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# Design of incentive programs for accelerating penetration of energy-efficient appliances

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## HIGHLIGHTS

- We researched incentive programs design and implementation worldwide.
- This paper seeks to inform future policy and program design.
- We identify design and identify advantages and disadvantages.
- We find that incentive programs have greater impact when they target highly efficient products.
- Program designs depend on the market barriers addressed and the local market context.

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## ABSTRACT

Incentives are policy tools that sway purchase, retail stocking, and production decisions toward energy-efficient products. Incentives complement mandatory standards and labeling policies by accelerating market penetration of products that are more energy efficient than required by existing standards and by preparing the market for more stringent future mandatory requirements. Incentives can be directed at different points in the appliance's supply chain; one point may be more effective than another depending on the technology's maturity and market penetration. This paper seeks to inform future policy and program design by categorizing the main elements of incentive programs from around the world. We identify advantages and disadvantages of program designs through a qualitative overview of incentive programs worldwide. We find that financial incentive programs have greater impact when they target highly efficient technologies with a small market share, and that program designs depend on the market barriers addressed, the target equipment, and the local market context. No program design is inherently superior to another. The key to successful program design and implementation is a thorough understanding of the market and identification of the most important local obstacles to the penetration of energy-efficient technologies.



## 1. Introduction

Numerous studies have demonstrated that the penetration of energy-efficient equipment is far below the level that is cost-effective for energy consumers (IPCC, 2007; McNeil et al., 2008; Letschert et al., 2012). Energy-efficiency policies seek to close this gap (Golove and Eto, 1996) by identifying and addressing the barriers that prevent consumers from investing in energy-efficient equipment. These barriers are diverse, including lack of information, split incentives (e.g., between landlords and renters), high transaction costs (costs of participating in a market), lack of technical expertise, and lack of energy-efficient equipment on the market (Eto et al., 1996; Sathaye and Murtishaw, 2004; Jollands et al., 2010; Murphy and Meier, 2011). One of the most significant barriers that policy makers identify to the purchase of energy-efficient equipment is the relatively higher up-front costs of efficient products. In many instances, these costs deter potential purchasers even when investments appear to be in consumers' interest (i.e., when investments are cost effective over the equipment lifetime). Consumers place great value on immediate savings and heavily discount future savings (Hausman, 1979; Houston, 1983). Moreover, because they may not be able to easily evaluate future savings, consumers tend to have a low degree of confidence in expected paybacks. As a result, consumers often purchase the cheapest options available.

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Numerous incentive programs have been developed worldwide to address these barriers and accelerate the penetration of more efficient equipment. A recent study by the Buildings Performance Institute Europe (BPIE) screened 333 different financial schemes in Europe alone (BPIE, 2011). The DSIRE database records more than 1300 programs in the United States. (DSIRE, 2013). In some instances, these programs are part of national government energy-efficiency policies; in others, the programs are part of utilities' integrated resource planning strategies.

Although the literature describes energy-efficiency policy general (IEA, 2010; WEC, n.d.; Ortiz et al., 2009; Geller and Attali, 2005), the design and use of incentives worldwide has not been comprehensively studied. The literature addresses incentives in the United States (e.g., Nadel et al., 2003; DSIRE, 2013; Fuller et al., 2010; U.S. EPA, 2010; Eto et al., 1996), in Europe (BPIE, 2012; Vine, 1996), and, to some extent, internationally (Hilke and Ryan, 2012; Sarkar and Singh, 2010; Birner and Martinot, 2005). However, it rarely reports on the specific design or mechanisms by which programs aim to accelerate market penetration of residential appliances and equipment. For example, the recent BPIE (Maio et al., 2012) and IEA reports (Hilke and Ryan, 2012) address incentives that target building improvements but do not address the mechanisms that target residential appliances.

This paper attempts to remedy this gap in the literature by describing the main design characteristics of incentive programs that encourage consumers to purchase highly efficient residential appliances and equipment. The paper's objective is to provide those policy makers and program administrators considering implementing incentive programs an understanding of what these key characteristics are and what tradeoffs are involved with them. We first describe the regulatory frameworks that govern development of incentive programs in major economies, to characterize how incentives are being implemented globally. We then categorize the main elements of incentive program designs and analyze advantages and disadvantages of a variety of program designs. Finally, we provide a variety of examples to illustrate how programs in several major economies attempt to accelerate market penetration of efficient residential equipment and appliances.

## 2. Overview of policy frameworks and program designs

### 2.1. Policy frameworks

The typical policy frameworks in which incentive programs develop are either (1) direct government roll-outs with money raised through taxes or (2) mandatory savings goals (also referred as *obligations*) set for energy providers (also referred as *utilities*) to reduce their customers' energy use. This is illustrated in Fig. 1.

Incentive programs have been principally implemented by governments to fuel long-run growth of domestic clean product markets. By increasing production of efficient products that are at an early stage of development, incentive programs help technology (and thus the market) mature and spur private-sector investment. Implementation of incentive programs can also be motivated by the need to boost an economy in times of recession; governments deploy incentive programs to stimulate economic activity while also promoting clean technology development.

Governments have also created regulatory frameworks that compel energy providers to deliver energy savings. Energy providers often then become the administrators of energy-efficiency programs. Utilities' direct link to energy consumers and access to valuable data on energy usage patterns are a significant advantage in designing effective programs. However, energy efficiency is not an obvious business for utilities to undertake because when consumers save energy, utilities sell less of their product. Some

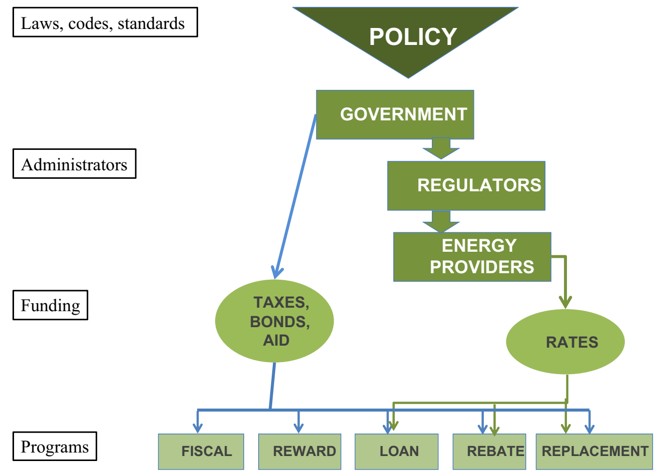


**Fig. 1.** Incentive program policy framework.

U.S. states have developed market regulations to remove utilities' disincentive to conserve energy and to incentivize utilities to invest in efficiency. These include regulations that decouple revenue and electricity sales and shareholder incentives to achieve energy efficiency beyond targets (Satchwell et al., 2011; EEWG, 2008; U.S. EPA, 2007; Schultz and Eto, 1990). In some cases, the responsibility for meeting savings goals is delegated to a third party or government agency that implements the programs.

Table 1 lists countries that have policy frameworks mandating that energy providers save energy.

Utilities in the United States have the longest experience – more than three decades – in executing energy-efficiency programs. However, the scope and intensity of these programs vary significantly among states. Twenty-seven U.S. states have set efficiency goals for their electric energy providers, and 12 also have goals for natural gas providers (DSIRE, 2012). According to the Consortium for Energy Efficiency's 2012 annual report (CEE, 2012), a total of US $8 billion was budgeted for gas and electric efficiency programs in 2011, a 20-percent increase over the previous year. Of this funding, one-third is allocated to residential-sector efficiency measures. California has by far the largest share of rate-funded programs, with a budget of US$3.1 billion over three years and a requirement that about 1.3 percent of annual sales be met with energy-efficiency programs. Massachusetts has one of the most aggressive targets, 2.4 percent of annual sales.

In Europe, the UK was the first country to implement an obligation scheme in 1994, the Energy Companies Obligation (ECO). ECO has evolved and is now combined with another scheme called the Green Deal (DECC, 2011).

Other European countries—Denmark, the Flemish region of Belgium, Italy, France, and recently, Poland—have also implemented energy-saving obligation schemes (Lees, 2012; Staniaszek and Lees, 2012; Heffner et al., 2013). In France and Italy, the efficiency targets are accompanied by trading markets where a unit of energy savings known as a "white certificate" can be either sold or purchased. Energy saved in any sector counts toward meeting an obligation. A new EU directive on energy efficiency requires that all EU Member States implement utility energy savings obligations equivalent to 1.5 percent of annual sales (EC, 2012), so other European countries are expected to follow the example of those that have already adopted these schemes.

Other examples of savings obligation schemes around the globe include those in some Australian states, Brazil, South Korea, South Africa, China, and India (Balawant, 2012; Lees, 2012). The Australian state of New South Wales implemented the world's first mandatory greenhouse gas (GHG) emissions trading scheme in

**Table 1**
Examples of energy provider regulatory obligations.

| Country | Policy | Time frame | Obligation |
|---|---|---|---|
| **Australia (New South Wales [NSW], Victoria, South Australia)** | State-based energy-efficiency schemes | Since 2003 in NSW | Electricity and natural gas (electricity only in NSW) |
| **Belgium– Flanders** | Energy-saving obligation schemes | Since 1995 | Electricity |
| **Brazil** | Wire charge (PEE) | Since 1998 | Electricity |
| **Canada** | Province-based energy-efficiency schemes | Since 1985 | Electricity and natural gas |
| **China** | National energy efficiency regulations | 2011 to present | Electricity |
| **Denmark** | Demand-side management scheme | Since 1995 | Electricity, district heating, natural gas and heating oil |
| **EU** | Directive for energy saving obligations for member countries | TBD | TBD |
| **France** | White certificates | Since 2006 | Electricity, natural gas, and gasoline |
| **India (Maharashtra)** | Maharashtra public benefits-type charge | 2005 to present | Electricity |
| **Italy** | White certificates | Since 2005 | Electricity and natural gas |
| **Poland** | Energy-saving obligation scheme | Since 2011 | Electricity, district heating, natural gas |
| **South Africa** | The Standard Offer Program | Since 2011 | Electricity |
| **South Korea** | Rational Energy Utilization Act | Since 1995 | Electricity, district heating, natural gas |
| **US** | Utility-sector customer energy-efficiency programs and now energy-efficiency resource standard | Since 1975 | Electricity & natural gas |
| **UK** | Energy Efficiency Standards of Performance (EESoP), which became the Energy Efficiency Commitment (EEC), which then became the Carbon Emissions Reduction Target (CERT) | Since 1998 | Electricity and natural gas (residential sector only) |

2003, in which GHG emissions from electricity sales are capped each year (IPART 2008, 2010). Since 1998, the Brazilian power regulatory authority, ANEEL, has mandated that utilities invest at least 0.5 percent of their net revenues in energy-efficiency programs (Taylor et al., 2008). Programs are funded through a wire charge. The Brazilian Congress requires that about half of these funds must be spent on energy-efficiency measures targeted at low-income households. According to Taylor et al. (2008), investments from the wire charge proceeds are about five times greater than investments by PROCEL, the government program for electricity-sector efficiency.

Similarly, in South Korea, the Rational Energy Utilization Act covers investments rather than focusing on specific energy savings. The act requires that each energy utility establish an annual DSM investment plan with a total budget greater than the previous year's (Balawant, 2012).

In South Africa, the government set an initial energy-savings target of 4055 GW h (and 1037 MW) for the period 2011–2013. Eskom, South Africa's only utility, was allocated a budget of R 5445M (US$651 million) for programs to meet the target. A new phase, the Multi-year price determination 3, started in March 2013 with approved funding of R 5183M (USD 641M) for a period of 5 years, 2013 to 2018; savings goal are yet to be decided.

In China and India, utility efficiency programs are still in early stages of development. In November 2010, China adopted national energy-efficiency regulations that took effect on January 1, 2011 and require China's power grid companies to save the equivalent of at least 0.3 percent of their sales volume and 0.3 percent of maximum load compared with the previous year (Finamore et al., 2010; Plunkett et al., 2012). In India, the Maharashtra Electricity Regulatory Commission (MERC) instituted a public-benefits type of electricity charge on utilities, with the funds to be used to finance renewable-energy and energy-efficiency programs in the state. In late 2005, MERC ordered utility companies in the state to use these resources to start CFL programs in Mumbai's residential sector and in the Nasik District (Sathaye et al., 2006).

As can be seen from these examples, governments around the world are developing policy frameworks to increase the role of energy efficiency in meeting new energy demand. These new regulations often lead to the development of incentive programs.

### 2.2. Funding sources

Financial incentive programs are capital-intensive endeavors, entailing not just administration costs but also the costs of monetary incentives for each participating appliance unit. A variety of sources are tapped for funds, each with strengths and weaknesses. To transform markets, schemes must be viable over the long term, so funding must be sustainable. In addition, the scale of the funding must match the magnitude of the objective. And, because large capital transfers are involved, transparency is critical.

In most cases, government-sponsored incentive programs are funded through general government budgets financed by taxpayers. In the case of special stimulus packages, funding comes from exceptional funds, such as the American Recovery and Reinvestment Act of 2009 in the United States. 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 Environmental Facility. For example, Mexico's Programa Nacional para la Sustitución de Equipos Electrodomésticos (PNSEE) is supported by loans from the World Bank and capital from the Global Environmental Fund (WB, 2010). India's Super-Efficient Equipment Program (SEEP) for electric fans will be supported by the Clean Technology Fund (CTF), which is administered by World Bank (Chunekar and Singh, 2013).

These funding sources can leverage large amounts of capital but tend to have a short-term horizon. Incentive programs that result from a goal set for an energy provider's sales have a longer term horizon. They are funded either explicitly or implicitly by ratepayers. Explicit mechanisms charge a defined amount as part of the electricity rate. In the United States, South Africa, South Korea, and Brazil, energy-efficiency programs are generally 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 programs (Eto et al., 1998). Implicit mechanisms include the cost of energy-efficiency programs as part of the rate base used to determine retail energy prices. This is the case in the UK where the energy market is liberalized, and utilities recover their costs through their tariffs. Price impacts in the UK have been estimated at approximately 1.5 percent (Eyre et al., 2009).

Other funding mechanisms are less common and often less flexible. For example, a revolving fund can be established in programs where financial incentives are paid back with accrued energy savings. A prominent example of a revolving fund is the Kreditanstalt für Wiederaufbau (KfW) created by the German government. The KfW Institution partners with private banks to offer advantageous loan conditions to consumers wishing to invest in energy-efficiency improvements (KfW Bankengruppe, 2011). Revolving funds are an excellent source of capital for energy efficiency over the long term. However, these funds are generally better suited to programs that support investment in or refurbishment of large equipment.

Earmarked taxes can finance specific energy-efficiency programs. These taxes are especially powerful when they are applied to energy-consuming products and the resulting revenues are used to support purchase of efficient alternatives. For example, South Korea introduced a 5- to 6.5-percent tax on energy-consuming home appliances; the revenues from this tax were used to subsidize the purchase of highly efficient products by low-income households (IEA, 2010). This type of policy is sometimes referred as a *feebate*; a tax or "fee" on less-efficient equipment is used to fund a rebate on more efficient equipment. If designed and monitored carefully, this financing mechanism can be a revenue-neutral policy and can be independent of government general budgets. However, careful, continuous monitoring is required to make sure the balance is kept.

The recently introduced "Programmatic Clean Development Mechanism (CDM)" approach for financing energy-efficiency projects is being used in India's Bachat Lamp Yojana (BLY) program. Under this program, the state utility receives CDM revenues based on the number of CFLs sold; these funds are passed on to the consumer in the form of rebates on CFLs that reduce or eliminate the cost difference between the price of a CFL and an incandescent bulb. Several utility companies in India have implemented the BLY program (BEE (Bureau of Energy Efficiency) (no date)).

Table 2 lists the main funding approaches described in this subsection, with examples.

**Table 2**
Source of government funding for incentive programs

| Funding source | Examples |
|---|---|
| **Government budget** | • Most tax and subsidy incentive programs |
| **Stimulus funds** | • American Recovery and Reinvestment Act of 2009<br>• Japan's Eco-point Program |
| **International financial institution** | • Mexico's PNSEE<br>• India's SEEP |
| **Revolving fund** | • Germany's KfW loans<br>• U.S.'s PACE program |
| **Feebate** | • South Korea's promotion of energy-efficient goods |
| **Programmatic clean Development mechanism (CDM)** | • India's BLY program |
| **Rate charge** | • Brazil's wire charge<br>• Korea's electric power infrastructure fund and investments in demand side management<br>• U.S. state energy-efficiency programs<br>• UK carbon emissions reduction target (CERT) |

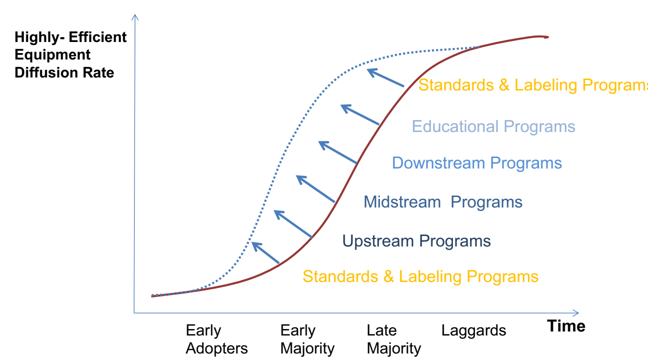


**Fig. 2.** Impact of market interventions on highly-efficient technology diffusion rate.

### 2.3. Program designs

The key challenge of incentive program design is to achieve durable market transformation (Rosenberg and Hoefgen, 2009; Nadel and Latham, 1998; Eto et al., 1996). Programs need to be tailored to address the different stages of an energy-efficient product's market diffusion in order to accelerate the product's penetration in a sustainable manner.

The diffusion of highly efficient technologies generally follows an S curve (Rogers, 1962, 2003). 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 the technology has proven itself, the technology's market penetration rates increase more quickly. Then market penetration of the technology levels off and only "laggards" are still resistant to adopting the new technology.

Fig. 2 illustrates how market interventions can help speed the diffusion of highly efficient technologies and can have permanent effects.

Standard and labeling (S&L) programs are generally the first order of policy intervention to transform the market of a specific end-use. S&L programs certify and rank technologies according to their efficiency and remove inefficient technologies from the market, thus raising the efficiency floor. Incentive programs are more easily implementable if a standard and labeling program already exists. The graph illustrates a cycle of market transformation, which begins with inefficient models being regulated out of the market through minimum energy performance standards (MEPS). Next fleet efficiency is raised using incentive programs. Incentives programs target HE technologies with the best efficiency rating identified by the labeling program. They raise the efficiency ceiling through a combination of upstream, midstream and downstream programs that address specific market barriers.

Incentives increase demand, and thus market penetration, for early-stage HE technologies, leading to economies of scale for manufacturers. Economies of scale, and the learning effects engendered by increased demand, streamline production and decrease the costs of production. The efficiency gains achieved through the incentive program can then be cemented by implementing standards that are more ambitious, resulting in a continuous cycle of improvement. This cycle can be repeated indefinitely as innovation produces more and more efficient technologies. Other market interventions, such as most-efficient awards, energy-efficient procurement or awareness programs can help complement this cycle to further accelerate the diffusion rate.

In countries with slow-moving standards and labeling programs or weak standards, incentive programs can help jump-start negotiations to set higher efficiencies. Incentive programs can also 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

**Table 3**
Elements of program design.

| | |
|---|---|
| **Efficiency criteria** | • What is the efficiency level targeted by the incentive program? |
| **Incentive amount** | • What is the amount of incentive offered? |
| **Incentive recipient** | • Who is the program's target participant? |
| **Form of incentive** | • What form of incentive is offered (a tax credit, cash rebate, low-interest loan, etc.)? |
| **Eligibility requirements** | • Are there any eligibility criteria to participate to the program? |
| **Recycling component** | • Does the program include a recycling component (most often included in replacement programs)? |

higher-efficiency products in the labeling 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).

Evaluations show that financial incentive programs are often most effective when they target products or efficiencies that have a small market share. Lees' evaluation of earlier British schemes, the Energy Efficiency Commitment (EEC) 1 and 2, shows that the share of free ridership (those who take advantage of incentives but would have purchased the efficient products even without the incentives) increases as the market share of an efficient product increases (Lees, 2008). That analysis suggests that technologies with a market penetration greater than 30–40 percent do not need to be financially incentivized. Based on similar results, Gold and Nadel (2011) conclude that incentive programs should last for only a limited time, usually around 5 years, because incentives become less effective over time. Different program designs can follow that target harder to reach consumers or laggards. Rosenberg and Hoefgen (2009) note that multiple coordinated market interventions over an extended period are more likely to affect the behavior of market actors than programs that include a single intervention during a short period of time. Over time, a program can increase the overall efficiency of the products on the market. Gold and Nadel (2011) found that the U.S. refrigerator tax credit upstream program has been largely successful because each extension of the program pushed the efficiency standard higher so that the next set of incentives would further increase the energy saved. One of the reasons for the program's success was robust stakeholder involvement and education regarding how to participate in the program. Nadel et al.'s (2003) review of market transformation initiatives in the United States points out that successful initiatives are multi-pronged efforts that include incentives as well as training and promotion.

Program designs vary significantly and are determined by such elements as, efficiency level targeted, amount of incentive offered, the incentive beneficiaries, the form of incentive instrument, eligibility criteria and whether the program includes a recycling component. Table 3 lists incentive program design elements.

### 2.3.1. *Incentive recipient*

Typically, incentives are provided directly to the customer. However, incentives can be provided to several other actors upstream of the consumer in the supply chain. To overcome specific market barriers, program administrators have gradually expanded the stakeholders to whom incentives are directed. For example, an increasing number of programs incentivize manufacturers to produce more efficient equipment. Retailers and distributors have also been targeted with incentives especially when product availability is a barrier to market penetration of more efficient equipment. Programs targeting consumers are referred to as "downstream" programs, programs targeting retailers and distributors are referred to as "midstream," and programs targeting manufacturers are referred to as "upstream."

Fig. 3 shows the upstream, midstream, and downstream points in a product delivery chain to which incentives can be directed. The figure also presents the main barriers to energy efficiency that each type of incentive program is designed to address, and the advantages and disadvantages of different program design options.

*Upstream incentives* are particularly effective for reducing the up-front cost of technologies that are at an early stage of penetration. Upstream incentives are offered to manufacturers to streamline their production lines and increase production at a lower price. The main advantage of these programs is that they can influence a large portion of the market through fewer actors and therefore have lower transaction costs. Moreover, by reducing the price before products reach the market, the incentive has more impact on purchase price than a downstream incentive.[1] This multiplier effect, which results from retailer markup, can be significant, as illustrated in the California example in Section 3.3.3. The main disadvantages of upstream programs are that financial incentives offered to manufacturers are not seen by consumers and that robust monitoring and verification are required to ensure the incentive is passed through to the consumers (Friedmann, 2011). Another drawback is that implementing these programs successfully requires estimating how much it will cost to the manufacturer to produce more efficient products so that the program administrator can negotiate a fair price for the incentive.

*Midstream incentives* encourage retailers to stock or sell a larger percentage of highly efficient products. These programs influence customers at their point of decision and help address the lack of availability of highly efficient products. They can be particularly effective when a consumer is replacing equipment in an emergency and the purchase decision depends on the immediate availability of a product. Targeting midstream actors can also be advantageous in split incentive situations as illustrated in the Texas example in Section 3.2. in which a rebate was offered to installers who purchased central air conditioners. Midstream programs also educate and motivate retailers to promote highly efficient technologies in general and to use electricity bill savings as a selling point for the products. A midstream program can be particularly effective when a program budget is small and the price of equipment is high. Because the profit margin for distributors and retailers tends to be small, even a small increase in profit from an incentive can give a retailer significant motivation to sell more-efficient equipment. A new program design called "market lift" rewarded retailers when their energy efficient product sale share increases above a pre-established baseline (Winch et al., 2010). However, focusing on the midstream point in the supply chain means more transaction costs than an upstream program (although fewer than in a downstream program). In addition, midstream programs tend to focus on a selection of distributors and retailers and therefore may not reach all the distribution channels. As a result, these incentives only affect the portion of the market that is reached by the participating retailers and/or distributors. Furthermore, it could be argued that choosing which retailer or distributor participates in a program is effectively "picking winners" and penalizing other retailers who are not chosen.

[1] For example, if a light bulb is marked up 40 percent above its manufacturing cost, a $1 incentive to the consumer will discount the price of the bulb by $1, but the same $1 incentive to the manufacturer will discount the customer price of the bulb by $1.40 because the price is reduced before the markup is applied. This is the multiplier effect of an upstream program.

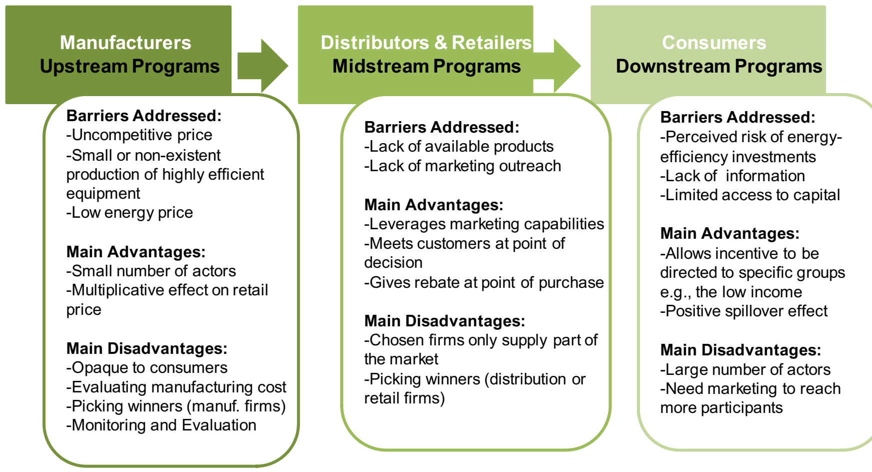


**Fig. 3.** Incentive program design along the supply chain.

*Downstream incentives* have the advantage of raising consumer awareness of highly efficient products, which has positive spillover[2] effects on other energy-efficiency purchases. The existence of a rebate is a signal in itself and may even be more important than the cash amount in some cases. Moreover, downstream programs have the flexibility to be directed to select populations, such as low-income households. A disadvantage of downstream programs is the transaction costs involved in engaging and giving rebates to large numbers of customers on an individual basis.

### 2.4. Evaluation

Policies and programs are not systematically and consistently evaluated. Governments do not always allocate time and money to evaluate their programs in detail. In addition, a particular program may have multiple goals, which can be broad, especially when they encompass research and development elements; this complicates evaluation of the program's success. Evaluation of rate-funded programs tends to be conducted more systematically as a necessary input to planning for future resource investment, and impact evaluations are generally part of the development of these programs (U.S. EPA, 2007). According to the 2012 CEE report, evaluation, measurement, and verification accounted for an average 3.6 percent of the total amount budgeted for U.S. rate-funded energy-efficiency programs.

#### 2.4.1. Energy savings

Methods of accounting for energy savings differ widely from one country to another and have a significant impact on results. For example, in California, the CPUC goal is expressed in annual savings accumulated during the 3-year program period whereas in Europe, the target is generally expressed in lifetime savings, encompassing aggregated savings accrued over the expected life of a measure installed during the program period.

In addition, different methods are used to calculate net savings, both among countries and among U.S. states. An incentive program's net savings are the percentage of energy savings strictly attributable to the program. Net savings do not include savings from program participants who would have undertaken the efficiency activities in the absence of the program (free riders) but include savings that resulted from the program's influence (spillovers). 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. Determining net savings can be difficult when, for example, different entities (such as utilities, national governments, and even local governments) offer financial incentives to the same set of consumers for the same appliance. Other considerations include the “rebound” effect, i.e., that reductions in energy costs cause customers to increase their energy use, diminishing the actual energy savings achieved.

Evaluations conducted during program implementation are also valuable for informing policy makers about possible flaws that can then be corrected. For example, when utilities in the US first encouraged the use of CFLs, some technologies did not performed as well as the replaced technology. This was corrected by the implementation of performance standards but, unfortunately, this experience left indelible trace in some customers’ perception of CFL quality.

In an evaluation, it is important to assess possible side effects (both costs and benefits) that might result from a policy so that decision makers have adequate information to determine whether to expand, limit, adapt, or continue the policy. For example, evaluations can assess impacts on peak electricity load (e.g., in the case of an air conditioner program), GHG emissions, jobs, public health (e.g., mercury from CFLs), water usage, and social equity. Despite their value, these types of evaluations are rarely conducted because they do not relate directly to policy goals and require significant time and resources.

#### 2.4.2. Cost effectiveness

The success of a policy can be measured by determining if the policy goal has been met and evaluating how effectively it has been met. The costs of reducing 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. Cost-effectiveness analyses assess the ratio of dollars spent per unit of energy saved and are typically considered an extension of impact evaluations. Many parameters enter into the cost-benefit analysis equation, notably due to the fact that energy savings can never be observed directly, but only inferred (Joskow and Marron, 1992; Sonnenblick and Eto, 1995; Eto et al., 1996; Prindle, 2009; Woolf et al., 2012; Ting et al., 2013; Kushler et al., 2014). Other parameters enter into the equation, such as the discount rate, which is used to calculate the present value of future savings from the measure implemented, and the ability to

[2] *Positive spillover effect* refers to the adoption of energy-efficient products by program non-participants as a result of increased knowledge about the benefits of energy efficiency.

**Table 4**
Incentive program examples.

| | Country | Program | Time frame | Form | Recipient | Administrator | Funding | Energy-efficient product |
|---|---|---|---|---|---|---|---|---|
| **Downstream** | **France** | Sustainable Development Tax Credit | 2005 to present | Tax credit | Consumers | Government | General budget | Boilers, home insulation, heat pumps, windows, renewable energy |
| | **Italy** | Tax Deduction for Energy Savings | 2007 to present | Tax deduction replacement | Consumers | Government | General budget | Efficient equipment and home insulation |
| | **UK** | Reduced VAT | 1998 to present | VAT reduction | Consumers | Government | General budget | Insulation material, heating control systems, heat pumps, wood-fueled boilers |
| | **S. Korea** | Carbon Cashbag | October 2008 | Eco-points | Consumers | Local Government | General and local budget | Home electronics, appliances |
| | **Japan** | Eco-point | 2009-2011 | Eco-points | Consumers | Local Government | Stimulus package | Air conditioners, refrigerators, TVs |
| | **Mexico** | PNSEE | 2009-ongoing | Replacement on-bill financing | Consumers | Government | International institution | Refrigerators, air conditioners |
| **Midstream** | **U.S. (TX)** | Distributor Air Conditioning Market Transformation | 2001 to 2004 | Rebate | Retailers | Utility | Rate funded | Central air-conditioning units |
| | **U.S. (CA)** | California Business and Consumer Electronics (BCE) | Since 2007 | Rebate | Distributors | Utility | Rate funded | Televisions, computer monitors |
| **Upstream** | **China** | Promotion Products Program | 2008 to present | Upstream subsidy | Manufacturers | Government | General budget | CFLs, air conditioners, TV, water heaters, washing machines, refrigerators |
| | **India** | Super Energy-Efficient Equipment Program (SEEP) | In development | Upstream subsidy | Manufacturers | Government | International institution | Ceiling fans |
| | **Sweden** | Ground-source Heat Pumps Technology Procurement Program | 1993 | Upstream technology procurement | Manufacturers | Government | General budget | Ground-source heat pumps |
| | **U.S.** | Federal Energy-Efficiency Tax Incentives for Manufacturers | 2005 to 2011 | Upstream tax credit | Manufacturers | Government | General budget | Residential refrigerators, clothes washers, dishwashers |
| | **U.S. (CA)** | California Upstream Lighting program | 2006 to 2008 | Upstream buy down | Manufacturers | Utility | Rate funded | CFLs |

measure savings that are net of other effects, as discussed in the previous section. On the other side of the equation, the definition and methods to calculate "avoided costs" of electricity supply resources can also vary according to source and no national or international benchmark exists.

In a review of 31 US states' ratepayer-funded energy efficiency programs, a study conducted by Lawrence Berkeley National Laboratory found the levelized cost of saved energy for utilities to be US $0.021 per kWh, assuming a six percent discount rate (Billingsley et al 2014). A similar review of 20 US states by the American Council for an Energy Efficient Economy (ACEEE) came to a comparable estimate: $0.028 per kWh (Molina 2014). Arimura et al. (2011) found that ratepayer funded energy efficiency programs in the US resulted in cost to utilities of US$0.05 per kWh saved when future savings are discounted at a 5 percent rate. In a study looking at European countries that have implemented white certificates, (Giraudet et al 2011) found that the cost of energy efficiency programs was in average €0.009 per kWh saved in Great Britain and €0.037 per kWh saved in France, with a discount rate of 4 percent.

These studies find the cost of saved energy from rate funded energy efficiency programs compares favorably to the cost of energy supply options. The cost of energy efficiency programs varies widely according to the measure considered and the region-specific regulatory eligibility criteria. A rigorous cost benefit analysis of programs is an important step before and after implementation since their success relies in part on the assurance that they are indeed being run cost-effectively. Cost effectiveness analyses should include appropriate treatment of what incentives have actually bought. For example, the kWh savings attributed to a program must include savings from spillover effects (see Section 2.3.1) but discount any free rider effects, savings from units purchased by consumers who would have bought the unit even in the absence of the incentive.

## 3. Examples of programs

This section presents a variety of examples to illustrate how incentive programs have been implemented in different countries. The examples listed in Table 4 are not meant to be exhaustive but to illustrate current country program designs. The examples listed in the table are detailed in the subsequent sections.

### *3.1. Downstream programs*

The subsections below describe the typical fiscal instruments used for downstream incentives as well as other types of downstream programs that offer award points and replacement of inefficient appliances.

#### *3.1.1. Downstream fiscal instruments*

Fiscal instruments, which include income and sales tax reduction, are popular incentives implemented by governments. A 2012 BPIE survey of Europe found that three countries had tax credit incentive programs, 11 countries had tax reduction schemes, and eight countries had VAT reduction schemes (BPIE, 2012). In total, 14 out of 29 EU Member States reported one or more fiscal incentives. Most of the incentives covered residential-sector efficiency improvements, the main focus of this study.

Since 2005, France has had a successful tax credit[3], the Crédit d'Impôt Développement Durable (CIDD). As of 2010, more than one household in five, i.e., 6.2 million households, had benefited from the French tax credit (French Ministry of Sustainable Development, 2012). Tax credits can be claimed for the purchase

[3] Tax credits directly reduce the taxes the consumer pays while tax deductions lower the consumer's taxable income.

of efficient boilers, heat pumps, windows, and renewable energy equipment. From 2005 to 2011, the tax credit averaged 1.94 billion euros per year of lost revenue to the government (Nauleau, 2013).

Since 2007, the Italian government has offered a tax deduction of 55 percent for the replacement of heating and air conditioning systems with more efficient units and for the cost of other home efficiency improvements (Pistochini and Valentini, 2011). Until December 2010, the program included a tax deduction of 20 percent for the replacement of old refrigerators (Ministero dello Sviluppo Economico, n.d). A tax deduction of 50 percent was recently added for the replacement of "white" appliances (refrigerators, washers, dryers, ovens, gas cookers, and freezers).

The main drawback of income tax incentives is that the taxpayer must pay the efficient equipment's up-front cost and recoup a part of that cost later through tax deductions or credits. The need to pay the full up-front cost deters some customers from taking advantage of this type of incentive, especially customers who are sensitive to up-front costs. This type of program design tends to be more attractive to those making larger investments in residential equipment.

Since 1998, the UK government has offered a reduced VAT for energy-saving products. Today, a VAT of 5 percent (instead of the normal 20 percent) is offered for the purchase of energy-saving residential products such as heat pumps and insulation materials. When these products are installed in new houses, a zero VAT applies. The program does not cover white appliances. (UK HMRC, 2013)

A VAT reduction has the advantage of being perceived by the consumer at the point of purchase. However, there is a risk that the VAT reduction might not be fully passed through in retail prices. In addition, the total amount of the reduction is limited by the amount of tax applicable to a product's price.

#### 3.1.2. Consumer reward points

Two countries – Japan and South Korea – have implemented subsidies in the form of reward points to encourage consumers to select highly efficient technologies. This innovative approach aims to promote low-carbon lifestyles by encouraging consumer responsibility and awareness.

In October 2008, South Korea launched the "Carbon Cashbag" program, operated by Ministry of Knowledge Economy (MKE) and the Korean Energy Management Corporation (KEMCO). Consumers who purchase low-carbon products get carbon credits from manufacturers, retailers, or banks that participate in the program. Points are stored on a Carbon Cashbag card and can be used for discounts on public transportation, basic utility charges, purchases of other efficient appliances, or tickets to cultural events. The program is voluntary, and companies that participate benefit from reductions in advertising fees and other public incentives. As of October 2011, 33 companies were participating in the program, with 18 products and 333 sub-products (McNeil et al., 2012).

The Japanese government ran the Eco-Point System from May 2009 to March 2011 as part of Japan's stimulus package. The goals of the scheme were threefold: stimulate the economy, accelerate penetration of high-energy-savings products, and assist the transition to digital television. This program granted eco-points for the purchase of air conditioners, refrigerators, and televisions that were rated four or more stars by the national energy-efficiency S&L program. The points, worth ¥1 each, could be exchanged for three types of goods: coupons and prepaid cards, highly efficient products, and products that promoted regional economies. The program's total budget was ¥693 billion ($8.7 billion)[4] (Japanese Ministry of Economy, Trade, and Industry (METI), 2010). An evaluation by the Ministry of Economy, Trade and Industry (METI) found that the program was very successful. The share of products shipped that had four or more stars increased from 20 percent to 96 percent for air conditioners, from 30 percent to 98 percent for refrigerators, and from about 84 percent to 99 percent for televisions. This resulted in estimated savings of 2.7 million tons of $CO_2$ per year. However, the program is also considered to have resulted in increased imports and caused a sharp decline in Japanese electronics sales (Aoshima and Shimizu, 2012). In 2012, Japan reinstated the Eco-Point program, adding awards for post-disaster reconstruction and wider diffusion of earthquake-proof and energy-efficient housing.

[4] The 2011 exchange rate was 79.8 yen per US$.

#### 3.1.3. Replacement programs

Replacement programs, also called early retirement and direct installation programs, replace inefficient residential appliances before the end of their useful lives with significantly more efficient appliances. This reduces electricity use by both encouraging the deployment of efficient appliances and ensuring that older, less-efficient appliances are removed from the stock. These programs have the added advantage of minimizing the potential of a rebound effect in which a household would expand its appliance capacity by keeping and continuing to use the older less-efficient appliances in addition to the new one.

Mexico's PNSEE has replaced large numbers of old appliances (Salaverría and Patricia 2010; SENER 2010). The program offers government-funded subsidies to consumers to replace their old refrigerators and air conditioners with new, more-efficient models. The subsidies cover a portion of the price of the new appliance and the costs for transportation, storage, and disposal for removing the old appliance. To receive the subsidy, consumers must surrender functioning refrigerators and room air conditioners that must be 10 years old or older. Davis et al. (2013) evaluated the program and found that it only reduced refrigerator electricity consumption by 7 percent and actually increased air conditioning electricity consumption because of a rebound effect: consumption increased as a result of energy efficiency.

### 3.2. Midstream programs

Targeting midstream actors can be particularly advantageous in split incentive situations. For example, in the case of central air conditioners, the product is usually purchased by the installer, who has no stake in the costs of the energy it will consume. Offering a rebate to installers for choosing efficient equipment can help mitigate this problem. This approach was used successfully in Reliant Energy's 2001–2004 Air Conditioner Distributor program in Houston, Texas. The program offered incentives to HVAC distributors with the goal of promoting the sale of at least 7500 t of central air conditioners that had a Seasonal Energy Efficiency Ratio (SEER) of $\geq 14$ (with a minimum eligibility of 13) (Garland et al., n.d.).

Because of their relative modest per unit savings, midstream programs offer a good alternative to downstream program for consumer electronics. When compare to a retailer's proffict margin on the product, incentives tend to be more significant. This is one of the reason that made California's utilities designed the Business and Consumer Electronics (BCE) Program in 2007. BCE provides midstream incentives to large retailers for the sale of high-efficiency consumer electronics, such as televisions and computer monitors. During the 2011 program year, the BCE program paid $13.8 million in rebates for more than 1.3 million high-efficiency consumer electronics products sold (Energy Solution, 2012).

### 3.3. Upstream programs

The subsections below describe three types of upstream incentive designs: technology procurement, fiscal incentives, and subsidies.

#### 3.3.1. Technology procurement

Sweden was one of the countries that pioneered upstream programs. In the early 1990s, the Swedish National Board for Industrial and Technical Development (also known as NUTEK) sponsored a technology procurement program in which a group of buyers and experts developed specifications for highly efficient ground-source heat pumps. The group specified high-quality heat pumps that were 30 percent more efficient and 30 percent less expensive than existing models on the market; the specifications also required elimination of ozone-depleting gases. Manufacturers were invited to compete to meet the group's specifications, with a guarantee that at least 2000 units of the winning model would be purchased. This program successfully stimulated the production of efficient heat pumps and started a market transformation (Kiss et al., 2012). Following this technology procurement program, highly efficient heat-pump models were supported by informational and monetary incentives, and, today, Sweden has the highest installed capacity of heat pumps per capita, and heat pumps are the most common source of space heating in single-family residences in the country, installed about 40 percent of homes (Lind, 2011). Evaluations have shown that one reason for the success of the Swedish technology procurement was that its development was primarily driven by the requirements of a group of buyers (Kiss et al., 2012).

#### 3.3.2. Upstream fiscal instruments

The U.S. Energy Policy Act of 2005 included a tax credit to incentivize production of energy-efficient refrigerator units. The U.S. government agency responsible for tax collection, the Internal Revenue Service, administered the program, whose goal was to transform the market by influencing manufacturers to produce increasingly energy-efficient appliances. An evaluation by Gold and Nadel (2011) found that these tax credits have been largely successful in stimulating robust stakeholder involvement and education;; furthermore, each successful extension of the tax credit program pushed the efficiency standard higher so that the next set of incentives would "achieve higher levels of energy savings cost-effectively."

#### 3.3.3. Subsidies

China's upstream subsidy program began with a CFL promotion program in 2008. Suppliers received subsidies to provide a 30-percent discount on wholesale purchases and a 50-percent discount on retail sales. In 2009 and 2012, the government extended the program to air conditioners, TVs, refrigerators, washing machines, and water heaters. The program's main goal is to promote energy-saving home appliances and stimulate the economy to offset the impact of the international economic crisis. To ensure that the program has the intended impact, new rules require that manufacturers must verify product shipments by means of a retailer's sales receipt in order to receive the subsidy.

Upstream program have also been implemented by utilities, for example, the California Upstream Lighting Program implemented by California's three largest investor-owned utilities. An evaluation by KEMA (2010) of the 2006–2008 program estimates statewide annual net savings to be about 1325 GWh, with net peak savings of approximately 134 MW. California utilities provided incentives to manufacturers averaging US$1.57 per bulb on nearly 100 million CFLs, and the average consumer discount at the register was US$2.70 per bulb, resulting in a multiplier of 172 percent (KEMA, 2010). The multiplier effect happens when a rebate given upstream is increased by the product markup, which results in a larger discount for consumers than if the rebate were given directly to them.

India's SEEP aims to support development of equipment that is 50 percent more efficient than current five-star appliances.[5] The program's first target is production of ceiling fans that consume 35 W of power, instead of the 50 W consumed by current five-star rating fans (Singh et al., 2012, Chunekar et al., 2011). An incentive is planned for every SEEP fan sold by manufacturers. A recent report from the Prayas Energy Group (Singh et al., 2012) describes the group's experience assisting the Indian Bureau of Energy Efficiency (BEE) in the development of SEEP, from conception to design and establishment of the implementation framework. Many interesting details of the program's design are described in the Prayas report, for example how the technical specification for the eligible product was established in close collaboration with the manufacturing industry and retail sector to take into consideration local industry conditions and consumer preferences. A distinctive feature of SEEP is that it gives manufacturers an opportunity to design and market products that are not yet available to Indian consumers.

### 3.4. Packages of programs

Different types of incentive programs can be implemented simultaneously or consecutively. A combination of upstream, midstream, and downstream programs can be used to help a market grow and mature, addressing the barriers faced by different market players—manufacturers, distributors, retailers, and consumers. Sweden is an interesting example of a long-term, integrated approach to incentive programs that started with the technology procurement program described in Section 3.3.1; that program was subsequently complemented with subsidies, favorable loans, training, and information campaigns.

The success of the Swedish programs and of other countries' market transformation initiatives is also the result of continuous monitoring and verification of the programs' impacts. Monitoring and verification provide needed information so that programs can be adjusted over time to respond to the dynamic growth of markets. For this reason, a budget should be earmarked for monitoring, verification, and evaluation of programs. Finally, programs should be developed in close collaboration with all stakeholders, and specifications for highly efficient equipment should be developed according to consumer preferences. Even programs that target manufacturers should be driven by the needs and preferences of consumers.

## 4. Conclusions and policy implications

Regulatory frameworks across many countries have been developed to induce the establishment of incentive programs, and there has been significant innovation and evolution in the design of these programs. The greatest challenges for incentive programs continue to be identification of market barriers, design of programs that successfully overcome barriers over the long term, and mobilization of stable, sustainable funding for energy-efficiency incentives.

Incentive programs often pay the up-front cost of efficient equipment and therefore require significant capitalization. Rate-funded programs inherently have a sustainable funding source and validate energy efficiency as a cost-effective energy resource for planning purposes. Other sources of funding include – but are not limited to – feebates, revolving loan funds, and CDMs. Policy

[5] The five-star rating is the highest rating available in India.

makers should share experiences to inspire the development of additional new funding mechanisms, including those to suit unique local circumstances.

Successful programs address the barriers that hinder the penetration of highly efficient products at different stages of a product's market diffusion. These programs use a holistic market transformation strategy in which upstream, midstream, and downstream incentives are part of a package of interventions that speed the adoption of more-ambitious standards. Incentive programs complement mandatory standards by accelerating market penetration of products that are more energy efficient than standards require, thereby preparing the market for future increases in the stringency of the standards.

Successful programs also depend on evaluation, monitoring, and verification, which in turn require a budget earmarked for those purposes. Evaluation should shed light not only on energy savings achieved and emissions reduced but also on lessons learned in program implementation so that these findings are shared globally to help other countries avoid trial-and-error learning.

There is no silver bullet for energy efficiency; policy must be developed on a case-by-case basis to respond to market barriers and must embrace local conditions.

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