Comments of Consumer Federation of America, Consumers Union, Consumer Action and Consumer Federation of California

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I. INTRODUCTION: CONSUMER APPROACH TO PERFORMANCE STANDARDS

The Consumer Federation of America (CFA),[1] Consumers Union[2], Consumer Action [3] and Consumer Federation of California[4] applaud the California Energy Commission (CEC) for proposing minimum energy efficiency standards for computers and displays. We believe that the need for such standards is clear and the benefits to consumers, the economy and the environment will be substantial. We base this conclusion on a report prepared last year by CFA entitled "Electricity Consumption and Energy Savings Potential of Consumer Digital Devices: The Role of California Appliance Standards Leadership," see Attachment A. We appreciate the opportunity to participate in this rulemaking process.

Unlike many of the others that will likely participate in this proceeding, our technical expertise is not in the design and construction of computers or displays, it is in the design and implementation of minimum energy standards. We believe that knowing how to build an effective standard is at least as important to arriving at a successful outcome as knowing how to

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[1] Consumer Federation of America is an association of more than 250 nonprofit consumer groups that was founded in 1968 to advance the consumer interest through research, advocacy and education.

[2] Consumers Union is the policy arm of Consumer Reports and works for telecommunications reform, health reform, food and product safety, financial reform, clean energy, and other consumer issues. Consumer Reports is the world's largest independent product-testing organization. Using its more than 50 labs, auto test center, and survey research center, the nonprofit rates thousands of products and services annually. Founded in 1936, Consumer Reports has over 8 million subscribers to its magazine, website, and other publications.

[3] Consumer Action, established in 1971, is a non-profit organization based in San Francisco that focuses on consumer education that empowers low- and moderate-income and limited-English-speaking consumers to financially prosper.

[4] The Consumer Federation of California is a non-profit advocacy organization. Since 1960, it has been a powerful voice for consumer rights. CFC campaigns for state and federal laws that place consumer protection ahead of corporate profit and also appears before state agencies in support of consumer regulations.

build a computer. Moreover, although we do not claim expertise in the technical design of appliances or devices, we do claim expertise in the economic analysis of technologies. We review existing studies of technologies to determine whether there are significant potential consumer savings. This analysis combines a review of the technical economic studies, prepared by others, and evidence on the market performance of appliances and devices.

Focusing on the consumer pocketbook, we have participated in dozens of rulemakings, and we always start from a basic question:

- Will a standard save consumers money?

If there appears to be potential savings we ask:

- Why is there an efficiency gap that appears to impose unnecessary costs on consumers?

If we find market imperfections that prevent the gap from being closed and cost savings realized, we then ask another question:

- How can the standard be best designed to achieve the goal?

A little over a year ago at the CEC's Energy Academy[1], CFA presented a major piece of research entitled "Energy Efficiency Performance Standards: Driving Consumer and Energy Savings in California." [5] We have attached the relevant sections of the broad analysis underlying that presentation in Attachment B as background so these comments can focus on why computers are ideal candidates for performance standards and why the staff analysis heads in exactly the right direction.

California energy authorities, like the California Energy Commission (CEC) and the California Air Resources Board (CARB) have a long, successful track record of writing effective standards to regulate energy consumption and air pollutants (respectively) that has made them a

[5] February 20, 2014.

world leader of this difficult, but increasingly vital art. Our preliminary analysis of the CEC proposal and reflections on the recent workshop reinforce our belief that the CEC is headed in the right direction with the proposed standards.

These comments are divided into two sections. In the next section, we review the prior analysis that had led us to support performances standards for household digital devices. In the final section, we offer observations on the presentations made at the CEC staff workshop. We focus primarily on the negative comments offered by the industry, which we find were unconvincing. We integrate positive comments offered by others, which reinforce our conclusion.

II. The Case for Minimum Efficiency Standards for Computers and Displays

A. Consumer Pocketbook Impact

At the outset, it is important to recognize the consumer interest in the energy efficiency of household digital devices. Our analysis shows that the energy consumption of these devices has increased by 500% in the past decade, driven by both increasing penetration and use.[6] These devices are all a part of energy use known as MEL, 'miscellaneous electrical load'. This is the energy used to power the huge range of electronics in homes. It has been estimated that a typical American home has forty products that constantly draw power, and people often do not even know they are paying for this hidden energy consumption.[7] In California and across the nation, these devices have come to represent a significant electricity load and drag on consumer budgets, in the range of 5 to 7 percent of electricity bills.[8] Addressing the energy that is wasted in this way is akin to going after the low hanging fruit.

[6] See CFA analysis, Attachment A, Figure 1 and accompanying text.

[7] http://standby.lbl.gov/, *http://www.washingtonpost.com/news/energy-environment/wp/2015/02/06/your-home-is-full-of-devices-that-never-turn-off-and-theyre-costing-you-a-lot-of-money/*

[8] See CFA analysis, Attachment A, Figure 3 and accompanying text.

The potential energy savings from computers alone, via technologies that are currently available is substantial, a reduction of one-third or more in their energy use.[9] Passing up consumer savings of hundreds of millions of dollars in California and potentially billions of dollars nationwide is simply unacceptable.

B. The Cause of the Efficiency Gap in Household Digital Devices

Our analysis shows that there is little doubt that the high electricity consumption of digital devices is the result of market imperfections.[10] The upper section in Exhibit 1 identifies the broad categories and specific types of market failures that our analysis shows performance standards are adept at addressing. We also highlight (underline) the specific market imperfections that affect the energy consumption of digital devices. The lower section in Exhibit 1 identifies the specific market imperfections that afflict the energy consumption of household digital devices.

The paramount, but not the only, cause of the market failure with respect to the energy consumption of digital devices stems from the fact that, in this case, energy is what economists call a 'shrouded attribute.' It is part of a bundle of attributes. Computers provide valuable specific functionalities to consumers and the energy consumption of those devices is not directly relevant or visible to the consumer (a motivation/calculation problem). The energy consuming attributes are bundled into the device by the manufacturer (an agency problem). Since electricity bills are aggregates of a month of consumption across a large number of electricity consuming durables (an information problem), consumers do not see how much electricity any specific

[9] See CFA analysis, Attachment A, Figure 4 and accompanying text.

[10] See CFA analysis, Attachment A, Section IV for specific analysis of household digital devices. See Attachment B, section F for a general discussion of why performance standards are a particularly useful tool for closing the efficiency gap.

device uses (a calculation problem). Because the devices are plugged in, there is little, if any, market pressure to improve the energy efficiency of these devices (a market failure).

EXHIBIT 1: MARKET IMPERFECTIONS, DIGITAL DEVICES AND PERFORMANCE STANDARDS

Imperfections Addressed by Standards: Highlighting Factors Affecting Digital Devices

SOCIETAL FAILURES	STRUCTURAL PROBLEMS	ENDEMIC FLAWS	TRANSACTION COSTS	BEHAVIORAL FACTORS
Externalities	Scale	Agency	Sunk Costs	Motivation
Public Goods	Bundling	Asymmetric Information	Risk	Calculation/ Discounting
Coordination	Cost Structure	Lack of Capital	Uncertainty	
Information	Product Cycle	Moral Hazard	Imperfect Information	
	Availability			

The Electricity Consumption of Household Digital Devices is a Particularly Difficult Problem for the Marketplace to Solve.

Externalities: Ultimately, the benefit of reducing energy consumption has value beyond the benefit that each individual directly enjoys from reduced energy consumption (a public goods problem).

Bundling/Agency: The manufacturers of the products make the key decisions about energy consumption and the bundle of attributes that will be made available in the market, thereby constraining the range of energy consumption levels the consumer has to choose from (principal agent problems).

Agency/Access to Capital: The manufacturers tend to focus on the primary product attributes and the first cost of the device, ignoring the life cycle cost (i.e. the total of acquisition and operating costs) since they do not pay the electricity bills. The manufacturers' interests are separate and different from the consumers' interests (split incentives problem).

Risk: Moving efficiency into mass market products runs the risk of being underpriced by inefficient products.

Imperfect Information/Motivation: The electricity consumption of these devices is not visible to consumers. The devices are purchased for their functionalities, which, given the dramatic increase in penetration and use, are highly desirable. The level of electricity consumption is not an attribute of the product to which consumers will pay much attention (a shrouded attribute problem).

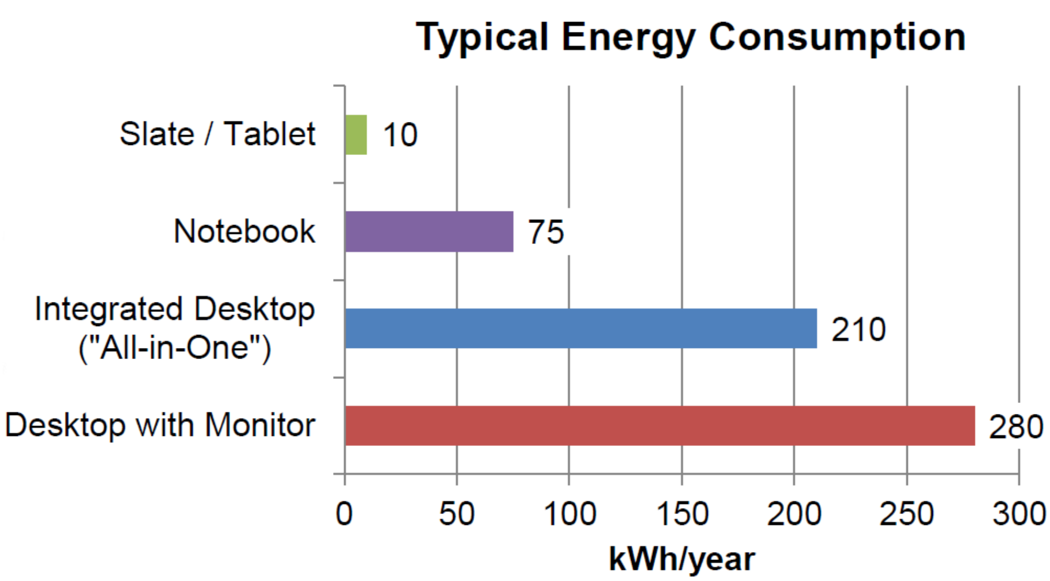
Calculation: Even if consumers are paying attention to energy use, it would be difficult for them to determine how much energy the devices use and the impact of reducing consumption. The information is either not readily available or the transaction cost of obtaining it is high (information and transaction cost problems).

Source: CFA analysis, Attachment A, pp. 24-26

If manufacturers felt this market pressure, they would do a better job of investing in energy efficiency. The proof of that proposition comes from the performance of similar devices, where they do feel such pressures. In contrast to computers and laptops, which are generally plugged in, the energy consumption of tablets and smart phones—mobile devices that are used when not plugged in—is extremely important to manufacturers. Battery life is an essential feature of these devices, which means the manufacturers compete vigorously to reduce consumption and increase battery life. Consumers can easily assess the efficiency and performance of these devices. When they are forced to frequently charge them over and over again —they know it's because a device is inefficient. Consumers can send a clear signal to manufacturers by not buying these inefficient devices or by expressing their dissatisfaction in reviews or direct communications. With these mobile devices that are used when they are not plugged in, manufacturers care a great deal about how efficient they are. Providing similar functions, these mobile devices consume one-tenth or less the electricity of the plugged in devices.

Exhibits 2 shows the dramatic difference between plugged in and mobile devices that provide similar functions. We offer this comparison to underscore the good job computer makers do when the market drives them to, not to suggest that they should put the same technology in all devices. However, it is likely that there are spillover and learning effects that will operate across

EXHIBIT 2: ANNUAL ENERGY CONSUMPTION OF KEY DIGITAL DEVICES



Source: NRDC Materials, CEC Staff Workshop, Computer, Computer Monitors, and Electronic Displays, TN #: 204158, April 15, 2015, p. 4.

devices that would facilitate and accelerate improvements in efficiency of plugged in devices once the manufacturers are motivated to improve efficiency by a standard.

Even if the amount of electricity used and its pocketbook impact were more visible and consumers were motivated and able to make the calculation, they still might not push the market to the optimal level of energy consumption because there are environmental externalities and economic social costs and benefits that are not likely to be reflected in the market transaction (an externalities, public good and coordination problem).

C. Performance Standards as the Ideal Tool for Reducing the Efficiency Gap

With clear market imperfections giving rise to inefficiencies, the next question becomes: why is a performance standard a good policy? Exhibit 3 identifies the characteristics we have found to be associated with effective standards. We generally prefer performance standards because they command, but they do not control by setting a goal and allowing manufacturers flexibility to decide how to meet the goal .[11]

EXHIBIT 3: KEY DESIGN FEATURES OF EFFECTIVE PERFORMANCE STANDARDS

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.

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

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.

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.

Responsive to industry needs: Recognizing 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.

Source: CFA analysis, Attachment B, pp. 44-49

[11] See Attachment A, Section F.

Our analysis shows that performance standards work best when they address a clear market imperfection and are technology-neutral, product neutral and pro-competitive. The standards establish a minimum level of efficiency but they do not dictate the technology. Standards work best when the manufacturers can design to meet the standard as they see fit. They will do so by choosing the least cost approach available to them. Different manufacturers will have different skill sets or different product lines and choose different technologies.

Performance standards like these give market certainty to stimulate adoption of cost effective energy saving technologies. Each manufacturer will set out to meet the standard in the most cost effective way that it can without the fear that it will be undercut by cheap, inefficient products that do not meet the standard. Once standards are in place, the products will succeed or fail on the merits.

Standards must also be reasonable in relationship to what can be technologically accomplished. If they go too far, impose costs that are too large or require technologies that cannot be developed or delivered in the necessary time frame, they can do harm, rather than good.

Historically, when it comes to standards, we have seen manufacturers line up in opposition, arguing that they impose unbearable or unconscionable costs on consumers – unbearable in the sense that they impose such high prices on consumers they will stop buying the devices or unconscionable in the sense that consumers will be forced to pay much more for a similar level of functionality or be forced to settle for devices that do not deliver the functionalities consumers want.. However, history shows that the claims that standards will impose huge and unacceptable costs on consumers invariably proves false.[12] Once the

[12] See CFA analysis, Attachment B, pp. 43-48..

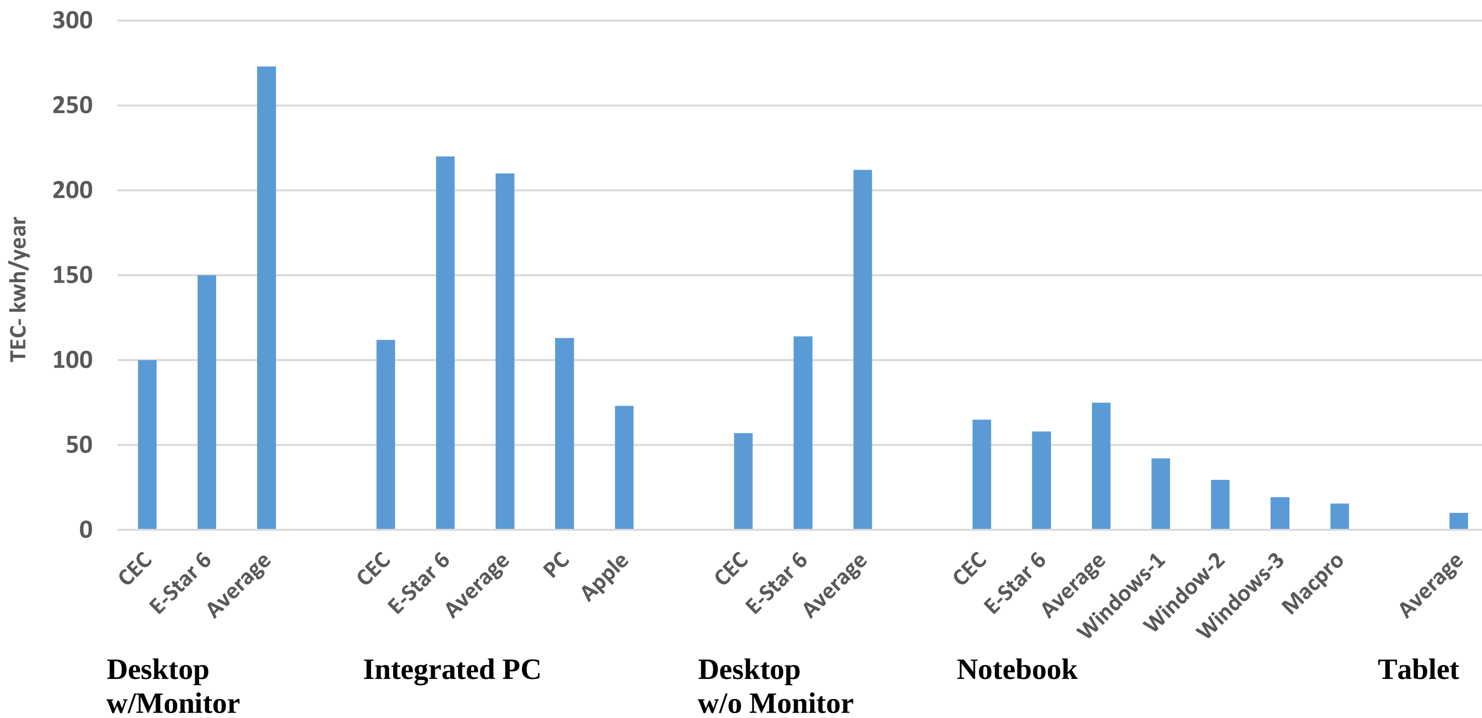
companies go to work to meet the standards in the least cost manner possible, their costs are one-third of the original estimates, and the benefits vastly exceed the costs. In this case, we believe the CEC has proposed standards that avoid this problem.

D. The CEC Proposal

Exhibits 4 and 5 locate the CEC proposal with respect to several important measures of where the market for computers and monitors is. It shows the CEC standard of "Typical Energy Consumption" compared to ENERGY STAR 6 levels, market averages and several examples of products available in the market. We will look at the terrain of the market in detail below. Here the important point is that the standard clearly is intended to significantly increase the energy efficiency of the devices. It is well beyond both the market average and ENERGY STAR. At the same time, there are specific products available that already meet the standard. In fact, a small but significant percentage of products in the market already meet the standard.

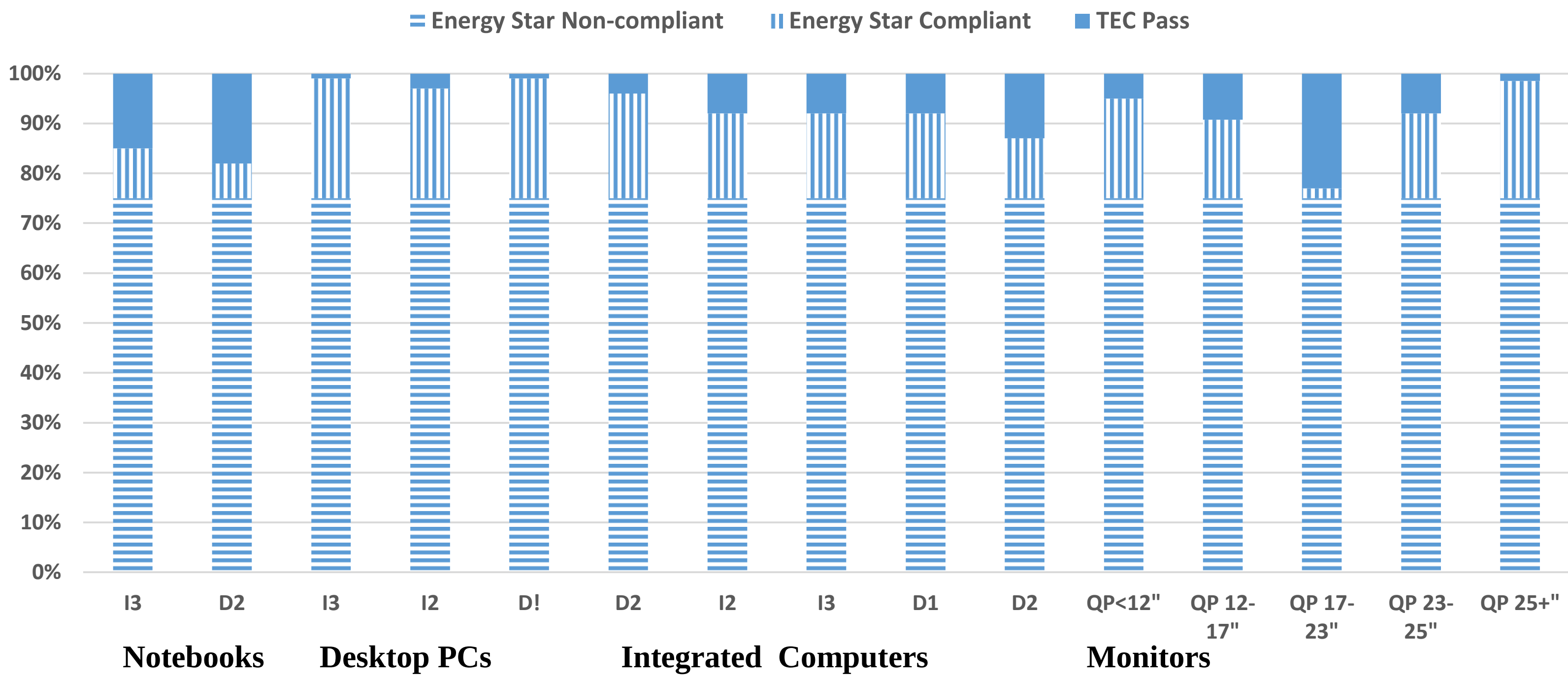
The standards focus on reducing energy consumption when the computer/display is not operating – i.e. in the off, sleep and idle modes. The comments also demonstrate "no regrets" approaches – such as setting defaults at the lowest level possible and automatic transitioning to lower levels of energy consumption when the computer is idle. This is a cautious approach which means the standards should not impair the ability of the computer to deliver the functionality that consumers want. This analysis provides strong evidence that the standard is technically feasible and not detrimental to consumers.

EXHIBIT 4: TYPICAL ENERGY CONSUMPTIONS, VARIOUS DEVICE TYPES AND STANDARDS



Sources: Targets from CEC Staff Report, p. 22; Averages are current (2014), not baseline (2018), Desktop is CEC usage (Staff Report, p. 9), adjusted with NRDC (p. 4), Monitors are from CEC Staff Report (p.45), other averages from NRDC, pp. 4, 7, 8; E-Star 6 from ITI, Sheikh, pp. 11, 12, 13.

EXHIBIT 5: ENERGY STAR COMPLIANCE AND CEC TYPICAL ENERGY CONSUMPTION (TEC)



Source: ITI Technet Presentations, *California Energy Commission, Staff Workshop: Computers, Monitors and Signage Displays,* April 15, 2015, Donna Sadowy slides 9, 10; Mark Hollenbeck, slide 8. Donna Sadowy, Slide 7: ENERGY STAR products are today's best in class for energy performance; don't represent greater market. Jan. 2018 is very aggressive schedule – planning for 2018 products starts in 2016.

Exhibit 6 shows the proposed standards are cost beneficial. Exhibit 5 contrasts the CEC estimate of the lifecycle savings and benefit cost ratios to the same statistics CFA estimated based on the data filed at the Commission in 2014. All of the benefit cost ratios are greater than one. For the standards proposed, they are greater than two. A benefit cost ratio greater than two suggests that the break-even point comes less than halfway through the assumed product life.

EXHIBIT 6: BENEFIT COST RATIO

Device	CEC, 2015		CFA/IOU 2014	
	Savings	Benefit/cost	Savings	Benefit/cost
Desktop	$69	35.1	$233	2.3
Monitors	$26.5	2.3	$19.7	1.9
Integrated PC			$115	1.2
Notebook	$2.3	2.3	$14.9	1.9

Source: CEC Staff Report, pp. 22, 48; CFA 2014, Appendix A, p. 27.

Based on the structure of the standard, its relationship to the current product market, and the benefit cost ratios, the proposed standards pass our test with flying colors on the most important of the characteristics. The benefits far exceed the costs, and they are product neutral, technology-neutral, and procompetitive. We also believe that they are responsive to consumer needs and industry needs, but these aspects deserve more attention. The targets set by these standards are moderate; if anything, our analysis suggests to us that the commission should go a little farther.

The standards are forward looking, but not very far, and the industry suggests that it needs more time to comply. This suggests to us that the judicious course for the CEC could well be to set standards that become progressively stronger over a number of design and build cycles. This gives the industry an opportunity to plan more significant changes or a sequence of changes that eases the glide path to higher levels of efficiency.

III. Workshop Presentations

A. Basic Criticism

The industry presentations and comments at the staff workshop reflect a number of misconceptions and misguided analyses that raise serious concern about the possibility for a meaningful dialogue as the regulatory process unfolds. The industry presentations demonstrate a fundamental misunderstanding of the purpose and function of a minimum performance standard. Exhibit 7 identifies the key points in the industry critique presented at the workshop and the alternative point of view presented by others.

Exhibit 7: Staff Workshop Comments

Issue area	Industry Critique	Supporting CEC
ENERGY STAR & The Market	Not representative[1]	Underestimates use[13]
	Exceeds historical levels[2]	Technological progress[14]
	Drive out of Market[3]	Existing products in market[15]
Critique of the Standard	Uniform percentage gain[4]	Large potential savings[16]
	Technology Already in devices[5]	Technological progress[17]
	Cost benefit/Cost Model[6]	Benefits underestimates[18]
	Design cycle.2 year[7]	Technology available/software[19]
	Data Gotcha[8]	IOU, CLASP[20]
Misleading Comparisons	Special Equipment[9]	Adders too large[21]
	Historic Improvement[10]	Contemporary Comparisons[22]
	Desktop to tablet[11]	Form Factor Comparison[23]
	Blaming Consumers[12]	Recognizing Consumer Limitation[24]

Sources: All citations are from presentations at the CEC Staff Workshop on Computer, Computer Monitors, and Electronic Displays, TN #: 204158, April 15, 2015. Industry Comments are individual authors in the ITI/Technet Computer Presentations. Non-industry comments are by individual organizations. Citations:

1 Sadowy, Sadowy, 7; Siekh, 5; Hollenbeck, 4,6.
2 Sadowy, 7, Sheikh, 11.
3 Sadowy, 7; Singh, 5.
4 Singh, 2.
5 Singh, 5.
6 Singh, 6; Siekh, 11.
7 Sadoway, 5, Verdun, oral
8 Sheikh, 14.
9 Harkin, 4; Sadowy, 14.
10 Harkin, 4
11 Additional Material,
12 Harkin, 5.
13 IOUs, 4, 5; NRDC, 2.9.
14 NRDC, 5
15 NRDC, 6.
16 IOUs, 6; NRDC, 5, Aggios, 7, 8.
17 NRDC, 6.
18 IOUs, 6; NRDC, 5, Aggios, 7, 8.
19 IOUs, 4, 5; NRDC, 2.9.
20 Dewart, by reference to earlier IOU analysis
21 IOUs, 11; NRDC xx
22 NRDC, xx
23 NRDC, 4.
24 NRDC, xx (defaults)

The industry comments express concern and criticize the CEC staff proposal in several ways.

(1) The proposal is criticized for writing rules that are deemed to be technically feasible and economically beneficial, even though they require a higher level of efficiency that is already observed in the market.

(2) The industry points out that many of the products now in the market do not comply with the standard that will go into effect in three years, suggesting that it, as consequence, the standard is infeasible.

(3) The industry demonstrates this non-compliance with reference to the compliance of the devices in the market with the current ENERGY STAR labelling program.

These criticisms are ill-founded and should not dissuade the Commission from issuing strong standards. Since the ENERGY STAR program plays such a prominent role in the industry comment, we begin with that point.

B. STANDARDS V. LABELS

The evidence presented at the staff workshop makes it clear to us that an information/labeling program is not enough to achieve the goals of California policy or to adequately promote the public interest because such a program is not designed to address the broad market imperfections we have identified in the market for efficiency of digital devices. The logic of a labeling program is to give consumers the information they need to make better choices and, presumably, demand more efficient appliances. If it does so, the efficiency gap should be reduced or disappear. In the case of computers, that has not happened. The ENERGY STAR levels of energy use are, themselves, well short of the level that could technically be achieved, based on the engineering/economic analysis. More importantly, after twenty years, the evidence shows that only a small fraction of computers sold in the marketplace are ENERGY STAR compliant. The labels have left a large segment of the market underperforming.

Unlike a performance standard, labelling might provide some pressure to improve the performance of some products, if it sends a strong enough market signal to incent the use of better technology, but it does not require all products to meet a standard. The evidence provided suggests that the ENERGY STAR program has not yielded broad improvements in market performance. The industry comments repeatedly state that ENERGY STAR does not reflect actual market performance.[13] Other data support this conclusion.[14]

The reason that the information program has failed is that the market imperfections are too profound. As discussed above, the market imperfections involve a great deal more than a lack of information. There is no reason to expect a labelling program to do the job of a performance standard under these conditions.

The ENERGY STAR labelling program suffers from several other flaws with respect to the goal of a standards approach. It is self-selected, unrepresentative, backward looking and not sales weighted. It does not present a picture of the market as it is, or more importantly, where the market is headed. The non-industry commenters point to the backward looking problem of ENERGY STAR by pointing out rapid technological progress that has taken place since the ENERGY STAR levels of energy efficiency were last set.

C. IMPACT OF A STANDARD

The fact that today many of the products in the market have been afflicted by a significant market imperfection and would not comply with the standard is not surprising. The

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[13] CEC Workshop Comments, Sadowy, p. 5; Shiekh, p. 10.

[14] Fiona Brocklehurst and Jonathan Wood, Eenrgy Consumption of Computers in the Chinese Market," CLASP, October 9, 2014, Energy Consumption of Gaming computers in the US, CLASP, October 30, 2014.

analysis has identified a significant energy efficiency gap. This counterfactual non-compliance (counterfactual because the standards are not in effect) tells us little about the ability of the industry to comply. In fact, once the industry has an incentive to increase efficiency via a standard, it will seek and find the least cost ways to do so.

In setting a standard that is intended to move the market toward a more efficient outcome, the Commission could not possibly simply rely on the current market equilibrium, which is what the industry seems to want. It must set the standard at a higher level than observed in a significant number of products in the market if the technology allows it to do so.

Recognizing that such a standard will require the industry to devote resources to improving the efficiency of the devices and that consumers will ultimately bear the cost of that improvement, the Commission should write standards that are achievable at a cost that is justified. Most statutes that govern the writing of standards by regulatory bodies impose this obligation by requiring that the standards be technically feasible and economically practicable or cost-beneficial. In fact, if the Commission has identified levels of efficiency that are feasible and beneficial based on some existing products, it will have done exactly what it must to comply with the California law and promote the public interest. The evidence presented to the Commission shows that there are compliant products available in the market today. This suggests that the proposed standards are technically feasible and the potential benefits are large.

The non-industry commenters stress that the evidence supports the conclusion that the standard is technically feasible and cost beneficial, which is the legal standard. They also point to the rapid technological progress that has taken place since the ENERGY STAR 6 levels were set as evidence to support the technical feasibility of the standards. They also argue that the potential benefits have been underestimated because actual consumption of electricity is higher than assumed in the CEC analysis and the allowance for adders is too large or not necessary.

The stipulation that standards are technically feasible and economically beneficial guards against making erroneous assumptions about what the industry can accomplish. Ironically, the industry presentations make the opposite error. To demonstrate what they cannot do, or should not be asked to do, they offer a series of comparisons with the rate of change of a number of mature products that bear no relationship to new digital products.

Ironically, at the same time, they bristle when we make comparisons between digital devices, objecting to the observation that the energy efficiency of notebooks and tablets is vastly superior to that of plug-in devices. They misinterpret our use of that comparison.

When we point to the remarkable success of the equipment makers in improving the energy efficiency of tablets and smart phones, we do not do so to suggest that the same technologies can or should be used in computers or notebooks, although we suspect that there are spillovers that have not been exploited. Tablets teach us what the industry can do when it has strong incentives to improve energy efficiency. We believe that reducing or removing the market imperfections will unleash the same kind of innovation and investment that has led to the improvement in the energy efficiency of tablets.

D. STANDARDS V. CONSUMER BEHAVIOR

The industry commenters also "blame" consumers for not operating their computers in the most efficient manner possible. This confuses the difference between behavioral policies and structural policies. Of course we want consumers to behave in a responsible way. Irresponsible consumer behavior is not an excuse for irresponsible producer behavior. We want consumers to drive their cars intelligently, but even when they do, there is an immense amount of energy that can be saved by operating more energy efficient cars. The same is true for computers. Moreover, we must design standards on the basis of real world behavior, not hypothetical ideal behavior. To the extent we can help consumers to behave well by designing devices better (e.g. built in technologies and default settings), we should attribute those gains to the standard. Computers and displays are overflowing with such opportunities, including default setting at the lowest level of energy consumptions necessary and automatic transitions to lower levels of energy consumption when possible.

E. HIGH END PRODUCTS

Industry has raised some questions about the ability of some (primarily high performance) models to consume less energy or to ramp up satisfactorily and still execute the desired functions. However, it is unclear whether this problem exists with the present design of devices and how difficult it would be to solve with new designs. Industry comments indicate a two year design and build cycle, which, depending on when the standards are issued, what their level is, and when they go into effect, could be challenging if significant redesign is necessary.

The empirical evidence reviewed by the Commission and the anecdotal evidence presented at the workshop strongly support the proposition that the proposed standards are economically beneficial. The industry objects to this conclusion, presenting worst case scenarios, particularly for high end devices, claiming that they will be driven from the market. This argument is based on two assumptions that are generally not true. They assume that:

(1) the industry will be unable to control the cost increases necessary to meet the standard through innovation, and

(2) customers will be unwilling to pay the increase, even though these are high value uses.

The bottom line here is simple. The industry worries about high end devices because that is where they make the highest profit. We worry about low and mid-level devices because that is where consumers waste the most money on unnecessary energy consumption. There is every reason to believe that the high end products will not be driven from the market, but will be supported by powerful market forces, i.e. the tendency of the industry to find the least cost solution while maintaining the functionality consumers want, the willingness to pay of consumers, and the foreclosure of sale of non-compliant products.

F. The Data Gotcha

At the staff pre-rulemaking workshop, it was quite apparent that the companies have a great deal of data that has not been shared with the CEC. Instead of taking a constructive approach working with the CEC so the agency can use the best data to write an effective rule, the industry appears to have taken a destructive approach, which seeks to ambush any rule by claiming the CEC does not have sufficient data. This gotcha strategy is irresponsible and counterproductive, to say the least.

G. Conclusion

We appreciate the Commission's consideration of our comments and the opportunity to make the case in support of the proposed efficiency standards for computers, monitors and displays which we believe will greatly benefit California consumers and, if history is any example, the nation.

Respectfully Submitted,

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ATTACHMENT A:
RESEARCH BRIEF
ELECTRICITY CONSUMPTION AND ENERGY SAVINGS POTENTIAL OF CONSUMER DIGITAL DEVICES: THE ROLE OF CALIFORNIA APPLIANCE STANDARDS LEADERSHIP

MARK COOPER
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FEBRUARY 2014

I. INTRODUCTION

Over the past decade, policymakers at the federal and state levels have sharply increased the level and coverage of energy efficiency performance standards, using both legislation and regulation. The requirements to increase the energy efficiency have affected consumer durables, [15] like automobiles, appliances, and buildings, and capital goods used by industry, like heavy-duty trucks, and electric motors.[16]

The Consumer Federation of America (CFA) has conducted economic analyses of many of these energy efficiency performance standards, focusing on the impact upon consumer pocketbooks.[17] CFA has also commissioned public opinion polls about consumer attitudes toward energy efficiency in general and performance standards in particular.[18] We have consistently found strong public support for increasing energy efficiency through standards and our economic analysis shows that this public support is well grounded in the economics of the standards adopted.[19] Our

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[15] In economics, a **durable good** or a **hard good** is a good that does not quickly wear out, or more specifically, one that yields utility over time rather than being completely consumed in one use…Examples of consumer durable goods include cars, household goods (home appliances, consumer electronics, furniture, etc.), sports equipment, firearms, and toys, http://en.wikipedia.org/wiki/Durable_good

[16] Appliance Standards Awareness Project, "Standards Scene Heating Up," "California Preps for New Rulemaking," "State of the States," *Appliance Standards Unplugged*, July 25, 2013; Mark Cooper and Jack Gillis, *Paying The Freight: The Consumer Benefits Of Increasing The Fuel Economy Of Medium And Heavy Duty Trucks,* Consumer Federation of America, February, 2014.

[17] *Consumer Federation of America, et al., Comments on the Proposed Rule 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards,* Docket Nos. EPA-HQ-OAR-2010-0799; FRL-9495-2, NHTSA–2010–0131, 2/13/12;; Consumer Federation of America, *CFA Comments to DOE on Equipment Price Forecasting for Refrigerators, Refrigerator-freezers and Freezers,* 03/24/11; Consumer Federation of America, *CFA and NCLC Letter to DOE Regarding Energy Conservation Standards for Residential Furnaces, Central Air Conditioners and Heat Pumps,* 10/17/11; Consumer Federation of America, *Comments to DOE on Set Top Boxes and Network Equipment as a Covered Consumer Product*, 09/22/11; Consumer Federation of America, *CFA Joins Coalition in Comments to DOE on Efficiency Standards for Battery Chargers,* 07/16/12; Cooper, Mark, *Testimony of Dr. Mark Cooper on the American Energy Initiative* before the House Energy and Commerce Committee, 03/17/11.; Cooper, Mark, Testimony on Appliance Efficiency Standards Legislation, 03/10/11; Consumer Federation of America, *Comments to DOE Urging Action to Advance New Lighting Standards,* 05/13/2013.

[18] Consumer Federation of America, 2011b, *CFA Appliance Efficiency Report*, 03/08/11; Consumer Federation of America, *National Survey Shows that Most Consumers Support 60 MPG Fuel Economy Standards by 2025,* 09/28/10; *CFA Surveys Reveal Record Public Concern About Gas Prices and Dependence on Oil Imports*, 03/16/11.

[19] A comprehensive review of the economic theory and empirical evidence supporting performance standards can be found in Mark Cooper, *Energy Efficiency Performance Standards: The Cornerstone of Consumer-Friendly Energy Policy*, Consumer Federation of America, 2013.

economic analysis shows that higher standards save consumers considerable sums of money because energy saving technologies lower consumer energy bills much more than they increase the cost of consumer durables.

Major consumer durables like automobiles and HVAC equipment (heating and air conditioning) and capital goods, like medium and heavy-duty trucks receive the most attention in the energy policy process, and rightly so. Gasoline used in cars and light trucks is the single largest household energy expenditure, reaching over $2150 in 2012.[20] The cost of diesel fuel used for medium and heavy-duty trucks, which is ultimately paid by consumers in the price of the goods and services delivered, was almost $1200 in 2012.[21] Expenditures for home energy (heating, cooling, hot water, appliances) was about $2,000 the same year, with heating being the largest single cost, followed by hot water and air conditioning.[22]

However, the fastest growing component of national energy consumption is the appliance category, which includes a mix of appliances including lighting, televisions and consumer electronics.[23] Moreover, within this broad category, the fastest growing segment of home energy consumption involves what are known as household digital devices, which include computers, internet connectivity and video network devices. This paper examines the growing importance and potential consumer benefits of adopting efficiency standards to cover these devices.

Given the dramatic growth in electricity consumption of these household digital devices, it is not surprising that they have begun to attract the attention of policymakers and, given the historic pattern of development of standards across the U.S., it would not be surprising if the state of California is the first to take up the issue of setting standards for these devices. California has traditionally played this leadership role in a number of areas, including not only appliances, and buildings, but also for vehicles.[24]

Although the California initiatives are frequently driven and measured by their environmental impacts, they accomplish their environmental goals largely by reducing energy consumption. They are driven by environmental concerns, but they are required to meet economic cost benefit criteria as well.[25] While CFA recognizes and appreciates the importance of the total social costs of energy consumption, our analysis has always focused on a narrower economic standard, the consumer pocketbook test. We always ask, "how does the benefit of

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20 These estimates are explained in Mark Cooper and Jack Gillis, *Paying the Freight: The Consumer Benefits of Increasing the Fuel Economy of Medium and Heavy Duty Trucks,* Consumer Federation of America, February, 2014.

21 Id.

22 Bureau of Labor Statistics, Consumer Expenditure Survey for 2010, U.S. Energy Information Administration, *Residential Energy Consumption Survey, 2009*, http://www.eia.gov/consumption/residential/data/2009/

23 U.S. Energy Information Administration, Heating and cooling no longer majority of U.S. home energy use, March 7, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=10271

24 Mark Cooper, *Energy Efficiency Performance Standards*, 2013, examines the role of California in appliance efficiency and building codes. CFA has recently analyzed the importance of California policy leadership in the light duty vehicle market in *The Zero Emissions Vehicle Program: Clean Cars States Lead in Innovation*, October 24, 2013

25 CFA has noted the near perfect correlation between reduced gasoline consumption and reduced vehicle carbon emissions, *Comments of the Consumer Federation of America, Environmental Protection Agency and Department of Transportation,*In the Matter of Notice of Upcoming Joint Rulemaking to Docket ID No. EPA-HQ-OAR-0799 Establish 2017 and Later Model Year Light Duty Vehicle GHG Emissions and Docket ID No. NHTSA-2010-0131 CAFE Standards, October 29, 2010.

reduced energy bills compare to the cost of including energy reducing technologies, i.e. what is the impact on the consumer pocketbook?"

Outline

Section II examines the remarkable increase in and current level of electricity consumption by household digital devices.

Section III discusses the potential savings and costs of increasing energy efficiency of household digital devices.

Section IV explains why the marketplace has failed to incorporate the beneficial technologies into these devices.

II. The Growing Importance of Household Digital Devices

As shown in the top graph of Figure 1, the amount of electricity consumed by household digital devices increased more than five-fold between 2000 and 2010. Our estimate of the 2013 national average consumption of 800 kWh for household digital devices is based on the weighted average of the presence of those devices in households. That is, we multiply estimates of the number of households across the nation with the device by the average usage per household and divide by the total number of households.

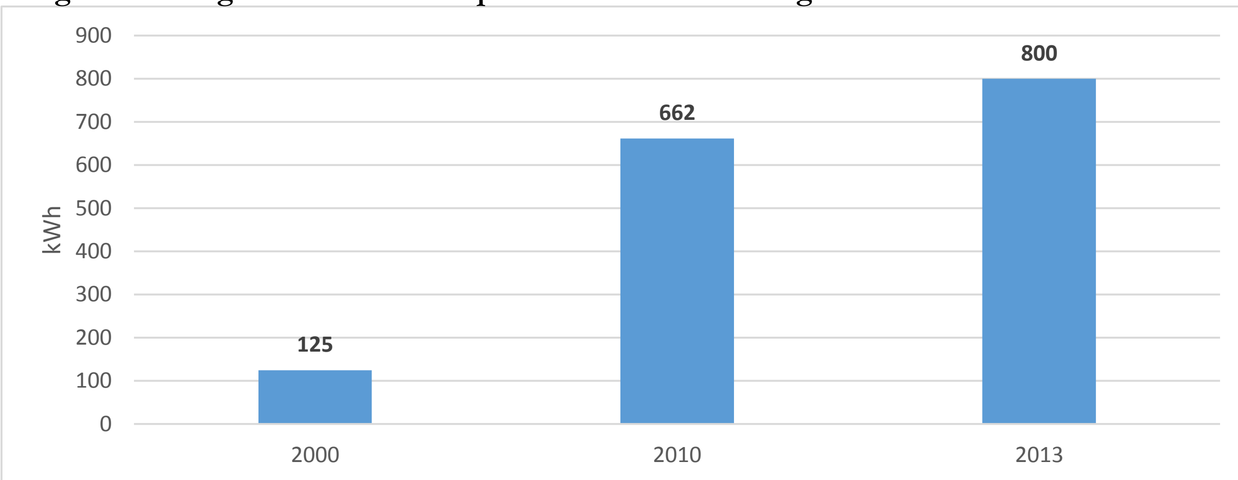
The increase in electricity use of these devices is driven both by increased penetration of the devices into households and increased use of those devices by households, as shown in the bottom graph of Figure 1. More households have more devices that they use more often for longer periods of time to accomplish tasks that consume more energy. Keeping in mind that in 2010 there were fewer than 120 million households, it is clear that these devices were not only approaching full saturation, but that some households had more than one device. Thus, in thinking about future levels of penetration, it may be more appropriate to think about some of these devices as personal rather than household.[26]

Figure 2 presents a second way to describe household digital device electricity consumption. It shows the estimated electricity consumption of a household that has one of each of the devices – a computer with a monitor, a laptop, a modem with a router, a cable set top box and a DVR – and uses those devises at the average level. Given the penetration of these devices, this household would be the modal or "typical" household. Two estimates are shown, one from the California utilities, one from the Consumer Electronics Association. Both estimates of electricity consumption for this "typical" household, are quite close to 800 kWh. Of course on a national average basis, some households do not have all of these devices, but some have more than one. Therefore, the weighted average seems reasonable.

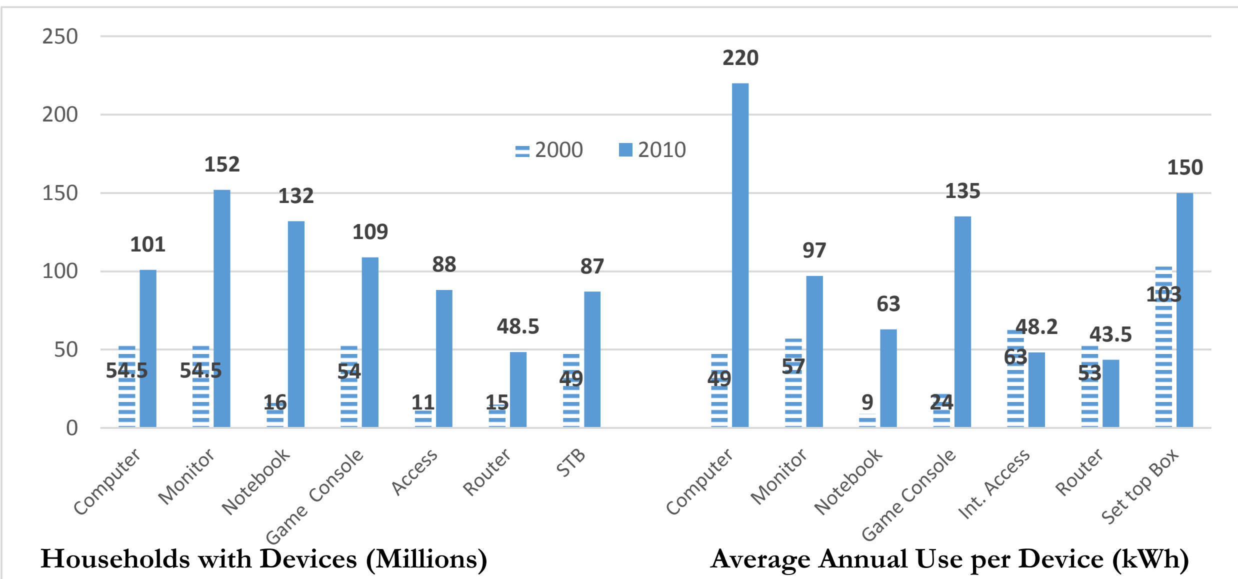
[26] The analogy here might be the comparison with wireline telephone subscriptions, which topped out at about 170 million (approximately 1.5 per household), while wireless subscriptions now exceed 330 million (more than one per person).

FIGURE 1: THE INCREASING IMPACT OF DIGITAL DEVICES ON HOUSEHOLD ELECTRICITY USE

Weighted Average Annual Consumption of Households Digital Devices

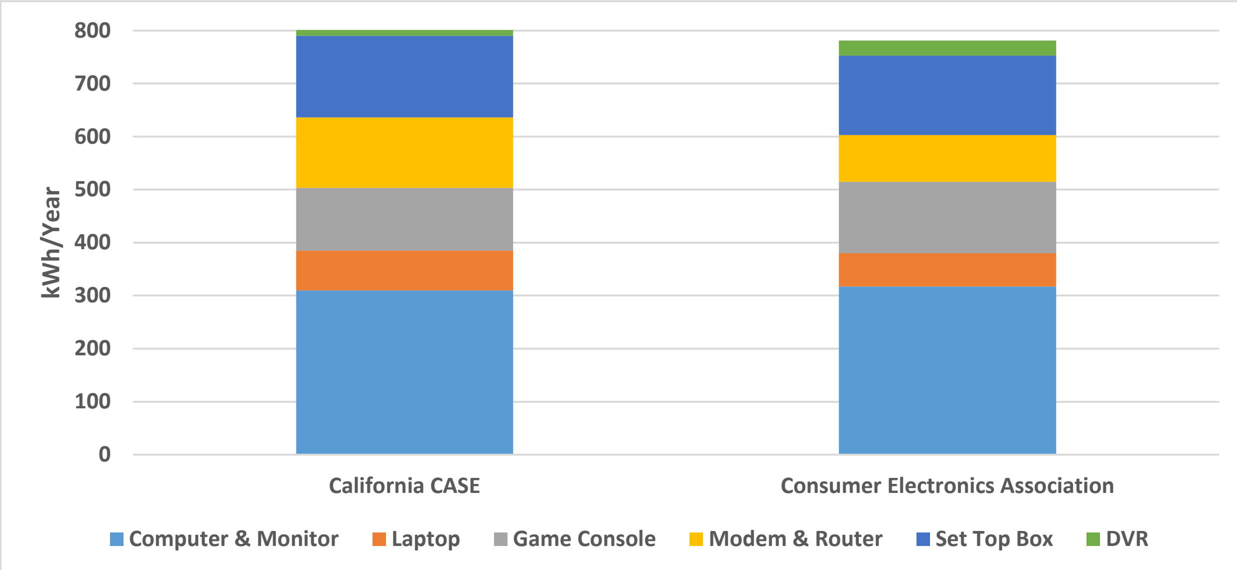


Penetration and Use of Computers, Game Consoles and Network Connectivity Devices



Source: Bryan Urban, Verena Tiefenbeck and Kurt Roth, *Energy Consumption of Consumer Electronics in U.S., Households: Final Report to the Consumer Electronics Association (CEA),* Fraunhofer Center for Sustainable Energy Systems, December 2011. 2013 assumes one-third the average annual rate of growth since 2010 as occurred in 2000 to 2010. This reflects a slowing of growth in computer ownership and subscriptions to multichannel video service, with continued strong growth in broadband connectivity and gaming. Weighted

FIGURE 2: ANNUAL CONSUMPTION OF A HOUSEHOLD WITH ONE OF EACH OF THE DEVICES

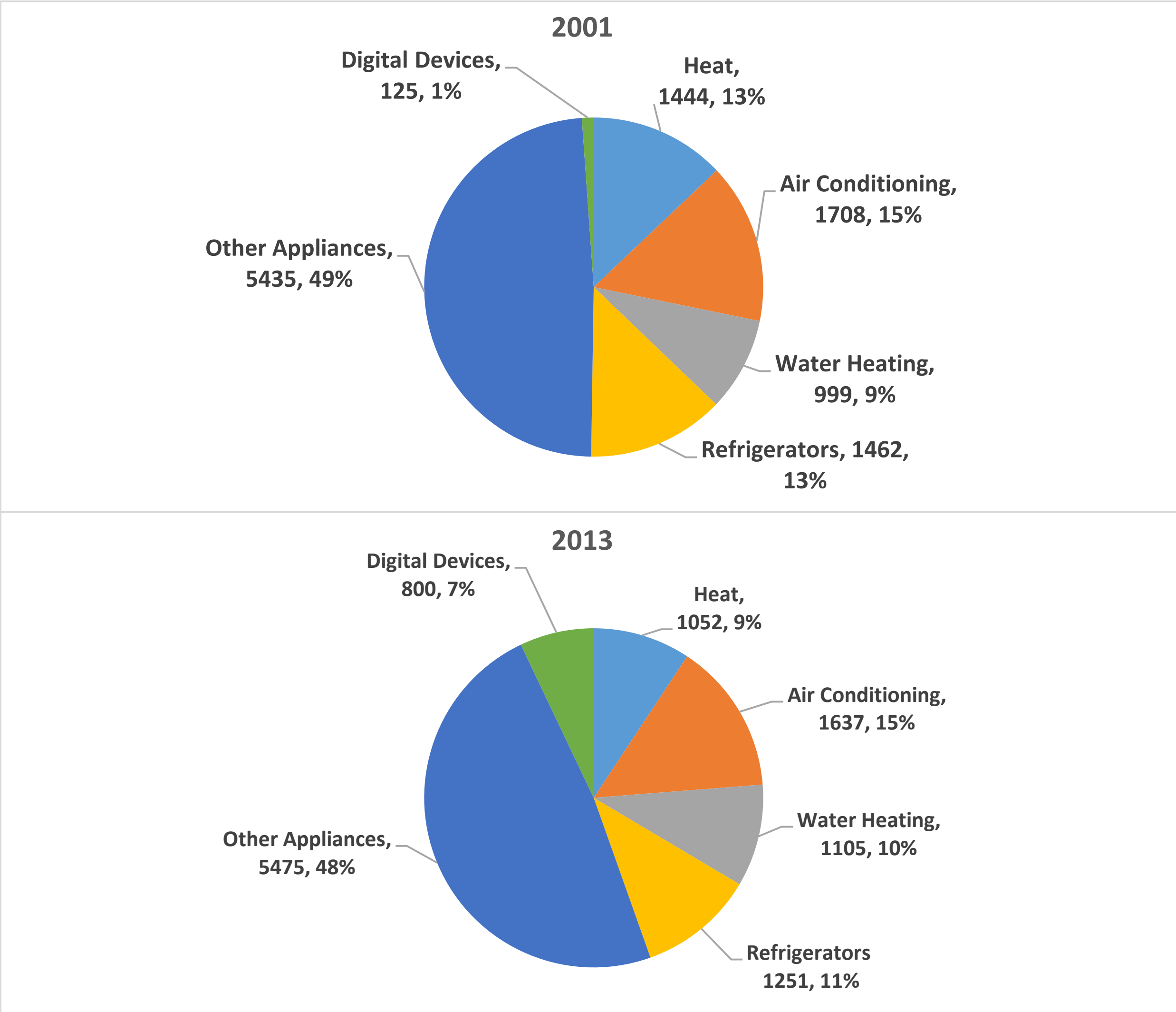


Source: Bryan Urban, Verena Tiefenbeck and Kurt Roth, *Energy Consumption of Consumer Electronics in U.S., Households: Final Report to the Consumer Electronics Association (CEA),* Fraunhofer Center for Sustainable Energy Systems, December 2011. Pacific Gas and Electric et al., Codes and Standards Enhancement (CASE) Initiative for PY 2013, Title 20 Standard Development, docket #12-AAER-2A, July 29, 2013. The IOU CASE Reports cover, Computers, Set Top Boxes, Small Network Equipment and Game Consoles.

As shown in Figure 3, we estimate that on a national average basis, by 2013, household digital devices are not only the fastest growing source of demand for electricity, these consumer electronics devices also consumed about half as much energy as air conditioning and two-thirds as much as home refrigeration.[27] Of course, air conditioning use is concentrated in specific regions while use of these consumer electronic devices is widespread across the country. The widely-dispersed nature of electricity consumption of household digital devices does not mean they should be ignored in consumer, energy or environmental policy. On the contrary, as discussed in Section III of this report, it makes it even more important to address the electricity consumption of household digital devices. Thus, household digital devices are one of the largest household users of electricity that have not been addressed by energy standards. While the rapid growth and dispersed nature of the use of these devices may have kept them off the radar screen of energy policy makers, it is clear that they are now an important driver of electricity consumption that deserves immediate and careful attention from decision makers with responsibility for energy policy.

[27] In fact, the relative importance of these devices on household electricity consumption in California is likely to be greater than the national average. California has a moderate climate, which means households use less air conditioning (about on third below the national average) and higher income than the national average, which likely leads to higher penetration and use of digital technologies (e.g. computer penetration is at least 10 percent above the national average). Combining these two factors, household digital devices account for almost three quarters as much electricity consumption as air conditioning for California households.

FIGURE 3: NATIONAL WEIGHTED AVERAGE ELECTRICITY CONSUMPTION KWH/HOUSEHOLD (Includes all households)



Sources and notes: The estimates of consumption by Household Digital Devices are subtracted from the "other appliance category." The 2009 RECS percentages of electricity consumption are adjusted to 2013, based on total electricity consumption in 2012. Residential Energy Consumption Survey (2001, 2009).

III. THE COST AND BENEFIT OF POTENTIAL ELECTRICITY SAVINGS

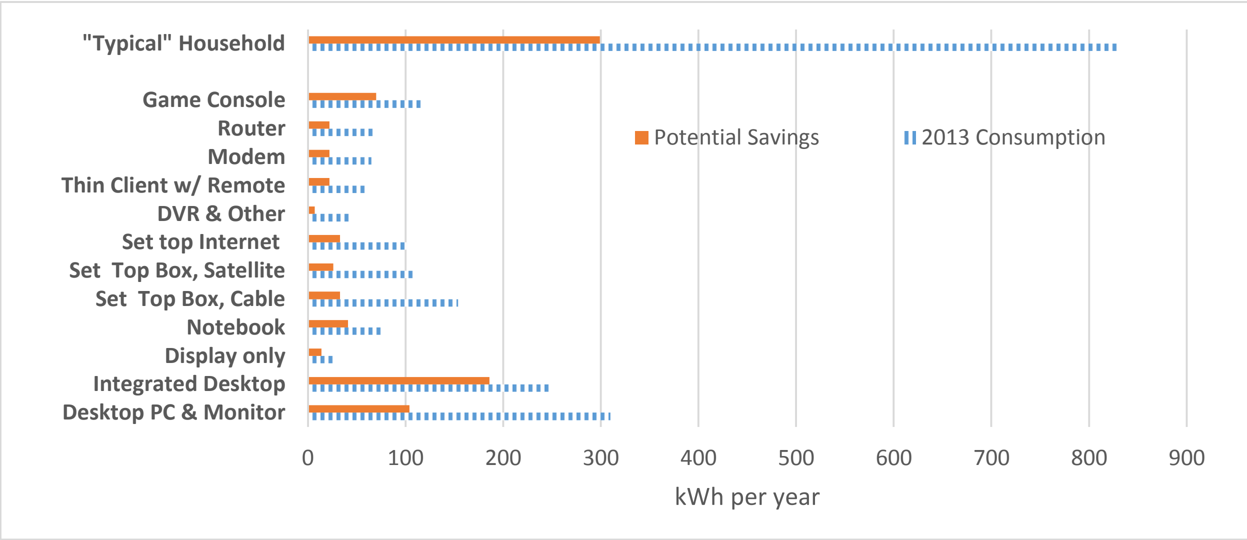
Recent analysis by the California investor-owned utilities (IOUs) demonstrates a substantial potential for electricity savings for these devices at a very attractive cost.[28] As shown in the top graph of Figure 4, the typical household could save almost 300 kWh per year for the "one of each" set of devices. This is a reduction of more than one-third in electricity consumption.[29] We use the

[28] Pacific Gas and Electric et al., *Codes and Standards Enhancement (CASE) Initiative for PY 2013, Title 20 Standard Development,* Docket #12-AAER-2A, July 29, 2013.

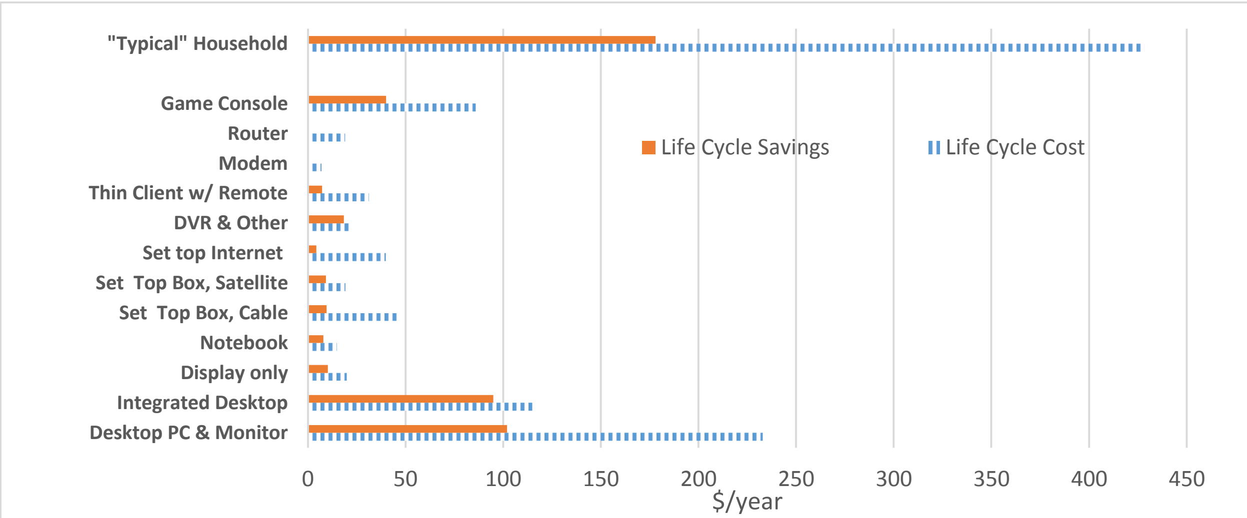
[29] A voluntary agreement has been reached for set top boxes that will achieve some of the potential savings.

estimates prepared by the California IOUs since they are recent and provide a consistent analytic approach across appliances that is clearly defined and documented. A review of other estimates of

FIGURE 4: COST AND BENEFITS OF IMPROVING EFFICIENCY OF DIGITAL DEVICES
Current Electricity Consumption and Potential Reductions



Life Cycle Costs and Benefits of Reducing Electricity Consumption



Source: Pacific Gas and Electric et al., Codes and Standards Enhancement (CASE) Initiative for PY 2013, Title 20 Standard Development, docket #12-AAER-2A, July 29, 2013. The IOU CASE Reports cover, Computers, Set Top Boxes, Small Network Equipment and Game Consoles.

potential energy savings and technology costs shows that these estimates are quite reasonable, even a bit on the cautious side.[30] The bottom graph of Figure 4 shows that for the "typical" households,

[30] A number of studies put the potential for various devices in the range of 30 to 85 percent. Some mix behavioral and technology options, although it is frequently possible to achieve savings that are attributed to behavioral changes with technology where the extent of behavior modification is uncertain. Few of the studies estimate costs but those

the cost of achieving these improvements in energy efficiency would be much smaller than the value of the electricity saved. For each of the individual devices, the benefits exceed the costs. Using a 3% discount rate, the benefits are 2.4 times larger than the cost. [31]

In short, the proposal submitted to the California Energy Commission by the IOUs for this important group of consumer durables, passes the consumer pocketbook test with flying colors.

IV. The Important Role of Standards

The strongly positive cost benefit analysis that supports including energy saving technologies in these household digital devices, always raises the question:

- Why hasn't the marketplace driven this result?

The answer to this question is well-known:

- The market for energy efficiency suffers from numerous obstacles, barriers and imperfections that inhibit the investment in energy efficiency technologies.

We have examined the debate over the "efficiency gap" – the gap caused by the failure to make economically beneficial energy efficiency investments – and the role of performance standards as a policy response to close it in great detail in a recent report.[32] Many of the obstacles to investment in energy efficiency that we have identified apply to household digital devices. The electricity consumption of these devices is a particularly difficult problem for the marketplace to solve.

- The electricity consumption of these devices is not visible to consumers.
- The devices are purchased for their functionalities, which, given the dramatic increase in penetration and use, are highly desirable. The level of electricity consumption is not an attribute of the product to which consumers will pay much attention (a shrouded attribute problem).

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that do yield results that are similar to the utility studies – see, e.g., Morris E. Jones, Jr., Belle W.Y. Wei, and Donald L. Hung, "Laptop Energy-Savings Opportunities based on User Behaviors," *Energy Efficiency,* 2013 (6); Won Young Park, Amol Phadke, and Nihar Shah, "Efficiency Improvement Opportunities of Personal Computer Monitors: Implications for Mark Transformation Programs," *Energy Efficiency,* (2013(6);Eric Hitting, Kimberly A. Mullins and Ines L. Azevedo, "Electricity Consumption and Energy Savings in the United States, Energy Efficiency, March, 31, 2012; Steven Lanzisera, Bruce Nordman, and Richard E. Brown, "Data Network Equipment Energy Use and Savings Potential in Buildings," *Energy Efficiency,* 2012 (5); Catherine Mercier and Laura Moorfield, *Commercial Office Plug Load Savings and Assessment: Final Report,* Ecova, July 2011; McKinsey Global Energy and Materials, *Unlocking Energy Efficiency in the U.S. Economy,* McKinsey and Company, 2009.

[31] Discount rates have long been a bone of contention in energy policy analysis. CFA views energy efficiency investments, particularly for electricity consuming durables, as very low risk since usage levels are stable and prices are not volatile. To the extent that consumers reduce their savings to acquire these devices and pay their bills, the opportunity cost is low, since the interest rates on low risk savings instruments is quite low. Under current market conditions, 3 percent, which is typically used as a low discount rate, may even be too high.

[32] Mark Cooper, *Energy Efficiency Performance Standards*, 2013.

- Even if consumers are paying attention to energy use, it would be difficult for them to determine how much energy the devices use and the impact of reducing consumption. The information is either not readily available (information problems) and/or the transaction cost of obtaining it is high (transaction cost problems) and/or the calculations are difficult for consumers to make given uncertainties about consumption and prices (behavioral and information problems).

- The manufacturers of the products make the key decisions about energy consumption and the bundle of attributes that will be made available in the market, thereby constraining the range of energy consumption levels the consumer has to choose from (principal agent problems).

- The manufacturers tend to focus on the primary product attributes and the first cost of the device, ignoring the life cycle cost (i.e. the total of acquisition and operating costs) since they do not pay the electricity bills. The manufacturers' interests are separate and different from the consumers' interests (split incentives problem).

- Ultimately, the benefit of reducing energy consumption has value beyond the benefit that each individual directly enjoys from reduced energy consumption (a public goods problem).

These characteristics make it highly unlikely that the marketplace will overcome these obstacles on its own to stimulate investment in energy efficiency increasing technologies. Simply providing consumers with more information about electricity consumption of the devices does not overcome the underlying problem on the demand side or the supply side.

Therefore, standards can play an important role. They address all four of the barriers identified.

- Standards put a floor under the level of energy consumption, without dictating which technologies can be utilized.

- Consumers do not have to master the economics of the level of energy consumption of the device.

- Because all manufacturers must abide by the same rule, there is less risk of adding the cost of the energy savings technology to the product.

- Producers who are better at adding technology at lower cost may benefit.

- Competition can be stimulated around the standard and may even go beyond it as the standard raises awareness.

Thus, the barriers are overcome to the level of the standard.

California's role in moving the nation forward in setting standards for these devices is also appropriate for a number of reasons.

- California is a large enough market to get the attention of the product manufacturers.
- Not only is the California economy large even on a global scale, but Silicon Valley in Northern California has a special place in the digital revolution, so it is likely to get the broad attention of policy makers.
- Given the experience of the past quarter of a century, there is a great deal of experience with this type of standards setting process in California.
- The fact that the California IOUs have conducted extensive analysis and proposed a set of standards that achieves significant savings reflects this history and bodes well for the process.

Given the highly positive cost benefit analysis and the demonstration that there are numerous technologies available that could meet or beat the standard, the proposed levels are a good starting point, but just a starting point. In our review of the literature, we identified a number of characteristics that make performance standards effective in responding to the market barriers and imperfections that inhibit investment in efficiency. The proposed initial levels of the standards would capture many of the characteristics.

Technology Neutral: Taking a technology neutral approach to a long term standard unleashes competition around the standard that enables the industry to present consumers with a wide range of choices at that lowest cost possible.

Product Neutral: Performance-based standards are set in ways that accommodate different levels of performance and features. Therefore, the standards accommodate buyer preferences; and do not try to supplant them. Standards level the playing field for efficient devices.

Responsive to industry needs: Establishing a long term performance standard recognizes the need to keep the standards in touch with reality. Standards need to be set at a moderately aggressive level that is clearly beneficial and achievable and can take into account dynamic changes in technology.

Responsive to market needs: Setting standards that are market-friendly facilitates compliance. The standards do not require radical changes in the types or size of equipment the industry produces; so, the full range of choices will be available to the market. These characteristics make standards pro-competitive.

CONCLUSION

Increasing numbers of consumer electronics (digital devices) in the home coupled with higher usage levels have resulted significant growth in energy consumption over the past decade. There is an opportunity to save consumers money on their energy bills through technology neutral, energy saving performance-based standards for these devices. These standards address the failure of the marketplace to incorporate cost-effective energy saving technologies into the products. California has led the nation on energy efficiency standards for vehicles, buildings and appliances and other electronics, such as battery chargers. It can be a leader once again by moving ahead on efficiency standards for consumer electronics and digital devices. Consumers will benefit from California's leadership.

ATTACHMENT B: EXCERPT FROM ENERGY EFFICIENCY PERFORMANCE STANDARDS: The Cornerstone of Consumer-Friendly Energy Policy

A. "THE EFFICIENCY GAP" AND PERFORMANCE STANDARDS: OVERVIEW

For over 30 years, economists, engineers and policy analysts have described a phenomenon in energy markets that came to be known as the "energy paradox" or the efficiency gap.[33] Engineering/economic analyses showed that technologies exist that could potentially reduce the energy use of consumer durables – everything from light bulbs to air conditioners, water heaters, furnaces, building shells and automobiles. Because the reduction in operating costs more than offset the initial costs of the technology, resulting in substantial potential economic benefits, we confront the "paradox:"

Even in the industrial sector, where firms are considered to be motivated primarily by economic profitability incentives, the efficiency gap is evident. A recent review of 160 studies of industrial energy efficiency investments conducted for the United Nations Industrial Development Organization (UNIDO) framed the analytic issue in terms that are similar to the terms we used.

> Why do organizations impose very stringent investment criteria for projects to improve energy efficiency?
> Why do organizations neglect projects that appear to meet these criteria?
> Why do organizations neglect energy efficient and apparently cost-effective alternatives when making broader investment, operational, maintenance and purchasing decisions?[34]

The answer offered in a UNIDO companion paper is grounded in both the new case studies and the long history of analysis of energy efficiency.

> Because of barriers to energy efficiency these seemingly profitable measures are not being adopted… these barriers may generally be characterized as "postulated mechanisms that inhibit a decision or behavior that appears to be both energy efficient and economically efficient. There is a large body of literature on the nature of barriers to energy efficiency at the micro and the macro level, which draws on partly overlapping concepts from neo-classical economics, institutional economics (including principal-agent theory and transaction cost economics), behavioral economics, psychology and sociology). Barriers at the macro level involve price distortions or institutional failures. In comparison, the literature on barriers at the micro level tries to explain why organizations fail to invest in energy efficiency even though it appears to be profitable under current economic conditions determined at the macro level.[35]

Comprehensive Frameworks and Empirical Evidence on the Efficiency Gap (Section II)

The efficiency gap literature provides a clear answer to the question of "why don't producers sell and consumers buy more energy savings technologies and lower their energy costs?" It shows that the efficiency gap is caused by barriers and imperfections on both the supply and demand sides of the energy market that inhibit the development and distribution of energy saving technologies. The emphasis on the supply side of the market is recent and extremely important. Among the most

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[33] Golove and Eto, 1996.
[34] Sorrel, Mallet and Nye , 2011, p. 11
[35] Schleich and Gruber, 201, pp. 1-2. A similar formulation is offered by Thollander, Palm and Rohdin, p.3.

important and frequently cited factors that inhibit investment in energy savings technology are the following.

Producers of energy using durables hesitate to include energy saving technologies in the products they sell because they are unsure of the market (risk), lack familiarity (lack of information), and skill with the technology and are not confident in their ability to implement the technology or how it will perform (lack of expertise). They are uncertain about technology costs (hidden costs) and future energy prices (uncertainty). They cannot capture the value of investing in the basic research and development necessary to move the technology toward introduction in the market (public goods problem of appropriability). Routines and organizational structures retard the ability to undertake different types of investments (inertia), so they allocate their capital investment (lack of capital) to enhance other attributes of the durables they think are more important (creating bundles of attributes that de-emphasize energy consumption).

Consumers do not demand energy savings technology because in many cases the actors who make the decision about which technologies to use are not responsible for paying the energy bills (split incentives). Consumers lack the knowledge and ability to project energy consumption and price (lack of information) and calculate lifecycle costs (lack of expertise). Habit makes it difficult to adopt new technologies (inertia). Consumers are sensitive to the first cost of consumer durables (lack of capital) and pay more attention to other attributes of the durables (making energy consumption a shrouded attribute).

Other critical factors in the market also contribute to the underinvestment in energy efficiency technology. Financial institutions do not factor the energy consuming characteristics of durables into their calculations (limited rewards of efficiency). Regulators set prices and deliver bills that make it difficult for consumers to adjust their behavior and value energy saving technologies (ineffective price signals). Coordination between aspects of the supply train is difficult (network effects). Positive effects of energy savings, like macro-economic benefits and improved productivity do not enter into private calculations (positive externalities).

Performance Standards: Evaluations of policy options to close the efficiency gap consistently find that standards that require consumer durables to use less energy are a very attractive approach to closing the gap. Energy performance standards address many of the most important market barriers and imperfections. They tend to reduce risk and uncertainty by creating a market for energy saving technologies, lower technology costs by stimulating investment in and experience with new technologies, reduce the need for information and the effect of split incentives, all of which help to overcome the inertia of routine and habit.

However, the literature points out that performance standards have positive effects if they are well-designed, enforced and updated. Key principles for the design of performance standards to ensure they are effective include the following.

- **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.

Cost benefit analyses of past efforts to increase energy efficiency support the conclusion that significant, economically beneficial energy savings opportunities can be captured with policies that target the development and acquisition of more energy efficient consumer durables.

Evaluations of policies to promote efficiency in general, as well as specific evaluations of performance standards show that they have proven to be highly cost effective, with benefits far exceeding costs. In fact, costs are frequently less than anticipated in regulatory proceedings because learning and economies of scale lower the cost of compliance. Benefits are underestimated because the economic stimulus that results from increasing the resources consumers have to spend on other goods and services is not taken into account.

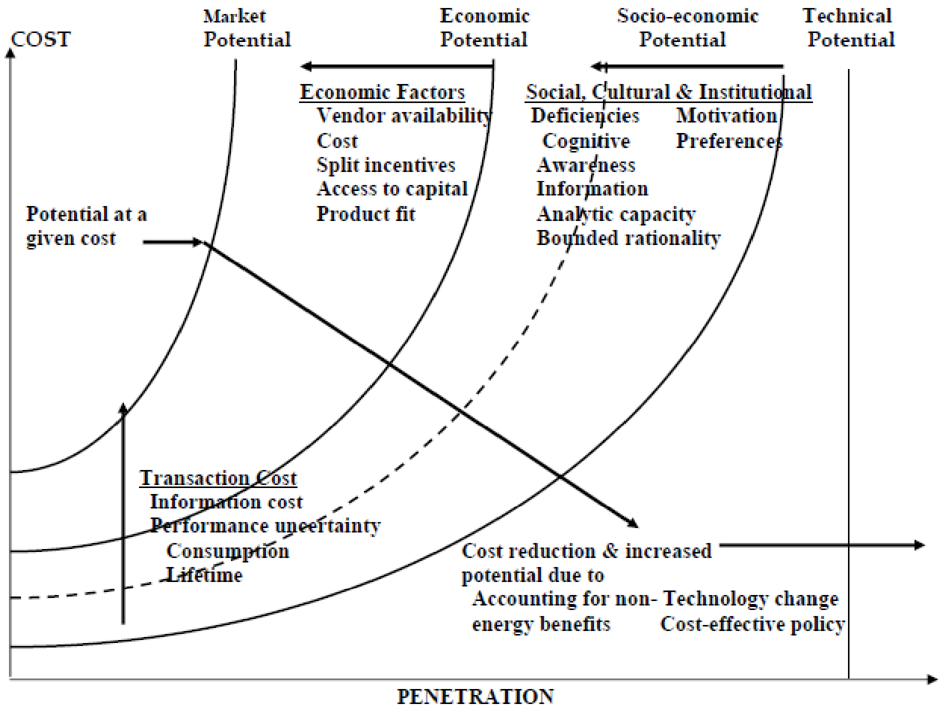
The net benefit of policies to promote greater efficiency tends to be underestimated in the proceedings to set standard levels because cost estimates do not take account costs savings associated with implementing new technologies, and indirect economic benefits of lowering energy costs are not included. It is noteworthy that well-designed standards have little or no effect on the other attributes of the products.

This section presents a comprehensive analytic framework that explains the energy efficiency gap by examining several frameworks that have been developed over the past two decades. These frameworks rest upon a strong foundation of empirical analysis that has been developed over more than a quarter of a century and strengthened considerably in the past decade. After developing the overall framework, we review the recent empirical evidence that supports key pieces of the framework.

B. THE LBL FRAMEWORK

An analytic framework that rests on a technology investment approach was offered by analysts at Lawrence Berkeley National Laboratory (LBL). As shown in in Exhibit II-1, one can use a technology investment framework to assess the factors that cause investment in energy efficiency to fall well short of the technical potential.

EXHIBIT II-1: PENETRATION OF MITIGATION TECHNOLOGIES: A CONCEPTUAL FRAMEWORK



Source: **Jayant Sathaye and Scott Murtishaw, *Market Failures, Consumer Preferences, and Transaction Costs in Energy Efficiency Purchase Decisions* (California Energy Commission, November 2004), p. 11.**

The LBL study identified broad categories of market imperfections, barriers, and obstacles that are important in determining the level of investments – economic, transaction cost, and social cultural and institutional. The analysis emphasizes the important role that policy can play in determining where the market will settle. Thus, there are six broad categories of factors that must be incorporated into the analysis of the level of investment in energy saving technologies. Market performance is influenced by:

- behavioral factors (social, cultural & institutional)
- economic factors
- transaction costs
- externalities (non-energy costs)
- technological change
- public policy

Exhibit II-2 summarizes an earlier 1996 paper prepared by other analysts at the LBL.[36] Exhibit A-II-2 provides citations. The analysis was framed in terms of the role of policy intervention to promote efficiency as states restructured the electricity market. The paper "focuses on understanding to what extent some form of future intervention may be warranted and how we might judge the success of particular interventions."[37] Restructuring did not spread throughout the

[36] Golove and Eto, 1996.
[37] Golov and Eto, 1996, p. iv.

utility industry and in the past few years, reliance on interventions in the market to increase efficiency and renewables has grown, even in the deregulated states.[38] The growth of market interventions is consistent with the conclusions in the LBL paper.

> We conclude that there are compelling justifications for future energy-efficiency policies. Nevertheless, in order to succeed, they must be based on a sound understanding of the market problems they seek to correct and a realistic assessment of their likely efficacy.[39]

EXHIBIT II-2: MARKET BARRIERS TO ENERGY EFFICIENCY

Barriers[1]	**Market Failures**	**Transaction Cost[2]**	**Behavioral factors[16]**
Misplaced incentives	Externalities	Sunk costs[3]	Custom[17]
Agency[4]	Mis-pricing[20]	Lifetime[5]	Values[18] & Commitment[19]
Capital Illiquidity[8]	Public Goods[22]	Risk[6] & Uncertainty[7]	Social group & status[21]
Bundling	Basic research[23]	Asymmetric Info.[9]	Psychological Prospect[24]
Multi-attribute	Information	Imperfect Info.[10]	Ability to process info[27]
Gold Plating[11]	(Learning by Doing)[25]	Availability	Bounded rationality[26]
Inseparability[13]	Imperfect Competition/	Cost[12]	
Regulation	Market Power[28]	Accuracy	
Price Distortion[14]			
Chain of Barriers			
Disaggregated Mkt.[15]			

William H. Golove and Joseph H. Eto, *Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency.* For citations, see Appendix A, Exhibit A-II-2

As shown in Exhibit II-2, the Golove and Eto paper identified four broad categories of factors that inhibited investments in energy efficiency – barriers, transactions costs, market failures, and behavioral (noneconomic) factors. It identifies about two dozen specific factors spread roughly equally across these four categories. A key aspect of the analysis is to identify each of the categories as coming from a different tradition in the economic literature. The barriers category is made up of market structural factors. The market failure category is made up of externalities and imperfect competition. The LBL paper bases a substantial part of its argument on a transaction cost perspective as a critique of neo-classical economics.

> Neo-classical economics generally relies on the assumption of frictionless transactions in which no costs are associated with the transaction itself. In other words, the cost of activities such as collecting and analyzing information; negotiating with potential suppliers, partners and customers; and risk are assumed to be nonexistent or insignificant. This assumption has been increasingly challenged in recent years. The insights developed through these challenges represent an important way to evaluate aspects of various market failures (especially those associated with imperfect information).[40]

Starting from the observation that "transaction costs are not insignificant but, in fact, constitute a primary explanation for the particular form taken by many economic institutions and contractual relations"[41] the LBL paper identifies such costs and information as a critical issue,

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[38] There has recently been a dramatic re-commitment to publicly-sponsored energy efficiency and a substantial increase in allocated resources, Sanstad, Hanemann and Auffhammer, 2006, p. 6-5.
[39] Golove and Ito, 1996, p. x.
[40] Golove and Eto, p. 22.
[41] Golove and Eto, p. 23.

pointing out that "the key issue surrounding information is not its public goods character, but rather its asymmetric distribution combined with the tendency of those who have it to use it opportunistically."[42] Indeed, information plays a very large role in the analysis, entering in six different ways. In addition to the public goods and asymmetry concerns, the paper identifies four other ways information can create a barrier to efficiency –"(1) the lack of information, (2) the cost of information, (3) the accuracy of information, and (4) the ability to use or act upon information."[43]

C. The RFF Framework

A more recent paper from Resources for the Future (RFF), entitled *Energy Efficiency Economics and Policy,* addresses exactly the same issues as the earlier LBL paper – the debate over the efficiency gap observed in energy markets. The authors of the RFF paper characterize the efficiency gap debate as follows:

> Much of the literature on energy efficiency focuses on elucidating the potential rationales for policy intervention and evaluating the effectiveness and cost of such interventions in practice. Within this literature there is a long-standing debate surrounding the commonly cited "energy efficiency gap..." Within the investment framework… the energy efficiency gap takes the form of under investment in energy efficiency relative to a description of the socially optimal level of energy efficiency. Such under investment is also sometimes described as an observed rate or probability of adoption of energy-efficient technologies that is "too slow."[44]

The RFF framework is summarized in Exhibit II-3. Exhibit A-II-3 provides citations. Exhibit II-3 is taken from the RFF paper, but extended in two ways. In the market failure category, it shows the distinction between the structural and societal levels suggested by the paper. It also includes a few more specific failures that were discussed in the text, but not included in the original table. There are about a dozen specific market failures spread across these categories.

Exhibit II-3: Market and Behavioral Factors Relevant to Energy Efficiency

Societal Failures	***Structural Failures***	***Potential Behavioral Failures***[11]
Energy Market Failures	Capital Market Failures	Prospect theory[12]
Environmental Externalities[1]	Liquidity constraints[5]	Bounded rationality[13]
Energy Security	Information problems[6]	Heuristic decision making[14]
Innovation market failures	Lack of information[7]	Information[15]
Research and development spillovers[2]	Asymmetric info. >	
Learning-by-doing spillovers[3]	Adverse selection[8]	
Learning-by-using[4]	Principal-agent problems[9]	
	Average-cost electricity pricing[10]	

Source: Kenneth Gillingham, Richard G. Newell, and Karen Palmer, *Energy Efficiency Economics and Policy* (Resources for the Future, April 2009). For Citations, see Appendix A, Exhibit A-II-3

The RFF paper suggests three broad categories of market failures – the individual, the interaction between economic agents and the fit between economic agents and society. We refer to these three levels as the behavioral, the market structural and the societal levels. In the present context, we consider behavioral failures to represent consumer behavior that is inconsistent with utility maximization, or in the current context, energy service cost-minimization. In contrast, market

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[42] Golove and Eto, p. 23.
[43] Golove and Eto, p. 20.
[44] Gillingham, Newell and Palmer, p. 7.

failure analysis is distinct in presupposing individual rationality and focusing on the conditions surrounding interactions among economic agents and society.[45] The societal level market failures are closest to what the traditional sources of the economic literature refers to as market failure. These are primarily externalities and public goods. These were also considered market failures in the LBL framework. The LBL barriers and transaction costs fit in the category of interactions between economic agents, as would imperfect competition.

One obvious point is that, once again, information problems occur in all categories of the RFF analysis, with several manifestations in each. Information can be a problem at the societal level since it can be considered a public good that is not produced because the authors of the information cannot capture the social value of information. It is a structural problem because, where it is lacking, even capable, well-motivated individuals cannot make efficient choices. Finally, where it is asymmetric, individuals can take advantage of the less informed to produce outcomes that are not efficient. It is a problem at the behavioral level where individuals lack the ability to gather and process information.

D. OTHER RECENT COMPREHENSIVE EFFICIENCY GAP FRAMEWORKS

In the past few years, several comprehensive reviews have been offered that attempt to depict the many diverse factors that underlie the efficiency gap.

The United Nations Industrial Development Organization

Exhibit II-4 summarizes a recent comprehensive review of the causes of the efficiency gap in industrial sectors across the globe. Exhibit A-II-4 provides citations. It is based on a conceptualization and analysis prepared for the United Nations Industrial Organization by analysts at universities in the United Kingdom (hereafter UNIDO). It is based on a review of over 160 studies of barriers to energy efficiency in industrial enterprises.

It can be argued that the analysis of industrial sectors provides the most compelling evidence that an energy efficiency gap exists, since these are contexts in which the incentive to adopt economically rational technologies should be strong, if not pure, and the knowledge and ability to evaluate alternatives should be greater than society at large. Moreover, since energy is a cost of doing business, records and data should be superior to the residential sector, so evaluation and calculation should be better. In spite of these factors pointing toward economic rationality, and notwithstanding assumptions of motivation and capability, these authors find solid empirical evidence that the efficiency gap exists.

As was the case in the LBL analysis, the UNIDO analysis identified a school of economic thought that can be closely associated with each of the categories of market barriers and imperfections. The broad categories in the UNIDO analysis match up well with the perspectives offered by LBL and RFF with the addition of the category of externalities. The UNIDO document offers six broad types of barriers, with two dozen subtypes.

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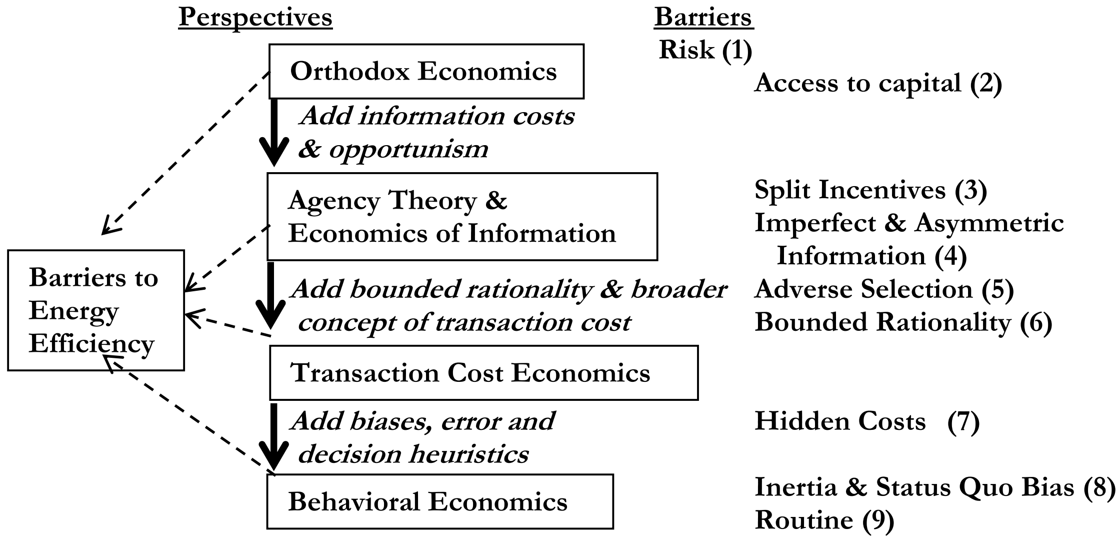
[45] Id., p. 8

EXHIBIT II-4: BARRIERS TO INDUSTRIAL ENERGY EFFICIENCY



Steve Sorrell, Alexandra Mallett & Sheridan Nye. *Barriers to industrial energy efficiency, A literature review,* United Nations Industrial Development Organization, Vienna, 2011, Figure 3.1 & Section 3. For citations, see Appendix A, Exhibit A-II-4.

McKinsey and Company

A fourth comprehensive approach that adds depth to the analysis is the framework offered in a detailed analysis of efficiency in the building sector prepared by McKinsey and Ccompany, which is described in Exhibit II-5. Exhibit A-II-5 provides citations. The McKinsey conceptualization of barriers and obstacles to energy efficiency uses three broad categories – structural, behavioral and availability. There are about two dozen specific barriers described. Moreover, McKinsey identifies nine different clusters of activity in the building sector. The manifestation of the barriers is different in the clusters, so McKinsey ends up with fifty discrete barriers.

Exhibit II-6 presents the framework utilized by the California Energy Institute in evaluating policies to increase energy efficiency in businesses. It is notable in two respects. First, it is oriented toward businesses, which is a useful antidote to the overemphasis on residential consumers in the efficiency gap debate. Second, it explicitly endeavors to summarize and compile the various approaches to analyzing the "efficiency gap," used by others. In doing so, it returns to the traditional distinction that is made between market failures, which are recognized in neoclassical approaches, and other obstacles to investment in energy efficiency in the market. It identifies two other broad categories – market barriers and non-economic factors.

EXHIBIT II-5: MCKINSEY AND COMPANY MARKET BARRIERS TO HOME ENERGY EFFICIENCY

Kckinsey Category	McKinsey Nature	McKinsey Description	Cluster
Behavioral	Awareness	Low priority, Preference for other attributes	CD, RLA
Availability	Availability	Restricted procurement, 1st cost focus	CD
Behavioral	Awareness	Shop for price and features	RD
Behavioral	Awareness	Limited understanding of use and savings	CEPB, EH, GB, RLA
Behavioral	Custom & Habit	Little attention at time of sale	NH
Behavioral	Custom & Habit	Underestimation of plug load	RD
Behavioral	Custom & Habit	Aversion to change	CI,
Behavioral	Custom & Habit	CFLS perceived as inferior	RLA
Behavioral	Hurdle	Payback-Hurdle, 28% discount rate	CEPB
Behavioral	Hurdle	Payback-Hurdle,40% discount rate	EH
Behavioral	Use	Improper use and maintenance	CEPB, EH, RD
Behavioral	Awareness	Not accountable for efficiency	CI
Availability	Capital	Competing use of capital	EH, GB, RLA, CI
Structural	Agency	Tenant pays, builder ignores	CEPB, EH, RD
Availability	Availability	Lack of contractors	EH
Availability	Availability	Lack of availability in area	NH
Availability	Availability	Lack of demand => lack of R&D	RD
Availability	Availability	Emergency replacement	RLA
Availability	Bundling	Efficiency bundled with other features	RLA
Structural	Owner Transfer	Lack of premium at time of sale	CD, NH, NPB, RLA
Structural	Owner Transfer	Limits payback to occupancy period	EH
Structural	Transaction	Lack of information	NPB
Structural	Transaction	Disruption during improvement process	EH
Structural	Transaction	Difficult to identify efficient devices	RD
Behavioral	Risk/Uncertainty	Business failure risk	CEPB
Behavioral	Risk/Uncertainty	Lack of reliability	CI
Structural	Transaction	Research, procurement and preparation	EH, GB, RLA

Clusters
CD = Commercial Devices;
CEPB = Commercial Existing Private Buildings;
CI = Commercial Infrastructure;
EH = Existing Homes;
GB = Government Buildings;
NH = New Homes;
NPB = New Private Commercial Buildings;
RD = Residential Devices;
RLA = Residential Lighting and Appliances

SOURCE: McKinsey and Company, *Unlocking Energy Efficiency in the U.S. Economy,* July 2009, Tables 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, Exhibits 14, 15, 16, 19, 21, 24, 26, 27, 29, 30. For citations, see Appendix A, Exhibit A-II-5

EXHIBIT II-6: MARKET FAILURES, BARRIERS AND NON-ECONOMIC FACTORS

<u>Neo Classical Economics</u>

Explanations for the gap:

1. The gap is illusory
2. There are hidden or unaccounted for costs of energy efficiency investments
3. Consumer markets are heterogeneous
4. High discount rates assigned to energy efficiency investments resulting from perceived risk

Conditions that are known to cause market failure:

1. externalities
2. public goods
3. imperfect information
4. imperfect competition

<u>Market Barriers</u>

1. Situations involving Misplaced or Split Incentives (also called agency problems)
2. Limited Availability of Capital,
3. Market Power
4. Regulatory Distortions
5. Transaction Costs
6. Inseparability of energy efficiency features from other desirable or undesirable product features

<u>Non-Economic Explanations</u>

1. Rationality is only one of several decision-making heuristics that may be applied in a given decision-making situation.
2. Decision makers employ varying decision-making heuristics depending on the situation.
3. Decision-making units are often not individuals.
4. Decisions made by organizations are affected by a wide variety of social processes and heavily influenced by the behaviors of their leaders.

Organizational Influences:

Authority

Size

Hierarchy of needs (1. Health and Safety Requirements,2. Regulatory Compliance, 3. Corporate Improvement Initiatives, 4. Maintenance) 5. Productivity, 6. Importance of Energy Efficiency to Profitability

Management policy 1. Whether the organization has annual energy efficiency goals. 2. Whether reserves and budgets are established for funding energy efficiency investments. 3. Whether hurdle rates for energy efficiency investments are high or low. 4. The review process that is to be used to evaluate energy efficiency improvements. 5. Who is responsible for "managing" the company's energy efficiency program).

Sources: Edward Vine, 2009, *Behavior Assumptions Underlying Energy Efficiency Programs For Businesses,* California Institute for Energy and Environment, January.

E. EMPIRICAL EVIDENCE OF MARKET BARRIERS AND IMPERFECTIONS

Appendix B provides brief descriptions of recent empirical studies that lend support to various aspects of the efficiency gap analysis. It provides descriptions of almost four dozen empirical studies (or reviews of empirical studies) from which these specific examples are drawn. We divide the literature into three broad areas: General (which address the market failures, barriers and imperfections), surveys (which are frequently used to determine willingness to pay and identify attitudinal obstacles to investment in energy efficiency), and cost benefit analyses (which test the central question: 'are standards worth it?')

Exhibit II-7 lists the full array of market failures, barriers and imperfections that cause the underinvestment in energy saving technologies derived from the conceptual discussion above. It identifies the individual problems that the recent empirical literature observed in the energy market. Citations are provided in Appendix A, Exhibit A-II-7.

Embedded in the literature reviews for each of the recent studies are citations to earlier empirical studies that provide the context for the more recent research. All of the failures, barriers and imperfections have been supported in the empirical literature, which is why they have been recognized in the conceptual frameworks. We will not review all the many studies that support each problem. Here we summarize several important, repeated broad themes.

EXHIBIT II-7: RECENT EMPIRICAL EVIDENCE ON MARKET FAILURES, BARRIERS AND IMPERFECTIONS

TRADITIONAL ECONOMICS & INDUSTRIAL ORGANIZATION

Externalities
- Public goods[1] & Bads[2]
- Basic research
- Network effects
- Information as a public good
- Learning-by-doing & Using[9]

Industry Structure
- Imperfect Competition
  - Concentration[13]
  - Barriers to entry
  - Scale[18]
  - Switching costs[20]
- Technology[23]
  - R&D
  - Investment[25]
- Marketing
  - Bundling: Multi-attribute[26]
  - Substitutes[27]
- Cost-Price
  - Limit impact of price[29]
    - Fragmented Mkt.[30]
    - Limited payback[31]

Regulation
- Price[34]
  - Infrequent
  - Aggregate, Avg.-cost[35]
- Lack of commitment[36]

NEW INSTITUTIONAL ECONOMICS

Endemic Imperfections
- Asymmetric Info[3].
- Agency[5]
- Adverse selection[6]
- Perverse incentives
- Lack of capital[10]

TRANSACTION COST
- Search and Information
- Imperfect info[14]
  - Availability[16]
  - Accuracy
  - Search cost[21]
- Bargaining
  - Risk & Uncertainty[24]
  - Liability
- Enforcement
- Sunk costs
- Hidden cost[28]

Political Power
- Power of incumbents to hinder alternatives
- Monopolistic structures and lack of competition
- Importance of institutional support for Alternatives[32]
- Inertia[33]

BEHAVIORAL ECONOMICS

Motivation & Values
- Non-economic[4]

Influence & Commitment
- Custom[7]
- Social group & status[8]

Perception
- Bounded Vision/Attention[11]
- Prospect[12]

Calculation.
- Bounded rationality[15]
- Limited ability to process info[17]
- Heuristic decision making[19]
- Discounting difficulty[22]

See Appendix A Exhibit A-II-7 for citations.

Positive Externalities

There is a very large literature on the externalities associated with energy consumption. Importantly, it 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.

There are two macroeconomic effects that have begun to receive a great deal of attention – multipliers and price effects. These will be discussed in greater length in the next section, as they belong in the cost benefit analysis as a substantial benefit. They can be briefly described as follows. Reducing energy consumption tends to reduce economic activities that have relatively small multipliers (especially when energy imports are involved as in the transportation sector) and increase economic activities that have large multipliers (including the direct effects of spending on technology and the indirect effect of increased household disposable income).

A second set of externalities that receives considerable attention is the effect of learning that can be stimulated by a performance standard that pushes firms to make investments they would not have made without the presence of the standard. This will be discussed in the next section, since it affects the cost side of the cost-benefit calculation.

Information and Behavior

Consumers and producers are poorly informed, influenced by social pressures and constrained in their ability to make the calculations necessary to arrive at objectively efficient decisions. Consumers and producers apply heuristics that reflect rationality that is bounded by factors like risk and loss aversion. Inattention to energy efficiency is rational, given the magnitude, variability and uncertainty of costs, as well as the multi-attribute nature of energy consuming durables. Consumers are influenced by social norms and advertising.

The product is a bundle of attributes in which other traits are important and energy costs are hidden costs. The resulting energy expenditures are important components of total household spending. Important benefits of energy consuming durables may be "shrouded" in the broader multi-attribute product.

Market Structure and Transaction Costs

Uncertainties about the nature of the market and the value and cost of technology and limitations of technological expertise and information play an important role, increasing the cost and raising the risk of adopting new technologies.

As a result of these factors, the marketplace yields a limited set of choices because producers and consumers operate under a number of constraints. Split incentives flowing from the agency problem are a frequently analyzed issue. When the purchaser of the energy consuming durables and the users are different people, inefficient choices result.

The market exhibits a high "implicit" discount rate, which we interpret as the result of the many barriers and imperfections that retard investment in efficiency enhancing technology. There are several aspects of the high discount rate that deserve separate attention. There is a low willingness to pay and a low elasticity of demand.

F. PERFORMANCE STANDARDS AS A POLICY RESPONSE TO THE EFFICIENCY GAP

A number of the comprehensive studies we have reviewed above also include evaluations of potential policy options for addressing the market barriers and imperfections. These are described in Exhibits II-8 through II-10. One of the clearest conclusions that can be derived from these assessments is that performance standards – appliance efficiency standards, auto fuel economy standards and building codes – are seen as a very attractive policy options because they are effective and address many important barriers.

For example, the European study summarized in Exhibit II-9 identifies over half a dozen ways in which performance standards address more than half a dozen barriers.

- The barriers addressed include transaction costs, economic uncertainties, lack of technical skill, Barriers to technology deployment, inappropriate evaluation of cost efficiency, insufficient and incorrect information on energy features, operational risks, and bounded rationality constraints.
- Mechanisms that reduce barriers include information and capacity building by stimulating the demand side, creation and promotion of a stable market, establishment of a methodology for calculating the energy performance of a building, standards on calculation of energy need for heating and cooling, standards on energy performance rating, ensure that there are sufficient incentives, demand side stimulation, creation of a functioning efficiency supply market, ensure that qualification, accreditation and certification schemes are available, reliable monitoring and diagnostics procedures.

Simply put, performance standards address more barriers and are more effective in overcoming them and more likely to achieve their goals. Similarly, in the McKinsey analysis discussed above, the combination of building codes and appliance standards addresses every one of the barriers.

We have long argued that performance standards are attractive for exactly this reason. Our earlier analysis identified a long list of market barriers and imperfections that are addressed by performance standards, as shown in Exhibit II-11. The ability of standards to address the market failure problems goes beyond their ability to address the barriers to investment in efficiency enhancing technologies that focus on consumer behavioral and transaction cost economics. Standards can address the behavioral and transaction cost problems that afflict the supply-side of the market, as well as some of the structural problems. [46] This evaluation of the important role of performance standards is supported by the recent evaluations.

[46] Cooper, 2009b, p . 64

EXHIBIT II-8: POLICY INSTRUMENT FOR REDUCING GREENHOUSE GAS EMISSIONS FROM BUILDINGS

Policy	Energy/CO2 Effectiveness	Cost Effectiveness	# of Barriers Addressed	Economic	Hidden Cost	Market Failure	Culture	Political
Appliance standards	High	High	3	1	1	1		
Energy efficiency obligations	High	High	2	1		1		
DSM	High	High	2	1		1		
Tax exemptions/ reductions	High	High	2	1		1		
EPC/ESCO	High	Medium/High	3	1	1	1		
Building codes	High	Medium	3	1	1	1		
Coop. Procurement	High	Medium	2	1		1		
Public leadership programs	Medium/High	High/Medium	4		1	1	1	1
Labeling and certification programs	Medium/High	High/Medium	3	1		1	1	
Procurement.	Medium/High	High/Medium	3	1	1	1		
Energy certificates	Medium/High	High/Medium	2	1		1		
Energy certificates	Medium/High	High/Medium	1	1				
Voluntary and negotiated agreements	Medium/High	Medium	2			1	1	
Mandatory audit requirement	High & variable	Medium	1				1	
Public benefit charges	Medium	High	2	1		1		
Capital subsidies,	High	Low	2	1		1		
Detailed disclosure programs	Medium	Medium	2			1	1	
Education and information programs	Low/Medium	Medium/high	2			1	1	
Taxation (on CO2 or fuels)	Low/Medium	Low	1	1				
Kyoto Protocol flexible	Low	Low	1			1		

Source: Sonja Koeppel, Diana Urge-Vorsatz and Veronika Czako, 2007,*Evaluating Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings – Developed and Developing Countries,* Assessment of Policy Instruments for Reducing Greenhouse Gas Emission from Buildings, Center for Climate Change and Sustainable Energy, Central European University, Tables 1 and 3.

EXHIBIT II-9: ASSESSMENT OF POLICY INSTRUMENTS IN PLACE IN THE EUROPEAN UNION

POLICY EVALUATION CRITERIA	Importance of main barrier the policy instrument addresses	Impact/ expected impact of policy instrument	Increased impact by further broadening or strengthening	Policy for specific barrier/ tackles several barriers	Clear/ appropriate to target/ barrier	Compatible with other instruments	Compatible with MS/ appropriate as EU instrument
POLICY APPROACH							
Directive on energy end-use efficiency and energy services	5	5	3	4	3	3	4
Energy performance of buildings directive	4	5	4	2	4	3	5
EPBD-related CEN mandate to develop a set of standards	3	4	4	2	4	3	4
Eco-design directive	3	3	4	2	3	4	4
Eco-label regulation	3	2	3	3	5	3	3
Energy labeling directive	2	3	4	3	4	4	4
Environmental technology verification	2	3	na	2	3	2	3
'Intelligent energy Europe" programme	2	2	na	3	3	1	4
Structural, Cohesion Funds & European Investment Bank	3	2	2	2	3	1	3
Energy taxation	1	1	2	1	3	1	1

Source: Andreas Uihlein and Peter Eder, 2009, *Toward Additional Policies to Improve the Environmental Performance of Buildings,* European Commission, Joint Research Centre, Institute for Prospective Technological Studies, Table 9.

EXHIBIT II-10: EVALUATION OF 20 POLICIES

Policy Type	Policy Instrument	Target	Achieved
Regulation	Building performance standards	2	4
Building regulations		2	1
Efficiency commitment		2	2
Mandatory target on consumption		2	2
Top runner	2	2	
Labelling of appliances		2	2
Obligation on management		1	1
Financial	Soft loans	2	3
Investment deductions		1	1
Information	Local advice	1	1
Energy audits public		2	4
Energy audits private		2	2
Network	1	1	
Industry concepts	1	1	
Individual advice service		1	1
Eco-driving	2	3	
FEMP	2	2	
Voluntary	Efficiency agreements	2	2
ACEA	2	2	
Procurement	Energy	1	1
BELOK	1	4	
		2=Quantitative	4=Achieved or overachieved

Source: Mirjam Harmeling, Lara Nilsson, and Robert Harmsen, 2008, "Theory-based Policy Evaluation of 20 Energy Efficiency Instruments, *Energy Efficiency,* 1, p.48.

EXHIBIT II-11: CAUSES OF MARKET FAILURE ADDRESSED BY STANDARDS

TRADITIONAL ECONOMICS & INDUSTRIAL ORGANIZATION

SOCIETAL FAILURES
- Externalities
- Information

STRUCTURAL PROBLEMS
- Scale
- Bundling
- Cost Structure
- Product Cycle
- Availability

NEW INSTITUTIONAL ECONOMICS

ENDEMIC FLAWS
- Agency
- Asymmetric Information
- Moral Hazard

TRANSACTION COSTS
- Sunk Costs
- Risk
- Uncertainty
- Imperfect Information

BEHAVIORAL ECONOMICS

BEHAVIORAL FACTORS
- Motivation
- Calculation/ Discounting

Source: Mark Cooper, 2009, Comments of the Consumer Federation of America, Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Department of Transportation, Environmental Protection Agency, 40 CFR Parts 86 and 600, 49 CFR Parts 531,633, 537, et al., November 28, p. 64.

III. COST/ BENEFIT ANALYSIS

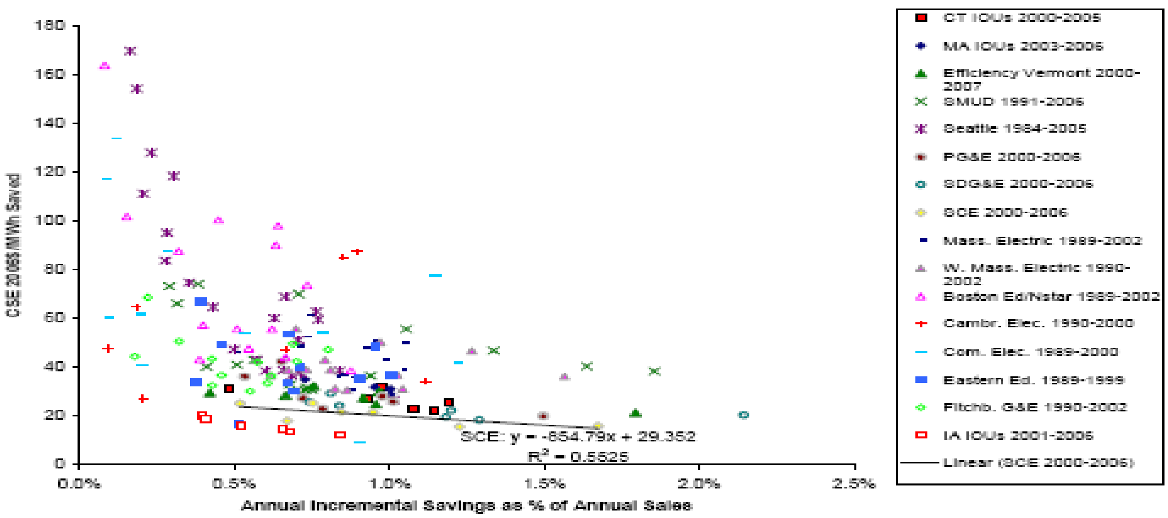
A. THE COST AND QUANTITY OF SAVED ENERGY

Cost

Engineering economic analyses provided the initial evidence for the efficiency gap. *Ex ante* analyses indicated that there would be substantial net benefits from including technologies to reduce energy consumption in consumer durables. As these policies were implemented *ex post* analyses were conducted to ascertain whether the *ex ante* expectations were borne out.

The most intense and detailed studies were conducted by utilities subject to regulation. Exhibit III-1 shows the results of analyses of the cost of efficiency in sixteen states over various periods covering the last twenty years. The data points are the annual average results obtained in various years at various levels of energy savings. The graph demonstrates two points that are important for the current analysis.

EXHIBIT III-1: UTILITY COST OF SAVED ENERGY (2006$/MWH) VS. INCREMENTAL ANNUAL SAVINGS AS A % OF SALES



Source: Kenji Takahasi and David Nichols, "Sustainability and Costs of Increasing Efficiency Impact: Evidence from Experience to Date," ***ACEEE Summer Study on Energy Efficient Buildings*** **(Washington, D.C., 2008), p. 8-363.**

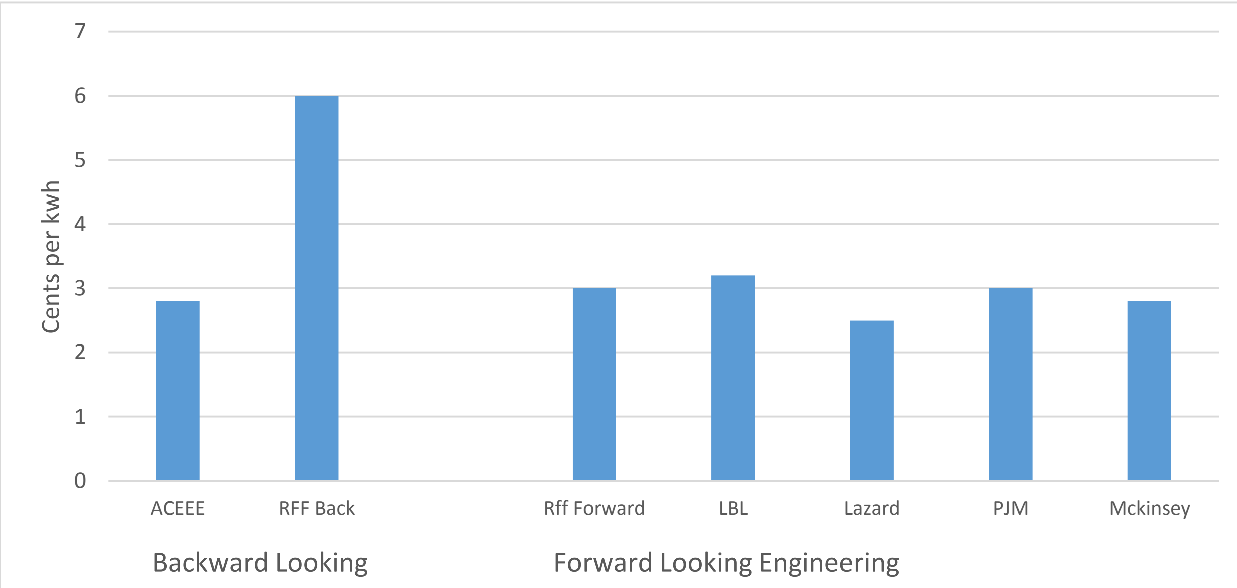
While the aggregate data in Exhibit III-1 appear to suggest a very strong downward trend, the data for individual utilities suggest a moderate downward trend. Exhibit III-1 shows the trend line for one individual utility. The trend is very slightly negative. The authors suggest that declining costs for higher levels of efficiency can be explained by economies of scale, learning and synergies in technologies. As utilities do more of the cost effective measures, costs decline. Also, if technical potential is much higher than achievable savings, economies of scale and scope and learning could pull more measures in and lower costs. This explanation introduces an important area of analysis in the "energy gap" debate – learning curves.

- First, the vast majority of costs fall in the range of $20/MWh to $50/MWh (i.e. 2 to 5 Cents/kwh).

- Second, the higher the level of energy savings, the lower the level of costs. There is certainly no suggestion that costs will rise at high levels of efficiency.

As shown in Exhibit III-2, several other efforts to look back at achieved costs reach similar conclusions, including estimates from Resources for the Future and the U.S. Department of Energy. The forward looking estimates from research institutions like Lawrence Berkeley labs and McKinsey and Company are similar. In fact, utilities and Wall Street analysts use similar estimates.

EXHIBIT III-2: THE COST OF SAVED ELECTRICITY



Source: Kenji Takahasi and David Nichols, "Sustainability and Costs of Increasing Efficiency Impact: Evidence from Experience to Date," *ACEEE Summer Study on Energy Efficient Buildings* (Washington, D.C., 2008), p. 8-363, McKinsey Global Energy and Material, *Unlocking Energy Efficiency in the U.S. Economy* (McKinsey & Company, 2009); National Research Council of the National Academies, *America's Energy Future: Technology and Transformation, Summary Edition* (Washington, D.C.: 2009). The NRC relies on a study by Lawrence Berkeley Laboratory for its assessment (Richard Brown, Sam Borgeson, Jon Koomey and Peter Biermayer, *U.S. Building-Sector Energy Efficiency Potential* (Lawrence Berkeley National Laboratory, September 2008).

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.[47] There are processes in which producers learn by experience to lower the cost of new technologies dramatically. The strong focus on the supply-side and innovation underlies the observation above that aggressive policies to stimulate innovation and direct technological change can speed the transition and lower the ultimate costs.

[47] The issue was made explicit in the appliance efficiency standards proceeding.

In the efficiency gap area, the issue of declining costs driven by technological change has received significant examination as a natural extension of the effort to project technology costs. One of the strongest findings of the empirical literature is to support the theoretical expectation that technological innovation will drive down the cost of improving energy efficiency and reducing greenhouse gas emissions. A comprehensive review of *Technology Learning in the Energy Sector* found that energy efficiency technologies are particularly sensitive to learning effects and policy.

> 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.[48]

The findings on learning curve analysis are extremely important because decisions to implement policies that promote efficiency and induce technological change are subject to intensive, *ex ante* cost-benefit analysis. Analyses that fail to take into account the powerful process of technological innovation that lowers costs will overestimate costs, undervalue innovation, and perpetuate the market failure. Detailed analysis of major consumer durables including vehicles, air conditioners, and refrigerators find that technological change and pricing strategies of producers lowers the cost of increasing efficiency in response to standards.

> 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.[49]

> The more specific point here is that, while regulatory compliance costs have been substantial and influential, they have not played a significant role in the pricing of vehicles. Vehicle prices have steadily increased over time, far exceeding the costs of emission control and safety equipment… These cost increases, to the extent they are substantial, are dealt with in the short run by a variety of pricing and marketing strategies and by allocating R&D costs further into the future and over more future models. As with any new products or technologies, with time and experience, engineers learn to design the products to use less space, operate more efficiently, use less material, and facilitate manufacturing. They also learn to build factories in ways that reduce manufacturing cost. This has been the experience with semiconductors, computers, cellphones, DVD players, microwave ovens – and also catalytic converters.
> Experience curves, sometimes referred to as "learning curves," are a useful analytical construct for understanding the magnitude of these improvements. Analysts have long observed that products show a consistent pattern of cost reduction with increases in cumulative production volume. …
> In the case of emissions, learning improvements have been so substantial, as indicated earlier, that emission control costs per vehicle (for gasoline internal combustion engine vehicles) are no greater, and possibly less, than they were in the early 1980s, when emission reductions were far less.[50]

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[48] Junginger, et al., 2008, p. 12; Kiso, 2009, find for Japanese automobiles that "fuel economy improvement accelerated after regulations were introduced, implying induced innovation in fuel economy technology."
[49] Dale, et. al., 2009, p. 1.
[50] Sperling, et al., 2004, p.p. 10-15.

A comparative study of European, Japanese and American auto makers 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).

> 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.[51]

Exhibit III-4, 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 percent. The estimates of the cost from industry were even father off the mark, running three times higher for auto technologies.[52] 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."[53]

While the very high estimates of compliance costs offered by the auto manufacturers 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. A simulation of the cost of the 2008 increase in fuel economy standards found that a technologically static response was 3 times more costly than a technologically astute response.

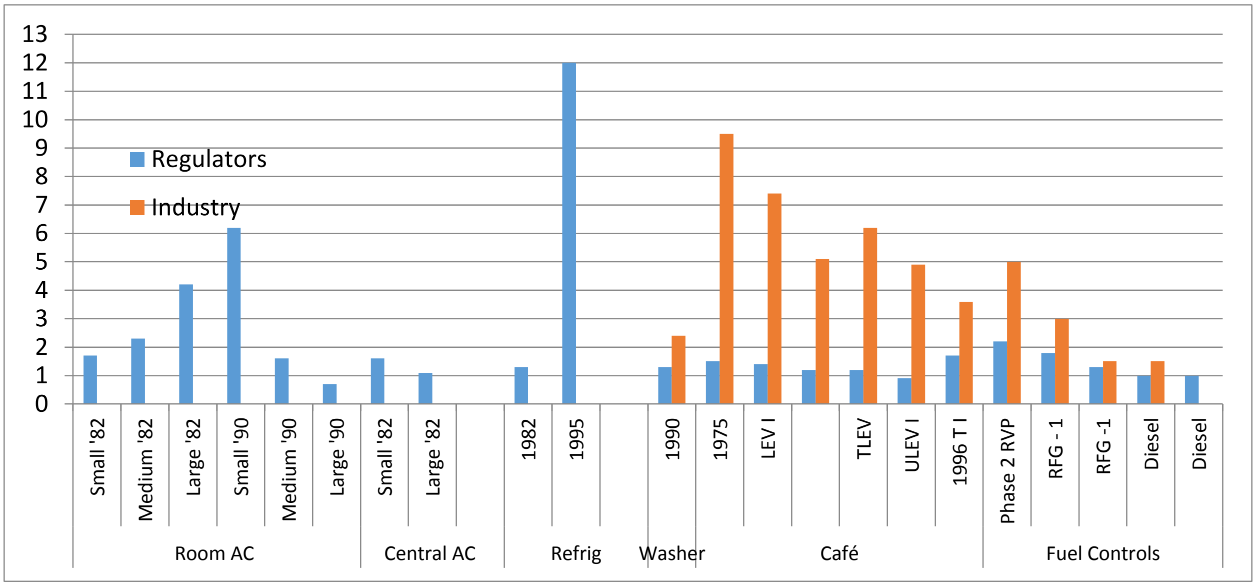
> We perform counterfactual simulation of firms' pricing and medium-run design responses to the reformed CAFE regulation. Results indicate that compliant firms rely primarily on changes to vehicle design to meet the CAFE standards, with a smaller contribution coming from pricing strategies designed to shift demand toward more fuel-efficient vehicles... Importantly, estimated costs to producers of complying with the regulation are three times larger when we fail to account for tradeoffs between fuel economy and other vehicle attributes.[54]

A recent analysis of major appliance standards adopted after the turn of the century shows a similar and even stronger pattern (see Exhibit III-5). Estimated cost increases are far too high. There may be a number of factors that produce this result, beyond an upward bias in the original

[51] Kuik, 2006,
[52] Hwang, and Peak, 2006.
[53] Harrington, 2006, p. 3.
[54] Whitefoot, et al., 2012, pp. 1…5.

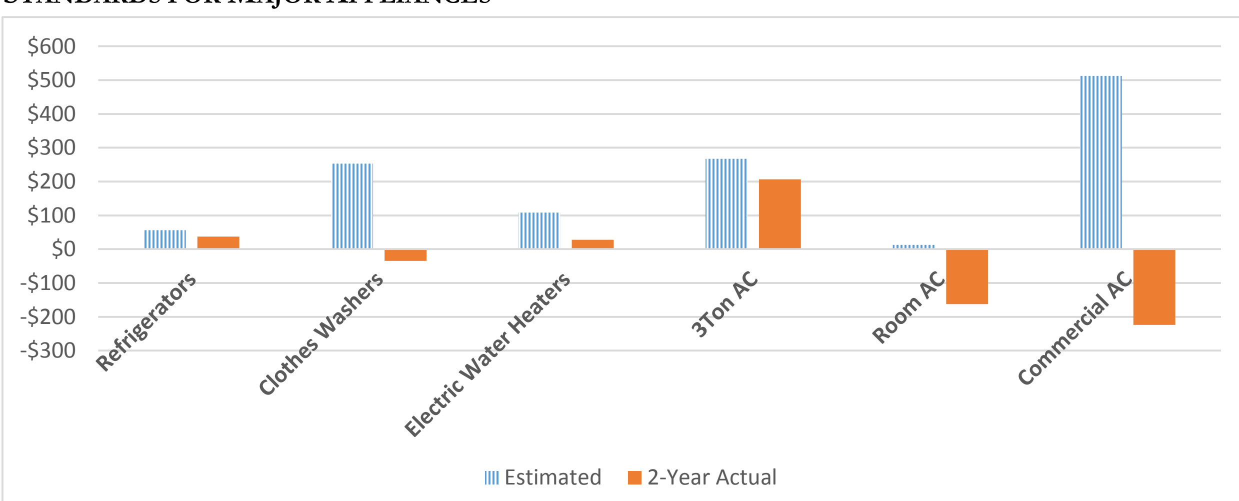
estimate and learning in the implementation, including pricing and marketing strategies. Sperling et al, 2004, emphasized the adaptation of producers in the analysis of auto fuel economy standards.

EXHIBIT III-4: 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.

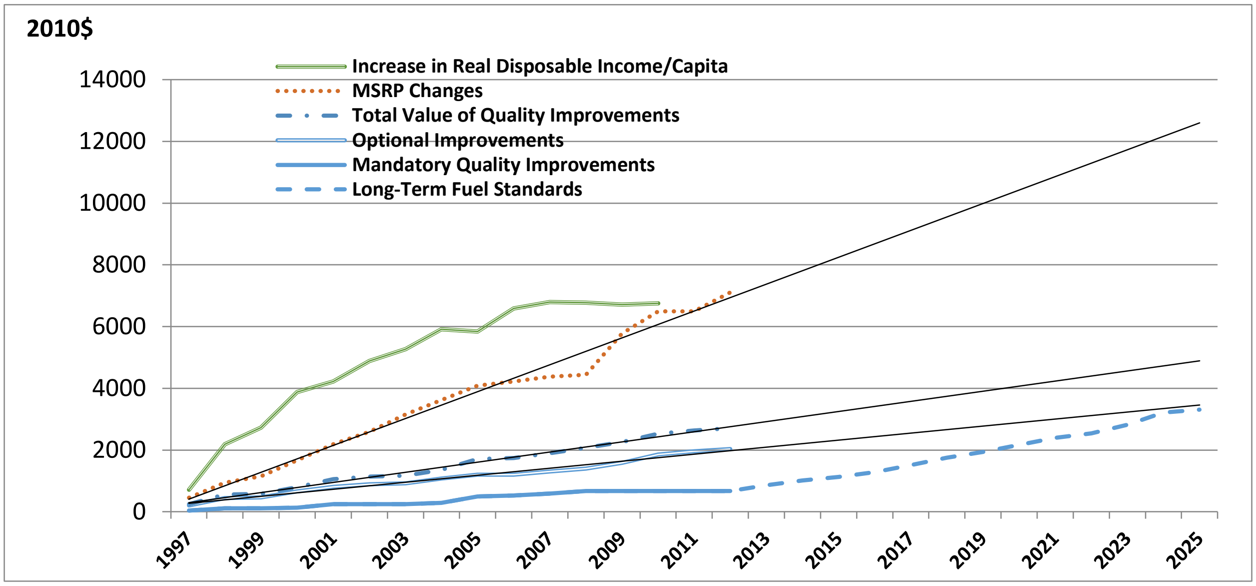
EXHIBIT III-5: ESTIMATED AND ACTUAL COST INCREASES ASSOCIATED WITH RECENT STANDARDS FOR MAJOR APPLIANCES



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

As shown in Exhibit III-6, in comments on the light duty truck and auto standards, CFA presented a historical analysis of cost increases associated with mandates that reflects the ability and strategy of producers to keep cost increases within the broad limits of industry practices.

EXHIBIT III-6: GRADUAL IMPROVEMENT IN FUEL ECONOMY CAUSES A SLOW AND STEADY PRICE INCREASE WHILE THE INDUSTRY HAS HANDLED QUALITY IMPROVEMENT WITH MUCH GREATER COSTS



Source: Bureau of Labor Statistics, Quality Changes for Motor Vehicles, various years; Consumer Price Index data base; Sources: Office of Regulatory Analysis and Evaluation, *Regulatory Impact Analysis, Corporate Average Fuel Economy,* 2011, 2012-2016, 2017-2025.

Many of the factors that are cited as causes of the declining cost, such as learning, standardization and homogenization of components, competitive outsourcing of components, and technological improvements in broader socio-economic environment),[55] represent market factors or externalities that are difficult for individual firms to control or profit from (appropriate), so they constitute externalities that policy must address, if the externalities are to be internalized in transactions. At the same time, performance standards simply shift the baseline of competition to a higher level of energy efficiency. To the extent that markets are competitive, normal competitive processes drive down the costs of innovation such as competition driven technological change, declining markups, and economies of scale.[56]

Even more fundamentally, there is evidence that the decision to increase energy efficiency can stimulate broader innovation and productivity growth.

> The case-study review suggests that energy efficiency investments can provide a significant boost to overall productivity within industry. If this relationship holds, the description of energy-efficient technologies as opportunities for larger productivity improvements has significant implications for conventional economic assessments.. … This examination shows that including productivity benefits explicitly in the modeling parameters would double the cost-effective potential for energy

[55] Weiss, et al., 2010, pp.774-775.

[56] Dale et al, 2009; Taylor, 2009; Freidrich, et al. 2009; Sperling, et al., 2004; Takahashi and Nichols, 2004.

efficiency improvement, compared to an analysis excluding those benefits.[57]

These positive findings on performance standards must not obscure two important strategic considerations that will have a major impact on the ultimate effectiveness of the standards. Our analysis of the dramatic increase in and broad support for the doubling of the fuel economy standard from new light duty vehicles identified a series of characteristics that are important to ensure a successful standards program. Our conclusions about standards setting are supported by the evaluations described above. They caution that performance standards have positive effects if they are maintained, enforced and upgraded. More broadly speaking, performance standards must be well designed. The redesign of the fuel economy standards for light duty vehicles appears to have included a series of characteristics that will improve performance (see Exhibit III-12). We have noted that the standards are technology neutral, procompetitive, long-term, attribute sensitive, and moderately aggressive.[58]

[57] Worrell, et al., 2003, p. 1081.
[58] CFA,2012, pp. 41-44.

EXHIBIT III-12: KEY DESIGN FEATURES OF EFFECTIVE PERFORMANCE STANDARDS (Modelled in Current Fuel Economy Standards for Light Duty Vehicles)

Long-Term: Setting a high standard for the next fifteen years is intended to foster and support a long-term perspective for automakers and the public, by reducing the marketplace risk of investing in new technologies. The long-term view gives the automakers time to re-orient their thinking, retool their plants and help re-educate the consumer. The industry spends massive amounts on advertising and expends prodigious efforts to influence consumers when they walk into the show room. By adopting a high standard, auto makers will have to expend those efforts toward explaining why higher fuel economy is in the consumer interests. Consumers need time to become comfortable with the new technologies.

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. There will soon be hundreds of models of electric and hybrid vehicles using four different approaches to electric powertrains (hybrid, plug-in, hybrid plug-in, and extended range EVs), offered across the full range of vehicles driven by American consumers (compact, mid-size family sedans, large cars, SUVs, pickups), by half a dozen mass market oriented automakers. At the same time, the fuel economy of the petroleum powered engines can be dramatically improved at consumer friendly costs as gasoline will continue to be the primary power source in the light duty fleet for decades.

Product Neutral: The new approach to standards accommodates consumer preferences; it does not try to negate them. The new approach to standards is based on the footprint (size) of the vehicles and recognizes that SUVs cannot get the same mileage as compacts. Standards for larger vehicles will be more lenient, but every vehicle class will be required to improve at a fast pace. This levels the playing field between auto makers and removes any pressure to push consumers into smaller vehicles.

Responsive to industry needs: The rule recognizes the need to keep the standards in touch with reality in several important ways. The standards are set at a moderately aggressive level that is clearly beneficial and achievable. The cost estimates are consistent with the results of independent analyses of technology costs made over the past decade. The standards are consistent with the rate of improvement that the auto industry achieved in the first decade of the fuel economy standard setting program. In practical terms, the standard also moves the U.S. into a position that is comparable to the other major car producing/buying nations in the world.

Responsive to consumer needs: The new approach to setting standards is consumer-friendly and facilitates automaker compliance. The attribute-based approach ensures that the standards do not require radical changes in the types or size of vehicles consumers drive; so, the full range of choices will be available to consumers. The standards do not require dramatic shifts in power train technologies or reductions in weight and offer flexibility and incentives for new technologies, and include a mid-term review. The setting of a coordinated national standard that lays out a steady rate of increase over a long time period gives consumers and the industry certainty and time to adapt to change.

Procompetitive: All of the above characteristics make the standards pro-competitive. Automakers 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.

APPENDIX A
ANNOTATED VERSIONS OF SECTION II EXHIBITS

EXHIBIT A-II-2: MARKET BARRIERS TO ENERGY EFFICIENCY

Barriers[1]	Market Failures	Transaction Cost[2]	Behavioral factors[16]
Misplaced incentives	Externalities	Sunk costs[3]	Custom[17]
Agency[4]	Mis-pricing[20]	Lifetime[5]	Values[18] & Commitment[19]
Capital Illiquidity[8]	Public Goods[22]	Risk[6] & Uncertainty[7]	Social group & status[21]
Bundling	Basic research[23]	Asymmetric Info.[9]	Psychological Prospect[24]
Multi-attribute	Information	Imperfect Info.[10]	Ability to process info[27]
Gold Plating[11]	(Learning by Doing)[25]	Availability	Bounded rationality[26]
Inseparability[13]	Imperfect Competition/	Cost[12]	
Regulation	Market Power[28]	Accuracy	
Price Distortion[14]			
Chain of Barriers			
Disaggregated Mkt.[15]			

William H. Golove and Joseph H. Eto, ***Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency;***

1) Six market barriers were initially identified: 1) misplaced incentives, 2) lack of access to financing, 3) flaws in market structure, 4) mis-pricing imposed by regulation, 5) decision influenced by custom, and 6) lack of information or misinformation. Subsequently a seventh barrier, referred to as "gold plating," was added to the taxonomy (p.9).
2) Neo-classical economics generally relies on the assumption of frictionless transactions in which no costs are associated with the transaction itself. In other words, the costs of such activities as collecting and analyzing information; negotiating with potential suppliers, partners, and customers; and assuming risk are assumed to be nonexistent or insignificant. This assumption has been increasingly challenged in recent years. The insights developed through these challenges represent an important new way to evaluate aspects of various market failures (especially those associated with imperfect information). Transaction cost economics examines the implications of evidence suggesting that transaction costs are not insignificant but, in fact, constitute a primary explanation for the particular form taken by many economic institutions and contractual relations (p. 22).
3) Transaction cost economics also offers support for claims that the illiquidity of certain investments leads to higher interest rates being required by investors in those investments (p. 23).
4) Misplaced, or split, incentives are transactions or exchanges where the economic benefits of energy conservation do not accrue to the person who is trying to conserve (p. 9).
5) Thus, as the rated lifetime of equipment increases, the uncertainty and the value of future benefits will be discounted significantly. The irreversibility of most energy efficiency investments is said to increase the cost of such investments because secondary markets do not exist or are not well-developed for most types of efficient equipment. This argument contends that illiquidity results in an option value to delaying investment in energy efficiency, which multiplies the necessary return from such investments (p. 16)
6) If a consumer wishes to purchase an energy-efficient piece of equipment, its efficiency should reduce the risk to the lender (by improving the borrower's net cash flow, one component of credit-worthiness5) and should, but does not, reduce the interest rate, according to the proponents of the theory of market barriers. (p.10). Potential investors, it is argued, will increase their discount rates to account for this uncertainty or risk because they are unable to diversify it away. The capital asset pricing model (CAPM) is invoked to make this point (p. 16).
7) Perfect information includes knowledge of the future, including, for example, future energy prices. Because the future is unknowable, uncertainty and risk are imposed on many transactions. The extent to which these unresolvable uncertainties affect the value of energy efficiency is one of the central questions in the market barriers debate. Of course, inability to predict the future is not unique to energy service markets. What is unique is the inability to diversify the risks associated with future uncertainty to the same extent that is available in other markets (p. 20).
8) In practice, we observe that some potential borrowers, for example low-income individuals and small business owners, are frequently unable to borrow at any price as the result of their economic status or "credit-worthiness." This lack of access to capital inhibits investments in energy efficiency by these classes of consumers (p. 10).
9) Finally, Williamson (1985) argues that the key issue surrounding information is not its public goods character, but rather its asymmetric distribution combined with the tendency of those who have it to use it opportunistically (p. 23).
10) [K]nowledge of current and future prices, technological options and developments, and all other factors that might influence the economics of a particular investment. Economists acknowledge that these conditions are frequently not and in some cases can never be met. A series of information market failures have been identified as inhibiting investments in energy efficiency: (1) the lack of information, (2) the cost of information, (3) the accuracy of information, and (4) the ability to use or act upon information (p. 20).
11) The notion of "gold plating" emerged from research suggesting that energy efficiency is frequently coupled with other costly features and is not available separately (p.11).
12) Even when information is potentially available, it frequently is expensive to acquire, requiring time, money or both (p. 20).
13) Inseparability of features refers specifically to cases where availability is inhibited by technological limitations. There may be direct tradeoffs between energy efficiency and other desirable features of a product. In contrast to gold plating where the consumer must purchase more features than are desired, the inseparability of features demands purchases of lower levels of features than desired. (p.12)
14) The regulation barrier referred to mis-pricing energy forms (such as electricity and natural gas) whose price was set administratively by regulatory bodies (p. 11).
15) On the cost-side of the equation, the critics contend that, among other things, information and search costs have typically been ignored or underestimated in engineering/economic analyses. Time and/or money may be spent: acquiring new information (search costs), installing new equipment, training operators and maintenance technicians, or supporting increased maintenance that may be associated with the energy efficient

equipment (p.16). [T]he class, itself, consists of a distribution of consumers: some could economically purchase additional efficiency, while others will find the new level of efficiency is not cost effective (p. 13).

16) Discounted cash-flow, cost-benefit, and social welfare analyses use price as the complete measure of value although in very different ways; behavioral scientists, on the other hand, have argued that a number of "noneconomic" variables contribute significantly to consumer decision making (p. 17).
17) [C]ustom and information have evolved significantly during the market barrier debate (p. 11).
18) In the language of (economic) utility theory, the profitability of energy efficiency investments is but one attribute consumers evaluate in making the investment. The value placed on these other attributes may, in some cases, outweigh the importance of the economic return on investment (p. 19).
19) [P]sychological considerations such as commitment and motivation play a key role in consumer decisions about energy efficiency investments (p. 17).
20) Externalities refer to costs or benefits associated with a particular economic activity or transaction that do not accrue to the participants in the activity (p. 18).
21) Other factors, such as membership in social groups, status considerations, and expressions of personal values play key roles in consumer decision-making (p.17). In order for a market to function effectively, all parties to an exchange or transaction must have equal bargaining power. In the event of unequal bargaining positions, we would expect that self-interest would lead to the exploitation of bargaining advantages (p. 19).
22) Public goods are said to represent a market failure. It has been generally acknowledged by economists and efficiency advocates that public good market failures affect the energy services market. (p. 19) [T]he creation of information is limited because information has public good qualities. That is, there may be limits to the creator's ability to capture the full benefits of the sale or transfer of information, in part because of the low cost of subsequent reproduction and distribution of the information, thus reducing the incentive to create information that might otherwise have significant value (p. 20).
23) Investment in basic research in believed to be subject to this shortcoming; because the information created as a result of such research may not be protected by patent or other property right, the producer of the information may be unable to capture the value of his/her creation (p. 19).
24) Important theoretical refinements to this concept, known as prospect theory, have been developed by Tversky and Kahneman (1981, 1986). This theory contends that individuals do not make decisions by maximizing prospective utility, but rather in terms of difference from an initial reference point. In addition, it is argued that individuals value equal gains and losses from this reference point differently, weighing losses more heavily than gains (p.21).
25) The information created by the adoption of a new technology by a given firm also has the characteristics of a public good. To the extent that this information is known by competitors, the risk associated with the subsequent adoption of this same technology may be reduced, yet the value inherent in this reduced risk cannot be captured by its creator (p. 19).
26) This work is consistent with the notion of bounded rationality in economic theory. In contrast to the standard economic assumption that all decision makers are perfectly informed and have the absolute intention and ability to make decisions that maximize their own welfare, bounded rationality emphasizes limitations to rational decision making that are imposed by constraints on a decision maker's attention, resources, and ability to process information. It assumes that economic actors intend to be rational, but are only able to exercise their rationality to a limited extent (p.21).
27) Finally, individuals and firms are limited in their ability to use — store, retrieve, and analyze — information. Given the quantity and complexity of information pertinent to energy efficiency investment decisions, this condition has received much consideration in the market barriers debate (p. 20).
28) This barrier suggests that certain powerful firms may be able to inhibit the introduction by competitors of energy-efficient, cost-effective products (p. 10).

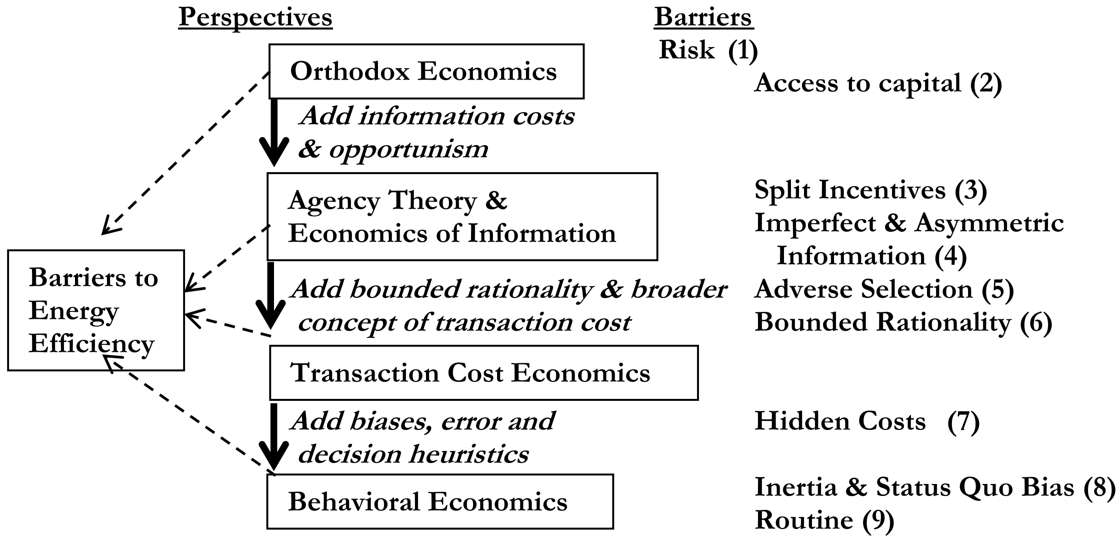
EXHIBIT A-II-3: MARKET AND BEHAVIORAL FAILURES RELEVANT TO ENERGY EFFICIENCY

Societal Failures	***Structural Failures***	***Potential Behavioral Failures***[11]
Energy Market Failures	Capital Market Failures	Prospect theory[12]
Environmental Externalities[1]	Liquidity constraints[5]	Bounded rationality[13]
Energy Security	Information problems[6]	Heuristic decision making[14]
Innovation market failures	Lack of information[7]	Information[15]
Research and development spillovers[2]	Asymmetric info. >	
Learning-by-doing spillovers[3]	Adverse selection[8]	
Learning-by-using[4]	Principal-agent problems[9]	
	Average-cost electricity pricing[10]	

1) Externalities: the common theme in energy market failures is that energy prices do not reflect the true marginal social cost of energy consumption, either through environmental externalities, average cost pricing, or national security (9).
2) R&D spillovers may lead to underinvestment in energy-efficient technology innovation due to the public good nature of knowledge, whereby individual firms are unable to fully capture the benefits from their innovation efforts, which instead accrue partly to other firms and consumers (11).
3) Learning-by-doing (LBD) refers to the empirical observation that as cumulative production of new technologies increases, the cost of production tends to decline as the firm learns from experience how to reduce its costs (Arrow 1962). LBD may be associated with a market failure if the learning creates knowledge that spills over to other firms in the industry, lowering the costs for others without compensation.
4) Positive externalities associated with learning-by-using can exist where the adopter of a new energy-efficient product creates knowledge about the product through its use, and others freely benefit from the information generated about the existence, characteristics, and performance of the product (12).
5) Capital: Some purchasers of equipment may choose the less energy-efficient product due to lack of access to credit, resulting in underinvestment in energy efficiency and reflected in an implicit discount rate that is above typical market levels (13).
6) Information: Specific information problems cited include consumers' lack of information about the availability of and savings from energy-efficient products, asymmetric information, principal-agent or split-incentive problems, and externalities associated with learning-by-using (11).
7) Lack of information and asymmetric information are often given as reasons why consumers systematically underinvest in energy efficiency. The idea is that consumers often lack sufficient information about the difference in future operating costs between more-efficient and less-efficient goods necessary to make proper investment decisions (11).
8) Asymmetric information, where one party involved in a transaction has more information than another, may lead to adverse selection (11).
9) Agency: The principal-agent or split-incentive problem describes a situation where one party (the agent), such as a builder or landlord, decides the level of energy efficiency in a building, while a second party (the principal), such as the purchaser or tenant, pays the energy bills. When the principal has incomplete information about the energy efficiency of the building, the first party may not be able to recoup the costs of energy efficiency investments in the purchase price or rent charged for the building. The agent will then underinvest in energy efficiency relative to the social optimum, creating a market failure (12).
10) Prices faced by consumers in electricity markets also may not reflect marginal social costs due to the common use of average-cost pricing under utility regulation. Average-cost pricing could lead to under- or overuse of electricity relative to the economic optimum (10).
11) Systematic biases in consumer decision making that lead to underinvestment in energy efficiency relative to the cost-minimizing level are also often included among market barriers. (8); The behavioral economics literature has drawn attention to several systematic biases in consumer decision making that may be relevant to decisions regarding investment in energy efficiency. Similar insights can be gained from the literature on energy decision-making in psychology and sociology. The evidence that consumer decisions are not always perfectly rational is quite strong, beginning with Tversky and Kahneman's research indicating that both sophisticated and naïve respondents will consistently violate axioms of rational choice in certain situations (15).
12) The welfare change from gains and losses is evaluated with respect to a reference point, usually the status quo. In addition, consumers are risk averse with respect to gains and risk seeking with respect to losses, so that the welfare change is much greater from a loss than from an expected gain of the same magnitude (Kahneman and Tversky 1979). This can lead to loss aversion, anchoring, status quo bias, and other anomalous behavior (16).
13) Bounded rationality suggests that consumers are rational, but face cognitive constraints in processing information that lead to deviation from rationality in certain circumstances (16); Assessing the future savings requires forming expectations of future energy prices, changes in other operating costs related to the energy use (e.g., pollution charges), intensity of use of the product, and equipment lifetime. Comparing these expected future cash flows to the initial cost requires discounting the future cash flows to present values (3).
14) Heuristic decision-making is related closely to bounded rationality and encompasses a variety of decision strategies that differ in some critical way from conventional utility maximization in order to reduce the cognitive burden of decision-making. Tversky (1972) develops the theory of elimination-by-aspects," wherein consumers use a sequential decision making process where they first narrow their full choice set to a smaller set by eliminating products that do not have some desired feature or aspect (e.g., cost above a certain level), and then they optimize among the smaller choice set, possibly after eliminating further products. (16) For example, for decisions regarding energy-efficient investments consumers tend to use a simple payback measure where the total investment cost is divided by the future savings calculated by using the energy price today, rather than the price at the time of the savings— effectively ignoring future increases in real fuel prices (p. 17). The salience effect may influence energy efficiency decisions, potentially contributing to an overemphasis on the initial cost of an energy-efficient purchase, leading to an underinvestment in energy efficiency. This may be related to evidence suggesting that decision makers are more sensitive to up-front investment costs than energy operating costs, although this evidence may also be the result of inappropriate measures of expectations of future energy use and prices (17).
15) Alternatively, information problems may occur when there are behavioral failures, so that consumers are not appropriately taking future reductions in energy costs into account in making present investments in energy efficiency (12).

Source: Kenneth Gillingham, Richard G. Newell, and Karen Palmer, *Energy Efficiency Economics and Policy* (Resources for the Future, April 2009)

EXHIBIT A-II-4: BARRIERS TO INDUSTRIAL ENERGY EFFICIENCY



Steve Sorrell, Alexandra Mallett & Sheridan Nye. *Barriers to industrial energy efficiency, A literature review,* United Nations Industrial Development Organization, Vienna, 2011, Figure 3.1 & Section 3.

(1) Risk: The short paybacks required for energy efficiency investments may represent a rational response to risk. This could be because energy efficiency investments represent a higher technical or financial risk than other types of investment, or that business and market uncertainty encourages short time horizons.

(2) Access to capital: If an organization has insufficient capital through internal funds, and has difficulty raising additional funds through borrowing or share issues, energy efficient investments may be prevented from going ahead. Investment could also be inhibited by internal capital budgeting procedures, investment appraisal rules and the short-term incentives of energy management staff.

(3) Split incentives: Energy efficiency opportunities are likely to be foregone if actors cannot appropriate the benefits of the investment. Wide applicability… Landlord-tenant problems may arise in the industrial, public and commercial sectors through the leasing of buildings and office space. The purchaser may have a strong incentive to minimise capital costs, but may not be accountable for running costs….maintenance staff may have a strong incentive to minimize capital costs and/or to get failed equipment working again as soon as possible, but may have no incentive to minimise running costs. If individual departments within an organization are not accountable for their energy use they will have no incentive to improve energy efficiency.

(4) Imperfect information: Lack of information on energy efficiency opportunities may lead to cost-effective opportunities being missed. In some cases, imperfect information may lead to inefficient products driving efficient products out of the market. Information on: the level and pattern of current energy consumption and comparison with relevant benchmarks; specific opportunities, such as the retrofit of thermal insulation; and the energy consumption of new and refurbished buildings, process plant and purchased equipment, allowing choice between efficient and inefficient options.

Asymmetric information exists where the supplier of a good or service holds relevant information, but is unable or unwilling to transfer this information to prospective buyers.

(5) Asymmetric information may lead to the adverse selection of energy inefficient goods.

(6) Bounded rationality: Owing to constraints on time, attention, and the ability to process information, individuals do not make decisions in the manner assumed in economic models. As a consequence, they may neglect opportunities for improving energy efficiency, even when given good information and appropriate incentive consumers do not attempt to maximise their utility or producers their profits.

(7) Hidden costs Engineering-economic analyses may fail to account for either the reduction in utility associated with energy efficient technologies, or the additional costs associated with them. As a consequence, the studies may overestimate energy efficiency potential. Examples of hidden costs include overhead costs for management, disruptions to production, staff replacement and training, and the costs associated with gathering, analysing and applying information.

General overhead costs of energy management: employing specialist people (e.g., energy manager); energy information systems (including: gathering of energy consumption data; maintaining sub metering systems; analysing data and correcting for influencing factors; identifying faults; etc.); energy auditing;

Costs involved in individual technology decisions: i) identifying opportunities; ii) detailed investigation and design; iii) formal investment appraisal; formal procedures for seeking approval of capital expenditures; specification and tendering for capital works to manufacturers and contractors additional staff costs for maintenance; replacement, early retirement, or retraining of staff; disruptions and inconvenience;

Loss of utility associated with energy efficient: problems with safety, noise, working conditions, service quality etc. (e.g., lighting levels); extra maintenance, lower reliability,

(8) Inertia and the status quo bias: Routines can be surprisingly persistent and entrenched. … This type of problem has been labeled *inertia* within the energy efficiency literature and identified as a relevant explanatory variable for the efficiency gap

(9) Routines as a response to bounded rationality the use of formal capital budgeting tools within investment decision-making. Other types of rules and routines which may impact on energy efficiency include: operating procedures (such as leaving equipment running or on standby); safety and maintenance procedures; relationships with particular suppliers; design criteria; specification and procurement procedures; equipment replacement routines and so on.

EXHIBIT A-II-5: MCKINSEY AND COMPANY MARKET BARRIERS TO HOME ENERGY EFFICIENCY

Kckinsey Category	McKinsey Nature	McKinsey Description	Cluster
Behavioral	Awareness	Low priority, Preference for other attributes	CD, RLA
Availability	Availability	Restricted procurement, 1st cost focus	CD
Behavioral	Awareness	Shop for price and features	RD
Behavioral	Awareness	Limited understanding of use and savings	CEPB, EH, GB, RLA
Behavioral	Custom & Habit	Little attention at time of sale	NH
Behavioral	Custom & Habit	Underestimation of plug load	RD
Behavioral	Custom & Habit	Aversion to change	CI,
Behavioral	Custom & Habit	CFLS perceived as inferior	RLA
Behavioral	Hurdle	Payback-Hurdle, 28% discount rate	CEPB
Behavioral	Hurdle	Payback-Hurdle,40% discount rate	EH
Behavioral	Use	Improper use and maintenance	CEPB, EH, RD
Behavioral	Awareness	Not accountable for efficiency	CI
Availability	Capital	Competing use of capital	EH, GB, RLA, CI
Structural	Agency	Tenant pays, builder ignores	CEPB, EH, RD
Availability	Availability	Lack of contractors	EH
Availability	Availability	Lack of availability in area	NH
Availability	Availability	Lack of demand => lack of R&D	RD
Availability	Availability	Emergency replacement	RLA
Availability	Bundling	Efficiency bundled with other features	RLA
Structural	Owner Transfer	Lack of premium at time of sale	CD, NH, NPB, RLA
Structural	Owner Transfer	Limits payback to occupancy period	EH
Structural	Transaction	Lack of information	NPB
Structural	Transaction	Disruption during improvement process	EH
Structural	Transaction	Difficult to identify efficient devices	RD
Behavioral	Risk/Uncertainty	Business failure risk	CEPB
Behavioral	Risk/Uncertainty	Lack of reliability	CI
Structural	Transaction	Research, procurement and preparation	EH, GB, RLA

SOURCE:
McKinsey and Company, *Unlocking Energy Efficiency in the U.S. Economy,* July 2009, Tables 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, Exhibits 14, 15, 16, 19, 21, 24, 26, 27, 29, 30.

Clusters
CD = Commercial Devices;
CEPB = Commercial Existing Private Buildings;
CI = Commercial Infrastructure;
EH = Existing Homes;
GB = Government Buildings;
NH = New Homes;
NPB = New Private Commercial Buildings;
RD = Residential Devices;
RLA = Residential Lighting and Appliances

McKinsey Categories Defined:

Structural. These barriers arise when the market of environment makes investing in energy efficiency less possible or beneficial, preventing measures that would be NPV-positive from being attractive to an end-user:

Agency issues energy efficiency less possible or beneficial, preventing a measure that would be NPV misaligned between economic actors, primarily between landlord and tenant These barriers arise when the market or environment makes investing in (split incentives), in which energy bills and capital rights are

Ownership transfer issues, in which the current owner cannot capture the full duration of benefits, thus requiring assurance they can capture a portion of the future value upon transfer sufficient to justify upfront investment; this issue also affects builders and buyers… Because developers do not receive the future energy savings from efficient buildings and are often unaware or uncertain of the market premium energy efficient building can command, developers have little financial incentive to invest in energy efficiency above the required minimum.

"Transaction" barriers, a set of hidden "costs" that are not generally monetizable, associated with energy efficiency investment; for example, the investment of time to research and implement a new measure High transaction barriers arise as consumers incur significant time "costs" in researching, identifying, and procuring efficiency upgrades

Pricing distortions, including regulatory barriers that prevent savings from materializing for users of energy-savings devices.

Behavioral: These barriers explain why an end-user who is structurally able to capture a financial benefit still decides not to

Risk and uncertainty over the certainty and durability of measures and their savings generates an unfamiliar level of concern for the decision maker. Many operators are risk averse and put a premium on reliability; they may not be inclined to pursue energy efficiency activities for fear of disrupting essential services.

Lack of awareness, or low attention, on the part of end-users and decision makers in firms regarding details of current energy consumption patterns, potential savings, and measures to capture those savings. Homeowners typically do not understand their home energy consumption and are unaware of energy-saving measures.

Custom and habit, which can create inertia of "default choices" that must be overcome. Enduring lifestyle disruptions during the improvement process. End-users retain preconceived and often inaccurate ideas about differences in functionality that limit the acceptance of certain products.

Elevated hurdle rates, which translate into end-users seeking rapid pay back of investments - typically within 2 to 3 years. This expectation equates to a discount rate of 40 percent for investments in energy efficiency, inconsistent with the 7-percent discount rate they implicitly use when purchasing electricity (as embodied by the energy provider's cost of capital). It is beyond the scope of this report to evaluate the appropriate risk-adjusted hurdle rate for specific end-users, though it seems clear that the hurdle rates of energy delivery and energy efficiency are significantly different.

Availability: These barriers prevent adoption even for end-users who would choose to capture energy efficiency opportunities if they could

Adverse bundling or "gold plating," situations in which the energy efficient characteristic of a measure is bundled with premium features, or is not available in devices with desirable features of higher priority, and is therefore not selected

Capital constraints and access to capital, both access to credit for consumers and firms and (in industry and commerce) competition for resources internally within balance-sheet constraints. Energy efficiency projects may compete for capital with core business projects.

Product (and service) availability in the supply chain; energy efficient devices may not be widely stocked or available through customary purchasing channels, or skilled service personnel may not be available in a particular market

Inconsistent quality of installation (sizing, sealing and charging, code compliance and enforcement) and improper use eliminates savings

EXHIBIT A-II-7: RECENT EMPIRICAL EVIDENCE ON MARKET FAILURES, BARRIERS AND IMPERFECTIONS

TRADITIONAL ECONOMICS & INDUSTRIAL ORGANIZATION

Externalities
- Public goods[1] & Bads[2]
- Basic research
- Network effects
- Information as a public good
- Learning-by-doing & Using[9]

Industry Structure
- Imperfect Competition
  - Concentration[13]
  - Barriers to entry
  - Scale[18]
  - Switching costs[20]
- Technology[23]
  - R&D
  - Investment[25]
- Marketing
  - Bundling: Multi-attribute[26]
  - Substitutes[27]
- Cost-Price
  - Limit impact of price[29]
  - Fragmented Mkt.[30]
  - Limited payback[31]

Regulation
- Price[34]
  - Infrequent
  - Aggregate, Avg.-cost[35]
- Lack of commitment[36]

NEW INSTITUTIONAL ECONOMICS

Endemic Imperfections
- Asymmetric Info[3].
- Agency[5]
- Adverse selection[6]
- Perverse incentives
- Lack of capital[10]

TRANSACTION COST
- Search and Information
- Imperfect info[14]
  - Availability[16]
  - Accuracy
  - Search cost[21]
- Bargaining
  - Risk & Uncertainty[24]
  - Liability
- Enforcement
- Sunk costs
- Hidden cost[28]

Political Power
- Power of incumbents to hinder alternatives
- Monopolistic structures and lack of competition
- Importance of institutional support for Alternatives[32]
- Inertia[33]

BEHAVIORAL ECONOMICS

Motivation & Values
- Non-economic[4]

Influence & Commitment
- Custom[7]
- Social group & status[8]

Perception
- Bounded Vision/Attention[11]
- Prospect[12]

Calculation.
- Bounded rationality[15]
- Limited ability to process info[17]
- Heuristic decision making[19]
- Discounting difficulty[22]

Citations

1. Macroeconomic: Edelstein and Killian, 2009, p. 13, [T]he cumulative effects on real consumption associated with energy price shocks are quantitatively important. We showed that the responses of real consumption aggregates are too large to reflect the effects of unanticipated change in discretionary income alone. Our analysis suggests that the excess response can be attributed to shifts in precautionary savings and to changes in the operating costs of energy using durables.
2. Committee On Health, Environmental, And Other External Costs And Benefits Of Energy Production And Consumption, **2011,** p. I, D]espite energy's many benefits, most of which are reflected in energy market prices, the production, distribution, and use of energy also cause negative effects. Beneficial or negative effects that are not reflected in energy market prices are termed "external effects" by economists. In the absence of government intervention, external effects associated with energy production and use are generally not taken into account in decision making. When prices do not adequately reflect them, the monetary value assigned to benefits or adverse effects (referred to as damages) are "hidden" in the sense that government and other decision makers, such as electric utility managers, may not recognize the full costs of their actions. When market failures like this occur, there may be a case for government interventions in the form of regulations, taxes, fees, tradable permits, or other instruments that will motivate such recognition.
3. UNIDO, 2011, p. 19, Asymmetric information exists where the supplier of a good or service holds relevant information, but is unable or unwilling to transfer this information to prospective buyers. The extent to which asymmetric information leads to market failure will depend upon the nature of the good or service…. In contrast to

energy commodities, energy efficiency may only be considered a search good when the energy consumption of a product is clearly and unambiguously labelled and when the performance in use is insensitive to installation, operation and maintenance conditions. But for many goods, the information on energy consumption may be missing, ambiguous or hidden, and the search costs will be relatively high. In the absence of standardised performance measures or rating schemes, it may be difficult to compare the performance of competing products. Taken together, these features tend to make energy efficiency closer to a *credence good* and hence more subject to market failure. Thus, to the extent that energy supply and energy efficiency represent different means of delivering the same level of energy service, the latter is likely to be disadvantaged relative to the former. The result is likely to be overconsumption of energy and under-consumption of energy efficiency.

4. Alcott, 2011, p. 1, Results show that beliefs are both highly noisy, consistent with imperfect information and bounded computational capacity, and systematically biased in manner symptomatic of "MPG illusion;" Alcott and Wozny, 2010.
5. Davis, xxx, p. 1; Extensive analysis of U.S. and global markets support the conclusion that this is an important impediment to greater energy efficiency of consumer durables. "The results show that, controlling for household income and other household characteristics, renters are significantly less likely to have energy efficient refrigerators, clothes washers and dishwashers."
6. UNIDO, 2011, p. 19, In some circumstances, asymmetric information in energy service markets may lead to the adverse selection of energy inefficient goods. Take housing as an example. In a perfect market, the resale value of a house would reflect the discounted value of energy efficiency investments. But asymmetric information at the point of sale tends to prevent this. Buyers have difficulty in recognising the potential energy savings and rarely account for this when making a price offer. Estate agents have greater resources than buyers, but similarly neglect energy efficiency when valuing a house. Since the operating costs of a house affect the ability of a borrower to repay the mortgage, they should be reflected in mortgage qualifications. Again, they are not. In all cases, one party (e.g., the builder or the seller) may have the relevant information, but transaction costs impede the transfer of that information to the potential purchaser. The result may be to discourage house builders from constructing energy efficient houses, or to discourage homeowners from making energy efficiency improvements since they will not be able to capture the additional costs in the sale price.
7. Ozaki and Sevastyanove, 2009.
8. Claudy and O'Dricoll, 2008, p. 11, "A growing body of literature around energy conservation contends that investment into energy efficiency measure is often motivated by "conviction" rather than "economics." Behavioral factors, including attitudes and values, explain a greater amount of variation in proenvironmental behaviour and provide valuable insights for policy makers and analysts."
9. Deroches, 2011, p. 1, Costs and prices generally fall in relations to cumulative production, a phenomenon known as experience and modeled as a fairly robust empirical experience curve… These experience curves… incorporated into recent energy conservation standards… impact on the national modeling can be significant, often increasing the net present value of potential standard levels… These results imply that past energy conservation standards analyses may have undervalued the economic benefits of potential standard levels.
10. UNIDO, 2011, p. iii, If an organization has insufficient capital through internal funds, and has difficulty raising additional funds through borrowing or share issues, energy efficient investments may be prevented from going ahead. Investment could also be inhibited by internal capital budgeting procedures, investment appraisal rules and the short-term incentives of energy management staff.
11. Alcott, 2009, p. 1. "I provide evidence to suggest that at least some of this effect is because consumers' attention is malleable and non-durable." UNIDO, pp. viii, Owing to constraints on time, attention, and the ability to process information, individuals do not make decisions in the manner assumed in economic models. As a consequence, they may neglect opportunities for improving energy efficiency, even when given good information and appropriate incentive consumers do not attempt to maximise their utility or producers their profits.
12. Sardiano, 2007, p. 1417, Decision making process to invest in energy efficiency improvement, like other investments, is a function of the behavior of individual or of various actors within the industrial firm. In this context, managerial attitudes toward energy conservation are also important factors… [E]nergy efficiency measures are often not overlooked by management because it is not a core business activity and it is thus not worth much attention.
13. Blumstein, 2013, p. 5, [T]he existence of market power dampens the responsiveness of suppliers of goods or services to consumer demand, as actors in a monopolistic or oligopolistic setting can more or less set prices and quality attributes.
14. Atari, et. al., 2010, p. 1. For a sample of 15 activities, participants underestimated energy use and savings by a factor of 2.8 on average, with small overestimates for lower-energy activities and large, underestimates for high-energy activities." Jessoe and Rapson, 2013, p. 34, "These results confirm the practical importance of one of economics' most ubiquitous assumptions – that decision makers have perfect information. Indeed, the absence of perfect information is likely to cause substantial efficiency loses both in this setting and others in which quantity is also

infrequently or partially observed by decision makers." Consumers Union, 2012, p. 8, "this suggests that many consumers are misinformed about the program requirements.

15. Green, German and Delucchi, 2009, p. 203; "The uncertainty/loss aversion model of consumers' fuel economy decision making implies that consumers will undervalue expected future fuel savings to roughly the same degree as manufacturers' perception that consumers demand short payback periods."
16. UNIDO, 2011, p. iii, Lack of information on energy efficiency opportunities may lead to cost-effective opportunities being missed. In some cases, imperfect information may lead to inefficient products driving efficient products out of the market. Information on: the level and pattern of current energy consumption and comparison with relevant benchmarks; specific opportunities, such as the retrofit of thermal insulation; and the energy consumption of new and refurbished buildings, process plant and purchased equipment, allowing choice between efficient and inefficient options.
17. Atari, et. al., 2010, p. 1. For a sample of 15 activities, participants underestimated energy use and savings by a factor of 2.8 on average, with small overestimates for lower-energy activities and large, underestimates for high-energy activities."
18. Montvalo, 2007, p. S10, Due to the size of investment and longevity or production processes it is very likely that the diffusion of new processes will occur in an incremental way.
19. Ito, 2010, p. 1, Evidence from laboratory experiments suggests that consumers facing such price schedules may respond to average price as a heuristic. I empirically test this prediction using field data.
20. Sardianou, 2007, p. 1419, Our empirical results also confirm that organizational constraints and human related factors can be thought of as barriers in incorporating the energy saving technology in incorporating the energy saving technology in the existing production process.
21. Sardianou, 2007, p. 1419, Having limited information with regard to energy conservation opportunities and their profitability is considered an obstacle…. Other possible barriers include lack of documentation of energy data.
22. Kurani and Turrentine, 2004, p. 1, One effect of limited knowledge is that when consumers buy a vehicle, they do not have the basic building blocks of knowledge to make an economically rational decision. When offered a choice to pay more for better fuel economy, most households were unable to estimate potential savings, particularly over periods of time greater than one month. In the absence of such calculations, many households were overly optimistic about potential fuel savings, wanting and thinking they could recover an investment of several thousand dollars in a couple of years.
23. Montvalo, 2007, p. A10, Finally, firms face the challenge of technological risk. The gains promised by new technologies have yet to materialize, a situation that contrasts strongly with the perceived reliability of the current, familiar operating process. In the literature on technology management it has been established that adoption or development of new production processes implies the capacity to integrate new knowledge and large organizational change.
24. UNIDO, 2011, p. iii, The short paybacks required for energy efficiency investments may represent a rational response to risk. This could be because energy efficiency investments represent a higher technical or financial risk than other types of investment, or that business and market uncertainty encourages short time horizons.
25. Montvalo, 2007, p. s10, Closely related to these technological opportunities are the firm and sector level capabilities to actually adopt new technologies. It has been reported that insufficient availability of expertise in clear production (eco-design) the current training and clean technology capacity building at the sector level and the insufficient understanding and experience in cleaner production project development and implementation, play a role in the adoption of new cleaner production processes. These factors can be expected to become even more critical at the level of small- and medium sized enterprises..
26. Gabaix and Laibson, 2005, p. 1; "We show that information shrouding flourishes even in highly competitive markets, even in markets with costless advertising, and even when the shrouding generation allocational inefficiencies." Hosain and Morgan, Brown, Hossain and Morgan
27. Sallee, 2012, "The possibility of rational inattention has two key implications. First, if consumers rationally ignore energy efficiency, this could explain the energy paradox. In equilibrium, firms will underprovide energy efficiency if consumers ignore it. If true, this would qualitatively change the interpretation of empirical work on the energy paradox. Most empirical work tests for the rationality of consumer choice across goods that are actually sold in the market. If rational inattention leads to an inefficiency set of *product offerings* (emphasis added), consumer might choose rationally among goods in equilibrium but a paradox still exists. Second, if consumers are rationally inattentive to energy efficiency, this could provide direct justification for regulatory standards and "no tech policies, such as the Energy Star Label System." Green, German and Delucchi, 2009, p. 203; This suggests that increasing fuel prices may not be the most effective policy for increasing the application of technologies to increase passenger and light truck fuel economy. This view is supported by the similar levels of technology applied to U.S. and European passenger cars in the 1990s, despite fuel prices roughly three times higher in Europe. It is also circumstantially supported by

the adoption by governments around the world of regulatory standard for light-duty vehicle fuel economy and carbon dioxide emissions.

28. UNIDO, 2011, p. iii, Hidden costs Engineering-economic analyses may fail to account for either the reduction in utility associated with energy efficient technologies, or the additional costs associated with them. As a consequence, the studies may overestimate energy efficiency potential. Examples of hidden costs include overhead costs for management, disruptions to production, staff replacement and training, and the costs associated with gathering, analysing and applying information. General overhead costs of energy management: employing specialist people (e.g., energy manager); energy information systems (including: gathering of energy consumption data; maintaining sub metering systems; analysing data and correcting for influencing factors; identifying faults; etc.); energy auditing; Costs involved in individual technology decisions: i) identifying opportunities; ii) detailed investigation and design; iii) formal investment appraisal; formal procedures for seeking approval of capital expenditures; specification and tendering for capital works to manufacturers and contractors additional staff costs for maintenance; replacement, early retirement, or retraining of staff; disruptions and inconvenience; Loss of utility associated with energy efficient: problems with safety, noise, working conditions, service quality etc. (e.g., lighting levels); extra maintenance, lower reliability.
29. Li, Timmins and von Haefen, 2009, "we are able to decompose the effects of gasoline prices on the evolution of the vehicle fleet into changes arising from the inflow of new vehicles and the outflow of used vehicles. We find that gasoline prices have statistically significant effects on both channels, but their combined effects results in only modest impacts on fleet fuel economy. The short-run and long-run elasticities of fleet fuel economy with respect to gasoline prices are estimated at 0.o22 and 0.204in 2005. "
30. Committee to Assess Fuel Economy, 2010, p. 2, The [Medium and Heavy Duty] truck world is more complicated. There are literally thousands of different configurations of vehicle including bucket trucks, pickup trucks, garbage trucks, delivery vehicles, and long-haul trailers. Their duty cycles vary greatly… the party responsible for the final truck configuration is often not well defined.; Lutzenheiser, et al., (2001, cited in Blumstein, 2013), p. viii, The commercial building "industry" is in fact a series of linked industries arrayed along a "value chain" or "value stream" where each loosely coupled link contributes value to a material building in process. Each link, while aware of the other links in the process, is a somewhat separate social world with its own logic, language, actors, interests, and regulatory demands. For the most part "upstream" actors constrain the choices and actions of "downstream" actors.
31. Sardianou, 2007, p. 1419, The lack of access to capital (76%) and the slow rate of return (74%) of energy savings investments are categorized as barriers.
32. UNIDO, 2011, p. iii, Routines as a response to bounded rationality the use of formal capital budgeting tools within investment decision-making. Other types of rules and routines which may impact on energy efficiency include: operating procedures (such as leaving equipment running or on standby); safety and maintenance procedures; relationships with particular suppliers; design criteria; specification and procurement procedures; equipment replacement routines and so on.
33. Montvalo, 2007, A11, organization capabilities refer to the firm's endowments and capabilities to carry out innovation… When the knowledge is not present in the firm adoption will depend on the firm's capacity to overcome shill lock-in, and to unlearn and acquire new skills. UNIDO, Inertia and the status quo bias: Routines can be surprisingly persistent and entrenched. … This type of problem has been labeled inertia within the energy efficiency literature and identified as a relevant explanatory variable for the efficiency gap.
34. Sardianou, 2007, p. 1419, Uncertainty about future energy prices (62%) is also characterized as a barrier [leading] to the postponement of energy efficiency measures.
35. Ito, 2010, p. 1, I find strong evidence that consumers respond to average price rather than marginal or expected marginal price.
36. UNIDO, 2011, p. 67, The government does not give financial incentives to improve energy efficiency, Lack of coordination between different government agencies, Lack of enforcement of government regulations, There is a lack of coordination between external organizations; Sardianou, 2007, p. 1402, [B]ureaucratic procedure to get government financial support is a barrier to energy efficiency improvements for the majority (80%) of industries.

APPENDIX B:
KEY CHARACTERISTICS OF AND FINDINGS OF EMPIRICAL STUDIES

General

Author, date	Geller, et al., 2006	Montevallo, 2007	Scleigh & Gruber, 2008	Brown et al., 2008	Sardinaou, 2008
Products	Multiple, aggregate sectors	Clean technologies	Commercial 19 sectors, 2848 Cos.	4 type of GHG emitters	Industrial
Method, period, size	Historic trend, 1973-2000	Review of empirical studies	Econometric. 9 variables	Review of Case studies 27 Expert Interviews	Survey
Scope National Cross National	 US. Japan, Europe, Calif.	Primarily US, EU	Germany	US 15 sectors	Greed
Actors	Regulator		Producer	Producers	Perception of barriers
Aspect Studied	Policy	Economic barriers	Attitude, Action	Barriers	Barriers
Key Findings	Substantial energy savings	appropriability access to capital lack of expertise Technological factors inertia stock of opportunities lack of capability in firms technology risk Organizational barriers capabilities coordination	Most important factors: Split incentives, Lack of information Policy recommendation Lower transaction cost, Performance stds, Financial incentives Audits, Benchmarks Focus on smaller firms	Iron Triangle of Barriers Incumbent Technology Support Systems Business Risk of Innovation High Transaction Costs Unfavorable Policy Environment	Risk, Lack of knowledge Lack of skill, adjustment costs operating costs, Capital rationing, hurdle rates Culture, Gov't policy
Framing observations & assumptions			Cites barriers in previous research: information, & transaction costs, access to split incentives, bounded rationality uncertainty & risk small savings, behavior organizational factors		

General, cont'd.

			Specific Products		
Author, date	UNIDO, 2011 (Sorrell, Mallett & Nye	Jesseo & Rapson, 2013	Allcott & Wozny, 2010	Kok et al., 2010	Li, 2010
Products	Industrial production process		Autos, new and used	Buildings	Appliance
Method, period, size	160 case studies (64 evaluated)	Field Experiment 1150+ subjects	National 1.1 million auto sales	Regression 48 MSAs	Regression
Scope		US	US	US 48 Metro areas	UC
National					California, PG&E sample
Cross National					
Actors	Market outcome	Consumers	Market outcome		Consumer
Aspect Studied	Attitude, Action	Response to information	Willingness to Pay	% Energy Star or LEED	Structural characteristics
Key Findings	7 main barriers: Imperfect information, Hidden costs. Access to capital, Split incentives, Bounded rationality, Risk/uncertainty Inertia 24 sub-types of barriers	3 st dev. Large reduction with info. $\simeq$ 15%	$.61/$1.00 of potential economic gains Efficiency is a shrouded attribute	Accredited professionals local policy increase % of building	agency and information are important factors
Framing observations & assumptions	Information Access to capital Split incentives Inertia Transaction costs	Shrouded attribute due to shrouded attribute intermediate input coarse billing Low elasticity			

Specific Products Cont'd

Author, date	Ito, 2010	Ozaki & Sevastyanova, 2011	Noailly, 2012	Mareur, et al., 2013
Products	Appliance	Hybrid Autos	Buildings	Appliances
Method, period, size	Regression	Survey, Jan. 2009, 1200+	Econometric, 9 nations 9 variables	Historical analysis
Scope National Cross National	Southern CA	US		US
Actors	Consumer	Consumer	Regulator	Policy makers
Aspect Studied	Price response	Attitude	Attitude, Policy	Cost, impact on features
Key Findings	Consumers respond to average, not marginal prices	Financial benefits are important, Social norms influence consumer behavior Practical, experimental & affective values should be communicated	Regulations significantly stimulate innovation, R&D expenditures slightly increase innovation, Energy price has little effect on innovation	Declining cost no reduction in features
Framing observations & assumptions	Cites:Liebman & Zechhauser	Cites Rogers' adoption facilitators: Advantage, Compatabilty Complexity, Trialability Observability	Cites: Johnstone on effectiveness of renewable obligations Jaffe/Sterns, Popp on little effect of price Invokes agency, split incentives	

Surveys

Author, date	Poortinga, 2003	Kurani & Turentine, 2004	Li, et al., 2009	Consumer Fed. , 2010
Products	Energy-saving measures	Autos	Willingness to pay for R&D Expenditures	Autos
Method, period, size	National Poll 455 respondents	Interview, 57 respondents	Contingent Valuation, National Referendum 2000+ respondents, split sample	National Poll 2000
Scope National Cross National	Netherlands	US	US	US
Actors	Consumers	Consumer Market outcome	Consumers	Consumer
Aspect Studied	Preference for types	Attitudes	Attitudes	Attitudes
Key Findings	Technical > Behavior > Shift in consumption Home > Transport Amount of energy saved is unimportant Environmental concern increases support	Consumers: do not pay much attention to fuel cost have ephemeral knowledge, at best are unable to estimate savings are overly optimistic about savings associate fuel economy with poor quality see vehicle as multi-attribute where fuel economy is not important use crude reference points: loan life, monthly cash flow	Willingness to pay: $137 per year > Increase R&D spending Reduce dependence on foreign Promote crop based fuels Demographics are important Income Gender Attitudes that matter Importance of energy issues Political ideology	Payback periods tested 3-5 yrs garner majority Lack awareness of US oil resources Information increases support for higher stds. 2/3 want higher mileage
Framing observations & assumptions		Notes Importance of advertising & promotion	Cites: NRC 2007 call for more research on NRC 2007 call for more research on social valuation and behavior Public concern about energy security, need to address climate change	

Surveys. Cont'd

Author, date	Consumer Fed, 2011a	Consumer Fed., 2011b	Consumer Rpts. 2010	Consumer Repts., 2012	Arimura, 2009
Products	Autos	Appliances	Household Energy	Autos	Electricity efficiency programs
Method, period, size	National Poll 1000+	National Poll 1003	National Poll 1536 Home Owners	National Poll 1702 random	Regression ~ 700 utilities, 5,000 obs.
Scope National Cross National	US	US	US	US	US
Actors	Consumers	Consumer	Consumers	Consumers	Utility-regulator
Aspect Studied	Concerns	Attitudes	Purchases, Attitudes	Concerns in purchase	Cost of saved energy
Key Findings	Great concern about: Gasoline prices (80+%) Mideast oil Dependence (70+%) Strong majority support for stds. 80% support of stds. 60% with 5 yr payback	Payback periods tested 3-5yr garner strong 70+% favorable 70+% support for stds Awareness increases support for stds.	Purchases of Efficient: Bulbs (81%) Energy Star (44%) Windows (29%) Insulation (24% HVAC/Water Heat (21-23%) Renewable system (3%)	Fuel economy (34%) Quality *17%) Safety (16%) Performance (6%) Style (6%) Small cars most popular 2/3 want higher mileage	$0.06/kwh existing states $0.03/kwh new states
Framing observations & assumptions					

Cost Benefit

Author, date	Freidrich, et al. 2009	Dale et al., 2009	Kiso, 2009	Hwang & Peak, 2010	Weiss, et al., 2010
Products	Utility efficiency programs	RAC, Refrig CAC, Clothes Wash	Autos	Autos, 11 innovations	6 Large Appliances
Method, period, size	Direct cost estimates, 14 states 53 year covered	Historic trend, 1965-2005 Time series/cross sectional	Historic trends 1988-2006	Historic trends 1975-2001	Historic Trends Energy & cost data
Scope National Cross National	US	US	Japanese Cars sold in US	US	Europe
Actors	Utility-regulator	Regulator Market outcome	Market outcome	Regulators Market outcome	Market Outcome
Aspect Studied	Cost of saved energy	Projected cost increase	Regulation	Regulation	Productivity Growth
Key Findings	Electricity: Avg. $0.025/kwh Range - $0.016-$0.044 Gas: Avg. $0.37/therm Range - $0.27-$0.55	2.1 times actual cost increase expected due to: Price increase less than expected due to: Technological change, Decreasing mark-ups, Economics of scale	Regulation induces innovation	Projected cost increase 1.48 times actual	faster after policy intervention
Framing observations & assumptions	Updates ACEEE 2004 study		Cites Newell that price & regulation impact efficiency Popp that price & regulation	Cites NESCAUM, 2000 Anderson & Sherwood, 2002 Harrington Et al, 1999	Evidence that efficiency improvement does Cites: Ellis, 2007 Bertoldi & Atanasiu, 2007 Dale, et al., 2009

Cost Benefit Cont'd

Author, date	Wie, Patadia & Kammen, 2010	Desroches, et al., 2011	Woolf, et al., 2011
Products	Electricity Resources	Learning Curves for Appliances	Learning curves for Standard
Method, period, size	Cost data 2010	Energy & cost data Long term series	Energy & cost data Long term series
Scope National Cross National	US	US	US
Actors	Market Outcome	Market Outcome	Market Outcomes
Aspect Studied	Jobs/Gwh equiv.	Productivity Growth	Productivity growth
Key Findings	Efficiency yields 2 to 3 times as many jobs	faster after policy intervention	
Framing observations & assumptions			

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