieved in the longer term if the program had only subsidized the most energy-efficient technologies that had a small market share, ie VS ACs. However, this would likely have had a lower impact on consumer spending in the shorter term. This case study also demonstrates the challenge of upstream programs monitoring and verification process. The government was able to minimize its subsidy by offering it upstream, but it also faced significant hurdles to make sure the subsidy was passed to the consumers.

3.3 MUMBAI CASE STUDY: RELIANCE INFRASTRUCTURE LTD. FIVE-STAR SPLIT AC PILOT PROGRAM

In India, the power sector is regulated at the state level. The state of Maharashtra has pioneered demand-side management (DSM) activities with the active participation of power distribution companies (DISCOMs) and support from the Maharashtra Electricity Regulatory Commission (MERC). MERC was one of the first state regulatory commissions to adopt DSM regulations based on the forum of regulators guidelines published in 2010 (MERC, 2010).

Reliance Infrastructure (RI) is one of Mumbai's DISCOMS, with a service territory covering an area of 400 square kilometers and serving about 2.9 million customers. The company's environmental goals include encouraging energy conservation and energy efficiency among its consumers. To achieve this goal, the company has implemented several pilot programs, including one for ACs.

RI provides discounted high-efficiency ACs for its commercial customers through a pilot program, the RI 5-Star Split AC scheme. MERC approved the program in October 2013, and it was launched in February 2014 with a two-year horizon. Its aims are energy conservation and providing value-added services to commercial-sector RI customers (ACs account for 60% of commercial electricity consumption in RI's service territory). Reduction in peak electricity consumption will be monitored. MERC has not set a specific efficiency savings target (MERC, 2010), and DSM programs are voluntary. Table 21 summarizes the features of the RI program.

Table 13. India Reliance Infrastructure Case Study Program Summary

Time Frame	February 2014 through January 2016
Goals	- Conserve energy - Increase consumer awareness
Objectives	Close the price gap between 3-Star AC models and 5-Star AC models for 1,500 units sold to commercial customers
Mode of intervention	Upstream
Specification	- Eligible units must be 5-Star rated - Old units must be surrendered
Financial incentive	$67 - $83 per unit
Administration	Reliance Infrastructure
Funding	Approximately $330,000
Impact	No impact yet
Evaluation	Planned at the end of the program

3.3.1 PROGRAM GOALS

No specific energy savings target are set by MERC, but MERC's guidelines direct DISCOMs to make DSM an integral part of their day-to-day operations and to undertake planning, design and implementation of cost-effective DSM programs on a sustained basis (MERC, 2010). MERC approves the implementation of programs that meet the following three requirements (MERC, 2010):

- They are cost effective for distribution licensees (utilities) and their consumers.
- They protect consumer interests and are implemented in an equitable manner.
- They result in overall tariff reductions for all distribution licensee consumers.

In this regulatory environment, RI has pursued several DSM pilot projects with the goals of mitigating growing energy consumption and increasing consumer awareness of the benefits of saving energy. One of RI's pilot projects targets ACs with the goal of discounting 1,500 wall-mounted 5-star split AC units that will replace window units. Incentives are meant to close the price gap between 3- and 5-star AC models.

3.3.2 MODE OF INTERVENTION

A request for proposal bid process was used to select the participating manufacturer. The bid process was intended to induce manufacturers to offer discounted 5-star, wall-mounted split AC units with the benefit of an exclusive right to sell a large order of ACs. Added rebates from RI are 4,000 rupees (R) (~US$67) for a 1.5-ton unit and R5,000 (~US$80) for a 2-ton unit. RI pays the rebates in addition to the discounted price that RI secured from the manufacturer as part of the bid process. The discounted price plus the rebate lower participant costs for the 5-star model to equal the market price for a 3-star model.

Participation in the bidding process was low. Only two manufacturers bid, which program administrators say resulted in a smaller discount than they had hoped for. Ultimately, Godrej Appliances was chosen to supply the AC units. Each of the two bidding competitors offered an all-inclusive price on each unit, which covers the discount on the cost of the new unit; the installation cost for the new unit; and removal, storage, and recycling costs for the replaced unit.

Participating consumers must first register with RI to join the program and must provide the previous month's utility bill to prove that they are current, ongoing RI customers. RI then gives the participant's details to the manufacturer, which works directly with the participants to determine their needs and choose the type of AC unit to replace the window unit. The manufacturer also sets up the appointments for installation. After successfully installing the new unit, the manufacturer has the participant sign a coupon that is submitted to RI. RI calls the participant to confirm successful installation. Once installation is confirmed, RI delivers the subsidy to the manufacturer.

Retailers are not involved in the program. Each participant is allowed up to three 5-star, wall-mounted split AC units. An old window AC unit in working condition has to be surrendered for each discounted unit purchased (a manufacturer representative checks the old units to ensure that they are in working condition). Participants can buy either a 1.5-ton unit or a 2-ton new unit.

The program is publicized by word of mouth by RI managers, through leaflets, and on utility bills. Businesses can participate on a first-come, first-served basis until the program reaches 1,500 units.

As noted above, Godrej Appliances is responsible for installing the new equipment, and removing and recycling old units. Godrej has to present certification to RI that the old units are disposed of according to guidelines of the Indian Ministry of Environment and Forests' National Regulations for Monitoring and Controlling Production and Use of ODSs. The recycling process includes collection and disposal of refrigerants in accord with the law. Godrej Appliances hired Earth Sense and Attero Recycling Pvt. Ltd. to dispose of used AC units. Both were approved by the Maharashtra Pollution Control Board to do the recycling. The AC program is part of a portfolio of RI pilot programs called "Change for Mumbai."

Figure 12. Reliance Infrastructure AC Program Marketing

3.3.3 FUNDING

Approximately (somewhat less than) two crore (20 million) rupees (~US$333K[17]) were budgeted for the program. This budget covers the rebate, administration costs, promotional costs, and measurement and verification costs. MERC approved the program to be paid for through rate recovery. MERC regulations allow distribution licensees to recover all costs incurred in DSM-related activities (including planning, designing, implementing, and monitoring DSM programs) by adding these costs to their annual revenue requirements. This enables ratepayer-funded DSM investments.

3.3.4 IMPACTS

There are no estimates of the energy, demand, or emissions savings from this project. However, the program goal is to incentivize participants to buy 1,500 5-star-rated AC models, which have a minimum EER of 3.5 in 2014, instead of 3-star models, which have EERs between 3.1 and 3.29 (India BEE, 2014). These numbers suggest that savings will be something like 10%, not 33%. RI reports that the typical AC model bought in its service territory is a 3-star model (Pramod Deo, 2014). A wall-mounted AC unit bought in 2014 with a 5-star rating should consume approximately 3,703 kWh per year (Boegle et al., n.d.; India BEE, 2014) whereas 3-star units use between 3,939 kWh per year and 4,180 kWh per year (Boegle et al., n.d.; India BEE, 2014). Using these figures, we estimate that first-year unit savings would be between 236 kWh and 477 kWh for a consumer with a 5-star unit obtained through the program, and total first-year savings for the program would be between 354 MWh and 716 MWh.[18]

[17] at $1 = R60

[18] Assumes an output of 18,000 British thermal units (Btu)/hour and usage of four hours per day, 180 days per year. EER = (Cooling capacity (Btu/hour)) / (Input power (W)) (Emerson Climate Technologies, 2007).

These numbers are all ex-ante estimates, and net savings could vary significantly. Results from the program's monitoring and verification will increase the accuracy of these estimates.

3.3.5 EVALUATION

To participate, RI customers have to agree to cooperate with the program's monitoring and verification procedures, which include RI installing plug-in electricity meters on the participant's property to begin measuring consumption 15 days before installation of the new equipment. Monitoring continues for 15 days after the new unit is installed. This method is the basis for measuring overall electricity savings for each participant.

Out of RI's total customer base of 2.8 million, 400,000 accounts are commercial and industrial customers who are eligible for the 5-star AC program. Because each participant is eligible for rebates on up to three units, the program has the potential to impact between 500 and 1,500 customers or between 0.125 percent and 0.375 percent of the eligible customer base.

RI's 5-Star Split AC program has just begun, so no results are available yet. Some important results to look at will be: how popular the program is, how fast rebates on the 1,500 units are claimed, whether the discount is too big (leading to the program being oversubscribed) or too small (resulting in weak uptake), what energy savings are achieved, whether larger (2-ton) units are preferred, what the cost per kWh is for RI to run the program, what the level of free ridership is, and what follow-up actions are taken. For example, will MERC call for an expanded program? If so, will more manufacturers participate in the bidding process? Will the program as it is structured be cost-effective for RI as a means of resource acquisition?

3.3.6 CONCLUSION

This program was implemented to offer a desirable service to the utility's customers in a very competitive market. By offering this program, RI brings energy efficiency into its business model, which will both reduce its peak load and offer a new service that will allow its commercial customers to reduce their electricity bills.

Other interesting aspects of the program so far include:

- Using bidding to select the manufacturer, which allowed RI to:
  - Achieve as large a per-unit discount as possible from manufacturers before applying the rebate
  - Delegate recycling, transportation, storage, and installation tasks to the market, thus taking advantage of market efficiencies, attaining competitive per-unit cost and, avoiding the program costs of the utility doing these tasks "in house"
- Two program features that should help to maximize the energy savings achieved:
  - The replacement requirement, which should help maximize energy savings and environmental impacts by taking old units off the grid and recycling ODSs
  - Requiring new units be 5-star rated, the highest rating available for ACs in India, which ensures that the program will only be promoting the most efficient units

DISCOM DSM programs in India are still mostly pilot projects. However, the number of pilot programs is growing as state regulators gradually implement DSM guidelines for DISCOMs. Energy-efficient AC programs have large potential in India, and the lessons from RI's current pilot project will be useful in scaling up and replicating the program.

3.4 MEXICO CASE STUDY: NATIONAL APPLIANCE REPLACEMENT PROGRAM

The Government of Mexico ran a replacement program for room AC units under the Programa Nacional de Sustitución de Equipos Electrodomésticos (PNSEE), also referred as the Efficient Lighting and Appliance Project. PNSEE was designed to replace highly energy-consuming appliances, i.e., refrigerators and ACs, with more energy-efficient units. This program builds on previous experience from a refrigerator replacement program implemented from 2002 to 2006 (World Bank, 2010). PNSEE started in March 2009 with a target of replacing 1.7 million refrigerators and ACs by 2012 (World Bank, 2010). As part of the project, old refrigerators and ACs were collected from consumers and sent to scrapping centers for dismantling and recovery of the refrigerants. Table 22 summarizes the features of the PNSEE program.

Table 14. Mexico PNSEE Program Case Study Summary

Time Frame	2009 to 2012
Goals	- Boost the economy - Reduce poverty - Reduce GHG emissions
Objectives	Replace approximately 170,000 AC units
Mode of intervention	- Downstream: provides rebates and financing to residential electricity customers - Early replacement program - On- bill financing - Refrigerant recycling
Specification	replaced units must be at least 10 years old and in working condition
Financial incentive	Between $25 and $70 in rebates and up to US$470 in financing depending on monthly energy consumption
Administration	Government of Mexico, National Electricity Commission, Trust Fund for Energy Savings, National Finance Bank
Funding	US$600 million for appliance replacements (approximately 10% were air conditioners)
Impact	More than 150,000 participants
Evaluation	Haas Energy Institute conducted an evaluation in 2012

3.4.1 PROGRAM GOALS

The program's goals are (WB, 2010):

(i) stimulating domestic demand for energy-efficient products;
(ii) strengthening social inclusion by improving the ability of low-income consumers to purchase more efficient appliances; and
(iii) reducing GHG emissions resulting from the switch to more efficient appliances

There are multiple benefits including non-energy benefits such poverty reduction and economic recovery. The program aims at helping particularly low-income households who tend to own very old and inefficient equipment. The program objective is to replace 1.7 million appliances, approximately 10% of which will be ACs, by providing instant discount vouchers to low-income consumers to help finance a portion of the upfront cost of acquiring new efficient appliances to replace old and inefficient ones. The objective is also to supplement these discount vouchers with financing by providing credits to low income and higher income households. Proper disposal of used equipment was also part of the objective of the program.

3.4.2 MODE OF INTERVENTION

To be eligible for the AC portion of the program, participants had to surrender a working AC that was at least 10 years old with a cooling capacity of at least 0.75 tons. Participants brought their utility bills to a participating retailer who scanned a bar code on the bill to find out the customer's eligibility for rebate and financing. Eligible participants received vouchers certifying the recycling of the old AC and proper disposal of the refrigerant gas. With this certificate, the participant could buy a new AC and get a direct incentive in the form of a discount on the final price of the new unit as well as a credit to pay the remaining cost of the new unit. The new AC had to comply with the 2008 Mexican AC energy efficiency MEPS.

Table 23 shows the incentive options based on participant average monthly electricity consumption during summer months. Electricity consumption was used as a proxy for determining whether a consumer qualifies as a low-to-medium-income household. Four different levels of consumption are specified as set out in Table 23, with different norms applying to refrigerators and air conditioners. Participants could receive up to US$70 in rebates and up to US$470 in financing for a new AC.[19]

Table 15. PNSEE Incentive Schedule for Rebates and Financing of New AC Units

Monthly summer electricity consumption (kWh)	Amount available for direct rebate (USD)	Direct support for costs associated with replacement (USD)	Maximum amount available to finance replacement (USD)
251—500 kWh	$70	$30	$335
501—750 kWh	$25	$30	$380
751—1,000 kWh	---	---	$405
>1,000 kWh	---	---	$470

Source: FIDE, 2011
*All numbers are approximate, based on an exchange rate of MX$12.8 to US$1.

The program also had a size requirement. The qualifying air conditioners had to be no more than one additional ton of refrigeration larger than the replaced air conditioner (1- to 3-ton capacity or mini-split ACs 0.75 to 5 ton).

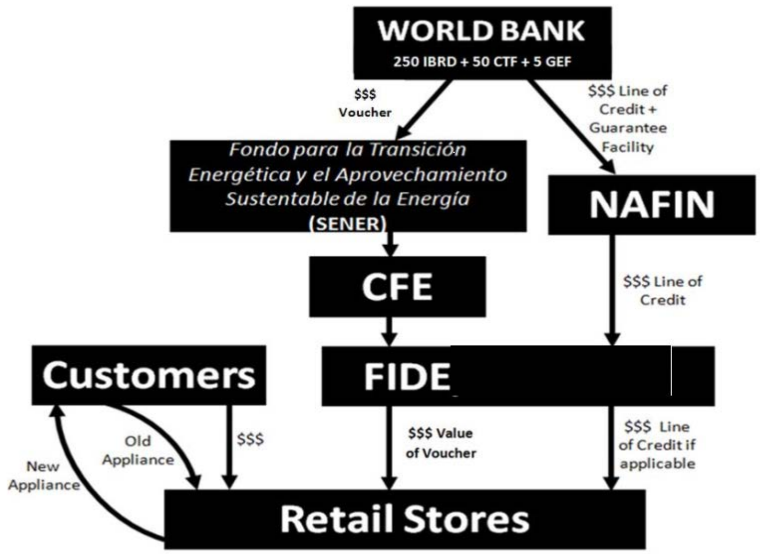
3.4.3 ADMINISTRATION

PNSEE was managed by the Mexico Secretaría de Energía (SENER) and operated by Fideicomiso para el Ahorro de Energía Eléctrica (Trust Fund for Energy Savings) (FIDE). FIDE, as the "Operator", was primarily responsible for reviewing consumer eligibility, managing payments to the retail stores under both the vouchers and the credit lines, verifying compliance of sales with the program's requirements, and transporting units (including delivering old units to storage and destruction sites for recycling). The Comisión Federal de Electricidad (Federal Electricity Commission, CFE, the state-owned, nation-wide electricity utility) was responsible for managing the flow of funds from SENER to FIDE to effect the payments to the retail stores under the vouchers, and for administering the repayments of credit offered to participants through its electricity billing system. Nacional Financiera (National

[19] Maximum rebates and financing were MX $6,000. Exchange based on MX $12.8 per US$1 (XE, 2014).

Finance Bank, NAFIN) was the provider of the credit lines. Figure 13 shows how funding was directed from the World Bank to program participants. It also illustrates how FIDE, CFE, NAFIN, SENER, and appliance retailers interacted and what their roles were in the program.

Figure 13. PNSEE Implementation Scheme: Flow of Funds



Source: World Bank, 2010

3.4.4 FUNDING

PSNEE was financed with World Bank loans, a GEF grant, and the Mexican government's federal budget. The overall budget for appliance replacements was approximately US$600 million for both refrigerators and ACs. Table 16 shows the budget contributions (World Bank, 2010).

Table 16. PNSEE Budget

Government of Mexico	US$55 million, including US$30 million for capitalizing the Guarantee Facility (see Financing section)
NAFIN	US$127 million
IBRD	US$195 million
Clean Technology Fund (CTF)	US$50 million, used with the NAFIN monies to capitalize the program's consumer loans
GEF	US$5 million to capitalize the guarantee facility
Consumers	US$176 million

3.4.5 FINANCING

An innovative feature of PSNEE was that participants could finance their AC purchases through their utility bills. Participants could apply at participating retailers for credit from NAFIN.[20] This credit had a lower interest rate than

[20] To qualify for financing, an applicant had to be the person named on the utility bill, had provide contact information for another person who could corroborate that the applicant lived at the address on the utility bill, and could not have a negative rating from the Círculo de Crédito, S.A. de C.V. (World Bank 2010).

other commercial loans and was recovered by the electricity company through monthly charges on participating customers' electricity bills. This strategy meant that the consumer's bill remained approximately the same but because of electricity saved by the new equipment, the difference between previous electricity use and post-replacement electricity use paid for the new equipment. Once the equipment was paid for, consumers enjoyed a reduced bill.

NAFIN made loans to customers through FIDE at a preferential 12-percent annual interest rate payable over a four-year term. Several credit enhancements were provided to achieve this lower-than-market rate.[21] First, the GEF and the Mexican government provided funds to capitalize a US$35-million guarantee facility, a loan-loss reserve that could be used to cover defaults.[22] Second, program rules stated that non-payment of the loan could result in the participant's power being shut off, which was thought to be a way to make the loan more secure because borrowers would not want to lose essential electricity service. Additionally, having loans paid off on utility bills lowered transaction costs for NAFIN, thereby lowering the cost of each loan. Finally, the Clean Technology Fund (CTF) loaned US$50 million for the program at preferential rates (World Bank, 2010).

Recycling

Another important feature of PNSEE was mandatory replacement and recycling of old units. A budget of approximately US$30 per unit was added for collecting and recycling costs (World Bank, 2010). Participating retailers were in charge of most of the logistics. This mandatory replacement ensured that the participating household did not continue to use the old AC or sell it on the secondary market. Without mandatory replacement, new, more efficient units might just be adding load to the grid.

Retailers transported new units to participants, verified that old units were eligible under program rules (i.e., they were at least 10 years old, were the right size, and were in working condition), and then transported the old units to one of the 98 authorized collection and dismantling centers, known as scrapping centers. At the scrapping centers, appliances were dismantled and the recovered metal and plastic were sold. The process also extracted CFC-12 and HFC-134a from refrigerators and HCFC-22 from ACs. Among these three gases, HFC-134a was sold back to the market whereas CFC-12 and HCFC-22 are transferred by the scrapping centers to Secretaría de Medio Ambiente y Recursos Naturale (Secretary of the Environment and Natural Resources, SEMARNAT)[23] -recommended recovery centers. In the absence of clear-cut guidelines for the treatment of recovered gases, the gases were stored by the recovery centers under the supervision of SEMARNAT (MLF, 2012).

Ozone-depleting gases such as CFC-12 have extremely high GWP. Therefore, destruction of such gases can generate a large number of carbon credits. About 166.7 tonnes of CFC-12 have been collected throughout the duration of the program and are now the subject of a pilot destruction project implemented by the Government of France and UNIDO (UNIDO, 2013). Currently, mechanisms governed by the Kyoto Protocol, such as the Clean Development Mechanism, do not cover these gases, so ODS destruction projects cannot earn Certified Emission Reductions under the CDM market. As explained in Section 2.4, other markets exist, among which the voluntary carbon market and the Mexican government is investigating applying for carbon reduction credits for retired refrigerants in these markets (CAR, 2014).

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[21] Between 2007 and 2009, interest rates for unsecured credit card debt were between 30 and 35 percent in Mexico; car loans (secured debt) were around 15 percent (World Bank, 2010).

[22] GEF provided a $5-million-dollar grant for the facility, and the Mexican government provided $30 million.

[23] SEMARNAT is responsible for regulating pollutants (including ODSs) in Mexico.

3.4.6 IMPACT

The Mexican program targeted early replacement of ACs before the end of their useful life. In this case, improvements should be compared to the unit replaced but only during the remaining life of the AC replaced. A "double baseline" should be considered for this type of programs: the remaining useful lifetime of the equipment that is replaced early, and the market average for the remaining life of the new equipment. According to World Bank estimates, units older than 10 years have significantly higher energy consumption than the current MEPS (20%[24]).

The overall goal of the program sought to replace a combined total of 1.7 million old, inefficient ACs and refrigerators (about 170,000 ACs). These replacements were expected to reduce CO_2 emissions by 5.16 $MtCO_2e$ and to save 10,041 GWh of electricity over the five years of the program (World Bank 2010).

3.4.7 EVALUATION

In 2013, Lucas Davis, Alan Fuchs, and Paul Gertler of the Energy Institute at the Haas School of Business, University of California, Berkeley, evaluated PSNEE using participant and non-participant utility bill data. As of February 2012, 1.5 million refrigerators and about 167,000 ACs had been replaced. The evaluation calculated an energy savings of approximately 400 GWh by 2012 (100 GWh per year for four program years) and 0.24 $MtCO_2$ (60,000 tons per year for four program years) (Davis 2013).[25] The increased energy usage observed by Davis et al is due to pent-up demand for cooling and contributes to the poverty reduction's goal of the program (see Section 2.6).

The researchers found that electricity consumption in households that purchased ACs through the PNSEE actually increased by 92 kWh per year. They attribute this result mainly to the rebound effect (see Section 2.6). As more efficient ACs cost less to use, participants tend to use them more to increase their comfort level.

Other more modest factors may include:

- Replacement of smaller units with larger units
- Added features that used more energy and that make ACs more convenient to use
- The fact that the average replaced unit was 10.9 years old—just older than the eligibility limit of 10 years (i.e., most replacements did not reap the energy savings that had been expected from replacing units that were 15 years old or older)
- Some replaced units being likely not in working condition at the time of the replacement (adding a new working unit in exchanging for a non-working unit would add to a household's total consumption even if the new unit was efficient)

3.4.8 **CONCLUSION**

PNSEE is one of the largest recycling programs in the world. The programs allowed nearly 1.6 million appliances to be collected, demanufactured and replaced with more energy efficient appliances. About 167,000 old AC units of 10 years or more of age have been removed from the Mexican market. With HCFC consumption unrestricted in developing countries until the end of 2012 and only being phased out gradually to 2040, Mexico's PNSEE can be used as a model for other developing nations to recycle and destroy potent global-warming and ozone depleting

[24] The average consumption of an old AC in low income households is 2,208 kWh per year while the average consumption of an efficient AC for these consumers is 1,773 kWh per year (WB, 2010).

[25] When cooling appliances are replaced, decreased CO_2 emissions attributed to energy saved by efficiency gains may represent only a small portion of the GHG emissions reductions. This is because high-GWP refrigerants can be recovered from replaced units and disposed of according to best environmental practices. Refrigerants such as CFCs have a GWP that is thousands of times greater than that of CO_2.

gases. However, more international efforts are needed to encourage increased demand for carbon reduction credits from developing countries retired refrigerants.

Evaluation has shown that ACs were particularly subject to rebound effects. However more research is need to assess how much of this rebound effect is due to unsatisfied demand by low income households and what's been the impact on poverty reduction which was one goal of the program.

3.5 NEW YORK CASE STUDY: CONSOLIDATED EDISON RESIDENTIAL APPLIANCE REPLACEMENT PROGRAM

The New York utility Consolidated Edison (ConEd) has instituted a number of demand-reduction programs focusing on the residential, multi-family, and commercial sectors. In 2010, among the energy-efficiency incentive programs ConEd operates under the State of New York's Energy-Efficiency Portfolio Standard (EEPS), ConEd began a rebate program for room ACs. Because New York City's housing stock is old and a large portion was not built with central air conditioning, and because it is difficult to retrofit tall buildings with central ACs, room ACs are an important and ubiquitous consumer of residential electricity in the city. New York City has one of the largest numbers of ACs of any city in the world (Coltro, 2014). The ConEd program offers US$25 to all residential customers[26] for the purchase of a new Energy-Star-rated room ACs. The offer is seasonal, only available from May to August. Table 25 lists the features of the ConEd program.

Table 17. U.S. - New York ConEd Program Case Study Summary

Time Frame	Began 2010, ongoing through at least 2015
Goals	Save energy to meet regulatory energy-reduction targets (part of a larger suite of programs)
Objectives	Provide rebates to consumers to reduce the price gap between energy-efficient and standard products
Program Type	Downstream: rebates to residential electricity customers
Specification	Eligible units must be Energy-Star endorsed
Financial incentive	US$25 per unit
Administration	Consolidated Edison, Honeywell, and Jaco Environmental
Funding	Approximately $1.1 million, budget from New York's System Benefits Fund
Impact	- 59,193 units in 2 years - 1,210 MWh of net savings - 758 kW net peak demand savings
Evaluation	Evaluation planned at the end of the program

[26] Customers living in multi-family buildings can participate only if the utility bill is in their name; i.e., the building must be sub-metered. Tenants in master-metered buildings cannot participate.

3.5.1 PROGRAM GOALS

In 2009, New York's state regulator, the New York Public Service Commission (PSC), established EEPS 1, which set energy-savings targets for utilities to achieve through energy-efficiency programs. EEPS 1 ran from 2009 through 2012. EEPS 2 runs from 2013 until 2015.

Electric savings goals from all ConEd energy efficiency programs are 64,756 MWh from 2012 to 2015. ConEd hopes to achieve approximately 17% to 18% of the electricity savings goals mandated by the PSC through the AC incentive program (this is between 11K MWh and 11.7K MWh over the 2012-2015 EEPS 2 time frame).

3.5.2 MODE OF INTERVENTION

ConEd's approximately 1.3 million residential customers can participate in the room AC rebate program between May and August. There is no size restriction on the new AC units and no requirement that new units replace old units. Through the program each customer is eligible for a rebate of US$25 for each of two, Energy-Star-rated room AC units per season. Participants can apply by mail or on line. They must fill out an application and show proof of purchase of an Energy-Star-rated model. Applicants receive a check in the mail a few weeks after they apply.

Table 18. US ENERGY STAR Qualified Room Air Conditioner Eligibility

Capacity (Watts)	ENERGY STAR EER
<2,550	3.57
2,551 to 4,457	3.60
4,458 to 6,367	3.57
> 6,367	3.12

The original rebate amount was US$50 per unit, which was established to ensure that program costs per unit passed the New York Technical Manual's Total Resource Cost test. However, this incentive was concluded to be high because it led to oversubscription of the program, so the rebate amount was decreased to the current US$25 per unit.

Most AC sales take place during just a few months of the year. Program administrators originally thought that they should open the program at the end of May, assuming that consumers mostly buy ACs in June and July. After talking with retailers, however, they realized that sales begin as soon as temperatures reach the low 70s (Fahrenheit), sometimes as early as early April. Thus, beginning the program in late May could have caused the program to miss a large portion of the seasonal demand for ACs, and any money spent on promotion late in the season would be wasted. Therefore, ConEd begins the program in early May. This understanding of the market helped ConEd keep costs per unit to a minimum.

3.5.3 ADMINISTRATION

Until the middle of the last decade, energy conservation and efficiency programs had been housed with the New York State Energy Research and Development Authority (NYSERDA). Around 2007, NYSERDA began to transfer responsibility for the programs to the utilities because 1) utilities wanted to target specific markets to reduce energy consumption and avoid capital investments, and 2) customers are more familiar with their utilities than with NYSERDA, so from a customer-relations perspective, it made more sense for utilities to run energy-efficiency programs. Program operations are contracted to Honeywell, which processes applications, verifies accounts, and disburses checks to participants. Honeywell also connects with retailers and manufacturers to promote the program. The bulk of room AC sales are concentrated in a few areas around the city. Honeywell communicated with retailers in those areas to gain insight on best ways to market the room AC program.

3.5.4 FUNDING

The program is funded through New York's System Benefit Fund. The program budget is established through filings with the PSC; ConEd forecasts the savings achievable with the program and includes a proposed budget in the rate case[27] submitted to the PSC. The PSC either approves or modifies the budget submitted by ConEd. Currently the ConEd portfolio budget is US$7.3 million per year, of which US$1.1 million is for the AC program. The utility estimated that approximately 18 % of the EEPS 2 savings goal can be met through the room AC program. ConEd may change the percentage of savings it aims to achieve through the AC program based on the results of an evaluation of the program that has just been released.

ConEd does not break down its budget by program, but program managers estimate that the room AC program budget breaks down approximately as shown in Table 19.

Table 19. ConEd AC Budget Breakdown

Incentives	$770,000	70%
Marketing	$110,000	10%
Administration	$165,000	15%
Evaluation, Monitoring and Verification (EM&V)	~$55,000	5%

3.5.5 REPLACEMENT PROGRAM

The room AC program does not require that an old AC unit be surrendered to qualify for the rebate. ConEd decided against a replacement requirement primarily because that requirement would add another layer of cost and would have affected cost-effectiveness estimates for the program. ConEd did not want to deal with installing AC units and found that installation, eligibility verification, and other transaction costs would be too high for the program to be cost effective. All measures that qualify for incentives under ConEd's DSM portfolio must meet the total resource cost test (a test of cost effectiveness, see Section 2.6) as defined in the PSC's New York Technical Manual.

[27] The rate case is the regulatory determination – generally a negotiation between the investor-owned utility and the regulator (in this case the PSC) – of what tariff the utility will be allowed to charge until the next rate case (not including rate adjustment mechanisms).

However, a separate program that recycles AC units exists. It can be used alone or paired with the rebate program. The operations of the recycling program are also contracted to Honeywell, which subcontracts the transport, storage, and recycling of old units to Jaco Environmental.

3.5.6 MARKETING

The room AC program is promoted through utility bill inserts, messages on utility bill envelopes, direct mail, email blasts, and by manufacturers and retailers where eligible models are displayed. Program administrators note that the program does not need a lot of marketing (Coltro, 2014). Only approximately 10% of the budget is spent on marketing. ConEd tries to minimize marketing costs by promoting the program only during targeted times of year and by using low-cost email blasts as a major part of the marketing effort. The utility also cross-promotes the program with other DSM programs.

3.5.7 IMPACT

In 2010 and 2011, 59,193 units were sold through the program. Gross energy savings were 2,575 MWh (ex-ante estimates were 2,378 MWh), and net savings were 1,210 MWh. Gross peak demand savings were 1,612 kW (compared to an ex-ante estimate of 4,027 kW), and net peak demand savings were 758 kW. The low net savings numbers are because of an estimated high rate of free ridership. The low observed gross peak demand savings are because of the actual peak coincidence of ACs being lower than assumed.

3.5.8 EVALUATION

In October 2013, Energy and Resource Solutions published an evaluation of ConEd's room AC program. The evaluation methodology consisted of 190 telephone surveys, three months of on-site metering for 55 of those respondents, review of program tracking data, and review of program participants' billing data. The evaluation categorized participants into "high population density" areas (Manhattan, Brooklyn, and the Bronx) and "medium population density areas" (Westchester, Queens, and Staten Island). The evaluation revealed several significant findings (ERS 2013):

- Free ridership was estimated at 53% (the evaluator concluded finding spillover effects was outside of the scope of the evaluation).
- Participants in "high density" areas had higher consumption than those in "medium density" areas.
- Hours of use were longer than expected, and consumption peaks were later in the day than expected, resulting in a lower peak coincidence factor for room ACs, which is why observed peak demand savings were below ex-ante estimates.

The lower-than-estimated savings meant that the program cost per kWh saved was greater than had been estimated. The evaluators made recommendations to improve the program's per-unit costs, including:

- Targeting marketing efforts to higher-density-population areas where savings per unit are higher
- Re-designing the program as a midstream program to decrease transaction costs
- Implementing tiered incentives with higher rebates for higher-efficiency AC models
- Bundling AC rebates with additional measures

3.5.9 CONCLUSION

The ConEd program teaches several important lessons, most importantly how assumptions can significantly affect results. For example, if peak demand reduction is a program goal – often the case for programs targeting ACs – then assumptions about peak demand coincidence have a large impact on the program's outcome. Assuming a higher peak coincidence than is the case can leave program goals unrealized, program budget dollars spent on energy savings (but not peak demand), and the electricity system's capacity needs unchanged.

Another lesson of the ConEd program is that there are several strategies for maximizing AC program marketing dollars:

1. Program needs to target higher-efficiency AC models to minimize free ridership of the program
2. ACs are a seasonal product. If program administrators know the market well (e.g., when peak buying occurs), they can spend marketing money at the most effective times and avoid wasting money on promoting an AC incentive after most consumers have finished buying for the year.
3. ACs are often one appliance among several in an energy-efficiency portfolio and can thus be cross-promoted with other eligible appliances.
4. As was the case in New York, there may be parts of a service area where ACs consume more electricity per unit than in others. If so, focusing promotion and marketing on the high-consumption areas can increase the energy savings per marketing dollar spent.

Examining ConEd's program also raises questions about whether the lack of cost effectiveness of a replacement requirement in New York City is applicable in other locations. For ConEd, replacement program and transaction costs would make it difficult for the program to pass the total resource cost test. However, the benefits of requiring replacement may be greater in other locations and the costs less. If the stock of ACs in a given service area has a higher average consumption than the stock of ACs in New York City – which is likely the case in many emerging economies – then the savings per unit might also be significantly better than those from replacement in New York City. Furthermore, in most places, labor and other costs may be lower than in New York. Some transaction costs could therefore be proportionally lower. Thus, replacement programs might be more cost effective elsewhere, and the benefits – ensuring that old ACs' demand is eliminated from the grid – might outweigh those costs.

3.6 INDONESIA CASE STUDY: PROMOTING ENERGY EFFICIENCY FOR NON-HCFC REFRIGERATION AND AIR CONDITIONING (PENHRA)

The refrigerator and AC manufacturing sectors are the fastest-growing sources of HCFC emissions in Indonesia. The country received a grant from the Montreal Protocol's Multi-lateral Fund (MLF) for the implementation of a performance-based HCFC phase-out management plan (HPMP). Under the HPMP, industries producing refrigerators and AC equipment[28] have to phase out HCFCs completely and convert to non-HCFC technologies by 2018. MLF has asked its implementing agencies to assess opportunities for mobilizing resources to achieve climate co-benefits during the transition to non-ODSs (See Section 2.4 for more information on ODS).

In this context, UNDP, an implementing agency of the MLF and the GEF, has proposed additional investments from the GEF during the transition to non-ODSs, to enhance manufacturing of energy-efficient equipment. The project also includes implementation of policy interventions for accelerating market transformation. Table 20 lists the features of the PENHRA program relevant to the financial incentive offered to manufacturers to upgrade their facilities to produce energy efficient ACs.

Table 20. Indonesia PENHRA Program Case Study Summary

Time Frame	2015 to 2017
Goals	- Reduce GHG emissions
Objectives	Significantly improve the energy efficiency of refrigeration and air conditioning equipment manufactured and used in Indonesia Consider and evaluate the feasibility of the application of energy efficient, low GWP refrigerant alternatives to HCFCs and HFCs
Program Type	Upstream: grants to manufacturers to improve product designs and upgrade production lines to manufacture energy-efficient units
Specification	Not yet defined
Financial incentive	Not yet defined
Implementing Agent	UNDP and Ministry of Energy and Mineral Resources
Funding	US$5M GEF, US$19M co-financing
Evaluation	The project has not been implemented yet. It is waiting for final GEF approval.
Opportunities	The project is expected to be implemented back to back with HCFC phase-out to maximize climate benefits. This project is the first of its kind and can be replicated in countries that are developing HCFC phase-out implementation plans and received financing from the MLF.

[28] In 2009, one-quarter of HCFC emissions were from refrigerator and AC manufacturing.

3.6.1 PROGRAM GOALS

The main goal of this project is to leverage MLF support for Indonesia's HPMP to simultaneously improve the energy efficiency of refrigeration and air conditioning equipment manufactured and sold in Indonesia. The idea is that the stakeholders that participate in Indonesia's HPMP will receive additional assistance to achieve higher energy efficiencies in the products they produce. The project also includes activities that will further promote the use of applicable low GWP refrigerants and will involve the provision of technical assistance on the prototype development, testing, and commercialization of the EE RACs that will make used of feasible energy efficient, low GWP refrigerant alternatives. (GEF, 2015)

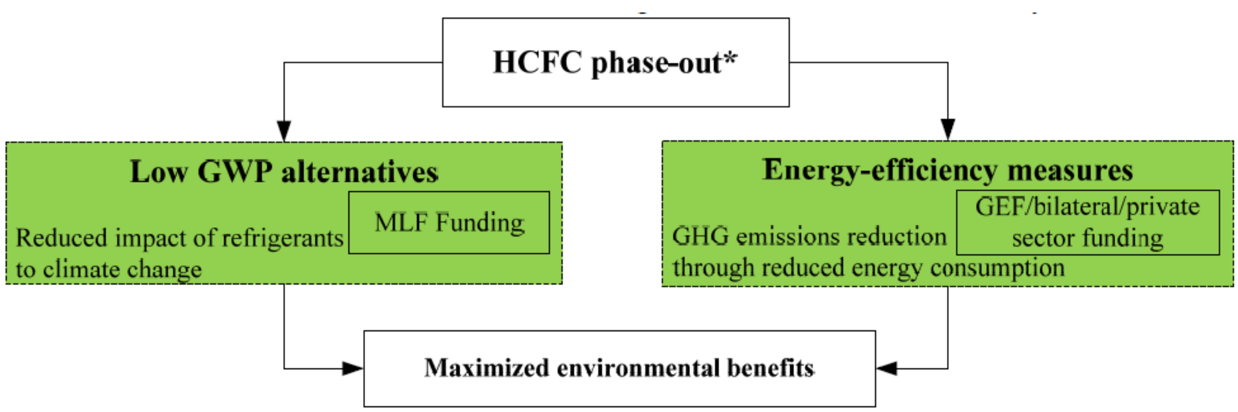
One additional goal of this program is to learn from the design and implementation process to assess the potential for replicating it in other countries that have HPMPs funded by the MLF.

While the country transitions from HCFCs to non-ODSs under the HPMP, technical interventions to introduce safe low-GWP alternatives (reducing the impact of refrigerants on climate change) and to improve energy efficiency (which will reduce GHG emissions through reduced energy consumption) can be most cost effectively. Timely interventions to introduce safe, efficient, low-GWP alternative technologies would maximize the reductions in direct and indirect CO_2 emission reductions in Indonesia, helping meet Indonesia's voluntary CO_2 emission reduction targets.

> ***HPMP Background***
>
> *Under the Montreal Protocol on Substances that Deplete the Ozone Layer, country members, including Indonesia, have agreed to phase out the consumption of HCFCs by refrigeration, ACs, foam, and firefighting. Control measures include:*
> - *A freeze on production and consumption of HCFCs from January 1, 2013, at the Baseline Level (average of 2009 and 2010 consumption levels)*
> - *Reduction of 10% from the Baseline Levels by January 1, 2015.*
> - *35% reduction by 2020*
> - *67.5% by 2025*
> - *97.5% by 2030*
> - *Complete phase out by January 1. 2040.*
>
> *The accelerated phase-out of HCFCs is expected to make significant contributions to ozone layer protection as well protection of the global climate system because of the high GWP of HCFCs.*

The proposal was approved by GEF Council in June 2013 and is now in the detailed design stage.

Figure 14. Funding Flow for Indonesia's HCFC Phase-out and Energy-Efficiency Measures



Source: GEF, 2013.

3.6.2 MODE OF INTERVENTION

The PENHRA project consists of four main components: (1) policy framework, (2) public awareness, (3) manufacturing investment, and (4) training for the refrigeration and air-conditioning industry.

The third component, manufacturing investment, is particularly interesting for this report because it included grants to manufacturers that wish to upgrade to produce more efficient products. The grants are intended to cover the incremental costs incurred for energy-efficiency improvements.

Indonesia's AC industry is concentrated in a relatively small number of well-organized enterprises. About 65% of ACs are manufactured by 15 large enterprises that have good technical and managerial capability. The remaining manufacturing of ACs takes place in small- and medium-sized enterprises. The main challenge for achieving the energy-efficiency improvements identified in the GEF proposal is the price difference between the existing refrigeration and air-conditioning equipment (e.g., room air conditioners) available on the market and energy-efficient products. Consumers are very sensitive to price. This has hampered the local manufacturing sector's ability to invest in upgrading production lines to make more efficient products that are more costly for consumers. Indonesian consumers lack knowledge about energy-saving benefits of efficient products. Moreover, local manufacturing companies lack the technical capability and the financial resources to develop and commercialize energy-efficient products.

Each component of the GEF project aims at addressing a specific barrier that hampers the penetration of efficient products in Indonesia, as summarized in Table 21.

Table 21. Indonesia Program Components

Project Component	Barriers Addressed	Outcome
1- Policy, Regulation and Standards Development for the refrigeration and AC (RAC) Industry	Policy and Institutional	Enforcement of policies, laws, and regulatory support mechanisms to ensure manufacturing and sale of certified quality energy efficient refrigerators and ACs
2- Capacity Building and Awareness Enhancement on the Production and Utilization of Energy Efficient Refrigerators and ACs	Information	Increased consumer awareness of benefits of energy-efficient refrigerators and ACs
3- Promoting Investments for Energy Efficiency Enhancements in the RAC Industry	Financial	Increased production and sales of energy-efficient refrigerators and ACs and enhanced manufacturer capacities to produce efficient equipment
4- Technical assistance for RAC Industry in Energy Efficiency Enhancements	Technical	Enhanced industry knowledge of and capacity to produce efficient refrigerators and ACs

Source: based on project description, GEF, 2013

The program component that promotes industry investment in energy efficiency is intended to overcome financial barriers by helping manufacturers access financial resources to upgrade their facilities so that they can produce more efficient products. One expected outcome of this program component is design and implementation of a financial assistance program. Grants will be provided to manufacturers based on eligibility criteria that will be determined during the program's development.

The intent of the financial support under PENHRA is to cover only the incremental costs that manufacturers incur to improve product designs and upgrade production lines to manufacture energy-efficient refrigerators and ACs. As noted earlier, these improvements will be made at the same time that manufacturers are upgrading their facilities, supported by an MLF grant, to phase out use of HCFCs.

3.6.3 ADMINISTRATION

The Indonesian Directorate General for New and Renewable Energy and Energy Conservation under the Ministry of Energy and Mineral Resources is the lead agency implementing PENHRA. The Ministry of Energy and Mineral Resources is responsible for enacting AC energy-efficiency policies and regulations and providing technical assistance for improving energy efficiency. Implementation is expected to be carried out in close collaboration with the Ministry of Environment and the Ministry of Industry.

UNDP is the lead international implementing agency overseeing both the HPMP and GEF projects in Indonesia. Implementation and monitoring of the HPMP is managed by the Indonesia Ministry of Energy through the National Ozone Unit with the assistance of UNDP and, as noted earlier, financial assistance from the MLF.

Through another UNDP project to accelerate the penetration of efficient ACs (Barrier Removal for Cost-effective Development and Implementation of Energy-Efficiency Standards and Labeling project, BRESL), Indonesia received a grant of US$ 1.8 million to implement a standards and labeling program. With this grant, the Ministry of Energy and Mineral Resources has developed national energy-efficiency standards and labeling for ACs that are expected to be enacted during 2014. The barrier removal project also helped Indonesia's government establish a database of energy-efficient products and implement a consumer education scheme.

3.6.4 FUNDING

MLF monies have been leveraged as co-financing for the GEF AC proposal. The MLF approved a total of US$ 8.9 million for modification of production lines in stage 1 of the HPMP. The manufacturing subsidy component of PENHRA directly builds on this technology upgrade to provide additional grants to manufacturers for upgrading production lines to manufacture energy-efficient products. Table 22 shows the funding by activity.

Table 22. PENHRA Budget

	Indicative Grant Amount ($) (GEF)	**Indicative Co- financing ($)**
1- Policy, Regulation and Standards Development for the refrigeration and AC (RAC) Industry	503,500	842,040
2- Capacity Building and Awareness Enhancement on the Production and Utilization of Energy Efficient Refrigerators and ACs	1,753,300	2,786,421
3- Promoting Investments for Energy Efficiency Enhancements in the RAC Industry	2,077,000	13,895,938
4- Technical assistance for RAC Industry in Energy Efficiency Enhancements	449,022	822,640
Subtotal	**4,782,822**	**18,347,039**
Project Management Cost	238,000	768,010
Total Project Cost	**5,020,822**	**19,115,049**

3.6.5 IMPACT

The project description estimates that 1.48 Mt of CO_2 emissions reduction will result from project implementation. This estimation is calculated over 10 years of equipment lifetime and would be the sole result of penetration of more energy-efficient commercial and industrial refrigerators[29], chillers and ACs, not including the changeover to low-GWP refrigerants. The assumptions consider a current AC baseline EER of 9.5 and an objective of EER of 10.8 resulting from the project. In 2012, 1.44 million AC units were sold. This total is assumed to increase by 5% per year (GEF, 2015). No other information is given, for example about average capacity, load equivalent hours, or emissions factors for electricity consumption. As a comparative reference, emissions from fuel combustion in Indonesia's residential sector were equal to 17.37 Mt of CO_2 for just one year - 2012 (IEA, 2013).

The project description also estimates a GEF unit abatement cost of about US$ 1.11/t CO_2, considering a total funding of US$ 5 million from GEF for the PENHRA project.

During the same time frame as the AC program, the HPMP is anticipated to reduce 32 tonnes of ODSs in the refrigerator manufacturing sector and 54 ODP tonnes in the AC manufacturing sector (Indonesia MOF, 2012).

3.6.6 EVALUATION

No evaluation has been conducted because the project is only starting. As requested for all GEF projects, a mid-term review evaluation is planned for June 2016.

3.6.7 CONCLUSION

At this early stage, little can be said regarding the program's success or lessons that can be learned. However, the program concept may be interesting to other countries that have a refrigeration and AC manufacturing base and have to phase out consumption of HCFCs. The MLF has approved stage-1 HPMPs in 138 countries. As many as 40 countries are already preparing stage-2 HPMPs (UNEP, 2013b). The conversion of AC refrigerants is one of the measures that are implemented to comply with the different HPMP stages. During this conversion, new upstream incentive programs similar to the Indonesia example can be developed to target emissions reductions that provides in addition to HCFC phase-out objectives, energy-efficiency enhancements. Those activities are not eligible for MLF funding but can be funded from other sources such as the GEF in the Indonesia example.

Additional research is needed to provide countries with guidance on viable, reliable, climate friendly refrigerant alternatives that are conducive to energy-efficient improvements, which is not the case for all alternatives. Depending on the alternatives selected, the phase-out of HCFCs can either significantly contribute to climate change mitigation or significantly undermine a country's efforts to reduce its climate impact.

[29] Domestic (Household) Refrigeration is not cover under PENHRA program.

3.7 INDIANAPOLIS CASE STUDY: INDIANAPOLIS POWER AND LIGHT COOLCENTS DEMAND RESPONSE PROGRAM

Indianapolis Power and Light (IPL) is a retail electric service provider in Indianapolis, Indiana. Since 2002, IPL has offered a direct load-control program that focuses on residential CACs.[30] The program employs an adaptive load control receiver installed outside the home, which can manage the CAC's cycle rate so that the unit puts no demand on the grid during certain intervals of time. Aggregated over thousands of participants, this relieves IPL's need for significant amounts of capacity; it can ensure reliability if the grid is strained, and it can reduce IPL's need to pay for energy when energy is most expensive. Table 31 lists the features of IPL's program.

Table 23. Indianapolis Power and Light (IPL) Program Case Study Summary

Time Frame	2002 to the present
Goals	- Peak demand savings - Economic savings from reduced energy use when it is most expensive (at peak demand hours)
Objectives	Incentivize customer to reduce their consumption of ACs during peak period. Through the DR program, IPL avoids paying the highest marginal generation costs during peak demand hours. It directly saves on utility bills for customers that opt-in to IPL's voluntary Time of Use rates
Specification	The program uses adaptive load control switches to manage participants' AC use during program events (i.e. when certain criteria have been met, such as the marginal price of generation rising above a certain amount)
Financial incentive	$5 per month during summer months (June through September), up to $20 max
Program Type	Direct incentive to utility customers through utility bill credit
Implementing Agent	Indianapolis Power & Light and GoolCents
Funding	$1.3 million in 2013 (though only 83% was spent to realize 99% of the goals)
Impact	IPL's DR resources are equal to approximately 1% of installed capacity; in 2013, nearly 20% of eligible customers participated in the program
Evaluation	An evaluation is conducted each year for regulatory filings

3.7.1 PROGRAM GOALS

Because it helps IPL avoid paying the most expensive generation costs (marginal prices during peak hours), the DR program cuts costs for all IPL customers, including both participants and non-participants. DR events (trigger

[30] Note: Although most of the ACs in the US are CACs (not room ACs) the technology and program design for demand response (DR) for either CACs or room ACs are likely to be similar. Hence lessons learned from this case study are likely to apply to both kinds of ACs.

conditions that allow IPL to cycle participants' CACs) are based on economic criteria; for example, if wholesale costs rise above $0.10 per kWh, IPL can cause a proportion of participant ACs to begin cycling less often (this is direct load control). The reduced cycling uses less energy at a time when the marginal kWh is most costly, so overall costs are reduced. [31]

3.7.2 MODE OF INTERVENTION

Approximately 200,000 IPL customers are eligible to participate in IPL's CoolCents DR Program. Between June and September, the program provides a US$5 per month incentive (up to US$20 in one year) to residential customers who allow IPL to remotely reduce their AC use.[32] IPL places an adaptive load control switch (see Figure 15) on the customer's CAC. The switch can "cycle" the unit, i.e., reduce the amount of time it is on, during a DR event. Cycling is not done outside of the hours of 10 am to 5 pm. IPL originally cycled units to be off 30% of every hour during an event. After an evaluation showed that 30% off cycling was resulting in less than the 1 kW demand reduction per unit that IPL expected, cycling was increased to 50% of every event hour. Now the utility is realizing 1 kW per unit. Generally the cycling is either unnoticeable or minimally noticeable from the customer's perspective.

Figure 15. A Cooper Power Systems LCR-5200 adaptive load control switch

3.7.3 ADMINISTRATION

IPL uses a third-party administrator, CoolCents, to implement most program aspects. CoolCents markets the program, recruits and enrolls participants, installs and services the adaptive load control switches (Figure 14), and provides customer service for enrolled participants. It also verifies participant eligibility and tracks participating customers. Promotion of CoolCents is coordinated with marketing for energy efficiency programs.

[31] This demand may shift to off-peak hours, when the marginal price per kilowatt hour is much lower.
[32] The incentive is per unit; many program participants have more than one participating unit.

3.7.4 FUNDING

IPL spent $1.3 million on the CoolCents program in 2013, just 83 percent of its total budget for the program, while achieving 99 percent of program demand and energy savings goals. The program is paid for with ratepayer funds. A DSM adjustment is made on all customer utility bills. The collected funds pay for the CoolCents program in addition to other efficiency and DR programs.

3.7.5 EVALUATION

At the end of 2013, the program had approximately 39,000 customers, about 20 percent of IPL's eligible customer base. An evaluation conducted by TecMarket for the 2013 program year found that the program had saved 28 MW of demand and 191 MWh of energy.[33] The average program cost per kWh saved is $0.069 compared to the minimum event-triggering criterion of a marginal price of at least $0.10 per kWh.

The summer of 2014 was very mild in Indianapolis, and only one DR event was called during the program months. IPL offers an incentive of US$5 per month for each participant signed up for the program, regardless of how much the customer's AC is cycled and for how long. Another approach that could be taken is to offer an incentive that is based on the amount of output provided by the participant. For example, if a participant's AC cycle frequency was changed twice in a month, the participant would be paid accordingly and would receive nothing if their AC cycling frequency was not changed at all in a month.

3.7.6 CONCLUSION

The CoolCents program is evaluated each year. Recommendations from the most recent evaluation focus on collecting more precise and representative usage data to obtain more accurate program performance information.

The CoolCents program has proven to be a cost-effective way for IPL to avoid paying for some of the most expensive energy during the year.

CoolCents program administrators note that DR can be particularly helpful in areas where the population is growing. Concentrating DR efforts in areas where there are new, additional needs for electricity distribution can directly mitigate increased capacity needs. This finding could be valuable in emerging economies where development in new areas may be prevalent, or in areas where new ACs being brought on line are straining the grid a peak load hours.

IPL has a total generation capacity of 3,353 MW. The 29,925-kW capacity of the program is about 0.89% of the utility's overall capacity.

By end of 2013, the program had 39,089 participants, approximately 20% of IPL's 200,000 eligible customers (Allen and Willis, 2014).

[33] Energy savings are calculated by multiplying the power savings by the length of the event. These are not overall savings because reduced use during event hours is often followed by increased use after the event is over. However, they represent kWh that were avoided during the time when energy is most expensive.

4. DISCUSSION

In this section, we analyze and compare the case studies presented in Section 3.

4.1 GOALS AND OBJECTIVES

Experience among programs shows that clearly defined goals facilitate communication of a program's efforts and value to stakeholders. Goals also define the indices against which the programs will be measured. Objectives are generally determined after an analysis of the market barriers that hinder energy efficiency; they form the basis of the program's design.

The most commonly stated goal of the programs in these case study is energy savings, but there are often additional goals. In the China and Mumbai programs, raising public awareness is another overarching goal. In Indonesia, where the program is funded in part by international climate funds, the main goal is the reduction of GHGs through energy efficiency. In China and Mexico, goals include economic recovery. Furthermore, the Mexican program aims at poverty reduction.

Objectives toward goals vary to some degree, but all attempt to reduce the price difference between efficient products and products that simply meet the MEPS. This results from a common observation across programs: the main barrier for energy efficiency is the higher up-front cost of energy efficient ACs. Table 25 summarizes the goals of the case study programs as well as their objectives (the tactics and strategies employed to achieve the goals).

Table 24. Summary of Case Study Programs' Goals and Objectives

Program	Goals	Objectives
China	- Boost the economy - Transform the market - Increase energy-efficiency awareness	- Increase penetration of energy-efficient products by removing the first-cost barriers - Develop a label to increase public awareness of the benefits of energy-efficient products
Mumbai	- Energy conservation - Increase energy-efficiency awareness	Close the price gap between 3-Star AC models and 5-Star AC models for 1,500 units sold to commercial consumers
Mexico	- Boost the economy - Reduce poverty - Reduce GHG emissions	- Replace 170,000 AC units before their end of life - Recycle refrigerants
New York	- Save energy to meet regulator energy-reduction targets	-Provide consumer rebates to reduce the price gap between energy-efficient and standard products
Indonesia	- Reduce GHG emissions - Save energy	- Increase energy-efficiency of ACs manufactured
Indianapolis	- Reduce Peak Load - Save Money	- Incentivize consumers to reduce AC use during peak hours

The China case study program had dual goals of promoting energy-efficient products to "benefit the people" and boosting sales of home appliances to help the country recover from the 2008 financial crisis. The use of energy-efficiency incentive programs to boost the economy is not new. The American Recovery and Reinvestment Act of 2009 and the Japanese government's eco-point programs have similar goals. These programs do not actively seek to reduce energy consumption but rather to increase sales of efficient energy-consuming products. Hence it is critical that evaluations of such programs are not based solely on energy savings, but also include criteria related to the original goal of the program.

In the U.S. case studies, the stated goals are energy savings and peak load reduction. These programs are designed to make energy efficiency the first choice in resource planning and thus to meet energy savings and peak-load reduction targets set by regulators. To measure program administrators' progress toward these goals, regulators developed evaluation, measurement and verification analyses to confirm that programs meet their commitments.

4.2 FUNDING AND FUNDING SOURCES

Financial incentive programs are capital intensive, entailing not just administration costs but also monetary incentives for each participating AC unit. Therefore, funding is an important part of program development and scope. A variety of sources can be tapped for funds, as illustrated by the various case study programs.

The Chinese program illustrates how government funding can leverage very large amounts of capital and have a national impact. This program had the largest funding allocated to the transformation of the AC market: US$1.85 billion over 18 months for the first round (June 2009 to May 2011). The budget for ACs alone was not available for the second round (June 2012 to June 2013), but total funding for that round was US$4.2 billion, covering flat-panel televisions, ACs, refrigerators, washing machines, and water heaters. A key reason for the magnitude of funds allocated is that the program was motivated by the need to boost China's economy after a slowdown in 2008. The government deployed the incentive program to stimulate economic activity while also promoting clean technology development. Table 26 summarizes the case study funding sources.

Table 25. Summary of Case Study Funding

Program	Source of Funding	Funding (US$)
China	Government	Round 1: $ 1.85B Round 2: NA
Mumbai	Ratepayers	$330,000
Mexico	GEF, IBRD, CTF, Government, Private sector	$60 M
New York	Ratepayers	$1.1 M
Indonesia	GEF, Government, Private sector	$25 M
Indianapolis	Ratepayers	$1.3 M

Government funding generally does not provide a sustainable source of funding for market transformation. It is also subject to a country's political climate. Ratepayer funds are a more sustainable funding. In the two U.S. cases, energy-efficiency programs are funded by a small levy or charge — a fraction of a cent per kilowatt-hour — on electricity sales. This levy goes into a common public fund that is used to recover the cost of implementing efficiency programs. In the Mumbai case study, the program cost is also recovered through electricity sales but as part of the rate base used to determine retail energy prices. India is gradually developing a regulatory structure similar to that in the U.S., in which ratepayer funds are used to recover program costs (PACE-D, 2013).

As can be seen in Table 25, the funding level varies significantly among the cases studied in this report, from a small pilot program in Mumbai with a budget of US $330,000 to a large national program in China with a budget of US$1.85 billion. This reflects the differences in potential scope and geographic coverage of AC programs; both are linked to the territory covered by the program's administrative body. National programs tend to have larger scope;

utility (energy provider) programs are limited to the provider's service territory. Little is generally known on how budgets are spent. In our case studies, the breakdown was available only for New York's program; about 70% was spent on incentives, 15% on administrative cost, 10% on Marketing and 5% on EM&V (Table 19).

A few programs in developing countries use money from international climate funds. Mexico's PNSEE is supported by a loan from the IBRD and a grant from the GEF (WB, 2010), and Indonesia's PENHRA program is supported by a grant from GEF (GEF, 2013). In both cases, the grants from the international climate funds leverage funding from the national government and private companies. In the Mexico case, about two-thirds of the program costs are leveraged by co-financing. In the Indonesia case, 85% of the program costs are leveraged by co-financing.

4.3 PROGRAM DESIGN OVERVIEW

Incentives can be directed at different points in the AC supply chain as one may be more effective than another depending on the technology's maturity, market penetration, supply chain and market barriers. As noted earlier, incentives are typically implemented through downstream, midstream, or upstream programs, and each addresses different barriers.

Table 26 summarizes some of the main program design features of the case studies, which are discussed in the following subsections.

Table 26. Summary of Case Study Program Design Elements

Program	Program Type	Energy-Efficiency Specification	Features	US$ per unit
China	Upstream	Tier 1 and Tier 2	Endorsement label	R 1: $30-$127 R 2: $29 to $63 depending on AC size
Mumbai	Upstream	5-Star	- Replacement program - refrigerant recycling	$67 - $83 depending on AC size
Mexico	Downstream	MEPS	- Early replacement program - On- bill financing - Refrigerant recycling	Between $25 and $70 in rebates and up to US$470 in financing depending on monthly energy consumption
New York	Downstream	Energy Star	Marketing targeted in the spring	$25 per unit
Indonesia	Upstream	Not yet determined	Attention to ODSs, energy efficiency, and GWP	Not yet determined
Indianapolis	Demand Response	Not Applicable	An adaptive load control device placed on AC	$5 per unit per month up to $20 per year

Program Type

Upstream incentives are effective for influencing a large portion of the market through fewer actors and therefore have lower transaction costs. This is one of the main reasons that the Chinese government used an upstream program for its very large market (Fu and Liu, 2014). In the Mumbai case study, an upstream program was used to achieve the maximum cost reduction in energy-efficient products. A bidding process was used to buy down the price of the efficient models, resulting in a reduced price to consumers through a combination of manufacturer discounts and program incentives. By reducing the price before products reach the market and therefore before the retailer markup, upstream programs have a greater impact on purchase price than downstream programs. However, the most challenging aspect of upstream programs is making sure that the incentive reduction is passed through to consumers. Program administrators must have robust monitoring and verification to ensure the full benefits go to the consumers. In the China and Mumbai programs, the incentives are delivered only after manufacturers prove that their products have been sold at a specific price. Upstream programs can be invisible to the consumers, but both of these programs used advertising to encourage consumers to buy the discounted products. This was part also of strategy to raise public awareness about the benefits of buying efficient products.

Downstream incentives have the advantage of raising consumer awareness of the benefits of highly efficient products, which has positive spillover effects on other energy-efficiency purchases. The existence of a rebate is a signal in itself and may be even more important than the cash amount in some cases. Moreover, downstream programs have the flexibility to be directed to selected populations, such as low-income households, like in the Mexican example.

Energy-Efficiency Specification

Most of the programs we studied targeted AC products with either endorsement labels or the most efficient levels on a comparative energy efficiency label scale. Table 27 estimates the efficiency improvements targeted by the programs based on the different label ratings, the energy efficiency rating and the percentage increase compare to MEPS.

Table 27. Energy-efficiency Specification Comparison

	Size (Watts)	baseline year	EER MEPS	EER Program Target	EE improvement
CHINA, Round 1	**FS, Split type, 2800<CC<=4,500**	**2009**	2.6	3.2-3.4	27%
CHINA, Round 2	**FS, Split type, CC≤4500**	**2012**	3.2	3.4-3.6	9%
	VS, Split type, CC≤4500	**2012**	3.2	4.5-5.2	52%
INDIA	**Split type, CC=5,200**	**2014**	2.9	3.5	21%
PENHRA	**Room AC, 3,134**	**2015**	2.8	3.2	14%
NEW YORK	**Room AC, 4,458 to 6,367**	**2012**	3.10	3.57	15%

Incentive programs target efficiency rating 14% to 52% higher than MEPS across the programs listed in Table 27. However, it is important to note that programs cannot be compared solely on their EER targets because they happen at different point in time, in the different market, for different product size, and goals are sometime different (replacing old stock, stimulating new sales). Moreover, EER rating does not necessarily translate into energy savings: program targeting very high EER ratings may have little uptake when the cost of the product remains high.

Additionally, the baseline of new AC sales is not necessarily the MEPS, especially in countries with slow-moving or weak standards, or in instances where the label for the lowest level of efficiency is perceived to be analogous to "low-quality". For example, in India's "star" rating program, the market average of sales tends to be around 3 stars

(EER of 3.1 to3.29) because hardly any manufacturers produce 1- or 2-star rated AC products (Pramod Deo, 2014). In the Mexican program, the baseline efficiency of the products replaced is lower than the MEPS because the program replaces units that have to be at least 10 years old.

One of the findings from the U.S.–New York program evaluation was that the program had a high free-ridership effect, estimated at 53%. This implies that over half of participating households would have bought Energy-Star ACs even in the absence of the program, reducing the program's estimated net energy savings by 53%. One explanation for the large percentage of free riders is that the program targeted an energy-efficiency specification that had already a significant market share. The evaluation study included a recommendation to implement tiered incentives, with higher rebates for higher-efficiency models. Similar observations have been made about other programs and have been pointed out in several evaluation studies (Lees, 2008; Gold and Nadel, 2011; de la Rue du Can, 2014)

Features

The case study programs illustrate some specific program features that complement program goals:

Replacement eligibility
A few programs, including the Mexican and Mumbai programs evaluated in this report, have a replacement component in their eligibility criteria that requires participants to surrender old units to be eligible for the incentive. This feature accelerates the rate at which the old appliance stock is replaced. The programs aim to reduce electricity use by both encouraging the deployment of efficient ACs and ensuring that older, less-efficient ACs are removed from the stock. These programs have the added advantage of minimizing the potential for increasing demand from old equipment that could otherwise be re-sold on the secondary market. The economic feasibility of early replacement depends on the vintage of the unit being replaced, the installed cost of the new unit, and the energy savings from the new unit. These programs are often directed at low-income households, which tend to have older, less-efficient appliances than the average household. Besides the energy-efficiency benefits, programs that replace old equipment are also attractive because they offer an opportunity to recycle old appliances and properly dispose of refrigerants that deplete ozone and contribute to global warming.

On- bill financing
The Mexican case study features an innovative financing design that allows participants to pay for the efficient unit through their electricity bills. This on-bill financing programs allow consumers to spread out the up-front cost of buying an energy-efficient appliance and to offset the monthly payments with the energy savings from the unit. Because most consumers are familiar with paying their electricity bill, even if they are not familiar with taking out a loan, on-bill financing could be used to reach many different consumer segments.

ODS recycling
Recycling ODSs and other components of old ACs goes along with replacement programs. As mentioned in Section 2.4.2, ACs contain refrigerants that deplete ozone and have high GWP. Recycling old units and properly disposing of these gases allow reduced impacts on the ozone layer and could also reduce climate change impacts if replaced with low-GWP refrigerant using ACs. However, this recycling comes at a significant cost, estimated at US$30 per unit in the Mexican program. The possibility of receiving carbon credits for disposing of these gases offers governments a potential avenue to recover the recycling costs.

Incentives

As can be seen in Table 26 the monetary incentives provided range from US$29 to $127 in the programs we analyzed. These incentives depend on the criteria in each program. The Chinese, Mumbai, and New York programs offer different monetary incentives according to the size/capacity of the equipment. In our case studies, only the Chinese program offered incentives according to the level of efficiency. One interesting aspect of the Mexican program is that the incentive offered varied according to the level of electricity consumption. Electricity consumption was used as a proxy for determining whether a consumer qualifies as a low-to-medium-income household in terms of its electricity consumption. Lower consuming households were eligible for larger vouchers to target lower income customers.

4.4 EVALUATION

The rigor of program evaluations varies widely. Rate-funded programs tend to have the most rigorous evaluations because their level of success impacts planning for future resource investment and they are part of a cyclical regulatory process. Regulators need accurate estimates of energy savings to plan for future energy capacity. According to a 2012 Consortium for Energy Efficiency report, evaluation, measurement, and verification accounted for an average 3.6% of the total amount budgeted for U.S. rate-funded energy-efficiency programs. Government-funded programs are not systematically evaluated. In addition, a particular program may have multiple goals, which can be broad, especially when the goals include economic stimulus; multiple goals complicate evaluation of the program's success. International Climate fund projects are not evaluated at the project level. However, some institutions, for example GEF, require mid-term reviews and a final evaluation report.

Evaluations of energy savings help us estimate the net savings resulting from a program, i.e., the energy savings strictly attributable to the program. Net savings exclude free ridership, rebound effects, and other program effects but include spillover effects. Table 28 summarizes parameters that should be considered in estimating net energy savings.

Table 28. Parameters to Consider in Estimating Net Program Energy Savings

Effects	Description
Rebound effect	Reduction in energy costs causes customers to increase their energy use, diminishing the actual energy savings achieved.
Free ridership	Savings from program participants who would have undertaken the efficiency activities in the absence of the program should be excluded.
Spillovers	Savings beyond the program participants that resulted from the program's influence should be included.
Other programs	Net savings also exclude the demand-reduction effects of other programs – such as standards and labeling, building codes, and other financial incentive policies – and of external phenomena such as economic recession or accelerated economic growth.

Third-party evaluations were available for four out of six programs studied in this report. The two U.S. programs (New York and Indianapolis), have regulatory obligations to retain third parties to evaluate their programs. In these cases, the evaluations helped the program administrators modify the programs to optimize impacts. Two other programs had evaluations sponsored by independent organizations. The Collaborative Labeling and Appliance Standards Program (CLASP) assessed the Chinese promotion program, and researchers from the University of California (UC), Berkeley evaluated the Mexican program. Table 29 summarizes some key findings of these evaluations.

Table 29. Summary of Case Study Evaluation Findings

Program	Evaluation	Main Findings	Recommendations
China	CLASP	During the program's 2nd round, the penetration of targeted energy-efficiency requirement was already high	Target higher level of efficiency
Mexico	UC Berkeley	High rebound effect offsetting energy savings	None specified
New York	Contracted out	Free-ridership accounted for 53% of savings	Implement tiered incentives with higher rebates for higher-efficiency models
Indianapolis	TecMarket Works, et al	Achieved 99% of objectives including approximately 30 kW	Improve data gathering for better evaluation precision

An interesting finding across the evaluations is that programs tend to have a higher free-ridership when they target AC products that already have significant penetration. This is the case in the New York and the second round of the China programs. In both cases, evaluation studies recommended targeting higher efficiency levels.

However, as the efficiency level required by a program increases, the program cost also increases because more efficient products tend to be more expensive. Program administrators need to balance these different factors influencing energy savings to maximize results at the lowest cost.

Another important parameter to consider when evaluating net savings is the share of rebound effects. This is one of the main findings from the UC Berkeley evaluation on the Mexican program. Davis, et al. determined that the program experienced a significant rebound effect which had a net impact of slightly increasing energy consumption. However, these results should not necessarily be considered negatively because the rebound effect is also the result of improved service value, which is essential for wealth creation and social development. More research is needed to understand how increased energy use was correlated with increased service. Low income household programs tend to have a modest return for energy efficiency investment when only energy savings are considered. However, these investments have additional co-benefits for energy providers, program participants, local communities and society as a whole. These non-energy co-benefits are not currently considered in the program evaluation conducted by Davis et al. but may need to be included in order to provide a more complete picture of the impacts of this program.

Evaluations help measure the success of a program in relation to the goals set by policy makers. Other measures of success that can be taken into account include the program's participation rate and its long-term market transformation impacts.

Cost Effectiveness

The costs of reducing energy consumption are a major concern for policy makers. However, measuring the success and calculating the cost effectiveness of energy-efficiency programs are very challenging tasks and difficult to compare. Comparison of cost and savings implies that they are calculated using the same methodology, but many factors enter in the equation: gross versus net savings, discount rate, and administrative costs, for example. Table 31 summarizes some of the findings based on the data and evaluation available for the case studies but should not be compared across programs, since a fair comparison would need to account for various contextual factors that are not represented in the energy saving cost per se.

Table 30. Case Study Program Cost per kWh Saved

Program	Energy saving cost ($US/kWh)
China	$0.02
Mumbai	$0.05 – $0.09
Mexico	$0.086
US- New York	$0.04 – $0.09

The studies concluded that the cost of saved energy by ratepayer-funded energy-efficiency programs compares favorably to the cost of energy-supply options.

5. LESSONS LEARNED

Policy makers, regulators, and utilities, and multi-lateral institutions can use incentive programs to transform the AC market to:

1) Increase penetration of energy-efficient AC models and thereby reduce growth in energy consumption
2) Include DR communication devices in ACs to reduce growth in peak demand and increase grid reliability
3) Induce and accelerate a shift to refrigerants that are non-ozone-depleting and have low GWP to ameliorate ozone and climate-change impacts

Energy Efficiency

The cases studied in this report demonstrate that incentive programs can transform markets for energy efficiency. These programs are particularly effective in transforming markets for energy-efficient products that have a low penetration. The China case study shows how a large national program rapidly changed the penetration of energy-efficient products from 5% to 70% in less than two years, at a cost well below the cost of new energy supply. However, the New York case study shows that free-ridership can have a large impact on a program's success and that targeting higher efficiency levels may be most effective. The Mexican case study highlights the need to understand the rebound effect that may offset some of the expected energy savings of a program. This program also highlights the need to assess the co-benefits of incentive programs. The Mumbai case study shows that it is possible to use a bidding process to incentivize manufacturers to produce efficient products.

Large, cost-effective energy savings remained untapped by consumers. Incentive programs can be designed to remove the significant barriers that prevent consumers from accessing efficient equipment and help consumers to save on their energy bills. In addition to saving energy, incentive programs can also impact in other benefits of increased energy efficiency such as increased energy reliability, increased productivity, and increased social welfare. Program goals need to be clearly stated, and attention must be paid to the potential for a significant rebound effect in economies that have large unsatisfied demand.

Features that increase program co-benefits include:

- Incorporate a replacement component to reduce the stock of old ACs and limit the use of old equipment.
- Use marketing to increase public awareness of the benefits of energy efficiency.
- Engage with manufacturers to reduce transaction costs.

One important lesson learned is that energy savings impacts from incentive programs tend to be higher when they target efficiency levels that have a low market penetration. Otherwise, programs have a high share of free ridership, as demonstrated in the New York case study.

By increasing the market penetration of highly efficient technologies that are at an early stage of development, incentive programs helps to streamlining the production process and allows manufacturers to take advantage of economies of scale and learning effects. This contributes to further reduce the cost of production. Incentive programs should be temporary and then target higher efficient levels. In Lees' evaluation of the British schemes, the Energy Efficiency Commitment (EEC) 1 and 2, the analysis suggests that technologies with a market penetration greater than 30–40 percent do not need to be financially incentivized (Lees, 2008).

In the case of ACs, it is also important to adopt a technology-neutral approach. Incenitve programs should be employed to help move the market for VS ACs only which are the most efficiecnt technology to cool air. In the case studies, incenitives are often offered to both VS and FS ACs. This stems from the fact that S&L are not technology neutral in many countries and have performance rating for both technologies which can be misleading for consumers (li et al, 2013).

Demand Response

Because ACs consume significant amounts of energy particularly during times of peak demand, the ability to manage their consumption can free up significant peak capacity, helping to ensure grid reliability and address other issues, such as intermittency issues associated with renewable energy sources, which may become an important and expanding addition to emerging countries' power generation mix.

DR is not common in emerging countries. Advanced communication technologies can increase the efficiency and effectiveness of DR although certain program structures can use inexpensive technologies or no technology at all.

Recycling Refrigerants and Shifting to Low-GWP Refrigerants

ACs use refrigerants that are powerful GHGs; some also damage the ozone layer. AC incentive programs can reduce the impact of refrigerants on the environment through two different strategies:

- By requiring that new efficient equipment replace old units and establishing a collection, storage, and disposal process to ensure that old units are retired and the refrigerants are safely disposed
- By maximizing the environmental benefits of the refrigerants used in new products

Incentive programs targeting ACs could help accelerate the transition to the fourth generation of low-GWP refrigerants. The Indonesia case study shows how a program can be designed to maximize climate benefits through energy-efficiency enhancements when a country transitions to non-HFC refrigerants. More opportunities exist, and implementing agencies need to seek funding to maximize environmental benefits.

Conclusion

Incentive programs have a significant role to play in transforming the market to more efficient ACs. These programs can also help reduce peak load and move the market toward ACs that have low GWP. Finally, incentive programs can help remove old inefficient equipment from the stock faster and allow recycling of ACs' environmentally damaging refrigerants.

Global experience with AC incentive program designs shows that programs are very diverse, and there is no single model that is universally applicable. Programs should be designed taking into account the specific barriers that hinder the penetration of more efficient products in the local market.

Although global experience is encouraging, and results are positive, more efforts are needed to move the market faster toward efficient and innovative technologies that better answer the challenges posed by growing demand for cooling services. Moreover, a program has yet to be designed that combines multiple objectives, e.g., refrigerant transition, efficiency improvement, and demand-response participation. Policy makers and program administrators need to develop innovative designs to achieve these multiple inter-related goals.

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