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A Review of Non-Regulatory Energy Efficiency Measures in the United States

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A Review of Non-Regulatory Energy Efficiency Measures in the United States

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Executive Summary

Increasing energy efficiency is ubiquitous in many economies, and several mechanisms for achieving this increase, from mandatory policies to voluntary initiatives, have been proposed and implemented. In the United States, the Department of Energy, during the development of its energy conservation standard rules, evaluates the benefits from several of these mechanisms. In this report, we review how estimates of benefits from two types of voluntary energy efficiency initiatives – rebates and voluntary energy efficiency targets (VETs) – compare to the same benefits estimated for minimum energy efficiency standards (MEPS) established in the United States for residential appliances, commercial and industrial equipment, and lighting applications (referred to simply as “products” for the remainder of this report) between 2010 and 2020. Our results show that, overall, these two voluntary measures are estimated to provide, altogether, 36% of the total energy savings estimated to be provided by new efficiency standards, with a total net-present value that corresponds to 52% of the net-present value estimated for standards. When considering all energy conservation rules reviewed in this report, the energy savings a rebate program is estimated to achieve ranges from less than 1% to 86% of the savings from new standards set for the same type of product and at the same level of energy efficiency. As for VETs, the energy savings range from less than 1% to 78% of the savings from standards. Results vary widely across types of products due to (a) the relevance of the monetary incentive relative to incremental upfront costs considered for each type of product, and (b) the estimated level of market barriers associated with each type of product. While voluntary energy efficiency initiatives are not as effective as MEPS in transforming the market and raising the bar of energy efficiency for energy consuming goods in an economy, when applied in tandem with MEPS they can be powerful instruments for promoting and increasing energy efficiency in the economy.

Keywords: energy efficiency, minimum energy efficiency standards, rebates, voluntary energy efficiency targets.

1. Introduction

Most economies have well-established goals and approaches to improve energy efficiency in order to reduce greenhouse gas emissions and increase energy security. Several mechanisms, government- or industry initiated, have been proposed and implemented to achieve increased levels of energy efficiency. These mechanisms range from mandatory minimum energy performance standards to voluntary energy efficiency initiatives. Mandatory standards seek to remove inefficient models from the market, while voluntary initiatives, such as labels, rebates, and tax credits applied to efficient models, attempt to influence consumer's choice when they are shopping for energy-consuming products.

In the United States (U.S.), the Energy Policy and Conservation Act (EPCA, 1975) established a regulatory program to enforce minimum energy conservation standards for appliances and equipment in the country. The program gives the Department of Energy (DOE) the authority to develop and implement test procedures and minimum energy-efficiency standards. DOE is required to set standards that improve energy efficiency and are "technologically feasible and economically justified."[1] Currently, DOE's minimum energy-efficiency standards cover approximately 60 categories of products including consumer, commercial and industrial, lighting, and plumbing applications.[2] In addition, some state and local regulations, especially building codes, require that new buildings and building retrofits meet certain requirements that also contribute to reducing the energy consumed in the building.

Voluntary programs, energy labels, and energy efficiency monetary incentives are also available in the U.S. Voluntary programs are used to raise consumer awareness about energy efficiency. They help with "advancing the bar for manufacturers, designers and builders, and other stakeholders." (ASR, 2013). One example is ENERGY STAR, a government program initiated in 1992 by the Environmental Protection Agency (EPA). The program provides "simple, credible, and unbiased information that consumers and businesses rely on to make well-informed decisions" regarding residential, commercial, and industrial energy efficiency.[3] ENERGY STAR certified products are independently verified to meet energy efficiency criteria that significantly exceed federal minimum standards. The products are listed on the program's website and identified by a special label. Another example of a voluntary initiative is the NEMA Premium program, an initiative of the National Electrical Manufacturers Association (NEMA) that promotes high-efficiency electric motors.[4] Similar to the ENERGY STAR label, the qualified motors are identified by the NEMA Premium logo. Another example of an energy related label is the EnergyGuide label, which is a label that manufacturers are required to display on their

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[1] 42 U.S. Code, Title V, Part B. "Energy Conservation Program for Consumer Products Other Than Automobiles."
[2] U.S. Department of Energy. "About the Appliance and Equipment Standards Program." https://www.energy.gov/eere/buildings/about-appliance-and-equipment-standards-program. Retrieved 26 June 2020.
[3] Energy Star. "About ENERGY STAR." https://www.energystar.gov/about. Retrieved 26 June 2020.
[4] National Electrical Manufacturers Association. "NEMA Premium Motors." https://www.nema.org/Products/Pages/NEMA-Premium-Motors.aspx. Retrieved 26 June 2020.

products.[5] The label provides information that allows the consumer to compare a product with similar models based on their annual energy consumption and expected operating costs. Energy efficiency tax credits have been provided by the federal government and state governments, and utilities all over the country have sponsored rebate programs.[6] The energy efficiency tax credits allow consumers to subtract the value of the tax credit associated with their energy efficiency upgrade from the amount of taxes they owe that year. Energy efficiency rebates allow consumers to get cash back for their energy efficient purchase. Usually, the benefits from the latter are realized more quickly than from tax credits.[7] All these initiatives seek to increase market adoption of high-efficient energy goods.

This report reviews the energy and economic benefits from non-regulatory policies estimated by DOE in their energy conservation rules published between 2010 and 2020.[8] It relies on publicly available data found in the Technical Support Document (TSD) that accompanies each rule. These data compare the national energy savings (NES) and net-present value (NPV) estimated to be achieved from new energy efficiency standards with the corresponding values estimated to be achieved from rebate programs and voluntary energy efficiency targets (VETs) designed to promote products at the same level of energy efficiency as the one set by the new efficiency standards. Additionally, the TSDs compare the benefits from energy efficiency standards with those from tax credits and bulk government purchases, which also promote energy efficiency. However, the benefits from these two alternative measures are typically significantly lower than the benefits from rebates and VETs and, therefore, are not addressed in this report. In the following sections, we describe the methodologies used to estimate the benefits from rebates and VETs, present results of the analyses conducted during the above-mentioned rules, and discuss those results.

2. Methodology

As part of the technological feasibility and economic analysis of a new energy efficiency standard for a given product, DOE identifies one or more increased levels of energy efficiency, compared with the lowest efficiency on the market, and assesses their costs and benefits at the level of individual consumers and at the aggregate, national level.[9] Models of the product being

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[5] EnergyGuide is administered by the U.S. Federal Trade Commission (www.consumer.ftc.gov/articles/0072-shopping-home-appliances-useenergyguide-Label).

[6] See, for example, the "Database of State Incentives for Renewables & Efficiency" (DSIRE), operated by the North Carolina Clean Energy Technology Center. https://www.dsireusa.org/.

[7] U.S. Department of Energy. "Energy Efficiency Tax Credits, Rebates and Financing: What Options Are Available for You?" https://www.energy.gov/articles/energy-efficiency-tax-credits-rebates-and-financing-what-options-are-available-you. Retrieved 26 June 2020.

[8] Not all energy conservation rules published between 2010 and 2020 are included in this review. Only the ones that estimate benefits for non-regulatory policies and programs.

[9] Please refer to "Standards Development and Revision" (https://www.energy.gov/eere/buildings/standards-development-and-revision) and Wiel and McMahon (2001) for more details on DOE's decision-making process of new energy efficiency standards and the typical analyses that underlie and support that decision. This is also described in 42 USC 6295(o) (https://www.govinfo.gov/app/details/USCODE-2010-title42/USCODE-2010-title42-

assessed that are available on the market are classified into categories of energy efficiency levels (EL).[10] Energy savings are estimated based on the average annual energy consumption for each EL. Depending on the characteristics of the product being assessed, this analysis can be quite complex. For example, it accounts for aspects like product usage[11] and expected lifetime, which can vary significantly depending on how the product is used for a range of applications[12] and in different contexts.[13] The total national energy savings from units shipped over 30 years, under the effect of new standards set at the EL L^*, are estimated as:

$$\Delta G_{L^*} = \sum\nolimits_{y=1,30} \Delta G_{L^*,y} \qquad [1]$$

$$\Delta G_{L^*,y} = G_{L^*,y} - G_{0,y}$$

$$G_{C,y} = \sum\nolimits_{l=1,L} \sum\nolimits_{z=1,Z} \left(s_{l,y,z|C} \cdot g_{l,z} \cdot \sum\nolimits_{t=1,T_{l,z}} p_{l,z}(t) \right)$$

where:

$$s_{l,y,z|C} = \begin{cases} s_{l,y,z} & l > C \\ \sum\nolimits_{l=0,C} s_{l,y,z} & l = C \\ s_{l,y,z} & l < C \end{cases} \qquad [2]$$

$$g_{l,z} = \mu_{l,z} \cdot u_{l,z} \qquad [3]$$

and:

ΔG_{L^*} Total national energy savings from models shipped during a 30-year period starting in the year the new standards become effective

$\Delta G_{L^*,y}$ Total national lifetime energy savings from models shipped in year y

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chap77-subchapIII-partA-sec6295). For examples of implementation of DOE's decision-making process, please refer to the Notices of Final Rule of Energy Conservation Standards for Uninterruptible Power Supplies (https://www.regulations.gov/document/EERE-2016-BT-STD-0022-0035) and Portable Air Conditioners (https://www.regulations.gov/document/EERE-2013-BT-STD-0033-0053).

[10] ELs are numbered as 0, 1, 2…, with EL 0 representing the lowest efficiency available on the market, and higher EL numbers denoting higher energy efficiency levels.

[11] For example, annual operating hours or number of times the product is used during a week or a year.

[12] Electric motors are used, for example, for conveyance, compression, pumping, fans, and in machinery.

[13] The frequency the product is used, as well as the duration of its use and the load to which it is submitted may vary, for example, across regions, climate zones, seasons, household and building characteristics, and types of industry.

$G_{L^*,y}$ Total national lifetime energy consumption of models shipped in year y if new standards are set at EL L^*

$G_{0,y}$ Total national lifetime energy consumption of models shipped in year y if no new standards are set

$G_{C,y}$ Total national lifetime energy consumption of models shipped in year y, under the effect of standards set at EL C

z Combination of an application and a context where the product is used

$s_{l,y,z|C}$ Shipments of models that meet EL l, shipped to z in year y, under the effect of standards set at EL C

$g_{l,z}$ Unit total annual energy consumption of models that meet EL l and are used in z

$\mu_{l,z}$ Unit energy consumption per unit of usage (e.g., hour, cycle) of models that meet EL l, when used in z

$u_{l,z}$ Number of annual units of usage (e.g., hours, cycles) for which models that meet EL l are used, when used in z

$p_{l,z}(t)$ Probability that models that meet EL l and are used in z will be operational in the t^{th} year of their life

$T_{l,z}$ Maximum lifetime of models that meet EL l when used in z.

DOE estimates all variables in expressions [2] and [3] for each EL and then evaluates expression [1] for each EL. This is done under the assumption that models with efficiency below the efficiency associated with the evaluated EL will no longer be available on the market after a new energy efficiency standard based on that EL becomes effective. Therefore, under the new energy efficiency standard:

- an individual consumer, shopping for a model whose efficiency is below the efficiency associated with the EL being evaluated, will have to instead purchase a model that meets the efficiency associated with the evaluated EL, and

- at the aggregate level, all shipments of models with efficiency below the efficiency associated with the EL being evaluated, will be transferred to models that meet the efficiency associated with the evaluated EL (see expression [2]).

The increased efficiency will provide consumers with a cash flow of energy cost savings over the lifetime of the new, more efficient unit purchased under the effect of the new minimum standards. However, the increased efficiency usually comes at a cost. More efficient models rely on newer technologies and, due to development costs and lack of economies of scale, tend to be more expensive than models with lower efficiency (Blum, 2015). DOE evaluates, for each

EL, whether the energy cost savings outweigh the incremental costs associated with a new unit that meets the efficiency associated with the EL. This is expressed by the *net-present value* (NPV) of the investment consumers will make in more efficient models. DOE estimates the national NPV from units shipped over 30 years, under the effect of new standards set at the efficiency level corresponding to EL L^*, as:

$$N_{L^*} = \sum_{y=1,30} \left(\left(Q_{0,y} + C_{0,y} \right) - \left(Q_{L^*,y} + C_{L^*,y} \right) \right) (1+d)^{1-y} \quad [4]$$

$$Q_{l,y} = \sum_{z=1,Z} h_{l,y,z} + i_{l,y,z} - v_{l,y,z} \quad [5]$$

$$C_{l,y} = \sum_{z=1,Z} \sum_{t=1,T_{l,z}} s_{l,y,z|C} \cdot \left(g_{l,z} \pi_z(y+t) + m_{l,z}(t) + r_{l,z}(t) \right) \cdot p_{l,z}(t) \cdot (1+d)^{1-t} \quad [6]$$

where:

N_{L^*}	National NPV, in the year the new standards become effective, of models shipped during a 30-year period starting in that year
$Q_{0,y}$	Total national installed costs, in year y, of models shipped in that year if no new standards are set
$C_{0,y}$	Total national lifetime operating costs, in year y, of models shipped in that year if no new standards are set
$Q_{L^*,y}$	Total national installed costs, in year y, of models shipped in that year if no new standards are set
$C_{L^*,y}$	Total national lifetime operating costs, in year y, of models shipped in that year if no new standards are set
$Q_{l,y}$	Total installed costs, in year y, of models shipped in that year
$h_{l,y,z}$	Unit purchase cost of models that meet EL l, purchased in year y to be used in z
$i_{l,y,z}$	Unit installation costs of models that meet EL l, purchased in year y to be used in z
$v_{l,y,z}$	Unit monetary incentive provided to models that meet EL l, purchased in year y to be used in z
$C_{l,y}$	Total operating costs, in year y, of models shipped in that year
$\pi_z(y+t)$	Energy costs in the t^{th} year of life of models shipped in y and used in z
$m_{l,z}(t)$	Unit annual maintenance costs in the t^{th} year of life of models that meet EL l and are used in z
$r_{l,z}(t)$	Unit annual repair costs in the t^{th} year of life of models that meet EL l and are used in z

d Discount rate[14]

and $s_{l,y,z|C}$ and $g_{l,z}$ are as previously defined.

Positive NPV values indicate the investment in a more efficient model is cost-effective. This means that the present-value of the future cash flow of energy cost savings is greater than the incremental upfront costs associated with the efficient model.

Government actions that promote energy efficiency of products require that their benefits and costs[15] be compared with those of existing and alternative policies (Bernstein et al. 2005) and that they be ranked according to their effectiveness (Blum et al, 2013). Indeed, in the U.S., Executive Order (E.O.) 12866 requires that "economically significant regulatory action" provides "an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, identified by the agencies or the public (including improving the current regulation and reasonably viable non-regulatory actions), and an explanation why the planned regulatory action is preferable to the identified potential alternatives."[16] Therefore, in addition to estimating the energy savings and NPV from new potential energy efficiency standards, as described above, DOE evaluates what the corresponding savings and NPV would be if rebates were provided, and if voluntary energy efficiency targets were set to promote products at the same level of energy efficiency as targeted by the EL proposed for new standards (target EL).

DOE evaluates the benefits from rebates based on a methodology that estimates the increase in market penetration that could be achieved by reducing the upfront costs of models that meet the target EL through a monetary incentive. In the case of VETs, DOE estimates the increase in market penetration that could be achieved from reducing the market barriers to models that meet the target EL, which is similar to the stimulus the ENERGY STAR labeling program provides to consumers to encourage them to purchase energy efficient models.[17] In both cases, since the alternative initiatives are not mandatory, the distribution of future shipments across ELs are not expected to behave in the same way as defined in expression [2]. Rather, shipments under the effect of each of those alternative initiatives can be estimated from:

[14] Based on the Office of Management and Budget (OMB) Circular A-4 (https://www.reginfo.gov/public/jsp/Utilities/a-4.pdf), DOE uses 3% and 7% discount rates in its analyses.
[15] Despite the relevance of accounting for both benefits and costs of energy efficiency policy measures, some regulatory schemes do not require the assessment of costs of those measures.
[16] Executive Order 12866, Regulatory Planning and Review. 58 FR 51735 (October 4, 1993).
[17] In this case, DOE assumes the stimulus would lead manufacturers to gradually reduce the production of units with efficiency below the one corresponding to the target EL.

$$s'_{l,y,z|L^*} = \begin{cases} s_{l,y,z} & l > L^* \\ s_{L^*,y,z} + \theta_{L^*} \cdot \sum_{l=0,L^*-1} s_{l,y,z} & l = L^* \\ (1-\theta_{L^*}) \cdot s_{l,y,z} & l < L^* \end{cases} \quad [7]$$

where:

$s'_{l,y,z\|L^*}$	Shipments of models that meet the efficiency associated with EL l, shipped to z in year y, under the effect of a monetary or informational incentive provided towards models that meet the efficiency associated with EL L^*
θ_{L^*}	Market penetration increase of models that meet the efficiency associated with EL L^*

and $s_{l,y,z}$ is as previously defined.

Expression [7] above is similar to expression [2], except for the transferring of shipments of models with efficiency below the target EL to models that meet the target EL. In this case, the assumption is that – since models with efficiency lower than the target EL will still be available on the market – not all consumers will upgrade their purchase from their former choice of a low efficiency model to a more efficient one that meets the target EL. This effect, in expression [7], is represented by variable θ_{L^*}. The variable expresses the fraction of the market that would shift their purchases of low efficient models towards models that meet the target EL.

Blum et al (2012) presents a methodology that can be used to estimate increases in market penetration of energy efficient models as a function of increases in their benefit-cost ratio. The methodology relies on custom market adoption curves, developed based on the work of Rufo and Coito (2002). The curves express the relationship between the market penetration of, and benefit-cost ratio from energy efficient models at different levels of market barriers to energy efficiency. Figure 1 shows the five market barrier reference curves presented by Rufo and Coito (2002); each curve is associated with a certain level of market barriers to energy efficiency. The figure shows that for the same benefit-cost ratio, markets with lower barriers to energy efficiency present higher levels of adoption of energy efficient models. Also, adoption increases with the benefit-cost ratio, though slower in markets with higher barriers to energy efficiency than in markets with lower barriers.

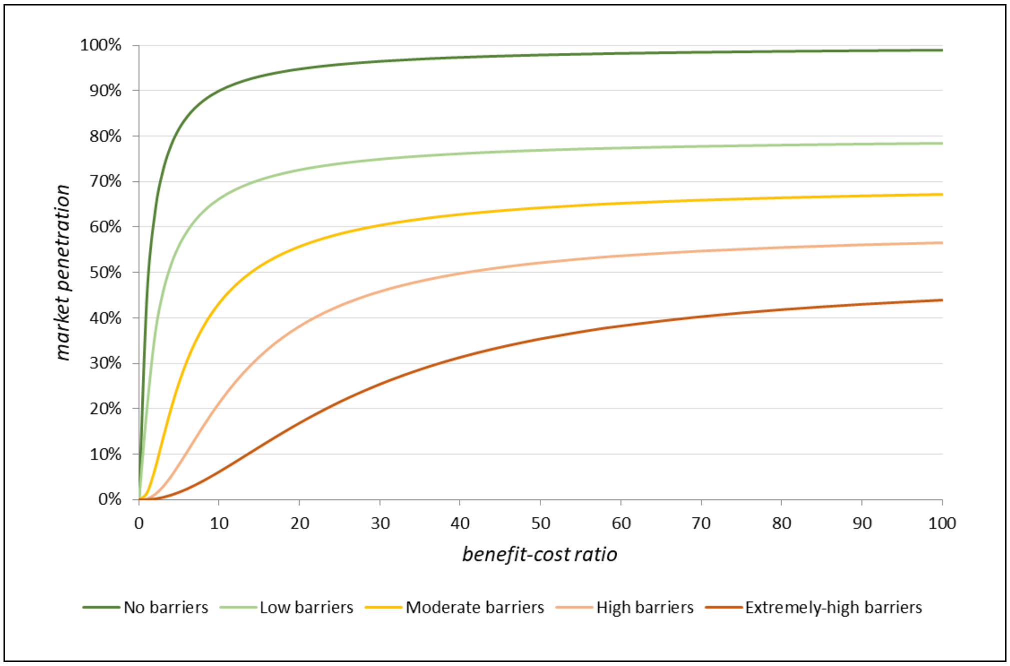


Figure 1: Market barrier reference curves

Blum et al (2012) propose an approach to adjust the general functional form that underlies the market barrier curves presented in Figure 1 to represent the market barriers to energy efficiency for a certain product. The process fits a custom market barriers curve based on the current benefit-cost ratio and level of adoption of efficient models of the product. Once a curve has been adjusted to represent the market for the product, it can be used to estimate the increase in market penetration that could be expected from an increase in the benefit-cost ratio of the product. Notice that a monetary incentive, like the one provided by a rebate offered towards more efficient models, reduces the upfront costs of those models, and thus increases their benefit-cost ratio. The custom market barrier curve can also be gauged to estimate new market barrier curves for the product under different assumptions of market barrier levels for that market. The lower the market barriers, the higher the market penetration of efficient models. By simulating a reduction in the market barriers for efficient models, similarly to what is expected from VETs, one can estimate – with no changes in the benefit-cost ratio – the corresponding increase in market penetration due to the reduced barriers.

Figure 2 illustrates how the market penetration curves described above can be used to estimate the effects of a monetary incentive and the effects of reducing the market barriers to energy efficient models for a hypothetical appliance. In the figure, the current market penetration of a model with a benefit-cost ratio of 5 is 10% (the 'No Incentives' data point in the figure). Providing a rebate that reduces the upfront costs by 50% and increases the benefit-cost ratio to 10 would increase the market penetration of the model to 25% (the 'Rebate' data point in the figure). The rebate is therefore expected to increase the market penetration of the model by 15% (the difference between the market penetration of the 'No Incentives' and 'Rebate' data points). The figure also shows that the market penetration of the model under lower market barrier conditions (the dashed line in the figure) can increase to 20% (the projection of the 'No

Incentive' data point onto the 'Reduced Market Barriers' curve). Therefore, a policy measure that could reduce the market barriers is expected to increase the penetration of the model by 10% (the difference between the market penetration of the 'No Incentive' and 'Vol Eff Target' data points in the figure).

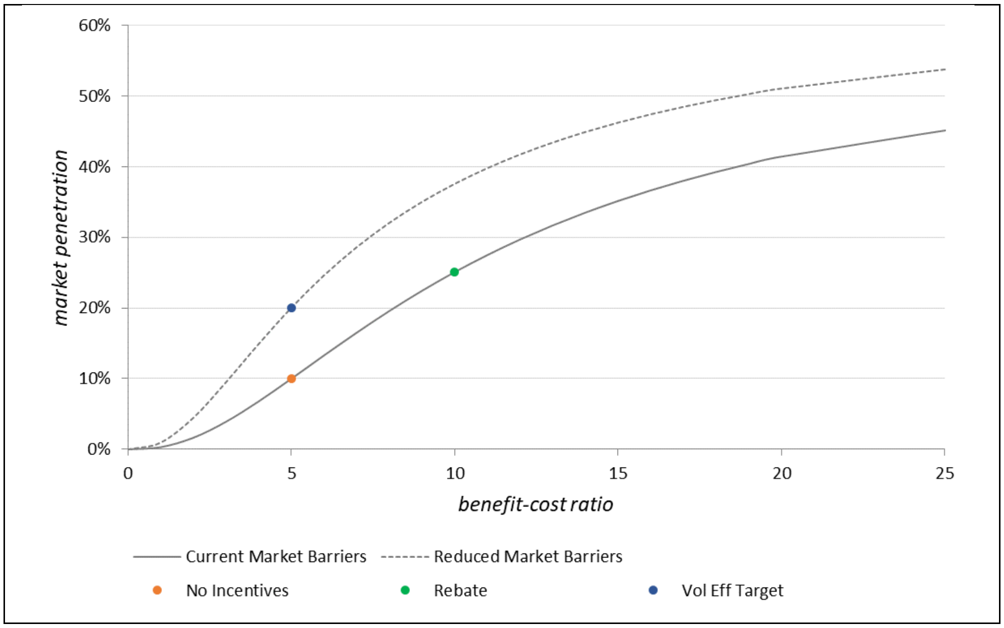


Figure 2: Example of how market barrier curves are used to estimate increase in market penetration

Once an increase in market penetration is estimated, either from a monetary (e.g., rebate) or an informational (e.g., label) incentive, it can be used in expression [7] to project changes in shipments that could result from these initiatives.

3. Estimated Benefits

The TSDs that support energy conservation rules provide estimates of energy and economic benefits expected to result from new energy efficiency standards. They also provide estimates of similar benefits that could be achieved from alternative, non-regulatory- policies and programs with the same energy efficiency as the target EL. We compare the estimated benefits resulting from alternative non-regulatory- policies and programs with their corresponding benefits from new energy efficiency standards. Note that the benefits estimated for new energy efficiency standards used in this comparison may not correspond exactly to the benefits estimated in support of the implemented energy efficiency standards. This is because, in some cases, the shipments projected under the new standards may differ from the ones projected for when no new standards are considered. For example, under the effect of new standards, shipments of new units may be reduced due to a price-elasticity effect or an increase in repairs (instead of replacements). Because the low-efficient models that would no longer be in the market when the new standards become effective would still be available under the non-regulatory policies, the latter are not subject to the effects that would reduce shipments after the new standards became effective. In addition, some TSDs present estimates of benefits from alternative policies and programs only for a subset of the products (also referred to as “product classes” or “equipment classes” in the TSDs) covered by the energy conservation standards. Therefore, for the sake of comparability, in some TSDs the benefits from new standards are estimated (a) as if shipments would not be affected by the presence of new standards, and (b) only for the product classes for which non-regulatory policies and programs are evaluated.

Table 1 presents the list of final rules included in this comparative assessment. Figure 3 shows the distributions of products across application type and the distribution of rules over time. Almost half of the products targeted by the rules (49%) are residential appliances. Commercial and industrial equipment represent 42% of the products covered by the rules, and lighting products represent 9%.

Table 2 and Table 3 present the energy and economic benefits estimated for rebates and VETs. Rebates targeting residential appliances were estimated to be able to provide 9.4 quads of energy savings, with an NPV ranging from 1.2 to 2.3 trillion dollars depending on the discount rate (dr) applied. VETs targeting residential appliances were estimated to provide 3.2 quads of energy savings, with an NPV of 8.7 to 25.9 billion dollars, depending on the discount rate used. Rebates targeting commercial and industrial equipment were estimated to provide energy savings of 6.7 quads with an NPV of 187 to 511 billion dollars, depending on the discount rate, while VETs targeting the same equipment were estimated to provide 1.5 quads of energy savings with an NPV of 1.9 to 58.8 billion dollars, also depending on the discount rate. Lastly, rebates targeting lighting applications were estimated to provide 2.3 quads of energy savings with an NPV between 6 and 11 billion dollars, depending on the discount rate considered, while VETs targeting lighting applications were estimated to provide 3.2 quads of energy savings with an NPV of 10.9 to 18.4 billion dollars, also depending on the discount rate.

Figure 4 and Figure 5 show how the estimated energy and economic benefits from rebates and VETs compared to those from new standards.[18] The 100-percent in the figures represents the benefits resulting from new standards.[18] Table 4 summarizes the results from Figure 4 and Figure 5. As shown in the table and figures, rebates for residential appliances are slightly more effective than for commercial/industrial equipment and lighting applications. Conversely, VETs appear to be more effective when targeting lighting applications compared with the other types of products.

[18] As mentioned above, the benefits from new standards used for comparing the estimated benefits resulting from alternative non-regulatory- policies and programs may not correspond exactly to the benefits estimated in support of the implemented energy efficiency standards.

Table 1: Final rules included in this review

Products	Application	Year*
Automatic Commercial Ice Makers	Commercial/Industrial	2015
Battery Chargers	Residential	2016
Ceiling Fan Light Kits	Lighting	2016
Ceiling Fans	Residential	2016
Clothes Dryers	Residential	2011
Commercial Air Compressors	Commercial/Industrial	2020
Commercial Air-Cooled Air Conditioners and Heat Pumps	Commercial/Industrial	2016
Commercial and Industrial Pumps	Commercial/Industrial	2016
Commercial Clothes Washers (2010); Commercial Clothes Washers (2014)	Commercial/Industrial	2010, 2014
Commercial Packaged Boilers	Commercial/Industrial	2020
Commercial Refrigeration Equipment	Commercial/Industrial	2014
Commercial Warm Air Furnaces	Commercial/Industrial	2016
Dehumidifiers	Residential	2016
Direct Heating Equipment	Residential	2010
Dishwashers (2012); Dishwashers (2016)	Residential	2012, 2016
Distribution Transformers	Commercial/Industrial	2013
Dedicated Purpose Pool Pumps	Commercial/Industrial	2017
External Power Supplies	Residential	2014
Fluorescent Lamp Ballasts	Lighting	2011
Furnace Fans	Residential	2014
General Service Fluorescent Lamps and Incandescent Reflector Lamps	Lighting	2015
Medium Electric Motors	Commercial/Industrial	2014
Metal Halide Lamp Fixtures	Lighting	2014
Microwave Oven Standby Power	Residential	2013
Miscellaneous Refrigeration	Residential	2016
Packaged Terminal Air Conditioners and Heat Pumps	Commercial/Industrial	2015
Pool Heaters	Residential	2010
Portable Air Conditioners	Residential	2020
Pre-Rinse Spray Valves	Commercial/Industrial	2016
Residential Boilers	Residential	2016
Residential Central Air Conditioners and Heat Pumps (2011); Residential Central Air Conditioners and Heat Pumps (2017)	Residential	2011, 2017
Residential Clothes Washer	Residential	2012
Residential Refrigerator-Freezers	Residential	2011
Room Air Conditioners	Residential	2011
Single Package Vertical Air Conditioners and Heat Pumps	Commercial/Industrial	2015
Small Electric Motors	Commercial/Industrial	2010
Uninterruptible Power Supplies	Residential	2020
Walk-In Coolers and Freezers (2014); Walk-in Coolers and Freezers (2017)	Commercial/Industrial	2014, 2017
Water Heaters	Residential	2010

* Year when the energy conservation standards final rule with new efficiency standards was published.

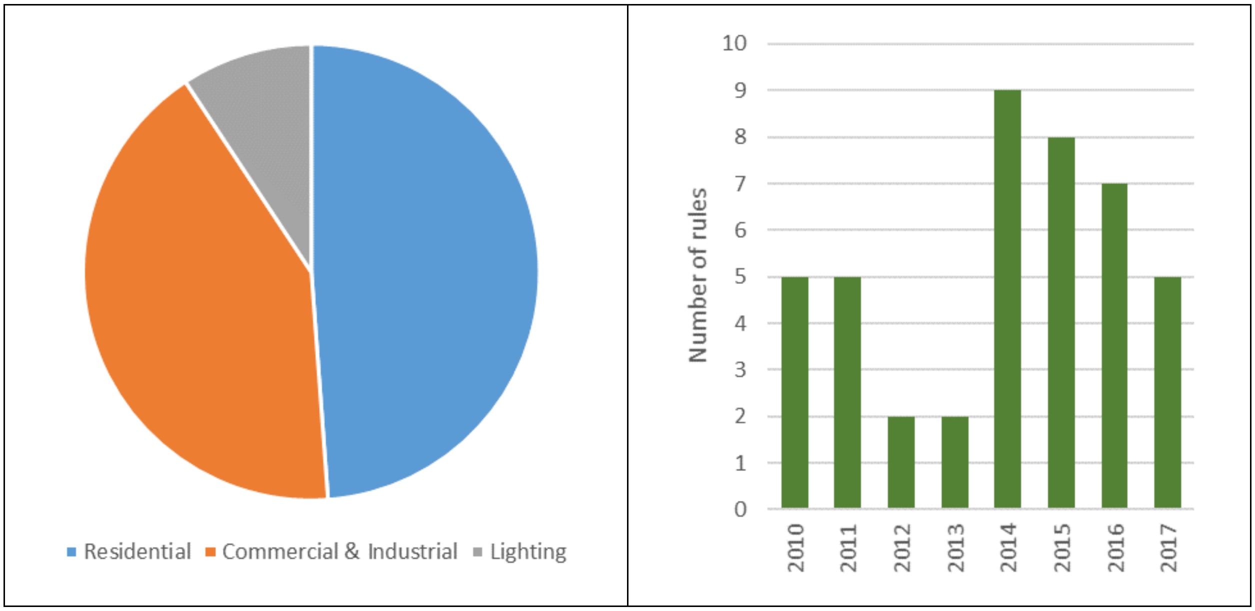


Figure 3: Distribution of products across application types and rules over time

Table 2: Energy and economic benefits estimated for rebates

Type of Product	Energy Savings (*quads*)	Net-Present Value (*billion 2019$*)	
		7% dr	3% dr
Residential Appliances	9.4	1,217	2,305
Commercial & Industrial Equipment	6.7	187	511
Lighting Applications	2.3	6	11

Table 3: Energy and economic benefits estimated for voluntary energy targets

Type of Product	Energy Savings (*quads*)	Net-Present Value (*billion 2019$*)	
		7% dr	3% dr
Residential Appliances	3.2	8.7	25.9
Commercial & Industrial Equipment	1.5	10.9	58.8
Lighting Applications	3.2	10.9	18.4

Table 4: Descriptive statistics of how NES and NPV from rebates and VETs compare to those from new energy efficiency standards

		Min	Q25	Median	Q75	Max
National Energy Savings						
Residential Appliances	Rebate	7.4%	23.3%	30.0%	59.3%	86.0%
	VET	2.1%	4.5%	10.0%	16.0%	77.5%
Comm & Ind Equipment	Rebate	0.2%	7.3%	27.9%	44.7%	84.8%
	VET	0.9%	5.3%	11.5%	13.0%	37.0%
Lighting Applications	Rebate	7.7%	8.9%	20.3%	35.6%	48.4%
	VET	19.6%	24.5%	28.7%	35.6%	48.4%
* All	Rebate	0.2%	11.4%	30.0%	49.2%	86.0%
	VET	0.9%	5.7%	11.5%	19.5%	77.5%
Net-Present Value (7% dr)						
Residential Appliances	Rebate	10.7%	18.5%	25.0%	50.5%	86.2%
	VET	1.6%	5.1%	10.1%	17.1%	85.3%
Comme & Ind Equipment	Rebate	0.2%	6.7%	26.7%	50.4%	86.1%
	VET	0.7%	4.9%	10.8%	13.9%	33.3%
Lighting Applications	Rebate	6.9%	8.1%	28.1%	48.4%	51.0%
	VET	23.3%	25.2%	28.0%	33.1%	41.7%
* All	Rebate	0.2%	11.4%	25.0%	50.5%	86.2%
	VET	0.7%	5.2%	10.8%	18.5%	85.3%
Net-Present Value (3% dr)						
Residential Appliances	Rebate	2.2%	21.1%	27.3%	51.8%	128.3%
	VET	1.7%	5.3%	10.5%	18.1%	85.5%
Comm & Ind Equipment	Rebate	0.3%	7.6%	31.1%	47.7%	86.0%
	VET	1.1%	6.3%	11.7%	13.4%	37.6%
Lighting Applications	Rebate	7.6%	8.4%	28.3%	47.9%	48.1%
	VET	24.0%	24.8%	28.4%	35.4%	46.2%
* All	Rebate	0.3%	11.4%	31.0%	49.1%	128.3%
	VET	1.1%	6.4%	11.7%	18.3%	85.5%

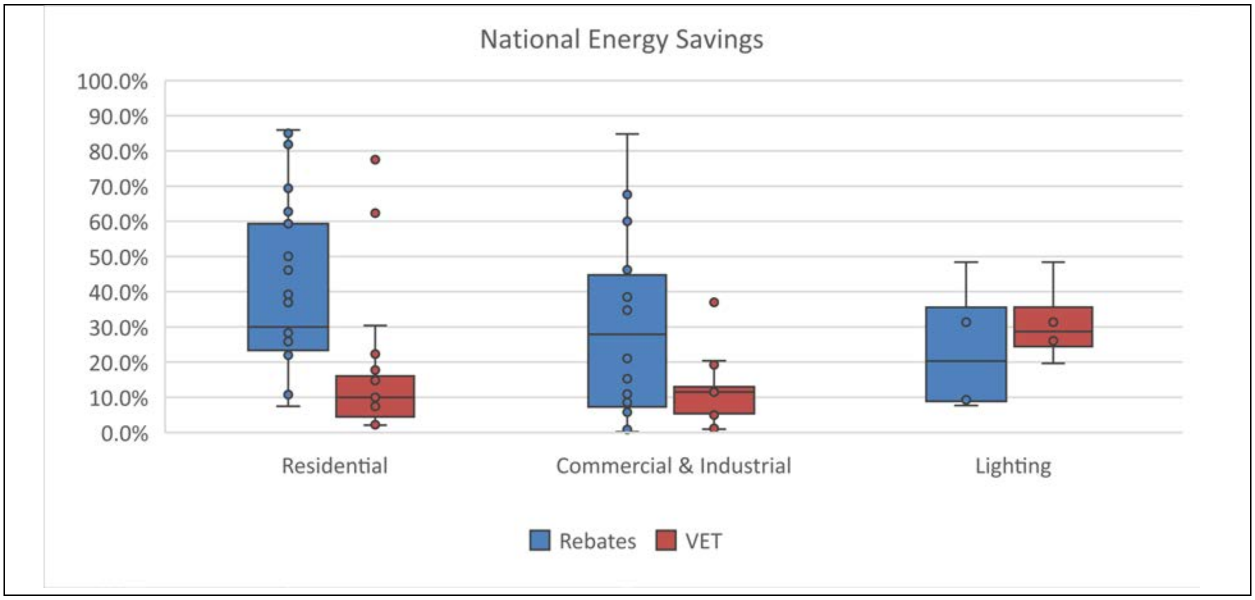
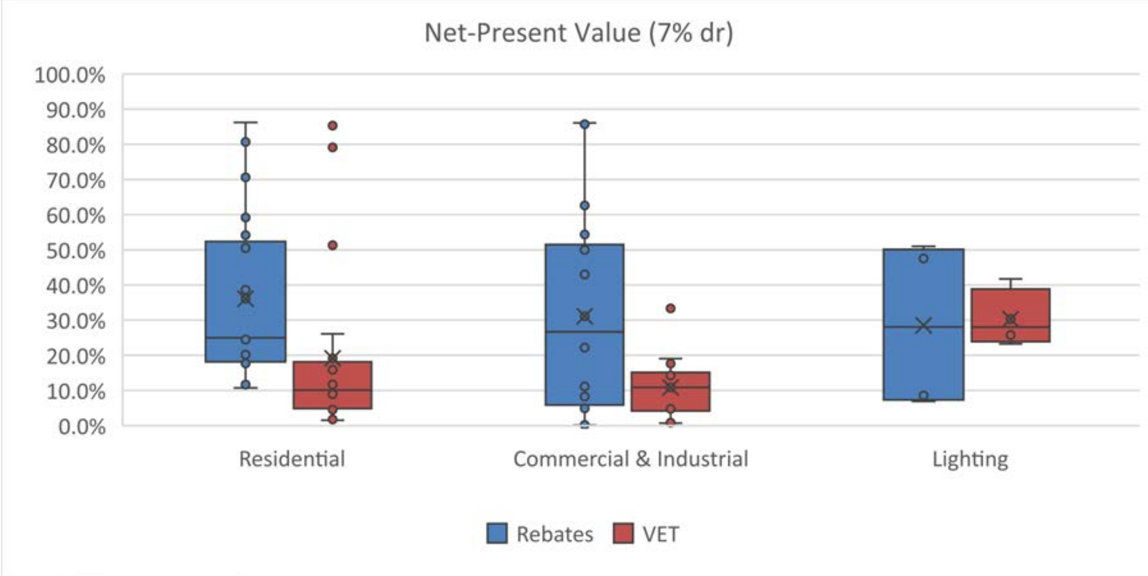


Figure 4: National energy savings compared to those from new minimum efficiency standards

The median national energy savings that result from rebates for residential appliances is 30% of the energy savings seen as a result of standards. The minimum energy savings that result from rebates for residential appliances is about 7% while the maximum energy savings is 86%. The median energy savings for residential appliances that result from VETs fall at 10% of the energy savings seen as a result of standards, while the range of savings is between roughly 2% and 78% of the energy savings seen as a result of standards. National energy savings from rebates provided for commercial and industrial equipment range from less than 1% to roughly 85% of the national energy savings resulting from standards, with the median energy savings falling at 28% of those savings seen as a result of standards. The median energy savings resulting from VETs applied to commercial and industrial equipment is approximately 7% of those seen as a result of energy efficiency standards, while the range of energy savings is between 1% and 37% when compared with the savings from energy efficiency standards. When considering rebates applied to lighting applications, results show that the median national energy savings fall at 20% of the national energy savings seen as a result of efficiency standards, with a range between 8% and 48%. Lastly, VETs applied to lighting applications result in median national energy savings of 26% when compared with the national energy savings resulting from energy efficiency standards. The range of national energy savings resulting from VETs applied to lighting applications is between 20% and 48% of those savings seen as a result of standards.



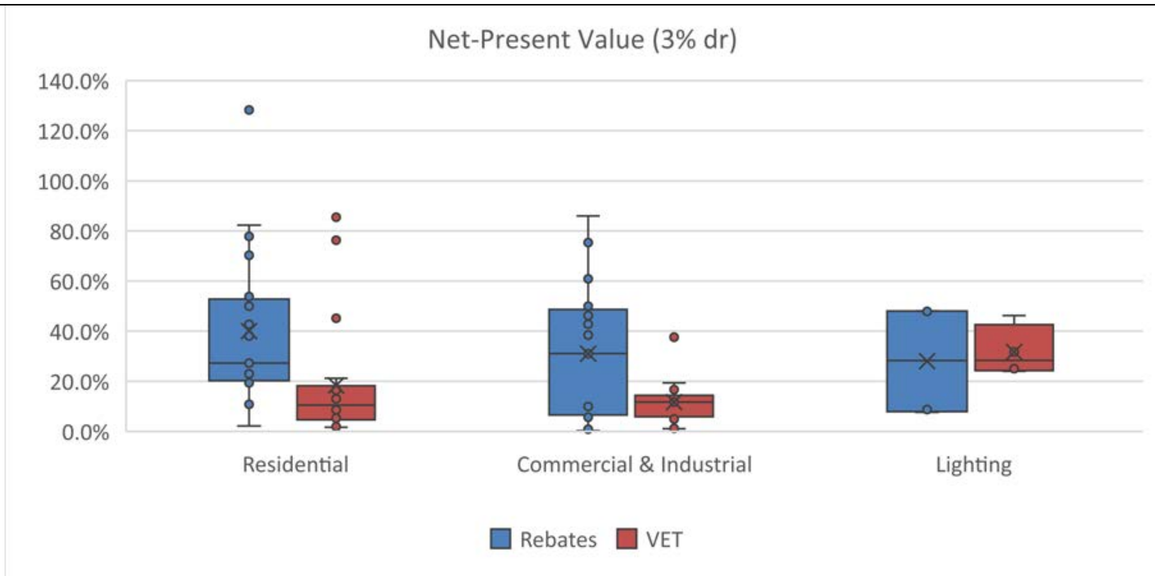


Figure 5: Net-Present Values compared to those from new minimum efficiency standards

In a few, very specific cases, the energy savings from rebates are estimated to be greater than 80% of the energy savings estimated for standards. This includes three residential appliances and one commercial and industrial equipment. The increase in market penetration that could be achieved by these rebate programs is estimated under the assumption that the rebate value would cover in full—or almost in full—all upfront costs. Additionally, shipments of these products are estimated to be dominated by sales to markets with below-to-moderate barriers to energy efficiency. The two assumptions combined overestimate the adoption of energy efficient products and, therefore, lead to high energy savings.

The NPV from an energy efficiency investment is directly affected by the energy savings resulting from the investment. Therefore, the way the NPV from the non-regulatory policies and programs relates to the NPV from the new standards (Figure 5) follows the same trends as seen in the comparative analysis of energy savings (Figure 4).

The large variation observed in the estimated changes in market penetration due to rebate programs result from a combination of two factors: (a) the relevance of the rebate value relative to the total incremental upfront costs associated with a model that meets the target EL, compared to a baseline model – a model rated at the lowest energy efficiency in the market; and (b) the level of barriers estimated for the market associated with the product.[19] Given a market for an energy consuming product, the larger the rebate amount the larger the impact (increase in market penetration) of the rebate. On the other hand, a rebate amount that reduces the upfront incremental costs by a certain percentage is expected to have a larger impact in a market with a low level of barriers than in a market with a high level of barriers.

In most of the analyses, the rebate values are defined based on rebate programs available at the time the analysis was performed,[20] and the level of market barriers are estimated based on the benefit-cost ratio and market penetration estimated for models rated at the target EL. As an example of how these two parameters combined can lead to estimates of very low impacts from a rebate program, a rebate of $60.30 (2021$)[21] offered towards some types of commercial walk-in coolers and freezers, corresponding to approximately 0.1% to 0.3% of their total installed cost in a market characterized by extremely high barriers, would increase their penetration by 0.06% to 0.32% and result in energy savings of 0.2% of the savings estimated from standards. On the other hand, a rebate of $38.62 (2021$)[22] offered towards electric clothes dryers, a market characterized by low-to-moderate barriers, would cover the incremental upfront costs in full, lead to an increase in market penetration of 51%, and result in energy savings of 85% of the savings estimated from standards.

Results for VETs also vary significantly, mostly for residential appliances. This is due to the assumptions made regarding the ability of a labeling initiative to reduce, over time, the barriers to energy efficiency and thereby increase purchases of models that meet the target EL. In most of the analyses, the assumption is that labels could reduce market barriers, over 10 years, by one level (e.g., from high to moderate barriers, or from moderate to low barriers). In some cases, however, the analyses relied on historical data of market adoption influenced by the ENERGY STAR program.

Overall, results show that the alternative policies and programs addressed in this review are estimated to provide, altogether, about 36% of the total energy savings estimated for the new standards, with an average[23] NPV corresponding to 52% of the NPV estimated for those standards. The NPV results are dominated by the NPV from rebate programs. The latter are

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[19] The level of barriers associated with the market can range continuously from the reference “no barriers” level to the “extremely high barriers” level.

[20] It is also assumed that the rebate programs would be available to all consumers, and that all consumers would be aware of these programs.

[21] The original rebate value assumed is $51.83 (2013$).

[22] The original rebate value assumed is $31.00 (2009$).

[23] Average here refers to the mean of the NPVs calculated with a 7% and 3% discount rates.

more ubiquitous in the analyses of the benefits from non-regulatory policies and programs and enjoy the benefit of a monetary incentive that reduces the total cost of the efficient product and thus increase its NPV. However, it should be noted that these various policies are not in competition. Regulatory and non-regulatory policies are not mutually exclusive, and there may be compelling reasons to pursue multiple separate policies addressing a given market.
Two sources of uncertainty affect our comparative analysis. First, the relative decrease in the incremental upfront costs provided by a rebate is not homogeneous across products. The TSDs report the value of the incentive used in each case. When available, the incentive values were obtained from current or past utility rebate programs. When not available, they were either (a) estimated from rebate programs offered to analogous products or (b) assumed to cover a certain fraction of the incremental product cost between a baseline model and a model that meets the target EL. In the latter case, the fraction ranged from 25% to 100% of the incremental upfront costs.

The second source of uncertainty is related to the magnitude and timing of the effects of informational incentives on reducing the level of barriers to energy efficiency in a certain market. While these should vary across products, due to the lack of empirical data to support a robust assumption, they are assumed (almost) the same in terms of the level of reduction in the market barriers they can induce over a period of 10 years. Therefore, the increase in market penetration estimated for VETs can be either under- or overestimated.

4. Conclusion

Energy efficiency measures can be mandatory or voluntary. Mandatory policies set energy efficiency targets that are legally binding and subject to enforcement. Voluntary programs target and promote products that meet a certain level of energy efficiency, but participation is not required. Therefore, it is reasonable to assume that the latter are not expected to be as effective as the former in transforming the market and raising the bar of energy efficiency for energy consuming goods. In the U.S., during the analysis of its energy conservation standards, DOE evaluates the potential benefits from alternative, non-regulatory- policies and programs. While these analyses and their results are available, for most of DOE’s energy conservation rules, to the best of our knowledge, they have not been previously evaluated together and at the aggregate level.

In this report, we review how estimates of benefits from two types of voluntary energy efficiency initiatives compare to the same benefits estimated for minimum energy efficiency standards established in the U.S. for residential appliances, commercial and industrial equipment, and lighting applications. Specifically, we compare the energy savings and net-present value that have been estimated for rebates and voluntary energy efficiency targets with those from energy efficiency standards set by DOE for 39 types of energy consuming products from 2010 to 2020. Approximately half of the products reviewed are residential appliances, and two thirds of the energy conservation rules examined were published on or after 2014.
Results show that, overall, the alternative, voluntary energy efficiency measures could provide,

altogether, as much as 36% of the energy savings expected to be provided by new efficiency standards, with an average net-present value[23] that corresponds to 52% of the NPV estimated for standards. When considering all energy conservation rules reviewed in this report, the maximum energy savings a rebate is estimated to achieve is 86% of the savings from the new standards set for the same type of product. As for VETs, the highest energy savings correspond to 78% of the savings from standards. Those results, however, are outliers, as shown from the distributions of the comparative benefits. According to our comparative analysis, the third quartiles of the distributions of all estimated relative benefits from rebates and VETs are, respectively, 49% and 19%; and the lowest contribution of these alternative measures to energy savings could be as low as less than 1% of the savings provided by energy efficiency standards. The effectiveness of alternative policies and programs to achieve higher levels of energy efficiency is therefore uncertain. Nevertheless, when applied in tandem with minimum efficiency standards, they can sometimes be powerful instruments for promoting and increasing energy efficiency in an economy.

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