POCKETBOOK SAVINGS, MACROECONOMIC GROWTH AND OTHER PUBLIC BENEFITS OF ENERGY EFFICIENCY APPLIANCE STANDARDS:

Benefit-Cost Analysis of Four Decades of Rules Shows they have Delivered Trillions of Dollars of Economic Value to Consumer and the Nation

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JULY 2017

TABLE OF CONTENTS

EXECUTIVE SUMMARY: (COMMENTS OF THE CONSUMER FEDERATION IN THE MATTER OF THE DEPARTMENT OF ENERGY REQUEST FOR INFORMATION REGARDING REDUCTION REGULATORY BURDENS) iv

I. INTRODUCTION 1

A. The Legal Context of Regulatory Reform of Appliance Efficiency Standards
B. Outline

II. THE LEGAL AND ANALYTIC FOUNDATION OF BENEFIT-COST ANALYSIS 4

A. Law and Regulatory Practice
EPCA, 1975
E.O. 12291 (Reagan, 1981)
E.O. 12866 (Clinton, 1993)
E.O. 13563 (Obama, 2011)
B. The Importance of Rigorous Benefit-Cost Analysis
Benefits and Costs
Market Imperfections
C. Performance Standards, Effective "Command-But-Not- Control" Regulation
D. Traditional Externalities: Environmental, Public Health and other Impacts

III. BENEFIT-COST ANALYSIS OF ENERGY EFFICIENCY STANDARDS 13

A. Costs and the Tendency to Decline
Empirical Evidence of Cost Declines
Explanations for the Overestimation of Costs
B. Benefits
Consumer Pocketbook Savings
Pass Through of Intermediate Costs
C. The Discount Rate
D. Rebound effect
E. Evaluation Metrics
F. A Comprehensive View of the Impact of Efficiency Standards
Consumer Preferences and Market Imperfections
Transfer Payments and Economic Growth

IV. MACROECONOMIC GROWTH AS A POSITIVE EXTERNALITY OF WELL-DESIGNED PERFORMANCE STANDARDS 21

A. Conceptualizing the Sources of Macroeconomic Stimulus
B. Quantitative Estimates

V. QUANTITATIVE ANALYSIS 27

A. The Track Record of Appliance Energy Performance Standards and Prices
Impact on Efficiency
Price

B. The Benefit Cost Analysis of Four Decades of Appliance Efficiency Standard
Past Standards
Present and Future Standards
C. Conclusion

ENDNOTES 35

LIST OF FIGURES

II-1: The Near Perfect Correlation of Greenhouse Gas Emissions and Fuel Economy 12
III-1: The Projected Costs of Regulation Exceed the Actual Costs: Ratio of Estimated Cost to Actual Cost by Source 14
III-2: Estimated and Actual Cost Increases Associated with Recent Standards for Major Appliances 15
IV-1: Macroeconomic Impact from Investing in Energy Efficiency 25
V-1: Appliance Efficiency Standards and Trends 28
V-2: Price Trends and Standards 30

LIST OF TABLES

II-1: Market Imperfections 10
II-2: Attributes of Effective, Command But Not Control Standards 11
IV-1: Multiple Benefits of Energy Efficiency 22
IV-2: Estimates of Macroeconomic Multipliers as a Multiple of Net Pocketbook Savings 26
V-1: Multivariate Analysis of Appliance Standards 29
V-2: Evaluation of Efficiency Standards, Past, Present and Future 32

EXECUTIVE SUMMARY:
(COMMENTS OF THE CONSUMER FEDERATION IN THE MATTER OF THE DEPARTMENT OF ENERGY REQUEST FOR INFORMATION REGARDING REDUCTION REGULATORY BURDENS)

The Consumer Federation of America[1] appreciates the opportunity to provide the Department of Energy (DOE) with guidance in its efforts to improve the regulatory process. Throughout its 50 years of existence, CFA has been a vigorous and continuous participant in the process of setting regulations to improve the efficiency of energy-using consumer durables and lower the cost of energy borne by consumers.[2] Electricity and natural gas, the two sources of energy most directly affected by DOE regulations, are a major household expenditure, representing over 3 percent of total expenditures, one of the 6 largest subcategories listed in the consumer expenditure survey.[3]

To guide the DOE, we have prepared and attached as Appendix A an analysis of the forty-year history of appliance efficiency standards.[4] The starting point for the DOE consideration of regulatory reform and relaxation must be a recognition of the remarkable benefits that the appliance efficiency standards have provided for consumers and nation.

CONSUMER POCKETBOOK AND MACROECONOMIC BENEFITS

In the period from 1988-2008, appliance efficiency standards:

- Delivered almost $500 million in consumer pocketbook savings[5] and
- Created $300 billion of indirect macroeconomic benefits,[6]
- At a cost of less than $200 billion,, yielding
- A benefit-cost ratio of over 4-to-1.

The recent past, 2008-2016, has been a particularly active period of standards writing because courts found that federal agencies had missed their statutory deadlines for updating rules and the Energy Independence and Security Act of 2007 rebooted the fuel economy standards for vehicles, while amping up the standards writing process for appliances.

The efficiency standards adopted after EISA are particularly consumer friendly because of the dramatic technological revolution in lighting, which the standards help to push into the deployment phase. Consequently, the standards will result in:

[1] The Consumer Federation of America is an association of more than 250 nonprofit consumer groups that was established in 1968 to advance the consumer interest through research, advocacy, and education.
[2] The CFA website (http://consumerfed.org/issues/energy/) provides links to 140 pieces of testimony and reports published in the past ten years dealing with the efficiency of energy-using consumer durables divided roughly equally between appliances and vehicles.
[3] https://www.bls.gov/cex/22016/midyear/quintile.pdf. Adding in fuel economy standards, which are governed by a structure of legal authority and administrative rules similar to that affecting appliances doubles the level of household expenditures and makes regulatory reform one of the largest consumer pocketbook issues for the Trump or any administration.
[4] Mark Cooper, 2017, *Pocketbook Savings, Macroeconomic Growth and Other Public Benefits of Energy Efficiency Appliance Standards: Benefit-Cost Analysis of Four Decades of Rules Shows they have Delivered Trillions of Dollars of Economic Value to Consumer and the Nation,* Consumer Federation of America, July.
[5] See Id., Section V.
[6] Id., Section IV explains why macroeconomic stimulus is an inherent benefit of efficiency standards and reviews the literature that estimates the magnitude of this benefit.

- Consumer pocketbook savings of about $400 billion and
- $350 billion of indirect macroeconomic benefits, at
- A cost of just under $80 billion,
- A benefit-cost ratio of over 8-to-1.

Thus, combining benefits of past and present standards, we see over $1.5 trillion in benefits with less than $300 million in costs, for a benefit cost ratio of about 6-to-1.

These estimates are all expressed in real, 2016 dollars based on a 3% discount rate.[7] We distinguish between pocketbook savings and macroeconomic impacts. The former are based on traditional regulatory impact assessments, the latter are based on a review of the extensive analysis of economic input/output models. We conservatively assume that every dollar of net increase in disposable income enjoyed by households as a result of more efficient consumer durables (i.e. energy savings minus technology costs) add another dollar to the gross domestic product. We do not include national security, environmental and public health benefits in the above calculations. These externalities are substantial and they could easily raise the benefit cost ratio to 6-to-1.

Moreover, the tendency for implementation costs to be well below agency projections of costs is not factored into the above estimates.[8] Of equal importance, detailed analysis of the impact of standards on major household appliances like refrigerators and air conditioners shows not only that the price increases are a small fraction of the estimates made by regulators and industry, but the increase in efficiency does not come at the expense of performance and quality.[9]

Future benefits that could be achieved under the current law and administrative approach have been estimated to be over $720 billion in consumer pocketbook savings at a cost of less than $240 billion. We add to this indirect, macroeconomic benefits of almost $500 billion, for a total of over $1.2 trillion and a benefit-cost ratio of 5-to-1.

THE LEGAL AND ANALYTICAL FRAMEWORK

This background of remarkable success should encourage the DOE to use restraint in changing a highly effective policy approach. Moreover, the Department of Energy's efforts to reduce regulatory burdens are constrained by laws.[10] This regulatory reform/relaxation proceeding cannot repeal and must be bound by three sets of laws.

- The laws of policy enacted by Congress that sets goals and Executive Orders that define the implementation path for agency action.
- The laws of economics that drive the benefits and costs of regulations.
- The laws of physics that link the consumption of fossil fuels and the emissions

[7] Id., Section III outlines the empirical assumptions and outcome measures.
[8] Id., Section III discusses the strong evidence that implementation costs are far less than agencies estimate or product manufacturers claim because well-crafted performance standards trigger market process of innovation and competition to deliver least-cost approaches to compliance.
[9] Section V-A.
[10] Section II discuses all three of these constraints on agency action. Section II-A discusses the legal aspect.

of pollutants as waste products.

The DOE is obligated under existing law and executive orders to adopt regulations that:

- strive to deliver the maximum net benefit in terms of energy efficiency,
- must be updated in pursuit of maximum net benefit on a regular basis and
- are not allowed to backslide.

The calculation of net benefits must

- take all benefits and costs into account, within the constraints of technologies that are feasible and practicable,
- be evaluated with discount rates ranging from 3% to 7%, and
- be quantified, if possible, but,
- where quantification is impossible or uncertain, qualitative evaluations are to be made.

This legal approach is perfectly consistent with the dominant framework of welfare economics.[11] The cornerstone of the policy that was laid forty-years ago is that there are numerous, persistent and substantial imperfections that afflict the market for energy efficiency. The aspiration of Congress and the guidance of the executive branch have established an institutional structure that has served the public and national interest by establishing reasonable and important goals and directing market forces to achieve those goals in the least-cost manner possible.

By statue and regulatory practice, the standards set by the DOE have been well-crafted to ensure their effectiveness. They take a "command-but-not control" approach that sets a performance standard but affords the manufacturers of energy-using consumer durables freedom and flexibility to meet the standards. They are technology and product neutral, setting moderately aggressive and progressive targets that are responsive to the needs of consumers and producers. They unleash market forces of competition and innovation around the standard, which explains why compliance costs have repeatedly, almost invariably, been well below the estimates made by regulators and far below the bloated cost estimates of industry.

CONCLUSION AND RECOMMENDATIONS

President Reagan set the institutional structure to implement DOE energy efficiency standards just six years after the legal foundation was enacted. Presidents Clinton and Obama refined that framework with the goal of improving it, within the constraints of law and past practice. Those Executive Orders still govern the process.

The courts and Congress took note of and acted to correct the failure of DOE to adopt beneficial regulation on the timetables mandated by in the legislation. In many respects, the

[11] Id., Section II-B discusses the economic analytic framework.

Trump Administration cannot legally impair this regulatory process. However, even where it can make changes legally, it should proceed with great care because the result would likely be to impose massive, unnecessary costs on consumers and the economy.

Regulatory reforms that relax the burden on businesses will violate the law and well-established policy and practice; if they do not increase the net benefits enjoyed by consumers and society. Such counter-productive "reforms" should not be implemented.

Agencies that refuse to adopt or delay the release of rules that increase net benefits because they cannot find two other rules to repeal, will also violate the law and established practice. The law requires the Department of Energy to act in the public interest, independently of other rules that might have become obsolete.

In sum, regulatory reform should earn its keep the old-fashioned way, by increasing, on a case-by-case basis, the net benefit of energy efficiency measures that raise consumer pocketbook savings and help to grow the economy.

I. INTRODUCTION

A. The Legal Context of Regulatory Reform of Appliance Efficiency Standards

The Request for Information (RFI) issued by the Department of Energy (published in the Federal Register on May 30, 2017) is among the first to contemplate fundamental changes in the approach to regulation in America under the Trump Administration.[1] As such, it demands a broad view of the process and how it has functioned in the past. The RFI recognizes that the recent Executive Orders on Regulatory Reform are laid atop the underlying statutes and Executive Orders in force that must be honored.[2] Executive Orders cannot repeal or redefine the Congressional intent of the authorizing statutes, they can only seek to improve the process by which the executive branch exercises the will of the Congress. Moreover, while Executive Orders can supplant earlier orders, great care should be taken in altering regulatory practice that has been successful and stood the test of time.

In the case of Department of Energy appliance efficiency standards, there is a remarkable record of success that must provide the context for and restrain efforts to reform the regulatory process. Over the course of more than forty years, with careful statutory goals and guided by a Reagan-era Executive Order whose principles remain in force to give strong guidance to the regulatory review process, Department of Energy regulations have yielded trillions of dollars of direct pocketbook benefits to consumers and indirect economic and environmental benefits to the nation. The consideration of reform of Department of Energy regulation must be informed by that remarkable track record of success.

That review must consider both the benefits and costs of standards, not because the deregulatory executive order says so (which it now does),[3] but because the underlying statutes have always required a full and careful benefit-cost analysis. Federal law not only imposes deadlines and requires benefit-cost analysis, but also requires that the conclusions be reasonably related to the facts before the agency.[4] Federal law constrains executive actions in other ways, requiring cooperation between federal and state agencies, and giving states a right to independent action under the American approach to federalism.

In this analysis, we offer guidance to the Department of Energy's regulatory reform effort that builds on the track record and the legal context.

The rule of law requires an agency to reach decisions that reflect a reasonable interpretation of the evidence on the record before it. The impact of policy on consumer pocketbooks and public support for consumer-friendly policies is important evidence. Our public opinion polling data shows that consumers overwhelmingly support efficiency standards.[5] Our economic analysis, summarized below, explains why they are right to do so – these standards have saved and continue to save consumers billions of dollars.

No area of policy reflects this reality better than energy efficiency standards. Triggered four decades ago by the oil price shocks of the 1970s, the use of standards to promote energy efficiency has enjoyed a remarkable degree of bipartisan and public support.[6] This support stems in large measure from the obvious benefit of efficiency.[7] Efficiency standards deliver massive pocketbook savings to consumers that helps to grow the economy.[8] The national security, public health and environmental benefits are substantial too, but much smaller than the direct consumer and indirect economic benefits.

In this paper we analyze the past, present and future impact of appliance efficiency standards on consumers and the economy using very conservative assumptions and conclude that they have produced, are producing and are likely to continue to produce massive public benefits. The long history of consumer benefits from and support for energy efficiency standards and this huge consumer stake in continuing to develop these standards make it clear that this is one of the biggest consumer pocketbook issues that the DOE and the current administration will deal with. Regulatory reform that threatens to stymie the implementation and enforcement of current appliance efficiency standards or the continued development of appliance efficiency standards would impose massive harm on the public.

B. OUTLINE

Given the long history of support for efficiency standards, the strong record of positive results, and the unprecedented nature of the attack on standards, this paper presents a comprehensive overview of why and how benefits have been consumer friendly for over four decades. Given the extensive conceptual and analytic framework we have presented in regulatory proceedings,[9] papers,[10] and research reports[11] over the past decade, this paper presents a brief overview of the analytic framework, but focuses on the quantitative evaluation of a full accounting of costs and benefits.

Section II explains the legal and analytic terrain on which regulatory reform must operate. It first describes the legal context, then offers an economic explanation of why performance standards work so well to save consumers money and grow the economy, particularly when applied to energy efficiency.

Section III describes the traditional approach to cost-benefit analysis prepared by regulatory agencies under their authorizing statutes and the Executive Orders in force. It discusses why there is a systematic tendency for regulatory agencies to overestimate the cost of compliance with well-designed performance standards.

Section IV describes the economic growth effects that inevitably flow from well-designed performance standards and argues that they should be included in any comprehensive cost-benefit analysis. We develop and use extremely conservative rules of thumb and show the impact they would have on the bottom line evaluation of efficiency standards.

Section V describes the quantitative methodology and discusses the estimates of costs and benefits of past, present and future appliance efficiency standards. It provides a new perspective in two ways. First, it introduces a consistent set of definitions and evaluations across the full range of efficiency standards. Second, it examines the benefits and costs from five points of view.

We examine past standards, generally in the period from the 1980s to 2007, to establish the baseline impact of efficiency standards in which we are not debating projections but looking at actual performance.

We analyze present standards, generally in the period 2008-2016. While there are still uncertainties here, the initial effect of the standards can be seen. Although we rely on the agency regulatory and technology impact assessments, real world effects support the conclusion that the effect has been positive.

We examine pending standards for the current period, 2017- forward. These involve many of the standards that the Trump Administration is seeking to delay, roll back, or repeal. Although they rest on agency documents, the decision to adopt these standards is based on the evidentiary record. Under the process of the Administrative Procedure Act the Trump Administration faces the challenge of reaching a different conclusion either by reinterpreting the record before the agency or by building a new record that reaches a contrary conclusion. Either way, the existing record poses a significant challenge to the new administration.

Finally, we consider future standards and the potential for consumer benefit from continued development of standards. Many of the authorizing statutes tell the agencies to adopt standards that achieve maximum feasible economic benefits within the bounds of technological feasibility. Some have timelines for the development of standards. This creates an impetus for the continuous development of standards that are in the public interest, as technology advances. In fact, many of the standards adopted by the Obama Administration were required by the courts because the prior two administrations had failed to execute the statutes responsibly. Moreover, Congress passed a major piece of legislation – the Energy Independence and Security Act of 2007 (EISA), which compelled auto and appliance efficiency standards to be adopted.

II. THE LEGAL AND ANALYTIC FOUNDATE OF BENEFIT-COST ANALYSIS

Because concerns about energy consumption were magnified by the energy price shocks of the 1970s, there is an extremely large and rich literature on why there is a significant and persistent "efficiency gap."[12] While the impetus to setting standards for energy consumption of durable goods was the urgent effect of price shocks on the economy and national security (both of which can be considered, "externalities" of energy consumption), engineering-economic analysis identifies numerous attractive opportunities to invest in energy saving technologies that cost less than the savings they generate. This literature offers a conceptual explanation based on the observation that there are imperfections on both the supply and demand sides of energy markets that lead producers to underinvest in energy efficiency and consumers to demand less efficiency than is economically justified.

That literature also contains hundreds, if not thousands, of peer-reviewed and published empirical studies of the actual and potential energy savings across a broad range of goods. It contains numerous comparisons of policy instruments in which performance standards repeatedly turn out to be among the most effective tools for addressing these market imperfections when they take a "command but not control," approach.[13]

A. LAW AND REGULATORY PRACTICE

EPCA, 1975

The contemporary, substantive requirements for setting standards began with Energy Policy Conservation Act, signed into law in 1975 are at 42 U.S.C. § 6295(o). The clearly defined goals are "maximum improvement in energy efficiency" subject to the constraint that they are "technologically feasible and economically justified" based on a finding that "the benefits of the standard exceed its burdens by, the greatest extent possible." The agencies are told to consider "the economic impact of the standard on the manufacturers and on the consumers, the savings in operating costs… compared to any increase in price of… or maintenance expenses of the covered products." Complex concerns are also raised like "any lessening of the utility or the performance"… or competition for," the covered products.[14]

Although amended from time to time, this language has stood the test of time and been incorporated into a series of executive orders. Less than a month into the Reagan Administration, Executive Order 12291 outlined the principles and practices to govern the evaluation and promulgation of rules and standards. Although these were modified slightly by later presidents, the basic structure has remained the same. Since the law was quite new when Reagan took office and few standards had been written, his executive order essentially established the practice.

E.O. 12291 (Reagan, 1981)

> Sec. 2. General Requirements. In promulgating new regulations, reviewing existing regulations, and developing legislative proposals concerning regulation, all agencies, to the extent permitted by law, shall adhere to the following requirements:
>
> (a) Administrative decisions shall be based on adequate information concerning the need for and consequences of proposed government action;

(b) Regulatory action shall not be undertaken unless the potential benefits to society from the regulation outweigh the potential costs to society;

(c) Regulatory objectives shall be chosen to maximize the net benefits to society;

(d) Among alternative approaches to any given regulatory objective, the alternative involving the least net cost to society shall be chosen; and

(e) Agencies shall set regulatory priorities with the aim of maximizing the aggregate net benefits to society, taking into account the condition of the particular industries affected by regulations, the condition of the national economy, and other regulatory actions contemplated for the future.

Sec. 3. Regulatory Impact Analysis and Review.

(a) In order to implement Section 2 of this Order, each agency shall, in connection with every major rule, prepare, and to the extent permitted by law consider, a Regulatory Impact Analysis. Such Analyses may be combined with any Regulatory Flexibility Analyses performed under 5 U.S.C. 603 and 604.

(b) Each agency shall initially determine whether a rule it intends to propose or to issue is a major rule, provided that, the Director, subject to the direction of the Task Force, shall have authority, in accordance with Sections l (b) and 2 of this Order, to prescribe criteria for making such determinations, to order a rule to be treated as a major rule, and to require any set of related rules to be considered together as a major rule.

(c) Except as provided in Section 8 of this Order, agencies shall prepare Regulatory Impact Analyses of major rules and transmit them, along with all notices of proposed rulemaking and all final rules, to the Director as follows:

(1) If no notice of proposed rulemaking is to be published for a proposed major rule that is not an emergency rule, the agency shall prepare only a final Regulatory Impact Analysis, which shall be transmitted, along with the proposed rule, to the Director at least 60 days prior to the publication of the major rule as a final rule;

(2) With respect to all other major rules, the agency shall prepare a preliminary Regulatory Impact Analysis, which shall be transmitted, along with a notice of proposed rulemaking, to the Director at least 60 days prior to the publication of a notice of proposed rulemaking, and a final Regulatory Impact Analysis, which shall be transmitted along with the final rule at least 30 days prior to the publication of the major rule as a final rule;

(3) For all rules other than major rules, agencies shall submit to the Director, at least 10 days prior to publication, every notice of proposed rulemaking and final rule.

(d) To permit each proposed major rule to be analyzed in light of the requirements stated in Section 2 of this Order, each preliminary and final Regulatory Impact Analysis shall contain the following information:

(1) A, description of the potential benefits of the rule, including any beneficial effects that cannot be quantified in monetary terms, and the identification of those likely to receive the benefits;

(2) A description of the potential costs of the rule, including any adverse effects that cannot be quantified in monetary terms, and the identification of those likely to bear the costs;

(3) A determination of the potential net benefits of the rule, including an evaluation of effects that cannot be quantified in monetary terms;

(4) A description of alternative approaches that could substantially achieve the same regulatory

goal at lower cost, together with an analysis of this potential benefit and costs and a brief explanation of the legal reasons why such alternatives, if proposed, could not be adopted; and

(5) Unless covered by the description required under paragraph (4) of this subsection, an explanation of any legal reasons why the rule cannot be based on the requirements set forth in Section 2 of this Order.

President Clinton replaced Reagan's executive order, but as the following text shows, his Executive Order 12866 kept the essential elements of the approach in place. In terms of the analysis below, it rendered the review more flexible and encouraged greater reliance on market forces. It introduced the concept of performance standards and called for careful review across all standards.

E.O. 12866 (Clinton, 1993)

Section 1. Statement of Regulatory Philosophy and Principles.

a. The Regulatory Philosophy. Federal agencies should promulgate only such regulations as are required by law, are necessary to interpret the law, or are made necessary by compelling public need, such as material failures of private markets to protect or improve the health and safety of the public, the environment, or the well-being of the American people. In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits shall be understood to include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach.

b. The Principles of Regulation. To ensure that the agencies' regulatory programs are consistent with the philosophy set forth above, agencies should adhere to the following principles, to the extent permitted by law and where applicable:

1. Each agency shall identify the problem that it intends to address (including, where applicable, the failures of private markets or public institutions that warrant new agency action) as well as assess the significance of that problem.
2. Each agency shall examine whether existing regulations (or other law) have created, or contributed to, the problem that a new regulation is intended to correct and whether those regulations (or other law) should be modified to achieve the intended goal of regulation more effectively.
3. Each agency shall identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.
4. In setting regulatory priorities, each agency shall consider, to the extent reasonable, the degree and nature of the risks posed by various substances or activities within its jurisdiction.
5. When an agency determines that a regulation is the best available method of achieving the regulatory objective, it shall design its regulations in the most cost-effective manner to achieve the regulatory objective. In doing so, each agency shall consider incentives for innovation, consistency, predictability, the costs of enforcement and compliance (to the government, regulated entities, and the public), flexibility, distributive impacts, and equity.

6. Each agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs.
7. Each agency shall base its decisions on the best reasonably obtainable scientific, technical, economic, and other information concerning the need for, and consequences of, the intended regulation.
8. Each agency shall identify and assess alternative forms of regulation and shall, to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt.
9. Wherever feasible, agencies shall seek views of appropriate State, local, and tribal officials before imposing regulatory requirements that might significantly or uniquely affect those governmental entities. Each agency shall assess the effects of Federal regulations on State, local, and tribal governments, including specifically the availability of resources to carry out those mandates, and seek to minimize those burdens that uniquely or significantly affect such governmental entities, consistent with achieving regulatory objectives. In addition, as appropriate, agencies shall seek to harmonize Federal regulatory actions with related State, local, and tribal regulatory and other governmental functions.
10. Each agency shall avoid regulations that are inconsistent, incompatible, or duplicative with its other regulations or those of other Federal agencies.
11. Each agency shall tailor its regulations to impose the least burden on society, including individuals, businesses of differing sizes, and other entities (including small communities and governmental entities), consistent with obtaining the regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations.
12. Each agency shall draft its regulations to be simple and easy to understand, with the goal of minimizing the potential for uncertainty and litigation arising from such uncertainty.

E.O. 13563 (Obama, 2011)

Improving Regulation and Regulatory Review
Section 1. *General Principles of Regulation.*

(a) Our regulatory system must protect public health, welfare, safety, and our environment while promoting economic growth, innovation, competitiveness, and job creation. It must be based on the best available science. It must allow for public participation and an open exchange of ideas. It must promote predictability and reduce uncertainty. It must identify and use the best, most innovative, and least burdensome tools for achieving regulatory ends. It must take into account benefits and costs, both quantitative and qualitative. It must ensure that regulations are accessible, consistent, written in plain language, and easy to understand. It must measure, and seek to improve, the actual results of regulatory requirements.

(b) This order is supplemental to and reaffirms the principles, structures, and definitions governing contemporary regulatory review that were established in Executive Order 12866 of September 30, 1993. As stated in that Executive Order and to the extent permitted by law, each agency must, among other things: (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor its regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

(c) In applying these principles, each agency is directed to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. Where appropriate and permitted by law, each agency may consider (and discuss qualitatively) values that are difficult or impossible to quantify, including equity, human dignity, fairness, and distributive impacts.

The pedigree, longevity and success of this law and administrative practice create a formidable institutional structure that deserves a great deal of respect and deference. As a result, energy performance standards enjoy a remarkable degree of public and bipartisan support.[15]

B. The Importance of Rigorous Benefit-Cost Analysis

Benefits and Costs

The principles that the laws and executive orders teach should be familiar to and learned by anyone who has taken Economics 101. Proper cost benefit analysis must include careful consideration of costs and benefits. In fact, an introductory economics text written by John B. Taylor,[16] who holds prestigious named appointments at Stanford University and the conservative Hoover Institute and who served as an Under Secretary of the Treasury in the George W. Bush administration,[17] defines cost benefit analysis as follows:

> Cost-Benefit Analysis: an appraisal of a project based on the costs and benefits from it.[18]

A more advanced text on *The Economics of Regulation and Antitrust*,[19] calls it benefit-cost analysis and explains the obvious need to include costs and benefits as follows:

> From an economic efficiency standpoint, the rationale for a benefit-cost approach seems quite compelling. At a very minimum, it seems reasonable that society should not pursue policies that do not advance our interests. If the benefits of a policy are not in excess of the costs, then clearly it should not be pursued, because such efforts do more harm than good. Ideally, we want to maximize the net gain that policies produce…
>
> The requirement that benefits exceed costs for sound regulatory policies has also given rise to a simple shorthand. The ratio of benefits to costs, or the benefit-cost ratio, must exceed 1.0 for a policy to be potentially attractive. This requirement serves as the minimum tests for policy efficacy, as our overall objective should be to maximize the spread between benefits and costs.[20]

The recent OMB advice letter calls for careful cost-benefit analysis.[21] The challenge as always will be to ensure that agencies do not engage in "fuzzy math." The threat of "fuzzy math" is nothing new and the APA takes a pragmatic approach to evaluating whether the agency decision is consistent with the record before it. The remainder of this section discusses the rationale for implementing standards to reduce the efficiency gap and describes the key elements that must be included in the benefit cost calculation to avoid "fuzzy math."

Market Imperfections

The cornerstone of the cost benefit justification for standards is the potential to produce a benefit. If the marketplace is performing well, it is difficult to justify policy intervention. If it not performing well for any variety of reasons, it is policy interventions in the market can improve market performance. Viscusi, et al., present an overarching observation as the starting point for this analysis.

> "If we existed in a world that functioned in accordance with the perfect competitive paradigm, there would be little need for antitrust policies and other regulatory efforts. All markets would consist of a large number of sellers of a product, and consumers would be fully informed of the product's implications. Moreover, there would be no externalities present in this idealized economy, as all effects would be internalized by the buyers and seller of a particular product.
>
> Unfortunately, economic reality seldom adheres very closely to the textbook model of perfect competition. Many industries are dominated by a small number of large firms. In some instances, principally the public utilities, there may even be a monopoly…
>
> Not all market failures stem from actions by firms. In some cases, individuals can also be contributing to the market failure."[22]

The key elements of this analytic framework were put into place a quarter of a century ago in Executive Order 12866 and they remain in effect today. They have stood the test of time because they further the goals enacted by Congress and comport with the precepts of economic analysis.

The empirical evidence with respect to energy efficiency indicates is that there is a significant failure of the market to produce optimum results. The recent literature, which has been reviewed in many recent proceedings, shows that there is a massive efficiency gap and there are numerous, well-documented market imperfections that lead to underinvestment and under-supply of energy saving technologies in consumer durable and commercial equipment markets.

Societal failures, like the national security implications of energy imports, were often the starting point for the consideration of policies to intervene in the market. Environmental externalities were another early and obvious market failure. The study of the market for energy efficiency has yielded many other sources of imperfections. We have documented and discussed these at great length in comments, as well as papers and reports. Table II-1 summarizes the intersection of our broad analysis of imperfections in the market for energy efficiency and the empirical evidence we have reviewed in hundreds of studies.

C. Performance Standards, An Effective "Command-But-Not- Control" Approach

Even with well documented market imperfections, there is no guarantee that the standards will deliver the benefits they claim. The design of standards is important.

Viscusi, et al., go on to describe several attributes of regulation that improve its efficacy, stating that "performance-oriented regulation," "give firms some discretion in terms of the means of their compliance," "utilization of unbiased estimates of benefits and costs," and "avoid… regulation of prices and production."[23] This observation is often repeated with respect to energy efficiency performance standards. Other key characteristics that the literature identifies as making for effective standards that promote innovation, in addition to flexibility, include certainty of standards, progressive moving targets, and elimination of information asymmetry.[24]

TABLE II-1: MARKET IMPERFECTIONS

Schools of Thought/Imperfection	Schools of Thought/Imperfection
Traditional	Transaction Cost/ Institutional
Externalities	Search and Information
Public Goods & Bads	Imperfect information
Basic Research/Stock of Knowledge	Availability
Network Effects	Accuracy
Learning-by-Doing & Using	Search cost
Localization	Bargaining
Industry Structure	Risk & Uncertainty
Imperfect Competition	Liability
Concentration	Enforcement
Barriers to Entry	Fuel Price
Scale	Sunk costs
Cost structure	Hidden cost
Switching costs	High Risk Premia
Technology-Innovation Economics	Incomplete Markets
R&D	Endemic Imperfections
Investment	Asymmetric Info
Marketing	Agency
Bundling: Multi-attribute	Adverse selection
Cost-Price	Perverse incentives
Limit impact of price	Lack of capital
Sluggish Demand/Fragmented Mkt.	Political Power & Policy
Limited payback	Monopoly/lack of competition
Behavioral	Incumbent power
Motivation & Values	Institutional support
Non-economic	Inertia
Influence & Commitment	Regulation
Custom	Price
Social group & status	Aggregate, Avg.-cost
Perception	Allocating fuel price volatility
Bounded Vision/Attention	Permitting
Prospect/ Risk Aversion	Lack of commitment
Calculation.	
Bounded rationality	
Limited ability to process info	
Heuristic decision making	
Discounting difficulty	

Source: Framework developed in Comments of the Consumer Federation of America, Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Environmental Protection Agency 40 CFR Parts 86 and 600, Department of Transportation 49 CFR Parts 531,633, 537, et al., November 28, 2009. Most recent update, including climate change literature available in Mark Cooper, 2017, The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector, (Praeger), Chapter 7 and Appendix II for a more recent comprehensive review.

There is a lot of empirical evidence that energy savings measures often provide an effective, cost-efficient approach to reducing greenhouse gas emissions, while generating co-benefits on employment and competitiveness…

> Well-designed regulation that is strict in ambition, but flexible in implementation would point companies to the problem of inefficiencies, trigger information gathering, reduce uncertainty and create a market push within an overall level-playing field. Compliance to regulation will lead to greater innovation (cleaner technologies, processes) as key means to reduce inefficiency, which will lead to environmental benefits, hence lower overall costs. Moreover, cost savings can (but do not always) lead to partial or full offset of regulatory compliance and innovation cost and hence increase overall competitiveness.[25]

In an earlier analysis, CFA explained that well-crafted performance standards exhibit a "command but not control" approach to deliver consumer benefits at least cost. These standards work best when they embody six principles, as described in Table II-2,[26] because they unleash market forces in pursuit of the goal.

TABLE II-2: ATTRIBUTES OF EFFECTIVE, COMMAND BUT NOT CONTROL STANDARDS

Long-Term: Setting an increasingly rigorous standard over a number of years that covers several redesign periods fosters and supports a long-term perspective. The long term view lowers the risk and allows producers to retool their plants and provides time to re-educate the consumer.

Product Neutral: Attribute based standards accommodate consumer preferences and allow producers flexibility in meeting the overall standard.

Technology-neutral: Taking a technology neutral approach to the long term standard unleashes competition around the standard that ensures that consumers get a wide range of choices at that lowest cost possible, given the level of the standard.

Responsive to industry needs: The standards must recognize the need to keep the target levels in touch with reality. The goals should be progressive and moderately aggressive, set at a level that is clearly beneficial and achievable.

Responsive to consumer needs: The approach to standards should be consumer-friendly and facilitate compliance. The attribute-based approach ensures that the standards do not require radical changes in the available products or the product features that will be available to consumers.

Procompetitive: All of the above characteristics make the standards pro-competitive. Producers have strong incentives to compete around the standard to achieve them in the least cost manner, while targeting the market segments they prefer to serve.

Sources: Testimony of Dr. Mark Cooper, Director of Research, Consumer Federation of America, on "Midterm Review and an Update on the Corporate Average Fuel Economy Program and Greenhouse Gas Emissions Standards for Motor Vehicles," Before the *Committee on Energy and Commerce Subcommittee on Commerce, Manufacturing, and Trade Subcommittee on Energy and Power*, U.S. House of Representatives, September 22, 2016.

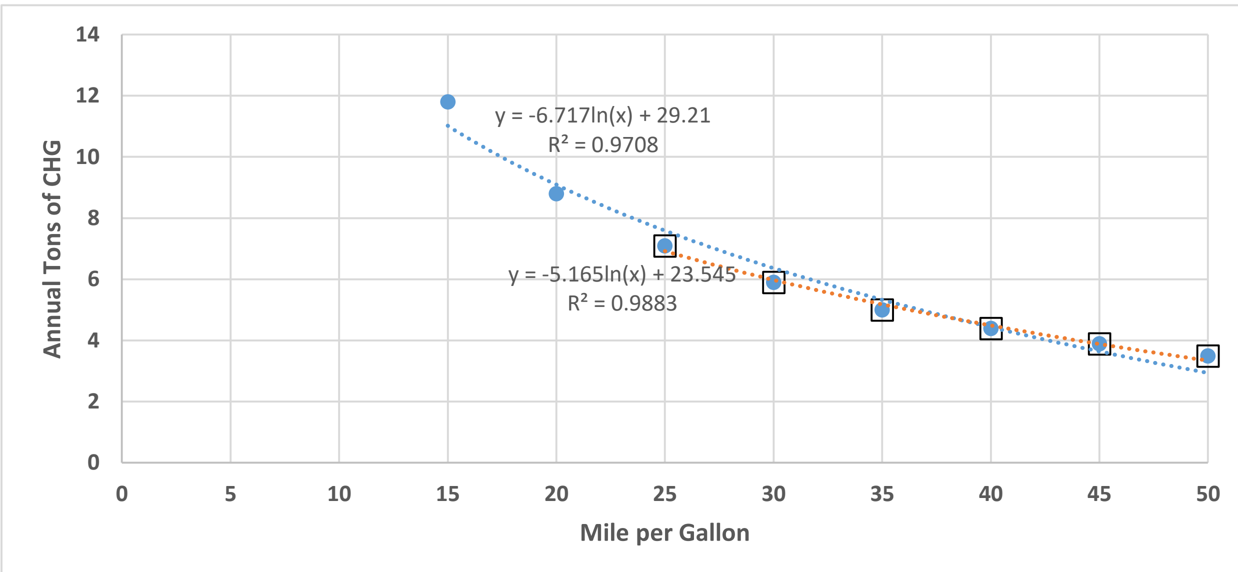
D. TRADITIONAL EXTERNALITIES: ENVIRONMENTAL, PUBLIC HEALTH AND OTHER IMPACTS

The history and broad framework of energy efficiency standards directly raises another important issues, as the Viscusi, et al., discussion highlights. There are a number of effects that can be considered externalities because they do not enter into individual consideration in consumer and producer transactions. One such externality that is grounded in the laws of physics is particularly important.

Because of the physical relationship between energy consumption and pollution emissions, one of the clear impacts of efficiency standards, whether instituted for energy, environmental, or public health reasons, is a reduction in pollution. The reduction of carbon emissions receives a great deal of attention today. The benefits of the reduction of emissions of non-carbon pollutants (e.g. SOX, NOX, particulates) are also important, have long been recognized, and the value of these is subject to less controversy.

As we pointed out long ago in our work on the Clean Cars program,[27] the near perfect correlation between the emission of pollutants and consumption of petroleum products in vehicles creates a powerful and inevitable connection between environmental protection and consumer pocketbook savings (See Figure II-1). The same is true for other fossil fuels used directly by consumers or to produce electricity. The amount of pollution associated with electricity consumption will depend on the mix of resources used to generate it, and as reliance on fossil fuels declines, so too will the amount of pollution reduction, but the least-cost and most effective approach to reduction of emissions remains improving energy efficiency.[28]

FIGURE II-1: THE NEAR PERFECT CORRELATION OF GREENHOUSE GAS EMISSIONS AND FUEL ECONOMY



Source: EPA, *Sources of CO_2 Emissions for a Typical Household,* www.fueleconomy.gov/feg/climate.shtml

The least cost approach to emission reductions is to improve the efficiency of vehicles and appliances by reducing their energy consumption. All the agencies involved in setting standards, EPA, NHTSA, DOE, be they emissions, appliances, or fuel economy are required to consider this economic benefit. This physical relationship makes the adoption of pollution reduction unique in writing environmental standards to regulate pollution because the avoided cost of energy consumption are direct and immediate pocketbook benefits of the standard. Viewed in this way, it can be argued that the consumer pocketbook savings are an inevitable, unintended consequence (an externality) of the reduction in pollution, which are not considered in the transaction.

III. BENEFIT-COST ANALYSIS OF ENERGY EFFICIENCY STANDARDS

A. Costs and the Tendency to Decline

The starting point of the analysis is the costs of standards, which has received a great deal of attention from the opponents of standards.[29] Interestingly, they have used the costs estimated by the agencies in their technical and regulatory analyses, with a 3% discount rate. We believe this is the appropriate basis for the analysis, but it is only the starting point.

The costs presented by the agencies are an appropriate starting point because the agencies tend to spend an immense amount of time analyzing these costs, including technology and maintenance. They do not just accept the high costs suggested by industry or the low costs put forward by efficiency advocates. They do independent analysis of costs, frequently engaging in engineering (tear down) studies and reviewing the technical literature, as well as numerous reports from the National Research Council of the National Academy of Sciences.[30] Although, as discussed below, the regulatory agencies still tend to overestimate costs because they do not fully reflect the dynamic, cost-reducing effects of market forces and market-driven innovation, their cost estimates are the best place to start and anchor the analysis.

For the analysis of the costs of past (older) standards, the studies tend to look to actual market data to estimate costs rather than projections of costs. This may rely on manufacturer price data, consumer expenditure data, or econometric (hedonic) estimates.

In this section, we argue that the strong evidence of overestimation of cost should be recognized in the cost benefit analysis. We recognize that the agencies run multiple scenarios to test the sensitivity of the results to assumptions and frequently apply Monte Carlo statistical tests to assess the likelihood of outcomes. But with strong historical evidence and well documented economic processes that explain a persistent and systematic pattern, the pattern demands more than just Monte Carlo sensitivity treatment. The outcome is more likely than a random disturbance.

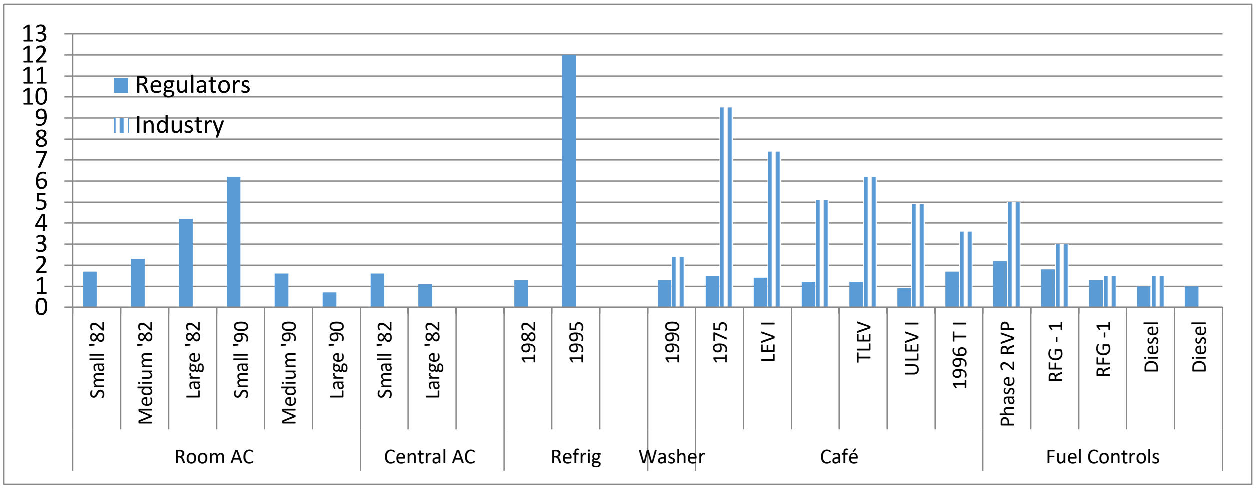
Empirical Evidence of Cost Declines

The consumer pocketbook benefits discussed above are the heart of the evaluation. A key factor that affects the cost-benefit analysis that is not fully included in the agency evaluations involves the tendency for costs to decline. The agencies' tear down analyses endeavor to capture the development of technologies and they have applied learning curves to project cost declines, but the market has proven more dynamic than they estimate.

Policies to reduce the efficiency gap, like performance standards, will improve market performance. By overcoming barriers and imperfections, well-designed performance standards will stimulate investment and innovation in new energy efficient technologies. A natural outcome of this process will be to lower not only the level of energy consumption, but also the cost of doing so. The efficiency gap literature addresses the question of how "learning curves" will affect the costs of new technologies as they are deployed. There are processes in which producers learn by experience to lower the cost of new technologies dramatically.

Figure III-1 shows the systematic overestimation by regulators of the cost of efficiency improving regulations in consumer durables. The cost for household appliance regulations was overestimated by over 100% and the costs for automobiles were overestimated by about 50%. The estimates of the cost from industry were even father off the mark, running three times higher for auto technologies.[31] Broader studies of the cost of environmental regulation find a similar phenomenon, with overestimates of cost outnumbering underestimates by almost five to one with industry numbers being a "serious overestimate."[32]

FIGURE III-1: THE PROJECTED COSTS OF REGULATION EXCEED THE ACTUAL COSTS: RATIO OF ESTIMATED COST TO ACTUAL COST BY SOURCE



Sources: Winston Harrington, Richard Morgenstern and Peter Nelson, "On the Accuracy of Regulatory Cost Estimates," *Journal of Policy Analysis and Management* 19(2) 2000, *How Accurate Are Regulatory Costs Estimates?,* Resources for the Future, March 5, 2010; ; Winston Harrington, *Grading Estimates of the Benefits and Costs of Federal Regulation: A Review of Reviews,* Resources for the Future, 2006; Roland Hwang and Matt Peak, *Innovation and Regulation in the Automobile Sector: Lessons Learned and Implications for California's CO_2 Standard,* Natural Resources Defense Council, April 2006; Larry Dale, et al., "Retrospective Evaluation of Appliance Price Trends," *Energy Policy* 37, 2009.

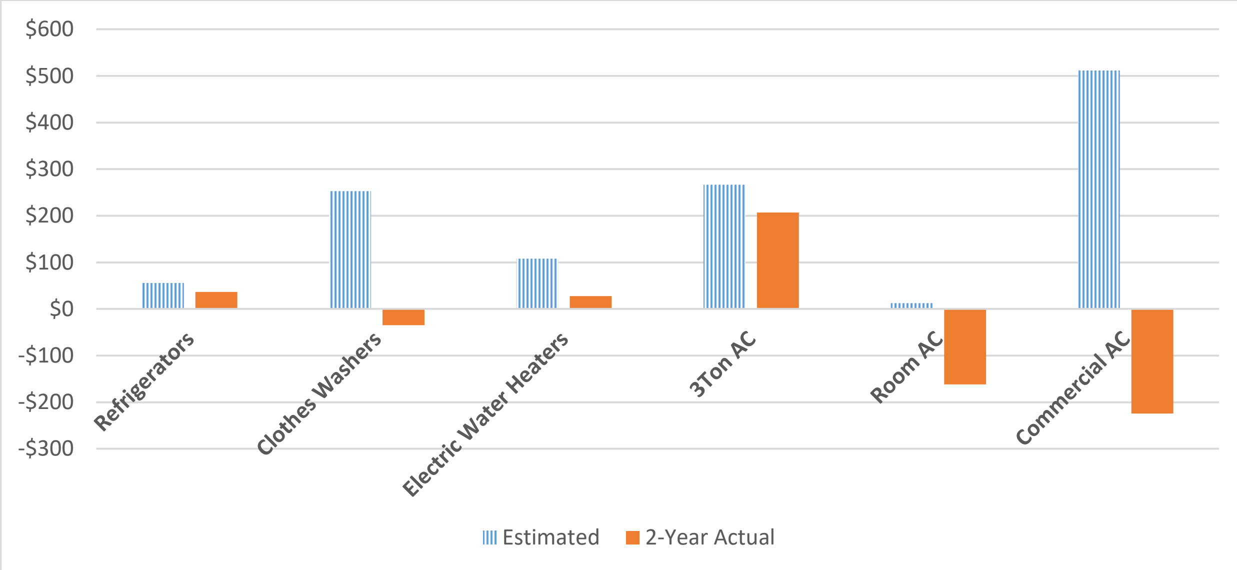
A recent analysis of major appliance standards adopted since 2000 shows a similar, even stronger pattern. Estimated cost increases are far too high, as shown in Figure III-2. There may be several factors, beyond an upward bias in the original estimate and learning in the implementation that produce this result, including pricing and marketing strategies. [33]

While the very high estimates of compliance costs offered by industry can be readily dismissed as self-interested political efforts to avoid regulation, they can also be seen as a worst-case scenario in which the manufacturers take the most irrational approach to compliance under an assumption that there is no possibility of technological progress or strategic response. Consistent with the empirical record on cost, a simulation of the cost of the 2008 increase in fuel economy standards found that a technologically static response was three times costlier than a technologically astute response.[34]

Explanations for the Overestimation of Costs

These findings of declining cost are not merely descriptive. Several analyses have introduced controls for quality and underlying trends using regression techniques. The findings are affirmed in these more sophisticated analyses.

FIGURE III-2: ESTIMATED AND ACTUAL COST INCREASES ASSOCIATED WITH RECENT STANDARDS FOR MAJOR APPLIANCES



Source: Nade, Steven l and Andrew Delaski, *Appliance Standards: Comparing Predicted and Observed Prices,* American Council for an Energy Efficient Economy and Appliance Standards Awareness Project, July 2013.

With such strong evidence of costs far below predictions by regulators who undertake engineering analysis, many authors have sought to identify the processes that account for this systematic phenomenon. For both appliances and vehicles, a long list of demand-side and supply-side factors that could easily combine to produce the result has been compiled.

On the supply-side, a detailed study of dozens of specific energy efficiency improvements pointed to technological innovation.[35] A comprehensive review of *Technology Learning in the Energy Sector* found that energy efficiency technologies are particularly sensitive to learning effects and policy.[36] This was attributed to increases in R&D expenditures, information gathering, learning-by-doing and spillover effects. Increases in competition and competitiveness also play a role on the supply side. A comparative study of European, Japanese and American automakers prepared in 2006, before the recent reform and reinvigoration of the U.S. fuel economy program, found that standards had an effect on technological innovation. The U.S. had lagged because of the long period of dormancy of the U.S. standards program and the fact that the U.S. automakers did not compete in the world market for sales, (i.e. it did not export vehicles to Europe or Japan).[37]

While the supply-side drivers of declining costs are primarily undertaken by manufacturers, a number of demand side effects are also cited, which are more the direct result of policy. Standards create market assurance, reducing the risk that cheap, inefficient products will undercut efforts to raise efficiency. Economics of scale lead to accelerated penetration, which stimulates and accelerates learning-by-doing. The effects of demand stimulus through macroeconomic stimulus also grows demand and accelerates innovation. Experiencing increasing economies and declining costs in an environment that is more competitive, leads to changes in marketing behaviors.

B. BENEFITS

Consumer Pocketbook Savings

In this analysis, we also accept the traditional agency approach to estimating consumer pocketbook savings as the primary benefit of the standards, using the 3% discount. When energy saving technology is added to energy using consumer durables or capital goods, the total amount of energy consumed declines. The decline in operating costs is larger than the capital cost increase, resulting in net pocketbook saving for consumers. As a general proposition, these benefits constitute the vast majority of the total benefits estimated by the agencies (two-thirds to four-fifths).

For studies of past (older) standards, analysts use actual market data on the energy consumption of the durable goods to calculate the annual savings. They then multiply by the average price of energy in each year (generally stated in constant, real terms) by the level of consumption. In the analysis that follows, all benefits are stated in 2106 dollars and discounted at 3%, to the extent possible.

Pass Through of Intermediate Costs

It is important to recognize that consumers are the primary beneficiaries of all efficiency standards, whether they apply to household consumer durables, or commercial/industrial energy consuming equipment. Just like any other cost, like wages or capital investment, the costs of energy are recovered by businesses from consumers in the prices they charge for goods and services that they sell.[38] We call this the "tooth fairy principle," since the tooth fairy does not pay for the energy consumed in the production and distribution of goods and services, consumers do.

Our analysis shows that the residential sector accounts for about half of the total revenue recovered for the production and delivery of electricity, natural gas and transportation fuels.[39] In econometric studies, these intermediate goods costs are not counted separately, rather they are reflected in the final goods and services. In fact, because energy costs are intermediate, and therefore a cost that is bundled and hidden from consumers, standards may be more necessary in this area, since the ability of demand to influence the energy market is shrouded.[40]

C. THE DISCOUNT RATE

No matter how lofty the goal of policy, the use of the public's money (whether for increased costs for energy consuming durables or to administer programs) to achieve a goal must not only deliver a benefit above the cost, it should also deliver a return at least as large as it could have if put to other uses. This is the opportunity cost of capital which is operationalized as the discount rate in the cost-benefit analysis.

Discounting over long periods of time has the effect of reducing the present value of dollars spent or saved later. However, when costs are incurred and benefits enjoyed over a long period, the benefit cost ratio is less affected than the total dollar amount. This is particularly true with standards that increase over time, since the marginal cost of later savings are assumed to increase in real terms. At year 15, a discounted dollar is worth $0.66 at 3%, while it is worth

$0.38 at 7%. At year 30, which tends to be the time horizon for the analysis, it is worth $0.42 at 3% and $0.14 at 7%. Since later values have less impact, the average value over 30 years is close to the mid-point value, $0.63 at 3% and $0.32 at 7%.

We have frequently argued that the 3% discount rate is the correct discount rate from the consumer point of view. It is a good, perhaps somewhat high estimate of the opportunity cost of consumer capital. It is also one of the anchor points ordered by the Office of Management and Budget (OMB), making it available in all formal agency evaluations.

In this paper, all values are converted to $2016, with BLS Consumer Price Index. All values are discounted at 3%, to the extent possible. For present and near future values, the Technical Support Documents and Federal Register notices provide the basic analysis so only a slight adjustment for the based bear is necessary.

D. REBOUND EFFECT

The studies by regulatory agencies also include a rebound effect. That is, consumers use part of the increase in pocketbook disposable income to do things that consume energy. From the environmental or energy reduction point of view, this is a negative. Energy consumption or emissions of pollutants is more than the simple improvement in efficiency suggests. From the consumer point of view, this is a positive, not a negative. That is, the fact that consumers use some of increased disposable income on energy indicates that they are using it to increase their utility. The rebound numbers (recently put at 10%, which is too high), are embedded in the analysis, and we have accepted them rather than recalculate benefits. Therefore, the rebound effect provides a small (at most 10%) “margin for error” in favor of the standards that will raise the economic benefit-cost ratio because the increase in utility has been incorrectly subtracted from the energy savings.

E. EVALUATION METRICS

In this section, we discuss the basic methodological approach to the analysis.

Benefit/Cost Ratios: Since the agencies report the costs and pocketbook benefits, it is straight forward to estimate the benefit cost ratios.

B/C = (Units Saved * $ per unit)/ ($ per appliance* number of appliances) =$ benefits/ $ costs

Each of the variables in this equation are estimates that are subject to uncertainties. The agencies engage in extensive technical analysis and utilize numerous sensitivity cases to build confidence in their results. We use their preferred or base case for our analysis.

Cost of Saved Energy: We have long argued that the cost of saved energy (which is frequently calculated in the academic literature on efficiency)[41] is a second, intuitive evaluation metric. Since the agencies identify all the technology costs (initial capital and additional maintenance) and the physical quantity of energy saved, it is possible to calculate the cost per unit of saved energy. The proposition is simple, if a consumer must spend X-$ to save Y-kWh of electricity, the cost per kWh saved can be calculated as

Cost of Saved Energy = $ Cost of Technology/# of kWh saved = $/kWh.

Using discounted, real costs and physical quantities provides an estimate that can be compared to the current, or excepted cost of consuming energy. Given that the efficiency investment brought about by the standards is highly beneficial, the cost of saved energy tends to be far below the cost of consumed energy. This view helps to understand how “bullet proof” the standards are in the sense that they are not dependent on projecting the future price of energy. That is, the real cost of consumed energy would have to fall to very, improbably low levels to make the standards a bad deal from the consumer point of view.

Payback periods: More recently, agencies have begun to show simple payback periods. While we believe that these are important from the consumer point of view, there are few examples of these. Those that have been done indicate attractive paybacks. Given the benefit cost ratios across the studies, they are generally less than half of the life the durable good. In some cases, where investments are financed, cash flow is positive in the first year.

Each of the metrics involves assumptions, about costs and some involve assumptions about the value of benefits. In this analysis, we report the benefit/cost ratio and the comparison between cost of saved energy and the current cost of consumed energy.

F. A Comprehensive View of the Impact of Efficiency Standards

In the analysis that follows, we include a “pure externalities” view of the cost benefit rules. This consists of two components (macroeconomic effects and environmental and other externalities) that are very unlikely to be internalized in the private transaction of the manufacture sale of an energy using consumer durable. As noted above, one can argue that consumer pocketbook savings are an externality of environmental regulation. In this analysis, we treat it as a direct benefit in of the rule.

Although we identify these separate components of the benefits, we believe that the correct way to view the standards is to start with the consumer pocketbooks savings and traditional externalities and recognize the additional macroeconomic stimulus created by adding new technology and lowering the total cost of owning and operating energy consuming durable goods. We reject two arguments that would narrow the view of the benefits of efficiency standards because the externalities are real.

We offer the scenario in which costs are projected to be 70% of the based case assumptions as a separate scenario.

Consumer Preferences and Market Imperfections

Opponents of regulation take a different view, arguing that, since there are choices in the marketplace, there can be no consumer utility gain from imposing standards. Consumers express their preferences and get what they want. We believe this is wrong on two counts.

First, the outcome in the market is not simply the result of consumer preferences, it is the result of all the forces that affect the options presented to consumers and that weigh on and constrain their choices. Manufacturers determine a narrow range of choices to present consumers and seek to influence consumers, through advertising and incentives, to purchase the vehicles that manufacturers want to sell. Consumer are imperfect in their calculations and projections about fuel usage and prices. Market imperfects matter and cannot be dismissed.

Second, consumers do express a great deal of interest in and concern about energy usage.

More importantly, as noted, once a well-crafted standard is adopted and implemented, it lowers the cost of driving. To the dismay of anti-standard, free market ideologues, and the surprise of consumers who end up with a more fuel-efficient cars than they thought they could get, it puts more money in the consumer's pocket. The inevitable result is to increase disposable income and, under any reasonable assumption, trigger the macroeconomic multiplier effect, which includes the consumption externality that lower prices because of reduced consumption is also triggered). The environmental and public health benefits of reduced pollution are also realized.

Transfer Payments and Economic Growth

It is possible to argue that the consumer pocketbook savings are just a transfer payments from energy producers to consumers and manufacturers of energy saving technology. As a transfer payment, they might not be considered a net gain for the economy or society.

We disagree with this on two grounds. First of all, transfers do matter. Manufacturers of energy-using consumer durables are quick to argue distributive effects when it comes to low income households, claiming incorrectly that it prices them out of the market. We think the distribution between consumers and energy suppliers does matter.

Second, if the transfers are not counted, but still recognized, then the macroeconomic effect becomes extremely important. As we have seen, some uses of disposable income have much larger multipliers than others. Transferring wealth from energy producers to energy consumers has a substantial positive impact on economic growth that should be taken into account.

This categorization and recognition of the broad benefits is not unique to energy efficiency standards. For example, a recent National Academy of Sciences Transportation Research Board report prepared for the Transit Cooperative Research Program, entitled, *Practices for Evaluating the Economic Impacts and Benefits of Transit,* noted that "Because of shifting demands and constrained budgets, transit agencies have an increasing need to consistently and defensibly document the economic impacts and benefits of the services they provide."[42] The report identifies direct and indirect benefits that are akin to those discussed in this section.

> Two primary forms of economic analysis are discussed in this report:
>
> *Impacts on the economy* – most often referred to as "economic impacts" or "economic development impacts," which encompass effects on jobs and income: and
>
> *The economic valuation of broader societal benefits* – sometimes referred to as "social welfare," benefits which encompass the valuation of "non-user benefits" (affecting quality of life, environments, and productivity) in addition to user benefits….

> Economic impact = the study of the net change in economic activity (jobs, income, investment or value added) resulting from a project, event, or policy.
>
> Economic valuation of societal benefits = the social welfare value of prices ($) and non-prices (non-$) benefits associated with a project, policy or event. The non-priced benefits are assigned a valued based on revealed or stated preference methods. [43]

This quote above includes all the impacts we have identified and the approach to valuing them, which we believe are the building blocks of a comprehensive and rigorous benefit-cost analysis.

IV. MACROECONOMIC GROWTH AS A POSITIVE EXTERNALITY OF WELL-DESIGN PERFORMANCE STANDARDS

In this section, we argue that one major externality has been present throughout the history of the energy efficiency standard setting process and should be recognized in rigorous cost benefit analysis. The macroeconomic stimulus that results from efficiency standards is a true externality, which Taylor broadly defined as "the situation in which the cost of producing or the benefits of consuming a good spill over onto those who are neither producing nor consuming the good."[44] These changes are invariably driven by the adoption of the rule and are not likely to be considered by the parties to the transaction.

A. CONCEPTUALIZING THE SOURCES OF MACROECONOMIC STIMULUS

The direct pocketbook savings of efficiency standards are the largest and most direct benefit of the standards, but this benefit has a second immediate and inevitable economic benefit. We have argued for at least a decade that the macroeconomic stimulus that results from shifting consumer spending from energy consumption to other goods and services is substantial. The academic literature supports the proposition that the higher multiplier on consumer disposable income results in an additional dollar of economic stimulus for each dollar of consumer savings.

This outcome reflects three effects. Direct and indirect growth comes from the economic activity (jobs) stimulated by the development and deployment of the energy saving technologies, which occurs directly in the new technologies and indirectly in the firms that supply new inputs for new technologies. Induced growth comes from the fact that the multiplier on energy spending is quite low compared to other activities. As disposable income is shifted from energy consumption to other goods and services, more economic activity is stimulated.

The literature on energy efficiency has a large body of research on the positive impact of reduced energy consumption on economic output. While the economic externalities of energy consumption originally entered the policy arena through the study of the negative recessionary impact of oil price shocks,[45] the positive impact of energy efficiency is becoming widely recognized and consistently modeled.[46] Importantly, the literature now goes well beyond the negative national security and environmental externalities, which are frequently noted in energy policy analysis. The macroeconomic effects of energy consumption and energy savings are important externalities of the efficiency gap.

The analyses cover a wide range of approaches. The qualitative analyses focus on very micro level impacts on individuals and utilities. For example, a recent analysis prepared for the OECD/IEA catalogued the varied positive impacts of energy efficiency, identifying over a dozen specific impacts, see Table IV-1. This list is replicated in several other qualitative analyses. Direct estimates of the non-economic benefits have been estimated at between 50% and 300% of the underlying energy bill savings.[47]

At a more macro and quantitative level, econometric models that use general flows of resources between economic activities have been used to assess the impact of increasing efficiency. In a sense, the coefficients in the macro models are representations of the relationships in the economy through which the micro level effects flow. No matter the level or approach, the evidence strongly supports the conclusion that there is a positive impact.

TABLE IV-1: MULTIPLE BENEFITS OF ENERGY EFFICIENCY

Area of impact & Specific Benefits
- Economic
  - Provider Benefit & Infrastructure
- Energy Prices
  - Public Budgets
  - Energy Security
  - Macro-economic effects
- Social
  - Health
  - Affordability
  - Access
  - Development
  - Job Creation
  - Asset Values
  - Disposable Income
  - Productivity
- Environment
  - GHG Emissions
  - Resource Mgmt.
  - Air/Water Pollutants

Sources: Lisa Ryan and Nina Campbell, *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements* (International Energy Agency, Insight Series 2012), p. 25.

Utility System

Generation
Transmission
Distribution
Line Loss, Reserves
Credit & Collections
Demand Response
Price Effect
Reduced Risk
Avoided Regulatory
Obligations & Costs
Reduced Terminations
Reduced Uncollectibles

Participant

Societal Risk & Security
Employment, Development
Productivity, Other economic
Health, Comfort, Bill Savings
O&M, Other resource Savings
Low Income Consumer Needs
Development
Employment
Property Values
Productivity

Societal Non-energy

Electricity/Water Nexus
Air quality
Water Quantity & Quality
Coal Ash & Residuals

Sources: James Lazar and Ken Colburn, *Recognizing the Full Value of Energy Efficiency* (Regulatory Analysis Project, September 2013), p. 6;

Benefit Type	Specific Benefit
Financial (other than energy cost savings)	Water and waste bill savings Reduced repaid and maintenance Increased resale value Improved durability
Comfort	Improved airflow Reduced drafts and temperature swings Better humidity control
Aesthetic	More attractive windows/appliances Less dust Reduced mold and water damage Protection of furnishings Dimmable lighting
Health & Safety	Improved respiratory health Reduced allergic reactions Lower fire/accident risk (from gas equipment)
Noise Reduction	Quieter equipment Less external noise intrusion
Education-related	Reduced transaction costs (knowing what to look for when purchasing equipment; ease of locating products) Persistence of savings Greater understanding of home operation
Convenience	Automatic thermostat controls] Easier filter changes Faster hot water delivery Less dusting and vacuuming
Other	Greater control over energy use/bills Reduced sick days Ease of selling home Enhanced pride Improved sense of environmental responsibility Enhanced peace of mind & responsibility for family well-being

Source: Jennifer Thorne Amann, 2006, *Valuation of Non-Energy Benefits to Determine Cost-Effectiveness of Whole-House Retrofit Programs: A Literature Review,* American Council for an Energy Efficient Economy, p. 8.

More Goods/Less Bads (in addition to waste & emission reduction)

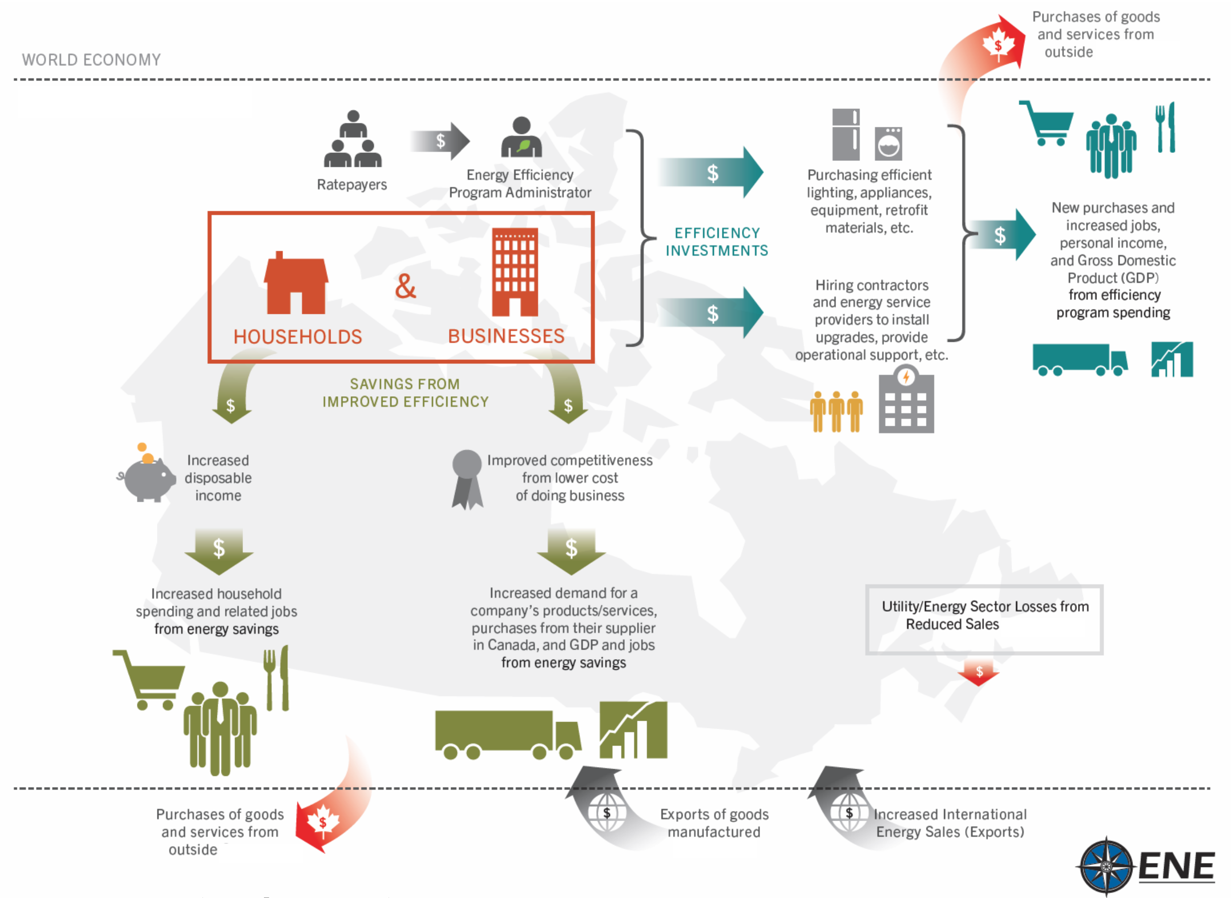
Operation & Maintenance	Production
Engineering controls	Output
Cooling requirements	Performance
Facility reliability	Process cycles
Wear and tear	Product quality
Labor requirement	Production Reliability

Work Environment	Other
Protective equipment	Less liability
Lighting	Public image
Noise	Capital saving
Temperature controls	Space saving
Air quality	Worker Moral

Source: Ernst Worrell, et al., *Productivity Benefits of Industrial Energy Efficiency Measures*, U.S. EPA, December 4, 2001.

Figure IV-1 presents the conceptual framing that describes on of the more frequently used models – the REMI model, which has been repeatedly applied in the U.S. and Canada.

FIGURE IV-1: MACROECONOMIC IMPACT FROM INVESTING IN ENERGY EFFICIENCY



Source: ENE (Acadia Centre),

Increasingly, research is showing that energy savings from energy efficiency improvements can deliver wider benefits across the whole economy such as increases in employment, GDP, trade balances, energy security, etc.…

One way to look at the macroeconomic impacts is to separate them into:

The cost and effects derived from investing in energy efficiency goods and services, and the effects derived from the energy savings (or reduced costs) from realizing an improvement in energy efficiency…

Increased energy efficiency can lead to more competitive production for 'business consumers" or energy, while for final consumers increased efficiency mainly leads to a demand shift from energy consumption to other goods. For the consuming sectors, it is relatively straightforward to observe how investment in energy efficiency and energy savings can lead to increased spending and economic activity with second round effects such as employment, government revenue, and price effects (if other investment and spending is not crowded out). There are likely to be positive income effects, unless household wage demand increases as the labor supply becomes more competitive.[48]

> Additional investment increases demand in the short-run and reduces energy costs in the long-term. On a regional level, efficiency and renewable measures create additional value added and employment…
>
> Due to the cost-efficiency of measures, additional expenditures and investment will not crowd out other investments or consumption. Energy savings and the decrease in energy costs are fully accounted for in the model…
>
> The direct effect comes from consumption of durable energy efficient goods, but there is a large indirect effect from additional consumption due to energy savings. The reallocation from energy expenditures leads to more employment. Employment rises significantly in the construction sector in industry, adding to the consumption effect.[49]

To the extent that natural gas consumption is reduced either directly using more efficient end-use equipment or indirectly through the reduction of electricity consumption, there can be a substantial consumption externality that benefits consumer pocketbooks.[50] The net effect of this mix of externalities is generally significantly positive.

B. Quantitative Estimates

In 2010, NHTSA noted one of the important externalities of reduced consumption, the downward pressure on prices, is a consumption externality. Although this is derived from an auto standard, it provides a comprehensive discussion of the macroeconomic benefits that we find in all efforts to apply these models. "Lower prices allow for additional purchase of investment goods, which, in turn, lead to a larger capital stock. These price reductions also allow higher levels of government spending while improving U.S. competitiveness thus promoting increased exports relative to the growth driven increase in imports. As a result, GDP is expected to increase because of this rule.[51]

The EPA reviewed the literature on the macroeconomic impact of reduced energy consumption.[52] It ran econometric models driven by the pocketbook savings. The analysis models three effects on impacts of the rule that trigger adjustments in the economy – increased cost for vehicles, decreased consumption of gasoline, and a reduction in the price of petroleum. It does not model the impact of reduced pollutions (carbon and non-carbon) or other changes (like reduced fueling time). It found a very substantial multiplier effect increasing the GDP by just under 1%, or $340 billion, by 2050. Discounting the incremental growth of the economy at 3%, which is the discount rate used as the base case in this paper, the total is just under $100 billion and it is reached by 2030. This is slightly larger than the total consumer pocketbook savings.

> This combination of effects—price increases for vehicles and lower demand and world oil prices—would impact all sectors of the economy that use light-duty vehicles and fuels as intermediate inputs (e.g., delivery vehicles) to produce final goods. Households would also be impacted indirectly as consumers of final goods, and directly as consumers of fuels and light-duty vehicles.
>
> It is important to note, however, that these potential impacts do not represent additional benefits or costs from the regulation. Instead, they represent the effects on the U.S. economy as its direct benefits and costs are transmitted through changes in prices in the

affected markets, including those for vehicles and their components, fuel, and the various resources used to supply them.[53]

The way the memo discusses these impacts, they are an indirect effect of the rule, a genuine externality. This approach has become quite common with detailed analyses of energy efficiency across a range of activities (autos, appliances, buildings, industries),[54] sectors (e.g. energy, manufacturing, service, particularly as it impacts use of labor)[55] and with a variety of analytic approaches (qualitative, econometric).[56] These efforts to model the economic impact of energy efficiency have proliferated with different models[57] being applied to different geographic units, including states[58] and nations.[59] The results differ across studies because the models are different, the impact varies according to the size of the geographic unit studied and because the assumptions about the level and cost of energy savings differ. These differences are not an indication that the approach is wrong. On the contrary, all the analyses conclude that there will be increases in economic activity and employment. Given that there are different regions and different policies being evaluated, we should expect different results.

The intense interest in jobs since the financial meltdown represents the beginning of the period we refer to as "the present" for the adoptions of standards, regulatory analyses tend to estimate the job impact on the industry. While this narrow view of economic impacts misses the much broader macroeconomic view discussed above, it is notable that the impact on the industry that is the target of the standard tends to be positive.[60] This results in part from the indirect effect – shifting jobs to new technology production within the sector – and in part from the induced effect, since reducing the total (ownership plus operating) cost use goes down, tends to increase demand in the mid and long terms. The energy sector is less than half as labor intensive as the rest of the economy, so the ratio of job creation for efficiency, compared to other production option in electricity is also two to one.[61] This effect is compounded where energy is imported (as in the transportation sector). As consumers substitute away from energy, the goods and services they purchase stimulate economic and disproportionately large job growth.

The rule of thumb – an approximate doubling of the economic impact – that emerges in the literature reflects the observation on jobs.[62] Similarly, in a study of 52 examples of increases in industrial productivity, where benefit was monetized, the productivity savings were 1.25 times as large as the energy savings.[63] Macroeconomic models measuring the outcome in change in GDP yield a "respending" effect that clusters around 90%.[64]

In this analysis, we take a very cautious approach to estimating the induced macroeconomic benefits of efficiency. We apply the multiplier only to the net pocketbook savings. That is, we subtract the technology cost from the savings before we use the multiplier. This ensures that we do not double count the indirect effect, although that might have an induced multiplier effect of its own.

We also do not include a separate impact of the consumption externality, the effect that U.S. consumption has on lowering the market price of energy. In petroleum, this number is substantial. Agencies have estimated it, but not included it in their cost benefit analysis. Where they have presented the calculations, it is equal to about one-fifth of what we call the macroeconomic multiplier.[65] In the appliance sector, this effect has been model by considering the impact that reduced electricity demand has on the price of natural gas.[66]

We do not apply the multiplier to the value of environmental, public health and other externalities. Although these have been monetized in the traditional cost benefit analysis, that monetization does not generally include macroeconomic multipliers. Since it could be argued that these costs are reflected in the model coefficients that are a representation of empirically observed real world relationships, out of an abundance of caution we do not apply the multiplier to these benefits, which is the traditional approach.

Table IV-2 shows the multiplier, with the GDP impact expressed as a multiplier of the value of net pocketbook savings. That is, we subtract costs from the estimated value of energy savings. This ensures we do not double count benefits.

Since none of these studies take the rebound effect into account, which the regulatory impact analyses subtract from total benefits, we show a multiplier adjusted for the rebound effect. While we have chosen not to add the rebound effect back into the pocketbook savings, it is necessary to add it into macroeconomic effect, since that is essentially what the rebound effect (to the extent there is one) represents, i.e. a respending of savings. To err on the side of caution, we assume the lowest value in the table and set the multiplier equal to the net pocketbook savings.

TABLE IV-2: ESTIMATES OF MACROECONOMIC MULTIPLIERS AS A MULTIPLE OF NET POCKETBOOK SAVINGS

Modeler	Model Date	Policy Assessed	Region	GDP/$ of Net Savings	
				Base Case	Rebound Adjustment
Roland-Holst	DEAR	Computer Standard	California	1.8	2.0
ENE	REMI	Utility Efficiency	Northeast	2.2	2.4
Cadmus	REMI	Utility Efficiency	Wisconsin	2.5	2.8
Arcadia	REMI	Utility Efficiency	Canada	2.7	3.0

Sources:
David Roland-Holst, 2016, *Revised Standardized Regulatory Impact Assessment: Computers, Computer Monitors, and Signage Displays,* prepared for the California Energy Commission, June.
ENE, *Energy Efficiency: Engine of Economic Growth: A Macroeconomic Modeling Assessment*, October 2008.
Cadmus, 2015, *Focus on Energy, Economic Impacts 2011–2014*, December.
Arcadia Center, 2014, *Energy Efficiency: Engine of Economic Growth in Canada: A Macroeconomic Modeling & Tax Revenue Impact Assessment,* October 30.

V. QUANTITATIVE ANALYSIS

A. THE TRACK RECORD OF APPLIANCE ENERGY PERFORMANCE STANDARDS AND PRICES

Impact on Efficiency

The track record of efficiency standards for household consumer durables is excellent, as shown in Figures V-1. Figure V-1 shows the record of five consumer durables since the late 1980s. Data on the efficiency of these devices has been compiled since then and it covers the period in which natural gas prices were deregulated. Efficiency is measured as the decline in energy use compared to the base year, which is set equal to 1. The performance of the furnace market is quite deficient with respect to energy efficiency, which had the weakest standards by far.

Examining the trends for individual consumer durables in Exhibit 11 suggests three important observations. First, the implementation of standards improved the efficiency of the consumer durables. Second, furnaces have been far less efficient than they should have been, since the DOE has set and maintained weak standards. Third, after the initial implementation of a standard, the improvement levels off, suggesting that if engineering-economic analysis indicates that improvements in efficiency would benefit consumers, the standards should be strengthened on an ongoing basis.

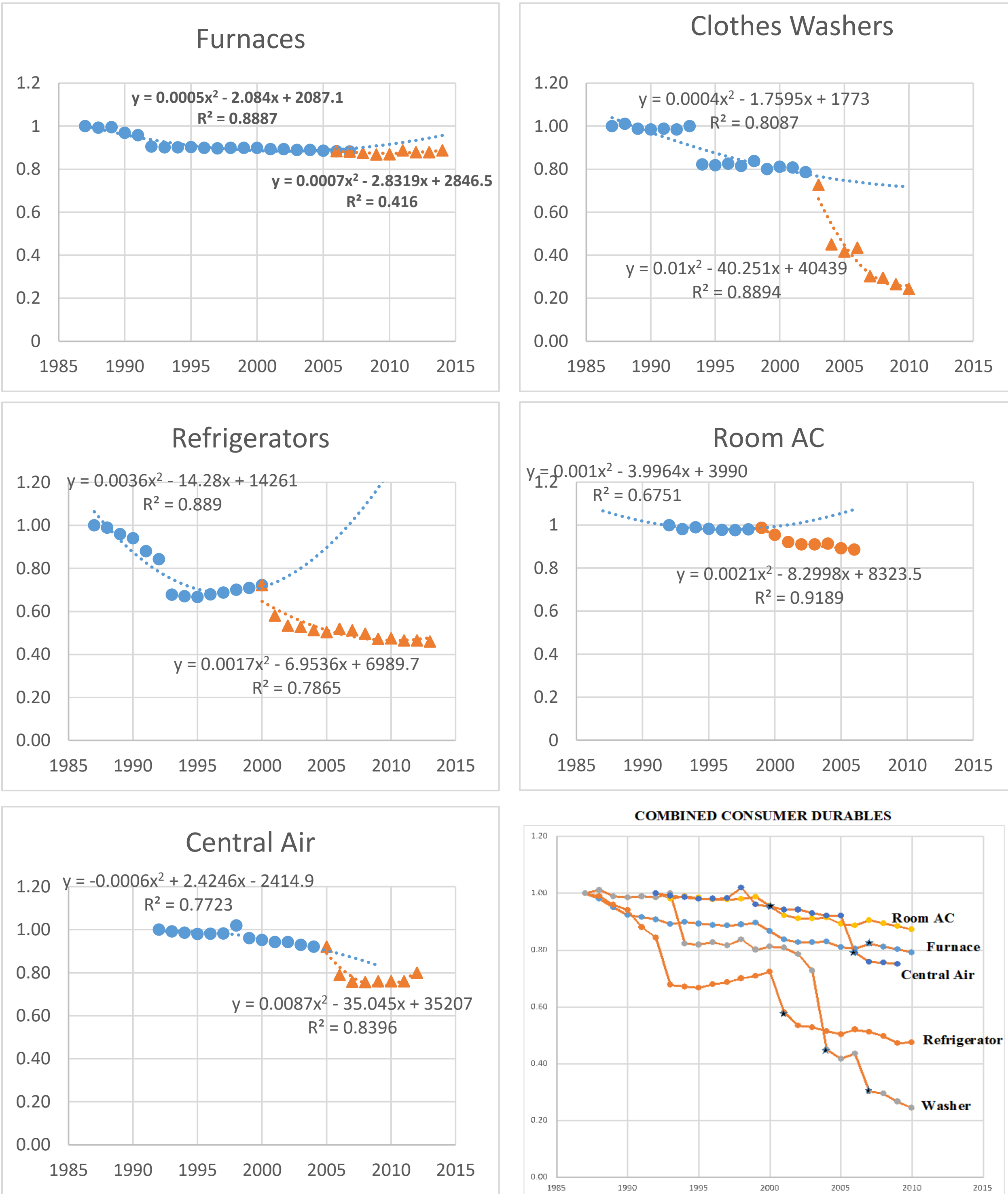
Table V-1 shows the results of econometric analysis of the data. The statistical analysis created (dummy) variables that identify each consumer durable and whether a standard was in place or not. We use the year to estimate the underlying trend. Exhibit 12 shows what is obvious to the naked eye in Figure V-1: Stricter standards as set by DOE lead to measurable improvements in appliance efficiency. Table V-1 shows that the observations that are obvious to the naked-eye in bivariate relationship in Figure V-1 are statistically valid. We present two sets of models, one based on all years and one based on shorter, five year periods before and after the standards are adopted.

We have built this analysis in the typical way that multivariate regression analysis is conducted. The dependent variable is energy consumption with the base year set equal to 1. Later years had lower values. We introduce a variable to represent the adoption of a standard.

This variable (known as a dummy variable) takes the value of 1 in every year when the standard was in place and a value of zero when it was not. A negative number means that the years in which the standard was in force had lower levels of energy consumption.

Similarly, the difference between appliances is handled with dummy variables. We include each appliance except furnaces, which shows how the other appliance performed compared to furnaces. Again, a negative number means that the other appliances had lower levels of energy consumption.

FIGURE V-1: APPLIANCE EFFICIENCY STANDARDS AND TRENDS
(BASE YEAR EFFICIENCY = 1; ▲ = NEW STANDARD)



Sources: Nadel, Steven and Andrew deLaski, *Appliance Standards: Comparing Predicted and Observed Prices*, American Council for An Energy Efficient Economy, July 2013; Steven Nadel, Neal Elliott, and Therese Langer *Energy Efficiency in the United States:35 Years and Counting*, June 2015

TABLE V-1: MULTIVARIATE ANALYSIS OF APPLIANCE STANDARDS

Variable	Statistic	5-years before/after				All Year			
		1	2	3		4	5	6	
Standard	β	-.1637	-.1386	-.1086		-.2260	-.1079	-.0803	-
	Std. Err.	(..0485)	(.0587)	(.0382)	(.0366)	(.0414)	(.0227)		
	p <	.000	.023	.007		.000	.010	.001	
Trend	β	NA	-.0053	-.0111		NA	- .0107	-.0135	
	Std. Err.		(.0081)	(.008)			(.0026)	(.0019)	
	p <		.51	.176			.000	.000	
Refrig	β	NA	NA	-.2775		NA	NA	-.2242	
	Std. Err.			(.0382)			(.0289)		
	p <			.000				.000	
Washer	β	NA	NA	-.2889		NA	NA	-.2144	
	Std. Err.			(.0561)			(.0391)		
	p <			.000				.000	
RoomAC β		NA	NA	.0478		NA	NA	-.0895	
	Std. Err.			(.0642)			(.0321)		
	p <			.383				.009	
CAC	β	NA	NA	-.0050		NA	NA	.0383	
	Std. Err.			(.0292)			(.0260)		
	p <			.864				.143	
R^2	.20	.21		.85		.29	.36	.75	

Statistics Beta coefficient and robust standard errors.

The impact of standards is statistically significant and quantitatively meaningful in all cases. The coefficient in column 6 (All Years, All Variables) indicates that the standard lowers the energy consumption by about 8%. This finding is highly statistically significant, with a probability level less than .0001. There is a very high probability that the effect observed is real. The underlying trend is also statistically significant, suggesting that the efficiency of these consumer durables was improving at the rate of 1.35% per year. Given that the engineering-economic analysis had justified the adoption of standards and that standards were effective in lowering energy consumption, this means the market trend was not sufficient to drive investment in efficiency to the optimal level.

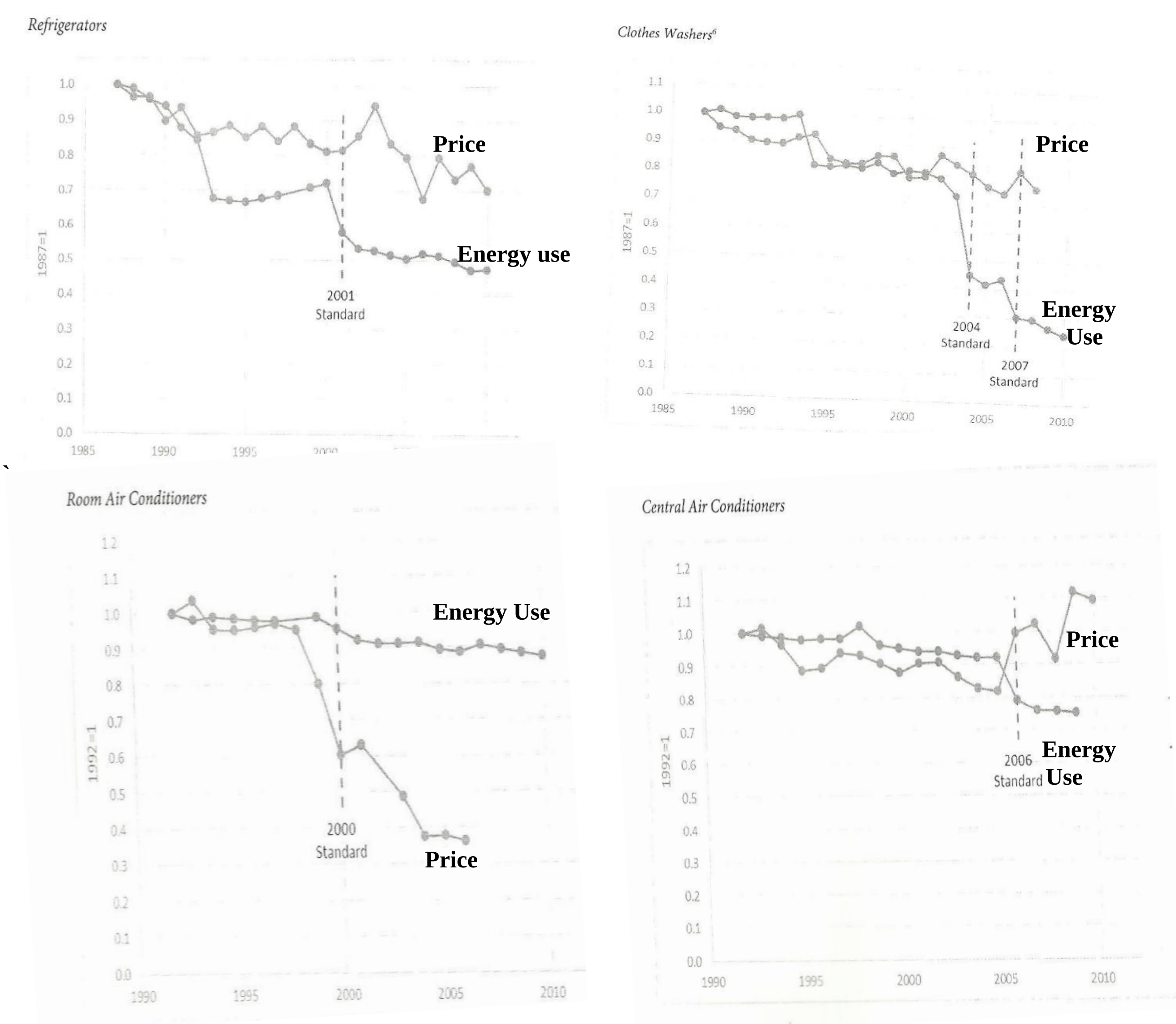
We include the variables for consumer durables other than furnaces, which means the Beta coefficient measures the performance compared to furnaces. Negative numbers indicate that the energy use declined more for the consumer durable other than for furnaces. Refrigerators, clothes washers and room air conditioners perform significantly better than furnaces. Central air conditioners show no statistically significant difference. Comparing the models with shorter terms to the all year model is consistent with the earlier observation. The impact of the standard is greater (almost 11% in column 3) because we have eliminated the out years where the effect of the standard has worn off. The impact of the trend is slightly smaller (1.1% per year) but the statistical significance is greatly affected by shortening the period because we truncate the trend.

Price

The engineering-economic analysis indicates that although the standards may increase the cost of the consumer durable, the reduction in energy expenditures is larger, resulting in a net benefit to consumers. We have also pointed to evidence that the costs of energy saving technologies tend to be smaller than the *ex-ante* analysis suggests because competition and other factors lower the cost. The experience of the implementation of standards for the household consumer durables is consistent with this interpretation.

While the efficiency was increasing, the cost of the durables was not, as shown in Figure V-2. There are five standards introduce for the four appliances in Figure V-2. In three of the cases (refrigerators, clothes driers – second standard, and room air conditioners), there was a slight increase with the implementation of the standard, then a return to a pre-standard downward trend. In one case (clothes driers – first standard) there was no apparent change in the pricing pattern. In one case (central air conditioners) there was an upward trend.

FIGURE V-2: PRICE TRENDS AND STANDARDS



Source: Steven Nadel and Andrew deLaski, *Appliance Standards: Comparing Predicted and Observed Prices,* American Council for an Energy Efficient Economy, July 2013.

We do not mean to suggest that the price increase was too big, compared to the engineering-economic analysis or that the standards lowered costs, although there are theories that would support such a theory (i.e. suppliers take the opportunity of having to upgrade energy efficiency through redesign to make other changes that they might not have made otherwise). However, this does indicate that the standards can be implemented without having a major, negative impact on the market.

The analysis of consumer durables also shows that there was no reduction in the quality or traits of the products. The functionalities were preserved while efficiency was enhanced at modest cost.

B. The Benefit Cost Analysis of Four Decades of Appliance Efficiency Standard

In this section, we discuss the costs and benefits of four decades of energy efficiency performance standards. We discuss the results in chronological order and start with the traditional benefit- cost factors.

The sources and notes identify the source of the estimates and any features of the analysis that deviate from the basic assumptions discussed earlier. In Table V-2 we have highlighted the key results. The traditional factors included – consumer pocketbook and traditional externalities are in bold. The "pure externalities" view that adds the macroeconomic and traditional externalities are underlined. The total benefits view, which combines the pure externalities and consumer pocketbook benefits are bold and underlined. The view that assumes costs are only 70% of the regulatory estimate is in italics. We do not apply this view to the past standards, since those costs are estimated directly from experience.

The results of the analysis in Table V-2 send a loud and clear message, which explains the strong public and bipartisan support for efficiency standards.

- Over forty years, past, present, and future, across all types of energy consuming durables, residential appliances and commercial equipment, the consumer pocketbook savings have far exceeded the cost of technology.
- The cost of saved energy is generally one-third of the current cost of consuming energy.
- The environmental, public health, and other externalities are roughly equal to the costs.
- Macroeconomic benefits generally run between two and three times the cost.
- Total benefits are generally six times the cost.
- Past Standards

The backward-looking evaluations of the broad impact of past standards are quite different than the technical support analyses that evaluate current and future standards, but they reach similar conclusions and support the methodology used for projections. The studies examine the units shipped, prices paid and the efficiency of specific products. They tend to use a higher discount rate than the one we use, but it is extremely difficult to adjust their findings, so we have only inflated the dollar amounts to state all costs and benefits in terms of 2016 dollars. The actual benefits would be higher with lower discount rates.

TABLE V-2: EVALUATION OF EFFICIENCY STANDARDS, PAST, PRESENT AND FUTURE

Type of Durable Good	Period (Source) (Discount rate, 3% exceptons noted)	Cost & Benefits Type	$2,016 Billions at 3% discou (except as Noted)	Evaluation of Standard Benefit/ Cost Ratio (b/c)	*b/c @ 70% of Cost*	Resource Value Cost of Saved Energy Billion $/ Quad BTU	Cost of Consumed Energy Bilion $/ Quad BTU	Value of other externalities Primarily Envirionmental $2016, billions	b/c	Externalities Macro-econ + Enviro/Health b/c	*b/c @ 70% of Cost*	Total benefits b/c	*b/c @ 70% of Cost*
Past													
Appliances	1988-2007	Technology Cost	$179			$2.29	$3.55						
	(Meyers, et al.)	Pocketbook Savings	$488	**2.73**				$156	**0.87**			**3.60**	
	3% to 2007	Macroconomic Benefits	$309	**1.73**						2.60			
	7% to 2040	Total Economic Benefit	$797	**4.45**								**5.32**	
Present													
Appliances	2007-2040	Technology Cost	$23										
	Light Bulbs	Pocketbook Savings	$212	**9.22**	*13.17*							**9.22**	*13.17*
	ACEEE	Macroconomic Benefits	$189	**8.22**	*11.74*					8.22	*11.74*		
		Total Economic Benefit	$401	**17.43**	*24.91*							**17.43**	*24.91*
	2007-2040	Technology Cost	$39										
	ACEEE assorted	Pocketbook Savings	$166	**4.26**	*6.08*							**4.26**	*6.08*
		Macroconomic Benefits	$127	**3.26**	*4.65*					3.26	*4.65*		
		Total Economic Benefit	$293	**7.51**	*10.73*							**7.51**	*10.73*
	2014-2044	Technology Cost	$26			$1.29	$3.55						
	DOE TSD	Pocketbook Savings	$62	**2.38**	*3.41*			$11	**0.42**			**2.81**	*4.01*
	Refrigerator	Macroconomic Benefits	$36	1.38	*1.98*					1.81	*2.58*		
		Total Economic Benefit	$98	3.77	*5.38*							**4.19**	*5.99*
Near Future													
Appliances	CFA Supported	Technology Cost	$35										
		Pocketbook Savings	$113	**3.23**	*4.61*			$18	**0.51**			**3.74**	*5.35*
		Macroconomic Benefits	$78	**2.23**	*3.18*					2.74	*3.92*		
		Total Economic Benefit	$191	**5.46**	*7.80*							**5.97**	*8.53*
Far Future													
Appliances	ACEEE	Technology Cost	$202.33										
	(assume b/c=3,	Pocketbook Savings	$607	**3.00**					**0.00**	2.00	*2.86*	**3.00**	*4.29*
	no water savings)	Macroconomic Benefits	$405	**2.00**									
		Total Economic Benefit	$1,012	**5.00**								**4.40**	*6.28*

Sources and Notes

Past: Stephen Meyers, James McMahon and Barbara Atkinson, *Realized and Projected Impact of U.S. Energy Efficiency Standards for Residential and Commercial Appliances*, LBNL, March, 2008. Converted from $2006 and a benefit cost ratio of 2.7-to-1 (p. 2). The study used a split discount rate, 3% for backward looking estimates and 7% for forward looking.

Present: (2008- 2014) is subtracted from the past. All adjustments to quantities are made to preserve the benefit cost ratios in the original. Lowell Unger, et al., *Bending the Curve: Implementation of the Energy Independence and Security Act of 2007*, ACEEE, October 2015. Dollars inflated from 2013 to 2016. Discount rate adjusted from 5% to 3%. Costs are derived from net benefits and benefit cost ratio after adjustment to preserve the original benefit cost ratio.

Near Future: These are based on a small number of rules that were on the cusp of being adopted and have been delayed, for which CFA has taken action to secure the consumer benefits.

> Compressors: https://energy.gov/sites/prod/files/2016/12/f34/Compressors_Standards_Final_Rule.pdf
> Ceiling fans: https://www.regulations.gov/document?D=EERE-2012-BT-STD-0045-0149
> Air conditioners,
> Pool pumps: Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment: Dedicated-Purpose Pool Pumps, December 16, 2016, p. I-2.

Far Future: This is based on the ACEEE estimate that identifies opportunities for further increases in appliance efficiency consistent with the statutory mandates for updating standards (Appliances in general: http://aceee.org/research-report/a1604). They project dollar value savings. We inflate to 2016$ and discount the total. We assume the benefit cost ratio will be slightly lower than the near future ratio of 3-to-1 to estimate costs.

The top two lines in the past analysis of appliance standards capture the core of the agency approach to cost benefit analysis. The top line shows the technology costs. With those technology costs in hand and the physical quantity of energy saved estimated, we can calculate the cost of energy saved. For the purpose of this broad overview, we compare the cost of saved energy to the current cost of consuming energy.

While the backward-looking studies do not monetize environmental and public health benefits, the appliance studies do estimate the amount of primary energy saved. This is a standard calculation in current rulemakings. These analyses consistently show that the externality value of the reduction of consumption by one quad is above $2 billion. Using that as a conservative estimate, we include the external value of past standards at $156 billion (78 quads).

We observe that the benefit cost (b/c) ratio for pocketbook savings is 2.7-to-1. The cost of energy saved is about two-thirds of the cost of consuming energy. The consumer pocketbook savings are just under $500 billion. Assuming, an average of 105 million households over the 19- year period, the savings work out to about $200 per year.

Externalities are .88-to-1 so that the total b/c ratio is 3.6-to-1. As noted above, this result has been intensively analyzed.

We then introduce the macroeconomic externalities. By assumption, they are equal to the net pocketbook savings, which in this case yields a benefit cost ratio just under 1.7-to-1. We show the dollar figure and the benefit cost ratio for the sum of pocketbook and macroeconomic benefits, which we call total economic benefits.

We also show a “pure externalities” view of the b/c analysis. This consists of two components (macroeconomic effects and environmental and other externalities) that are very unlikely to be internalized in the private transaction. The b/c ratio is 2.6-to-1. Even on the basis of pure externalities, the appliance efficiency standards are highly beneficial.

We believe that the consumer pocketbook savings should be included in the analysis. Therefore, combining the economic and externalities benefits, puts the ratio at just over 5-to-1. This pattern of results is typical of all the evaluations.

Present and Future Standards

For appliances, light bulb stand out with extremely high ratios, which reflects a major advance in technologies. The traditional approach to analysis of other appliances yields benefit cost ratios in the range of 2- or 4-1, with consumer pocketbook savings accounting for two-thirds to three-quarters of the total. The macroeconomic impacts have benefit cost ratios larger than one, which puts the “pure externalities” b/c ratios in the range of 2- or 3-to-1. The total benefit cost ratios are in the range of 4- or 6-to-1.

Future benefits that could be achieved under the current law and administrative approach have been estimated to be over $720 billion in consumer pocketbook savings at a cost of less than $240 billion. We add to this indirect, macroeconomic benefits of almost $500 billion, for a total of over $1.2 trillion at a cost benefit ratio of 5-to-1.

Apart from products that had not been regulated in the past, the past and present benefit cost ratios are similar in magnitude. A similar result has been observed in programs that improve the energy efficiency of buildings (weatherization), with a similar explanation being offered. Innovation economics counters the tendency that one might expect to see in a rising marginal cost of energy saving.

C. Conclusion

The combination of past, present, and future standards covers a period of almost half a century (1988-2030) of energy efficiency standards, launched by the rude awakening of the oil price shocks of the 1970s. The evidence that these standards are good for consumers, the economy, and the environment is clear and consistent across all the analyses.

All the analyses suggest that the pocketbook savings are likely to be in the range of 3- or 4-to-1. The cost of saved energy is generally one-third of the cost of consuming energy. Indirect economic impacts have a benefit-cost ratio of 2-to-1. Externalities would add another digit to the benefit cost ratio.

Economic theory provides a clear explanation for this large benefit-cost ratio in the combination of significant, persistent market imperfections that are addressed by well-crafted, "command-but-not-control," performance standards. We believe the strong public and bipartisan support for these programs reflects their positive economics, which should also inform policymakers and regulatory agencies in their regulatory "reform" endeavors. Reductions of regulatory burdens that do not increase net benefits should be rejected.

ENDNOTES

[1] 82 Fed. Reg. 24582 (May 30, 2017).

[2]Id., Acknowledging the Superior Force of the Law.

[3] Office of Management and Budget, Memorandum For: Regulatory Policy Officers at Executive Departments and Agencies and Managing and Executive Directors of Certain Agencies and Commissions, May 5, 2017, states "Agencies should continue to comply with all applicable laws and requirements. In addition, EO 12866 remains the primary governing EO regarding regulatory planning and review. Accordingly, among other requirements, except where prohibited by law, agencies must continue to assess and consider both the benefits and costs of regulatory actions, including deregulatory actions, when making regulatory decisions, and issue regulations only upon a reasoned determination that benefits justify costs."

[4] The Administrative Procedure Act (APA), Pub.L. 79–404, 60 Stat. 237, establishes the nature of judicial oversight over rulemaking agencies (https://en.wikipedia.org/wiki/Administrative_Procedure_Act_(United_States). The APA requires that in order to set aside agency action not subject to formal trial-like procedures, the court must conclude that the regulation is "arbitrary and capricious, an abuse of discretion, or otherwise not in accordance with the law." However, Congress may further limit the scope of judicial review of agency actions by including such language in the organic statute. To set aside formal rulemaking or formal adjudication whose procedures are trial-like, a different standard of review allows courts to question agency actions more strongly. For these more formal actions, agency decisions must be supported by "substantial evidence" after the court reads the "whole record", which can be thousands of pages long. Unlike arbitrary and capricious review, substantial evidence review gives the courts leeway to consider whether an agency's factual and policy determinations were warranted in light of all the information before the agency at the time of decision. Accordingly, arbitrary and capricious review is understood to be more deferential to agencies than substantial evidence review. Arbitrary and capricious review allows agency decisions to stand as long as an agency can give a reasonable explanation for its decision based on the information it had at the time. In contrast, the courts tend to look much harder at decisions resulting from trial-like procedures because those agency procedures resemble actual trial-court procedures, but Article III of the Constitution reserves the judicial powers for actual courts. Accordingly, courts are strict under the substantial evidence standard when agencies acts like courts because being strict gives courts final say, preventing agencies from using too much judicial power in violation of separation of powers.

[5] Results of over a dozen national random sample public opinion polls are among the 140 pieces of research to be found at the CFA website (http://consumerfed.org/issues/energy/)

[6] The Energy Policy Conservation Act was signed by a Republican president and had large majorities in both houses of congress. In fact, eight of the nine major pieces of legislation that effect the energy efficiency of consumer durables were signed by Republican presidents. Both the House and the Senate have voted overwhelmingly in favor of these laws (14 times in all) with over 85 percent voting in favor.

[7] CFA has argued this throughout its regulatory interventions, starting with fuel economy standards () and ending, most recently and explicitly in comments on EPA's final determination in the National Program for light duty vehicles ()

[8] CFA emphasized this throughout our regulatory interventions, see note 1. The issue was formally recognized in the National Program rule.

[9] In addition to the comments, testimony and reports listed on the CFA web site, CFA has presented a comprehensive analytic framework and literature review to the California Energy Academy (Mark Cooper, 2014, *Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California.* Presentation at the California Energy Commission's Energy Academy, February 20, 2014; 2013; *Energy Efficiency Performance Standards: The Cornerstone of Consumer-Friendly Energy Policy,* Consumer Federation of America, October 2013).

[10] The comprehensive literature review has been updated to include over 400 peer-reviewed papers published in the past 10-years that provide the conceptual and empirical foundation for understanding the market imperfection that policy can address to deliver substantial net benefits to consumers and society (see Appendices II and III in Mark Cooper, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Sector* (Santa Barbara, Praeger, 2017).

[11] We have identified these characteristics in the study of standards in a broad range of goods not limited to energy consuming durables (including light duty vehicles, heavy duty trucks, to gas furnaces) but also other goods computers and services (see Mark Cooper, "Command But Not Control: Progressive Capitalism and Regulatory Institutions for the Third Industrial Revolution: The Paris Agreement on Climate Change," *Session on Regulation and Industry Structure The Digital Broadband Migration*: *The Evolving Industry Structure of the Digital Broadband Landscape*, 2016).

[12] Mark Cooper, 2014, *Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California.* Presentation at the California Energy Commission's Energy Academy, February 20, 2014; 2013; *Energy Efficiency Performance Standards: The Cornerstone of Consumer-Friendly Energy Policy,* Consumer Federation of America, October 2013. See Mark Cooper, 2017, *The Political Economy of Electricity: Progressive Capitalism and the Struggle to Build a Sustainable Power Sector*, (Praeger), Chapter 7 and Appendix II for a more recent comprehensive review.

[13] We have identified these characteristics in the study of standards in a broad range of goods including light duty vehicles, heavy duty trucks, gas furnaces and computers. The key characteristics of "command but not control" regulation extend to policies that create institutional arrangement as discussed in Cooper, 2017.

[14] The full citation in the relevant section is as follows:

(o) Criteria for prescribing new or amended standards

(2)(A) Any new or amended energy conservation standard prescribed by the Secretary under this section for any type (or class) of covered product shall be designed to achieve the maximum improvement in energy efficiency, or, in the case of showerheads, faucets, water closets, or urinals, water efficiency, which the Secretary determines is technologically feasible and economically justified.

(B)(i) In determining whether a standard is economically justified, the Secretary shall, after receiving views and comments furnished with respect to the proposed standard, determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering-

(I) the economic impact of the standard on the manufacturers and on the consumers of the products subject to such standard;

(II) the savings in operating costs throughout the estimated average life of the covered product in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered products which are likely to result from the imposition of the standard;

(III) the total projected amount of energy, or as applicable, water, savings likely to result directly from the imposition of the standard;

(IV) any lessening of the utility or the performance of the covered products likely to result from the imposition of the standard;

(V) the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard;

(VI) the need for national energy and water conservation; and
(VII) other factors the Secretary considers relevant.

[15] Republican presidents signed the legislation that created the fuel economy program in 1976 and then reformed it in 2007. The laws passed both houses of Congress with large majorities. In fact, eight of the nine major pieces of legislation that effect the energy efficiency of consumer durables were signed by Republican presidents. Both the House and the Senate have voted overwhelmingly in favor of these laws (14 times in all) with over 85 percent voting in favor.

[16] Mary and Robert Raymond Professor of Economics at Stanford University, and the George P. Shultz Senior Fellow in Economics at Stanford University's Hoover Institution.

[17] He was a member of the President's Council of Economic Advisors during the George H. W. Bush Administration and Senior Economist at the Council of Economic Advisors during the Ford and Carter Administrations.

[18] John, B. Taylor, *Economics* (Houghton Mifflin, 11998, pp. 410, 896.

[19] W. Kip Viscusi, John M. Vernon and Joseph E. Harrington, Jr., *Economics of Regulation and Antitrust* (MIT, 2001).

[20] Id., pp. 28-29.

[21] Office of Management and Budget, Memorandum For: Regulatory Policy Officers at Executive Departments and Agencies and Managing and Executive Directors of Certain Agencies and Commissions, May 5, 2017,

[22] Viscusi, Vernon, and Harrington, 2000, pp. 2-3.

[23] Viscusi, et al., 2001, pp. 35-37.

[24] Luke Stewart, 2010, The impact of Regulation on Innovation in the United States: A Cross-Industry Literature Review, Institute of Medicien Committee on Patient Safety and Health IT, June.

[25] Institute for European Environmental Policy, Review of Costs and Benefits of Energy Savings: Task 1 Report 'Energy Savings 2030, May 2013 IEER, pp. 4…6.

[26] Cooper, 2014, "Energy Efficiency Performance Standards, slide 22.

[27] At the time of the filing in New Mexico, CFA issued a report entitled, A Consumer Analysis of the Adoption of the California Clean Cars Program in Other States, November 2007.

[28] Cooper, 2017, *The Political Economy of Electricity*, Chapter 5.

[29] American Action Forum, *Regulatory Rodeo*.

[30] National Academy of Sciences analyses have played a large part in the estimation of vehicle technology costs.

[31] Roland Hwang and Matt Peak, 2006, Innovation and Regulation in the Automobile Sector: Lessons Learned and Implications for California's CO2 Standard, Natural Resources Defense Council, April.

[32] Winston Harrington, 2006, Grading Estimates of the Benefits and Costs of Federal Regulation: A Review of Reviews, Resources for the Future, 2006; p. 3.

[33] Id.

[34] Whitefoot, Kate, Meredith Fowler and Steven Skerlos, 2012, Product Design Response to Industrial Policy: Evaluating Fuel Economy Standards Using an Engineering Model of Endogenous Product Design, Energy Institute at Haas, May, pp. 1-5.'

[35] Worrell, Ernst, et al., 2003, "Productivity Benefits of Industrial Energy Efficiency measures," Energy, 28(11): This examination shows that including productivity benefits explicitly in the modeling parameters would double the cost-effective potential for energy efficiency improvement, compared to an analysis excluding those benefits. (p 1)

[36] Larry Dale, et al., "Retrospective Evaluation of Appliance Price Trends," *Energy Policy* 37, 2009. p. 1. For demand-side technologies the experience curve approach also seems applicable to measure autonomous energy efficiency improvements. Interestingly, we do find strong indications that in this case, policy can bend down (at least temporarily) the experience curve and increase the speed with which energy efficiency improvements are implemented. 1. For the past several decades, the retail price of appliances has been steadily falling while efficiency has been increasing. 2. Past retail price predictions made by the DOE analysis of efficiency standards, assuming constant price over time, have tended to overestimate retail prices. 3. The average incremental price to increase appliance efficiency has declined over time. DOE technical support documents have typically overestimated the incremental price and retail prices. 4. Changes in retail markups and economies of scale in production of more efficient appliances may have contributed to declines in prices of efficiency appliances

[37] Onno Kuok, 2006, "Environmental Innovation Dynamics in the Automotive Industry," 2006, "The European car industry is highly dynamic and innovative. Its R&D expenditures are well above average in Europe's manufacturing sector. Among the most important drivers of innovation are consumer demand (for comfort, safety and fuel economy), international competition, and environmental objectives and regulations… One element of success of technology forcing is to build on one or more existing technologies that have not yet been proven (commercially) in the area of application. For improvements in the fuel economy of cars, many technological options are potentially available… With respect to innovation, the EU and Japanese policy instruments perform better than the US CAFE program. This is not surprising, given the large gap between the stringency of fuel-efficiency standards in Europe and Japan on the one hand and the US on the other…. One of the reasons for the persistence of this difference is that the US is not a significant exporter of cars to the European and Japanese markets." R D Van Buskirk, et al., 2014, "A retrospective investigation of energy efficiency standards: policies may have accelerated long term declines in appliance costs," Environmental Research Letter, November 14.

[38] CFA laid out this argument in comments supporting the heavy duty truck standard.

[39] Residential electricity revenues represent about 46% of total revenues, see the EIA data base at https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_02; Residential natural gas revenues represent about 65% of natural gas revenues, excluding for electric utilities, whose costs would be recovered in electricity bills. Allocating petroleum cost recovery is more complicated, but CFA concluded that residential consumer account for about 55% of transportation fuel costs. See, Mark Cooper, Paying the Freight, Consumer Federation of America, 2012.

[40] Shrouded attribute

[41] Cooper, 2017, Chapter 5.

[42] 2017, forward. This example is particularly appropriate since infrastructure spending and projects, on which transit would be an important area, appear to be widely supported because of the benefits they deliver to individuals and the economy

[43] Id., pp. 3… 10.

[44] Taylor, p. 898.

[45] James D. Hamilton, "Causes and Consequences of the Oil Shock of 2007–08," *Brookings Papers on Economic Activity* Spring; Warr, Benjamin S, Robert U. Ayres, and Eric Williams, 2009, *Increase Supplies, Increase Efficiency: Evidence of Causality Between the Quantity and Quality of Energy Consumption and Economic Growth*. 2009/22/EPS.ISIC, Faculty & Research Working Paper. INSEAD.

[46] In addition to the recent U.S. analysis by U.S. EPA/NHTSA, 2011, see Jamie Howland, et al., 2009, *Energy Efficiency: Engine of Economic Growth.* Rockport, ME: Environment Northeast; and New York State Energy Research & Development Authority, 2011, *Macro-Economic Impact Analysis of New York's Energy Efficiency Programs: Using REMI Software*. Albany NY: NYSERDA, August 4; Holmes Ingrid and Rohan Mohanty, 2012, *The Macroeconomic Benefits of Energy Efficiency: The Case for Pubic Action,* E3G, April; Cambridge Centre for Climate Change Mitigation Research, 2006, *The Macro-Economic Rebound Effect and the UK Economy*. Cambridge, U.K.: Cambridge Econometrics and Policy Studies Institute, May; and Lisa, Ryan, and Nina Campbell, 2012, *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements*. Insight Series. Paris, France: International Energy Agency, for a general global review.

[47] James Lazar and Ken Colburn, *Recognizing the Full Value of Energy Efficiency* (Regulatory Analysis Project, September 2013),

[48] Ryan, and Campbell, 2012, *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements*. Insight Series. Paris, France: International Energy Agency, pp. 1…2 …3.

49 Lutz, Christian, Ulrike Lehr and Martin Pehnt, 2012, *Economic impacts of energy efficiency and Renewable energy in Germany, 20th* International Input-Output Conference, June 26-29, pp. 1… 6-7…8.

[50] Ryan Wiser, Mark Bolinger, Matt St. Clair, 2005, Easing the Natural Gas Crisis: Reducing Natural Gas Prices through *Increased Deployment of Renewable Energy and Energy Efficiency, Lawrence Berkeley National Laboratory,* January.

[51] U.S. EPA, 2010, pp. 3-4.

[52] Memorandum To: Docket EPA-HQ-OAR-2009-0472, Subject: Economy-Wide Impacts of Greenhouse Gas Tailpipe Standards, March 4, 2010.

[53] Id., p. 1.

[54] The IEER review of studies lists seven studies covering the residential building and the industrial sectors covering a handful of European nations in 2010-2013. The effects studies were primarily employment, cost of saved energy and competitiveness. Worrel, et al., identified 70 industrial case studies, with 52 that monetized the benefits.

[55] Max Wei, Shana Patadia, and Daniel Kammen, 2010, "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the US?" *Energy Policy* 38.

[56] Ryan and Campbell, identify a dozen partial equilibrium models that have been applied to regions within nations, individual nations, groups of nations and the global economy. The effects analyze include GDP, employment by sector, public budgets, trade, distribution, and investment.

[57] For example, EPA, 2010, IGEM; Rachel Gold, et al., 2011, *Appliance and Equipment Efficiency Standards: A Money Maker and Job Creator,* American Council for an Energy Efficient Economy, January 2011, p. 9, based on the IMPLAN Model, 2009. Howland and Murrow and NYSERDA 2011, REMI),

[58] For example, New York (NYSERDA, 2011), New England (Howland and Murrow), California (David Roland-Holst, 2016)

[59] For example, U.S. (Gold,, 2011, EPA, 2010, Warr, Ayres and Williams, 2009) and UK (Cambridge Center, 2006), note recent studies on Asian economies, Korea, Canada and Spain,

[60] In the mid- and long-terms employment and output increase.

[61] Wei, Patadia, and Kammen, 2010, Gold, et al., 2011.

[62] ACEEE, "In our experience modeling efficiency investments, we find that re-spending the energy savings typically creates an equivalent number of jobs as implementing the investment." (p. 2)

[63] Worrell, et al., p. 5.

[64] Ryan and Campbell, p. 5., Howland, et al., 2009.

[65] EPA, 2012-2016,

[66] Wiser, Bolinger and St. Clair, 2005.