EFFICIENCY OPPORTUNITIES FOR EDISON-BASED LUMINAIRES

CONSULTANT REPORT

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ABSTRACT

The greatest opportunity for saving lighting energy in California homes lies in addressing the continuing prevalence of incandescent lamps. This report aims to cover the most relevant issues for seizing that opportunity. This includes a survey of available technologies, from solid-state lighting (LEDs) and compact fluorescent lamps to possible improvements in incandescent technology, international and national initiatives (government or industry-led) that can influence or guide California's process, lighting energy use projections for the next decade that quantify the effects of different options, and consideration of possible environmental impacts. A diverse array of policy options is evaluated, with broad recommendations for policies most likely to succeed.

KEYWORDS

Lighting, Energy-efficiency, Buildings, Energy policy

SUMMARY

The greatest opportunity for saving lighting energy in California homes lies in addressing the continuing prevalence of incandescent lamps. That is already done in part by the building code for new and renovated housing, but that affects a very small proportion of all houses each year. The majority of sockets in existing houses is still occupied by incandescent lamps, which have an efficacy (amount of light provided per amount of electrical power consumed) in the region of 10-17 lumens per watt (lm/W). When compared with the 50-70 lm/W of currently available compact fluorescent lamps (CFLs), incandescents are clearly very inefficient.

The efficacy of incandescent lamps could be doubled with technology presently available, such as halogen. Furthermore, industry experts suggest that, with some technological improvements, it could even approach 40 lm/W. Meanwhile, available light-emitting diode (LED) sources achieve 40 lm/W at the moment, could achieve 60 lm/W in a few years, and even breach 100 lm/W sometime in the next decade.

Several initiatives throughout the world aimed at improving lighting energy efficiency have recently been prominent in the media, described as bans on the incandescent lamp. They are, however, mostly concerned with raising the minimum allowable efficacy levels for incandescent lamps, phasing out noncompliant lamps in the next 10 years. Incandescent lamps of types that met the new minimum levels would still be allowed. Nonetheless, these initiatives would most probably amount to imposing a de facto ban on standard (that is non-halogen) incandescent technology. The US and European lighting industries have voluntarily proposed their own initiatives for increasing incandescent efficacy, albeit to lower levels and over a longer time span.

Projections indicate that, if present trends continue, lighting energy consumption in California households could reach 150 percent of current levels by 2018. In contrast, complete substitution of incandescents by compact fluorescents could approximately halve lighting energy consumption in the same period. The increase in incandescent efficacy proposed by the industry could bring consumption to around the same levels of today, although that outcome is highly dependent on consumers replacing old lamps by new lamps of the same light output and not by lamps of same wattage.

A successful policy to decrease residential lighting energy consumption in California would hinge foremost on stimulating high levels of consumer awareness and motivation, thus fostering favorable conditions for any other measures. These other measures should both comprise restricting availability of the most inefficient technologies and promotion of the most efficient ones. Long-term success would be compounded by frequent updating of building codes according to technological developments. Such a policy would need to be accompanied by measures establishing effective channels for the disposal of compact fluorescent lamps.

CONTENTS

1. INTRODUCTION

Broadly speaking, the goal of energy efficiency is to provide the same amenity using less energy. This report focuses on increasing the energy efficiency of lighting in California, specifically on lighting that uses the widespread “Edison-based”, i.e. screw-based, type of lamp.

The opportunities for increased energy efficiency are found in two distinct types of residential buildings. Newly constructed buildings are subject to efficiency requirements – e.g. Title 24 2005 requires that houses must either use high-efficiency lighting or use energy-saving switching devices such as occupancy sensors or dimmers. Other factors being equal, newer buildings will have lower energy consumption than existing buildings. This, however, is a small proportion of all buildings in California. The greatest opportunity for energy efficiency lies in doing something about all the sockets in existing buildings that are filled with standard incandescent lamps – the most energy-inefficient electric light source.

The energy efficiency goal becomes then to address this prevalence of incandescent lamp use. The following section provides an overview of the technologies in use, how they are used, and the technologies that are likely to be available in the future.

2. BACKGROUND: Technology

Technologies in Current Use

The overwhelming majority of Edison sockets are filled with either incandescent or fluorescent lamps. Incandescent lamps are usually one of three following types: A, BR or PAR. Fluorescent lamps are of the compact type (CFL). The typical characteristics of these lamps are shown in the box below.

Incandescent: A lamp

- Typical characteristics
  - Wattage: 40-100 W
  - Efficacy: 10-17 lm/W
  - Price: < $1 (Halogen long-life: $5)
- Typical applications
  - General lighting

Incandescent: BR Lamp

- Typical characteristics
  - Wattage: 30-150 W
  - Efficacy: 7-12 lm/W
  - Price: $4-7
- Typical applications
  - Downlights
  - Spotlights

Incandescent: PAR Lamp

- Typical characteristics
  - Wattage: 50-150 W
  - Efficacy: 6-15 lm/W
  - Price: $6-8
- Typical applications
  - Downlights
  - Spotlights

Fluorescent: CFL

- Typical characteristics
  - Wattage: 5-40 W
  - Efficacy: 50-70 lm/W
  - Price: $1-8 (non-dimming)
- Typical applications
  - General lighting

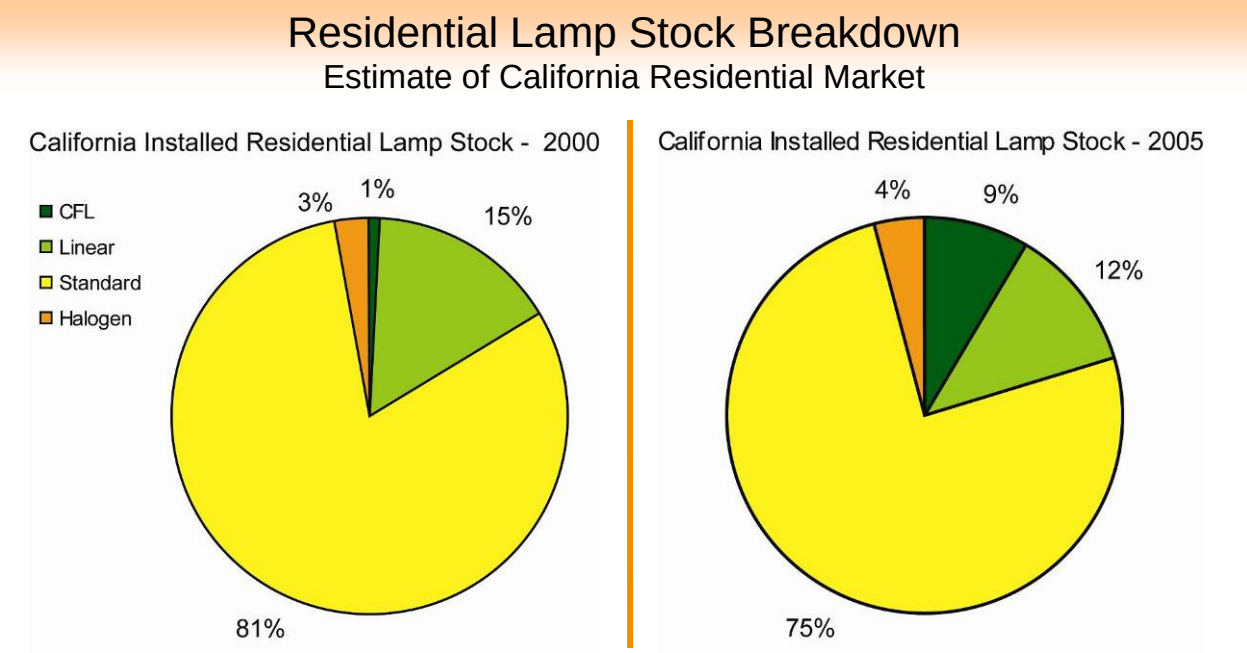

Figure 1 California residential lamp stock (Source: RLW Analytics CLASS Study)

Market penetration

Figure 1 shows the use of these technologies in California households for 2000 and 2005. It also includes other technologies that have significant residential use, linear fluorescent and halogen. Linear lamps are not screw-based, which is also the case for the majority of halogen lamps. Although the data show the share of CFL lamps increasing significantly, three quarters of all sockets still use incandescent lamps. Lamp sales data for California and the US is shown in Appendix A.

A CLTC-conducted preliminary survey of several builders showed that, in houses built in 2007, the majority (58%) of pre-installed fixtures are either linear fluorescent or pin-based CFL (i.e. not replaceable by incandescent technology). It is probable that this number should decrease after occupancy, since it does not include plug loads such as table lamps. It was also found that some builders do not preinstall fixtures in some rooms, especially bedrooms, which would further affect the number of incandescent lamps used. Nevertheless, this number can be taken as an indication that current building codes are having a positive effect on the composition of California's residential lamp stock.

These limitations notwithstanding, Figure 2 shows the result of combining this data with that already shown in Figure 1. The data suggests that the greatest opportunity for energy savings lies in all the sockets in already existing housing that use incandescent lamps. Naturally it would still be helpful, especially in the long run, to also address the incandescents that are in use in new houses.

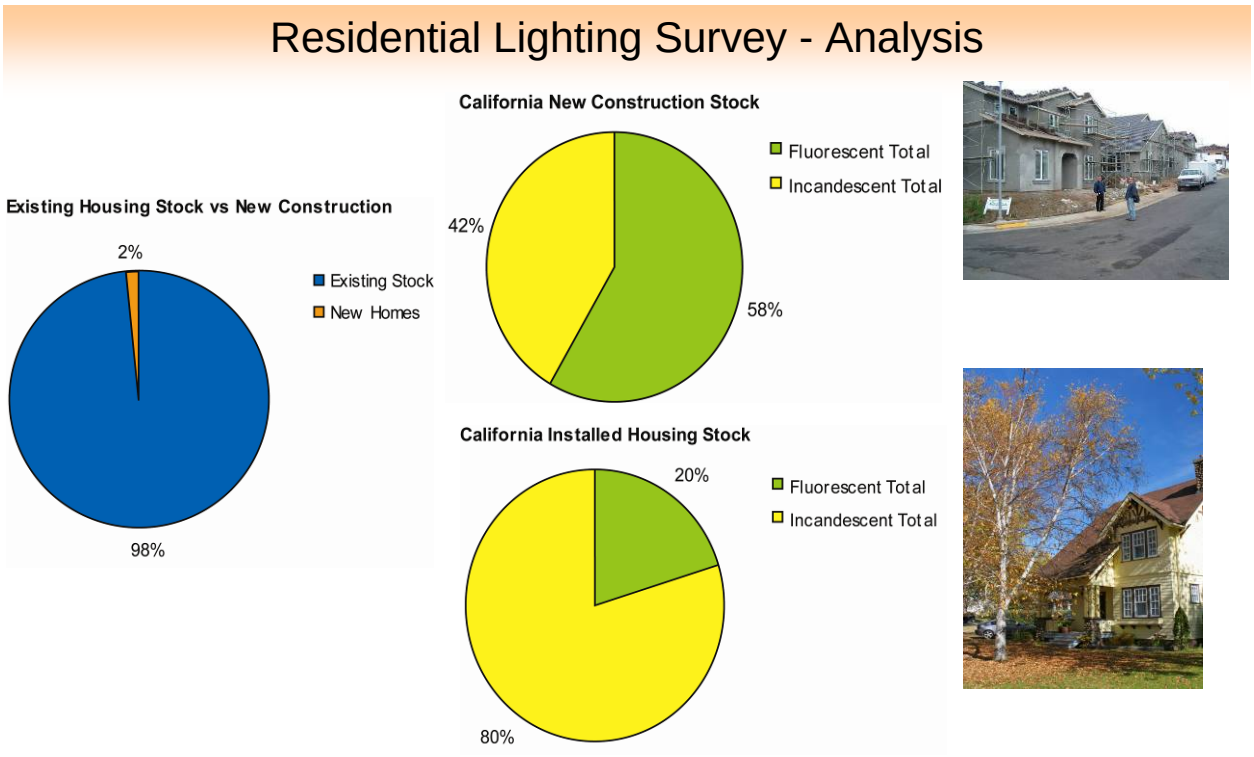

Figure 2 California residential lamp stock: new construction vs. existing households (Source: CLTC survey, RLW Analytics CLASS Study [RLW 2005])

Another fact suggested by the CLTC survey data is that the option that builders consistently choose to comply with code in general-use spaces is the use of dimmers (the other options being high-efficacy pin-based lamps or occupancy sensors). This is something to bear in mind regarding future energy efficiency policy, since compact fluorescent lamps fail catastrophically if used on dimming circuits, unless they are specifically designed for dimming.

Luminous Efficacy

Luminous efficacy, usually given in units of lumens per watt (lm/W), is the amount of light that a source emits per unit of power that it consumes.

The efficacy of each type of lamp lies within a range mainly determined by the type of physical phenomenon used to generate light. Incandescent lighting, in which a metal is heated by an electric current until it glows, is generally less efficacious than fluorescent lighting, in which light comes from an electric discharge through a gas – a process not unlike lightning. In broad terms, this happens because in incandescent lamps most energy goes into producing light at infrared wavelengths that are invisible to the human eye. In fluorescent lamps this is less so.

Within its typical range for each technology, efficacy can vary as a function of several factors. Some of the most relevant are described below.

Wattage

The efficacy of incandescent lamps increases with their wattage. For clear general service lamps, it can vary from around 10 lm/W for a 40 W lamp to around 17 lm/W for a 100 W lamp. This variation happens because, for equal lifetime, the lower wattage filament must be operated at a lower temperature, which means that less of the energy will be emitted as visible light (and more as infra-red light). The lower wattage filament is also thinner and has a larger surface for heat losses.

CFL efficacy also increases with wattage, although this is an indirect effect: the necessary increase in lamp size allows more efficient tube geometry.

Incandescent lamp life

The standard incandescent lamp is designed to last approximately one thousand hours. Lamps can be designed to last longer by making them with a thinner filament than the standard operating voltage would require, thus lowering its operating temperature and the rate of tungsten evaporation. This decrease in operating temperature results, as above with wattage, in a reduction of the amount of energy emitted as visible light and hence in efficacy.

Color rendering (fluorescent))

The standard metric for lamp color rendering is the Color Rendering Index (CRI). It is based on the difference in performance from an incandescent-type light source for an array of eight standard colors, and can take any values up to a maximum of 100. It has been argued that this metric is not only outdated, but also fundamentally inadequate for non-thermal (i.e. non-incandescent) light sources, but there is yet no consensus on what should replace it.

The CRI of incandescent lamps is usually very close to 100, and CFLs with CRI of 80-85 are widely available. The CRI of a fluorescent lamp depends on the substances, called *phosphors*, that coat the inside surface of the tube and transform the UV light generated by the mercury vapor inside the tube into visible light. There are phosphor mixes capable of attaining CRI of 90 and above, but they require more energy to produce light than other phosphors, therefore reducing lamp efficacy. For currently-available fluorescent lamps the efficacy reduction in going from 80 to 90 CRI is of at least 20%.

CFL Market Penetration – Issues

Anecdotal evidence suggests that energy awareness resulting from the 2001 energy events in California, and also monetary incentives in the form of direct utility rebates and other programs (e.g. Pacific Gas & Electric's (PG&E), "20/20") had some part in this decade's increase in residential CFL market penetration.

However, there is also evidence, partly corroborated by studies [LRC 2003], that consumer preference for the CFL over incandescent – and hence a significant increase in CFL market penetration – faces several barriers.

For some people, fluorescent technology still has a negative reputation, stemming mainly from the characteristics that this technology had a few decades ago, before triphosphor lamps

significantly improved color rendering and electronic ballasts replaced magnetic ballasts and their characteristic hum and flicker.

That being said, there are some other issues that people have identified as negative with CFLs. Some people find the color disagreeable, greenish, or that it reproduces skin tone unflatteringly. Another issue is color consistency from lamp to lamp and also between CFLs and incandescents. Many people are not aware that there are different colors (or color temperatures, to be more precise) available, which is not the case with incandescents.

For the growing number of California households equipped with dimmers there is the issue of compatibility with those devices. Most available CFLs are not designed for dimmers and fail – sometimes dangerously – if operated with that type of switch. Furthermore, the few available dimming CFLs sometimes exhibit undesired characteristics such as flicker and noise.

In enclosed and downlight fixtures, ordinary CFLs do not last nearly as long as their claimed life because of the high operating temperatures typical of that type of fixture. This is disconcerting for users who have been sold CFLs as having several times the life of incandescent lamps. There are lamps that use an amalgam of mercury and other metals to achieve high light output and long life at high temperature, but they have the significant drawback of taking a few minutes to reach their full light output.

Upcoming Technologies

Incandescent

Major lamp manufacturers have announced plans to increase the efficacy of incandescent lamps. One of the ways this can be done is by applying the already-existing halogen technology that is at present mainly used in pin-based reflectors (e.g. MR-16) or capsules (e.g. for torchieres), although some screw-based products already exist. So far, though, the latter have been designed and marketed with longer lamp life in mind. If optimized for efficacy and infrared-reflective coatings are used, presently-available halogen technology can allow for Edison-based A-lamps of standard (1000 h) lifetime with efficacies of around 20 lm/W and higher. Another way of increasing the efficacy of incandescents is to fill the lamp with krypton or xenon gas instead of the currently-used argon. Depending on several factors, krypton allows efficacy increases up to 20%, and xenon even higher, although its higher price can be drawback.

Industry experts suggest that, in the foreseeable future, enhancements in the filament structure could take incandescent efficacy to the vicinity of 30 lumens per watt (lm/W). This would represent, approximately, a doubling of efficacy relative to today's incandescents. With filament optimization for efficacy at the expense of lamp life it is conceivable that even 40 lm/W could be reached. However, it is doubtful that these lamps would have the low cost of current standard incandescents.

CFLs

Fluorescent technology is, as is incandescent, mature, with a high level of performance. There is, however, room for improvements in the particular case of CFLs which, being much smaller than tubular lamps, are more challenging to produce with the same performance. Efficacy, dimming performance and, although less so, color rendering are areas in which there is still a

gap between the best fluorescent technology and CFLs. It is yet to be determined if that gap can be completely bridged by advances in lamp and ballast technology.

The present trends in the evolution of CFL products seem to be towards smaller lamps that have shape and size similar to incandescents, and towards lamps with lower amounts of mercury, longer life and higher light output maintenance throughout product lifetime.

Solid State (LEDs)

A few Edison-base LED products are currently available. Not only are they hard to procure, but they are more suited to proof-of-concept demonstration than to actual consumer use, since their appearance, size, total light output and/or light quality are not yet comparable to currently-existing CFLs and incandescents for general lighting service. Their efficacy, although higher than that of incandescents, is also not yet competitive with CFL products.

The luminous efficacy of LED light sources is rapidly increasing, however. The screw-base LED products available today can have efficacies in the range of 40 lm/W, albeit with somewhat limited total light output. At the moment, increasing light output requires additional heat-dissipation elements that make the lamps too bulky. In the laboratory, LED efficacies of 60 lm/W are not uncommon today and it is conceivable that the 100 lm/W barrier could be breached early in the next decade.

As for color rendition, LED sources do not perform optimally just yet, but also seem to be improving in that regard. A recent study [Navigant 2006] suggests that it is conceivable that an Edison-based LED lamp equivalent to a current 13-watt CFL (i.e. light output equivalent to a 60 W incandescent) with comparable color quality could be available by the end of the next decade at a similar price.

Nevertheless, the introduction of these products in the Edison-based market would not only require correctly addressing size, total light output, heat dissipation and light quality but would also certainly elicit stiff competition from established technologies, which could remain competitive for decades.

3. BACKGROUND: POLICY

California

Title 20

State law charges the California Energy Commission with the responsibility of adopting efficiency standards for appliances. The legislature assigned the CEC this duty in 1975 when it adopted Public Resources Code § 25402 (c). This enabling legislation dictates that all adopted standards upgrades must be feasible, attainable, and cannot "result in any added total costs to the consumer over the designed life of the appliance."[1] This restriction requires that the CEC consider the economic implication of all policy decisions, and to design standards and methodologies to minimize the burden on the consumer. The opening line of § 25402 focuses the objective of standards passed down from the CEC on the "wasteful, economic, inefficient, and unnecessary consumption of energy."[2]

The CEC has been active in pursuing more efficient lamps and luminaires. In 2005, the CEC adopted new efficiency regulations for lighting under its Title 20, appliance efficiency authority. The new regulations included two tiers of regulations. The first tier, taking effect on January 1, 2006, set minimum efficiency standards for general service incandescent lamps. This first change affected a relatively small number of lamps, the least efficient on the market. In addition to incandescent lamp efficiency, this tier of regulations affected some metal halide luminaires.

The second tier of regulations goes into effect January 1, 2008. This tier includes "plateaus" of lamp wattages, designed to reduce lamp energy use 5 percent. For instance, consumers will be able to purchase 95 watt lamps, in place of 100 watt lamps. These standards will also affect some reflector lamps, not covered under the federal Energy Policy Act (EPACT) standards. The second tier of efficiency regulations also covers a wider range of metal halide luminaires, with more stringent standards.

Adopting further regulation through Title 20, §§ 1601-1608 provides the benefit of a technology neutral approach to regulation through a well established and trusted regulatory structure. No one specific type of technology is targeted and prohibited. Instead, it provides manufacturers with the flexibility and autonomy to decide on how to structure their own product mixes in a way that is most compatible with their own manufacturing capabilities.

Although Title 20 acts as a promising conduit to meet lamp efficiency standards, regulation through Title 20 alone also has its limitations. The most problematic application concern of Title 20 is the confusion from customers, who may not modify their purchasing behavior based on the availability of certain technologies over others. Further, this approach will encourage the development of "efficient" incandescent lamps, which although more efficient than traditional incandescent lamps, are highly inefficient as compared with CFLs or other technology. Consumers may fall prey to the marketing of "efficient" incandescent lamps, without realizing the

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[1] *Potential Appliance Efficiency Regulations for General Service and Reflector Incandescent Lamps and for Metal Halide Luminaries* (*hereafter* CEC Staff Report), California Energy Commission, dated December 2005. (*See* http://www.energy.ca.gov/2005publications/CEC-400-2005-041/CEC-400-2005-041-SF.PDF)
[2] California Public Resources Code § 25402. (*See* http://law.onecle.com/california/public-resources/25402.html)

true impact of their purchase. Finally, implementing standards through Title 20 should be compatible with future federal standards.

Title 24

The Building Code in California provides a resource through which the state can implement long-term changes to infrastructure. The Code, as set for by the Building Standards Commission (BSC), incorporates elements from three separate sources: agency created standards, standards adopted from the federal code, and standards that have been implemented by the California state legislature.[3] In 2001, the Energy Commission adopted the "Building Energy Efficiency Standards"[4] for both residential and non-residential application, in response to the statewide energy crisis and increasing energy bills.[5] This code was updated in 2005.

A 2008 update is under development and consists of three phases.[6] Phase 1 consists of workshops involving the Commission, utilities, and the input from other stakeholder groups. Phase 2 will present draft language for comment. Phase 3 will include the formal rulemaking, for implementation in 2009. Within this update, the Commission has the ability to modify portions of the appliance requirements to incorporate standards on incandescent lamps or lamps generally. Subchapter 4, "Nonresidential, High-rise Residential, and Hotel/Motel Occupancies – Mandatory Requirements for Lighting Systems and Equipment" applies to the design and installation of all lighting systems and equipment.[7] These standards also provide for exceptions, including for emergency lighting, some hotel guest lighting, daylighting, signage, and some external lighting.[8] Even with standards directed strictly to increasing the efficiencies of private households, Title 24 will be applied to over 200,000 new households every year.

Implementing lamp efficiency standards through Title 24, Part 6 creates a long term, structural impact, forcing the future of building construction and renovation to incorporate efficiency into design. Such requirements currently include high efficacy lamps, dimmers, and motion sensor requirements.

Title 24 fosters an environment to advance technology and increase building efficiencies in the future. However, it does not address the largest opportunity of where efficiencies can be increased: in existing buildings. California currently has over 12 million existing homes, many of which are older that will not be impacted by Title 24 unless they undergo a renovation.

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[3] http://www.bsc.ca.gov/title_24.html
[4] Title 24, Part 6. (a.k.a. The "Energy Code")
[5] *2005 Building Energy Efficiency Standards*, CEC. (*See* http://www.energy.ca.gov/title24/2005standards/index.html)
[6] *Id.*
[7] Title 24 § 130 (a)
[8] Title 24, §§ 131-132

AB722: Levine

AB. 722 (2006-07) was written to increase indoor and outdoor lighting efficiency by "replacing [the inefficient] incandescent [lamps] with more efficient [lamps] to reduce the demand for electricity" within the State.[9] This bill would have phased in, over a six-year period, minimum efficiency requirements for general-purpose lamps.[10] However, as of June 7, 2007 this bill has been marked as an inactive file, upon motion by Assembly Member Levine.

AB1109: Huffman

In contrast, AB1109 (2006-07) sets an efficiency performance standard for statewide lighting.[11] This bill would increase the efficiency of lighting systems and also focus on eliminating hazardous materials in general purpose lamps and improving the rate of recycling of lamps which contain hazardous materials.[12] The requirements of this bill, as amended for the California State Senate on August 31, 2007 Prohibit, after January 1, 2010, manufacturing for sale in the state certain general purpose lights, with exceptions, that contain hazardous substances at levels prohibited by the European Union. The Department of Toxic Substances Control (DTSC) would convene a task force to recommend the most effective methods to inform consumers about lamp recycling and the most cost-effective ways to approach recycling[13]

AB1109 requires the California Energy Commission (CEC) to develop efficiency standards and programs by December 31, 2008, to report on the current statewide energy consumption for lighting and to implement a plan, by December 1, 2008 to reduce those levels by 50% for indoor residential lighting, and 25% for indoor commercial and outdoor lighting use by 2018.[14] Finally, this bill requires the Department of General Services (DGS) to implement these policies within 2 years for all lamp purchases, in which historically accurate appearance is not necessary, and contracts made for the state.[15]

National

Federal

The National Electrical Manufacturers Association (NEMA) has proposed federal legislation to increase the minimum efficacy standards for incandescent lamps, corresponding to an efficacy increase of approximately 28%, to be gradually phased-in until 2018. This is done by providing the same light output with lamps that have lower wattage. The wattages proposed by the industry are reproduced in Table 1.

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[9] *Analysis for the Assembly Committee on Utilities and Commerce*, prepared by Edward Randolph, hearing dated April 23, 2007. (*See* http://www.assembly.ca.gov/acs/acsframeset2text.htm)
[10] *Id.*
[11] *Is it time to ban the bulb?*, authored by Craig DiLouie, the Lighting Controls Association. (*See* http://www.aboutlightingcontrols.org/education/papers/2007_bulb_ban.shtml)
[12] *Senate staff analysis, 9/07/07*(*See* http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1101-1150/ab_1109_cfa_20070907_195605_asm_floor.html)
[13] *Id.*
[14] *Id.*
[15] *Id.*

Common Wattage	Lumen Range	New Wattage Cap	Effective Date
100	1499-2600	72	Jul 1, 2012
75	1010-1489	53	Jan 1, 2014
60	730-1009	43	Jan 1, 2015
10	310-729	29	Jan 1, 2018

Table 1 Industry proposal for reduction of general service incandescent lamp wattage

In the Senate, a broad-ranging energy bill (S.1115) includes a “sense of Senate” section concerning the need for efficiency lighting standards but without going into detail. Such standards are proposed in a separate bill, S.2017, in the form of wattage caps for several lumen ranges, with an associated calendar for each range. As of September 4, these caps have exactly the same values as the NEMA proposal, although they come into effect at earlier dates (2012, 2013, 2014 and 2014, respectively). This bill also covers lamp labeling requirements, a yearly lamp market assessment, a lamp research and development program and mercury use and release reporting.

The House of Representatives version of the energy bill (HR.3236) takes a different approach. It prohibits the sale of 100 watt incandescent lamps after Jan 1, 2012, unless their efficacy is at least 60 lm/W. Effective on that date are also minimum efficacies for several lumen ranges (Table 2). After Jan 1, 2020, general service lamps with efficacies lower than three times the present efficacy of a 100 W incandescent lamp (i.e. three times 17 lm/W, 51 lm/W) are prohibited.

Lumen range	Minimum efficacy (lm/W)	Effective Date
200-449	15	Jan 1, 2014
450-699	17	Jan 1, 2014
700-999	20	Jan 1, 2013
1000-1500	22	Jan 1, 2012
1501-3000	24	Jan 1, 2012

Table 2 Minimum efficacies proposed in HR.3236 (Jul 31)

Last March, another bill (HR.1547) proposed to ban all lamps of less than 60 lm/W by 2012, increasing the minimum to 90 lm/W in 2016 and 120 lm/W in 2020. In June, another bill with the same title (HR.2751) was referred to the House energy committee. This bill requires somewhat lower efficacy levels and a different timeline: 25 lm/W by 2010 and 60 lm/W by 2015.

Other states

Other states have taken action to address Edison-base lighting energy efficiency. In Nevada, a bill (AB.178) banning lamps under 25 lm/W from 2012 has been signed by the governor in June. Connecticut, Minnesota, New York, New Jersey, North Carolina, South Carolina and Rhode

Island have all introduced bills that in one way or other restrict or ban the sale of incandescent lamps, but there has been no significant action in any of them at least since June.

International

In February of this year, Australia sparked worldwide attention with its proposal to, allegedly, ban the incandescent bulb. In fact, the proposal is not to ban but to impose stricter efficacy standards for the majority of general service lamps. By 2014, the minimum efficacy allowed is about 18-22 lm/W, depending on lamp wattage. Note that in Australia line voltage is 240 V AC, at which incandescent lighting is slightly less efficient than at the North American standard of 120 V. The proposed efficacy limits are approximately equivalent to around 22-26 lm/W at 120 V. After 2016, a second round of standards is expected to raise the minimum efficacy to levels above 35 lm/W (at 240 V).

Canada also expressed interest in a similar policy. The Canadian government announced last April that it intended to phase out inefficient lighting by 2012, using non-technology-specific national standards. These standards are currently being based on similar minimum efficacy levels as proposed by U.S. Senate Bill 1115, but using a continuous curve, rather than steps, in order to disallow the dimmest part of each lumen category. A public preliminary version of the standard is expected around the end of this year. In 2009, national standards already in place for incandescent reflector lamps (ER/BR) are expected to be revisited in order to make them more stringent.

In the European Union, under a 2005 European Commission directive to regulate products that have an energy and environmental impact, a study is undergoing to develop standards for office lighting (linear fluorescent and non-integrated CFL), and a new study targeting residential lighting has been launched this summer. The standards are to be ready in 2008 and 2009, respectively. Meanwhile, the European Lighting Council – a European counterpart to NEMA – has made public a proposal for Europe-wide regulation which, although divided into two stages of increasing stringency, is quite similar to the NEMA proposal in the United States, with slight differences in timing and efficacy levels. Independently of EU-wide activity, individual European countries have proposed or taken measures to curb the least efficient types of lamps. Earlier this year, the United Kingdom announced a plan to phase out inefficient general service incandescent lamp by 2011. Portugal passed a law establishing an excise tax on the same kind of product, although the efficacy level below which it applies is yet to be determined. Ireland, Belgium (Flanders) and, outside the EU, Switzerland, have also announced measures or plans.

In other countries policies have not yet been implemented, but discussions are underway to promote future lamp regulations. In Russia, the city of Moscow is urging residents to make the switch to CFLs on their own, without formal legislation from the government.[16] New Zealand has announced interest in following the Australian model to phase out the incandescent lamp.[17] The governments of India, Cuba, Venezuela, Vietnam, Indonesia, Thailand, and Ghana have also expressed interest in regulation.

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[16] *Id.*
[17] *Id.*

4. POLICY ELEMENTS

Ban

Implementing a policy, to totally ban the sale of all types of incandescent lamps is targeted to lamp manufacturers and distributors, by preventing the sale of specific goods within the state. Such a policy is intended to change the consumption pattern of the state by restricting the supply chain.

A total ban may be quickly implemented by setting a close effective date. It can be enforced through a series of penalties and physical restrictions. Although a ban is directed at the actions of manufacturers and suppliers, it may also hold retailers responsible for the sale of any prohibited good on the store shelves. Further, the ban could extend to a ban not only on the sale of a good, but also on the possession, although in that case enforcement costs would likely outweigh the benefit.

A decisive move such as this could propel energy efficiency legislation with fast and straightforward implementation. Most importantly, this policy is designed for maximum effectiveness in ridding the state of outdated and inefficient lamp technology.

A sales ban restricts commerce entirely for the targeted product and is enacted in situations when a certain product must be eradicated from use. This is often used in situations of moral turpitude, such as with the child labor laws of the early 1900s and with prohibition of the 1930s. A moral argument to preserve the environment for future generations in part motivates a ban on the sale of incandescent lamps. However, even a ban for entirely good motives may have unexpected detrimental consequences. A ban on the light bulb could create an illegal market of smuggling, due to the potential profit from the margin between the price point for a CFL at $3.00 and an incandescent at $0.50. This difference of $2.50 could sustain an illegal market, continually feeding consumers with replacement bulbs.

Another implication of a ban is that making incandescent lamps illegal would probably place regulation of their efficiency out of reach for the state.

General service incandescent lamps have capabilities which are not widespread, or as fully developed in competing technologies. Banning those lamps would then require consumers to purchase alternatives, such as CFLs. This could result in major frustration for consumers and builders alike due to the alternatives' non-backwards-compatibility with dimming circuits. Most CFL lamps sold cannot be used in all systems where incandescent technology works well. For example, the majority of non-dedicated-high-efficacy sockets in Title 24 homes are controlled by incandescent dimmers, which is the most favored of three mandatory design options because of the lower installation cost.[18] However, CFL performance is compromised when used with a dimmer, unless the CFL is specially designed for dimmer compatibility. Forcing consumers to misuse lamp technology could damage the reputation of CFLs, compromise future efficiency

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[18] *Suggested Modification to the Residential Lighting Section of Title 24*, National Resource Defense Council (NRDC), May 16, 2006. (*hereafter* NRDC) [The three design options are (1) highly efficient luminaries, (2) Occupancy sensors, and (3) dimmer switches.] (*See* http://www.energy.ca.gov/title24/2008standards/documents/2006-07-12_workshop/2006-07-11_LIGHTING.PDF)

potential, and encourage illegal markets for the incandescent bulb.[19]. As long as incandescent lamps are seen as having unique, desirable characteristics, such as ability to dim, there is incentive to circumvent laws forbidding use of incandescent lamps.

Appliance Standard

An appliance standard implemented through Title 20 would create a technology-neutral minimum efficiency requirement, based on a lumens per watt measure of efficiency. This standard may be directed towards manufacturers and distributors, targeting the whole of the product line they provide to California, "at the point of manufacture or import"[20], instead of targeting one specific technology in their product portfolio. This policy design overcomes distortions created by product and transaction costs, which prevent achieving certain efficiencies.[21] Appliance standards would reduce the total amount of energy consumed by appliances, or in this case, lamps, over time.

The best-known example of an effective appliance standard is the refrigeration regulations that were highly enforced through this section after the oil embargos of the 1970s. As a poster child for improved efficiency regulation, the standard imposed on refrigeration has cut this appliance's energy consumption by over three-fourths in years since.[22] The standards, originally adopted by the CEC have now been superseded by national efficiency standards set in 1987 and again in 1993, for a total savings of 130,000 megawatts capacity.[23] The imposition of these standards required increasingly efficient refrigerators. This, in 1972 a refrigerator used 2000 kWh/yr, while a 1990 refrigerator used 900 kWh/yr, and a 1998 refrigerator used 500 kWh/yr. Applying similar standards now for lamp efficiency would have a high likelihood of success and could again position California as a national model for change.

Drawing upon past successes, Title 20 provides a well-established and familiar forum within which to implement new policy measures. The creation of a technology neutral standard is less interfering in the market than a policy that singles out a certain type of technology. An efficiency standard preserves the autonomy of both manufacturers and distributors who may respond to market demands by adjusting their product mix according to consumer demands.

Although setting technology neutral standards may only minimally intrude on the market, proponents of stricter regulation may argue that this manufacturer-friendly approach is not effective. Without an education program to complement the technology neutral standard, reports that California is stricter on incandescent lamp efficiencies could confuse the consumer into perceiving these new "efficient" incandescents as equivalent in efficiency to CFLs which are, in fact, roughly 3 times more efficient. If this led to significant CFL substitution by "efficient" incandescent technology, it could conceivably lead to an actual increase in lighting energy consumption.

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[19] *Id.*
[20] *CBS Newsletter: Appliance efficiency standards*, study by Jim McMahon and Steve Pickle, Energy Conservation and Policy Group, Summer 1995. [*hereafter* Newsletter] (*See* http://eetd.lbl.gov/newsletter/CBS_NL/nl7/APS.html)
[21] *Id.*
[22] *California Energy Commission recommends to invest in efficiency*, written by Dennis Du Bois, dated February 2, 2006. (*See* http://energypriorities.com/entries/2006/02/california_energy_commissioner.php)
[23] *California illuminates the world*, by Craige Canine, National Resource Defense Council (NRDC), Spring 2008. (*See* http://www.nrdc.org/onearth/06spr/ca2.asp) *See also* Newsletter, *Supra.*

Building Code

By mandating energy-efficiency into every building that gets constructed or renovated, building codes have tremendous potential for a positive effect in the long term. They can also be frequently updated according to technological developments in order to maximize that positive effect in the long run.

The impact of these changes can already be seen now. In CLTC's survey of homes built in 2007, the majority of preinstalled fixtures installed were dedicated to high efficiency light sources. These changes can result in significant energy savings into the future.

However, despite the amount of good that a body of law like Title 24 provides for directing the future of growth in California, it does not address the issues with the currently existing infrastructure. It cannot be applied retroactively to existing buildings and – if imposing too costly restrictions – could conceivably reduce the amount of retrofits. Although Title 24 will increase the efficiency on 200,000 new homes every year, an existing 12 million plus households will be untouched by this law. In addition to these barriers to implementation, Title 24 also presents a challenge for enforcing the use of higher efficiency lamps in non-dedicated fixtures, since the Code imposes restrictions on building construction, but not on operations.

Fleet Standard

This standard is based on the automobile fleet model in which a car manufacturer must meet certain fuel efficiency standards across the average of the entire fleet of cars produced or sold. This allows the manufacturer to create a range of product offerings, from the highly efficient hybrid to the gas guzzling SUV. The analogy extends to lamp manufacturers, in which LED and fluorescent technologies correspond to the hybrid and the incandescent lamp to the gas-guzzler.

The automobile analogy may be used as a guide to anticipate certain advantages and pitfalls of applying this standard. This kind of standard is a technology-neutral tool that involves a low level of direct government control and instead relies more on market controls, thus increasing the autonomy of auto manufacturers.[24] Proponents argue that increasing the standard fosters the advent of new technology[25] while nay-sayers warn that standards that are set too high may encourage corner cutting, compromising product safety to meet a certain efficiency.[26] This kind of standard was imposed for automobile fuel consumption in 1975, anticipating a long period of rising gasoline prices following the 1973 OPEC oil crisis. At the time the Corporate Average Fuel Economy (CAFE) standard was viewed as attainable.[27] However, in the 1980s oil prices decreases, although still at a high level, and demand for more efficient cars abated. Satisfying demand and complying with the CAFE standard became increasingly difficult[28] and eventually, under pressure from automakers the National Highway Traffic Safety Administration, which sets

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[24] *Automobile and light truck economy: the CAFE fuel standards,* written by Robert Bamberger, Congressional Research Services, dated September 25, 2002. [*hereafter* CAFÉ standards] (*See* http://www.policyalmanac.org/environment/archive/crs_cafe_standards.shtml)
[25] *Id.*
[26] *Id.*
[27] *Id.*
[28] *Id.*

the CAFE standard, reduced the requirements between the years of 1986-1989.[29] With the 2001 blackouts in recent memory, this state finds itself in a position somewhat analogous to the oil crisis. A CAFE-type standard carries the risk of falling back into inefficient habits once the crisis has passed.

Another caveat with this type of standard is that it focuses on the behavior of manufacturers, without directly addressing the behavior of consumers. Continuing the automobile analogy, just as how purchasing a light truck for commuter use counters the intent of CAFE standard, so too would the use of incandescents for the living room fixtures and CFLs for closets. This type of standard requires a combination with significant efforts to promote energy-efficient consumer behavior.

Finally, enforcing a CAFE-style standard entails tracking shipments or sales of lamps, by type, size and/or efficiency. With sales of new automobiles, manufacturer output is readily tracked by the federal government, and aggregated state registration information is readily available. Lamp production volumes and shipments, in contrast, are not currently tracked. Far more lamps than cars are purchased in California each year, and a large variety of lamps exists. It would be costly to establish a monitoring program that could provide enough information that lamp fleet efficiency standards could function properly.

Rebates

A rebate system can function as an incentive to purchase or as a supplement to a product, and is usually offered by the manufacturer or retailer.[30] However, on socially pervasive matters like energy, governments can also offer rebates usually as incentives. The design and application of a rebate lends to complexities because a rebate is flexible in nature. The benefits from application include: drawing attention to the product, insulating products from negative reactions from customers due to price increases, and to collect consumer information.[31] The final advantage to a rebate offer is that it can be offered for a limited time. Thus, a rational end point would be at the time that economies of scale for the production of more efficient technology are projected to set in.

All of these features would be beneficial and easily integrated into a government efficiency program. Depending on the variables of its design, a rebate may encourage certain behaviors from the one who stands to benefit from that rebate. For example, mail-in rebates are used to increase purchasing, by offering the appearance of a lower cost to the consumer, although many consumers do not go to the effort to mail in the rebate. The design and application of a successful rebate program will reduce the cost to the rebate benefactor and reduce the effort required to receive the rebate, by the maximum amount feasible.[32]

Alternatively, the rebate design could target consumers at their point of purchase. Thus, rebates to retailers may encourage a change in the product mix as it appears on the shelves. Rebates

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[29] *Id.*
[30] The how and why of *rebates, written by Henry Norr, SF Gate, dated December 18, 2000.http*://www.sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2000/12/18/BU142549.DTL&type=printable
[31] http://en.wikipedia.org/wiki/Rebate_%28marketing%29
[32] *PMA mail in rebate benchmark study*, The PMA Educational Foundation, Inc., dated May 1, 2005. (*See* http://www.pmalink.org/membership/mailinrebatereport.pdf)

directly offered to consumers require additional publicity. Publicity may range from offers given at the store or mailed in, to promotional displays, etc. Consumer rebates may compliment a legislative tool like the Huffman Bill if the rebate is at the end of the CFL life. A buyback program at recycling centers, similar to the recycling of aluminum cans and plastic bottles could supplement the cost of the CFL while also keeping harmful toxins out of landfills and ground water.

Another possibility is to offer manufacturer level rebates, which may be useful if the savings are offered down the supply chain to reduce cost to the consumer. This level of rebate allows the manufacturer to take advantage of the low hanging fruit by reducing a barrier to production. It also encourages the consumer to apply unfamiliar technology. This could be easily represented by a discount in the final product, or in a mail-in offer.

Aside from this government structured, supply side rebate model, utilities, manufacturers, builders, and the government could offer consumers demand side rebates, which provide a rebate for meeting a certain level of efficiency. For example, manufacturers could provide a rebate for buying a certain mix or lighting system. Builders can provide a rebate for including certain efficiencies in the building.[33]

Utility rebates for new technologies are effective at developing public familiarity with these options. Using rebates to precede efficiency standards for an end use can encourage manufacturers to increase production, and can reduce consumer uncertainty regarding new products. In this application, rebates can improve the effectiveness of appliance and building efficiency standards,

Rebates also have disadvantages. Rebates may cause accounting and tax complications based on the organization's tax and financial structure. For a corporation, a rebate will impact the income statement because it pertains to working capital; but it is not earned income. Additionally, rebates that are delayed may not impact the correct accounting period. The SEC has just this year in 2007 filed a complaint against a firm, which improperly recorded income from the rebates expected on future transactions.[34] Such rebate fraud will incur an additional cost to the state because enforcement through litigation could increase as rebate models became increasingly popular in the state. Finally, the "switchback" market effect of rebates is a known phenomenon: consumers who use rebates to originally switch to CFLs may switch back to incandescent lamps upon the failure or breaking of a CFL lamp[35]. This phenomenon may be corrected for by encouraging consumer education on use and the eventual removal of incandescent lamps from the market. For such reasons, rebate programs to incentivize are most effective as a complement to another dominant regulatory program.

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[33] http://www.customenergy.com/whatwedo/rebates.html

[34] *Complaint, SEC v. Collins & Aikman Corp.*, dated March 26, 2007. (*See* http://www.sec.gov/litigation/complaints/2007/comp20055.pdf)

[35] *The European design competition "Lights of the Future" for energy-efficient lamps dedicated fixtures: a successful example of market transformation*, written by Paolo Bertoldi and Vincent Berrutto, European Commission DG JRC. http://re.jrc.cec.eu.int/energyefficiency/pdf/publications/ACEEE2002-paper77final.pdf

Tax Incentives

Tax credits are strictly a government-provided benefit, which has the overall impact of increasing the net income (after tax) of the benefactor. Implementation of the credit is easily achieved at the state level, and structured similarly for manufacturers, retailers, and consumers. California has a history of credits for all types of activities: renewable energy (wind and solar)[36], research and development[37], and so on. The state level tax credit could model its design on the federal Energy Star program credit.[38] Following the Energy Star model, credits can be offered to manufacturers, residences, home builders, and commercial buildings. Since credits can be directly applied to buildings, this financial model will integrate neatly with a Title 24 modification. California may benefit from co-branding under the Energy Star logo and framework.

The tax credit model has significant implications for the end user because it impacts the net income of the company or resident. Depending on the company's financial model, a manufacturer or consumer may prefer to receive a tax credit instead of a rebate (or vice versa) because the tax credit will impact the income statement and cash flow statements in different ways. Companies will favor whichever option improves their financials. This credit system could be easily integrated into a larger, all encompassing credit for energy efficiency.

Credits may be offered at any level of the supply chain to achieve different incentives. Credits offered to manufacturers aim to improve the availability of efficient technology.[39] Residents receive credits to compensate for the additional cost of using efficient technology.[40] Credits to builders require a designer to include certain energy efficient technology and concepts in the building design.[41] The final building credits are based on the percentage increase in efficiency that a given building design can achieve.[42]

A drawback to implementing such a system is the vulnerability to fraudulent claimants. The state might then have to increase its monitoring, enforcement, and prosecution efforts against fraudulent filings.[43]

Consumer Education

It could be said that a significant part of the inertia of consumers in transitioning to more efficient lighting technology derives from confusion and misunderstanding of the technology. Consumers have not found a strong enough motivation to rationalize the price difference between a standard incandescent lamp priced at $0.50 per bulb and a CFL lamp priced at $3.00 per bulb.[44] Educational outreach encompasses a variety of programs that are directed at

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[36] http://www.caltax.org/member/digest/Mar2003/3.2003.Micheli-ActualUsageOfTaxCredits.04.htm
[37] *Id.*
[38] http://www.energystar.gov/index.cfm?c=Products.pr_tax_credits
[39] Federal tax credits for energy efficiency, Energy Star. [*hereafter* Tax Credits] (*See* http://www.energystar.gov/index.cfm?c=products.pr_tax_credits)
[40] Mercury product labeling and notification: State Mercury added labeling guidelines, NorthEast Waste Management Officials Association (NEWMOA). [*hereafter* Mercury Label] (*See* http://www.newmoa.org/prevention/mercury/imerc/labelinginfo.cfm)
[41] Tax Credits, *Supra.*
[42] *Id.*
[43] http://www.politics.co.uk/the-economy/tax-credit-system-slammed-$8805389.htm
[44] Appropriations Analysis, *Supra.*

communication with the consumer. In a study conducted by the Efficiency Partnership, researchers have identified five market barriers to energy efficiency: (1) lack of public information, (2) lack of geographic consistency, (3) lack of continuous marketing, (4) limited promotional resources, and (5) lack of coordination.[45]

A platform which may act either as a model or a vector is California's highly successful "Flex Your Power" (FYP) campaign, which relies on a partnership between private and public organizations to promote various ways to save energy and reduce energy bills.[46] FYP provides a well-established forum to focus efforts on lamp efficiency in public education. For example, FYP already provides a great deal of information and tips for the consumer, including how to compare the light output of a traditional incandescent versus a compact CFL. A next step for the campaign could be to disseminate that information in ways that reduced the need for consumers to look themselves for information.

This type of instrument is probably more effective when in combination with other incentives to modify consumer behavior, whether market-based or regulatory.

Labeling

Labeling provides a very convenient access point for the CEC to communicate with the consumer. Labels can communicate a breadth of information, and a range of labels are currently used with appliances. An equivalent to an Energy Guide label – as used for appliances – may communicate information such as the environmental impact and energy usage of the product. This kind of label can also allow the consumer to compare operating costs. The European Union has created its own "EU Energy Label" which rates an appliance based on efficiency classes ranging from A (most efficient) to G (most inefficient) and includes other comparison information depending on the product.[47] Every lamp label in the EU includes the A to G classification, the luminous flux of the lamp (given in lumens) the electrical power consumption (given in watts), and the average life (given in hours).[48] These labels provide consumers with not only an expectation about the product but also highlight the greater impact that the bulb has on the environment.[49] Additional information that could be included is the carbon footprint, currently being researched as a standard for fuel efficiency. This type of standard can bridge across markets and tie into an eventual "cap and trade" market for carbon emissions.

Labels can become confusing for the consumer if they provide too much information, or use terms that are not easily understood. Labels should be used and monitored in a way to aid the consumer and not mislead or confuse the consumers' purchasing decision. In an effort to reduce confusion, the CEC may wish to include a brand label in addition to or in place of an informational label. Standardizing information reduces consumer confusion and eases consumer search by creating a familiar set of information and points of comparison between

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[45] *Efficiency partnership, 2004-2005 Flex Your Power coordinated statewide marketing and outreach program implementation program*, Flex Your Power.[*hereafter* Flex Your Power] (*See* http://www.fypower.org) (*See also* http://www.fypower.org/pdf/EP_PIP_Narrative.2.17.04.pdf)
[46] *Id.*
[47] Various articles on European Union energy labeling. [*hereafter* EU Energy Labels] (*See* http://en.wikipedia.org/wiki/European_Union_energy_label#Light_bulbs)
[48] *Id.*
[49] *Id.*

similar goods.[50] The value of a trademark is predicated on the notion that reducing consumer search adds value by increasing the economic efficiency of the product.[51] Branding certain lamps with an existing program such as "Flex Your Power" (FYP) will attract attention from the customer, since the brand is already known in California. A FYP label also creates an opportunity to advertise "efficiency tips" on every package.

Another alternative is to create a state level certification program based on the federal level Energy Star program (e.g. "California Star").[52] The aim of certification is to avoid rule making at the state level in anticipation of a federal standard set for implementation by 2015. If California chooses to base its brand on the Energy Star model, it can offer a variety of programs, such as tax credits, through associated campaign efforts. A California program could also reduce consumer search and increase the confidence that consumers have in their purchase by relying on a state-endorsed select grade of products. [53] Enforcement is an ongoing problem with certification and is a problem that Energy Star is currently combating. However labeling or certification is implemented, it is the challenge of the CEC to ensure that the label used is meaningful, consistent, and useful to the consumer's purchasing decision.[54]

The material contained in labels should be accurate; consumers should be able to trust in the content provided in the label. The purpose of labeling is to increase the transparency and impact of a good, with the intent of manipulating consumer behavior. Misbranding, or otherwise inaccurately representing the contents of the material on the label could be considered a violation of the Federal Trade Commission Act (15 U.S.C. 41 et seq.).[55]

An issue to be mindful of is determining who in the supply chain affixes the labels. California has harbored the burden of leading the country in efficiency standards but also shares this burden with parties on the supply chain. The CEC may demand that lamp manufacturers or distributors apply the labels for sale on California shelves, depending on where the responsibility logically falls. Retailers may also harbor responsibility to not knowingly selling products without the appropriate labels.[56]

Early Adoption by Government

Adoption by the state government could be achieved through the California Department of General Services (DGS) (as suggested in the Huffman and Torrico bills).[57] This department is responsible for entering into regular agreements with suppliers to the state. The goods must be approved, and contracts are generally, but not necessarily awarded to the lowest bidder or to the "Best Value" offer.[58] Bidding methodology varies depending on the estimated value of the

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[50] Cooperative labeling programs. (*See also* http://www.makebarcode.com/services/co_opLabels.html)
[51] *A search-cost theory of trademark defenses*, Stacy L. Dogan and Mark A. Lemley, dated March 1, 2007. (*See* http://www.law.stanford.edu/publications/details/3659/)
[52] Energy Star website. [*hereafter* Energy Star] (*See* http://www.energystar.gov/)
[53] *Id.* (*See also* http://www.energystar.gov/index.cfm?fuseaction=rebate.rebate_locator)
[54] Eco-labels website. (*See also* http://www.eco-labels.org/label.cfm?LabelID=39)
[55] 15 U.S.C. 69. (Commonly known as Fur Products Labeling Act). (*See* http://www.ftc.gov/os/statutes/textile/furact.htm)
[56] Mercury Label, *Supra.*
[57] http://www.pd.dgs.ca.gov/ *See also* "Bill Analysis", Nicol, Chuck. Assembly Committee on Approprations. May 16, 2007.
[58] [*hereafter* Department of Goods and Services] (*See* http://www.pd.dgs.ca.gov/sell2state/default.htm#statebuys)

contract.[59] Additionally, state law through the Public Contract Code, §§ 12400 – 12404 requires that the State engage in Environmentally Preferable Purchasing (EPP). The DGS identifies "Environmentally Preferable" products as "long lasting, high-quality, less toxic, reusable, and easy to recycle."[60]

State government could increase the effectiveness of its other efficiency requirements by initially implementing those standards before they are imposed on the public. The benefits of early government contracts could demonstrate to manufacturers that despite increased regulation, the government does support a market for highly efficient products. Additionally, it could lead by example the public to adopt more efficient lamp technology. The EU has created a legal obligation through the European Display® Campaign, requiring local authorities display the environmental performance of their government buildings.[61] This program can tie-in with other public awareness and labeling campaigns.

Wattage Excise Tax

The model behind any excise penalty is a statutorily imposed tax upon the use of a good. Traditional examples include a tax on goods like luxury vehicles or petroleum products. Besides directly addressing the issue of consumer inertia, the revenue generated could then be used to fund education and awareness programs.

A form this instrument could take could be a tax of $0.01 per nominal lamp watt. The idea is to incentivize consumers to purchase lamps that meet, but do not exceed, their lighting needs. As things are now, a 100 W incandescent lamp costs the same as a 60 W lamp, so there is no price signal to distinguish between incandescent wattages. Furthermore, this tax would further reduce the price difference between the price of incandescent lamps and CFLs. A threshold of efficiency could be defined, say defined by Energy Star requirements for CFLs, above which the tax would not apply, in order not to penalize the most efficient technologies.

A new tax could be unpopular with part of the public, but, with growing awareness of energy and environmental issues, this type of "green", or "energy security/independence" tax may actually be viewed as positive action to reduce waste and penalize irresponsible behavior.

Super CFLs

Another way of addressing the dominance of the incandescent lamp is to take steps to address the consumer acceptance issues with CFLs with an initiative that motivated manufacturer competition to develop a CFL lamp that addressed all those issues. This could be done, possibly in partnership with the utilities, by promising large volume orders of a lamp that could meet a high-performance specification.

Some of the primary consumer concerns have been the color quality and the appearance of the CFL lamp, compatibility with existing infrastructure (dimmers, timers, etc.), size, start-up and run-up time, the accidental release of toxins during disposal, and cost. If these were addressed,

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[59] *Id.*
[60] http://www.green.ca.gov/EPP/default.htm
[61] http://en.wikipedia.org/wiki/European_Union_energy_label#Light_bulbs

it is possible that consumers could actually *prefer* CFLs to incandescents, since they, for example, save money, energy, and pose less of a fire hazard.

The technical potential already exists for such a lamp. Dimmability, high color quality, light level and color constancy, long life, lamp size and shape similar to incandescent and reliable high-temperature performance are all achievable by fluorescent technology today. The amount of mercury that is used in fluorescent lamps has also been decreasing. No fundamental leaps or changes in fluorescent technology seem to be the question here: the challenge lies more in promoting market conditions in which existing or upcoming products that integrate these qualities have greatly increased volume demand. With strong incentives and decisive initiative, it is conceivable that significant market change could take place by the end of the present decade.

5. IMPLEMENTATION ISSUES

Certain challenges and concerns are common to more than one of the individual policy suggestions mentioned above. The following paragraphs will highlight those recurring problems.

Hazardous Waste

Without any changes in technology, there would be certainly an increase of mercury in the waste stream that would need to be dealt with if CFLs were to become more widespread. The public would certainly need to be educated, and an effective infrastructure implemented for separating CFLs from the rest of the waste. Anecdotal evidence indicates the current infrastructure to be markedly insufficient.

A question that has yet to be answered is whether the benefits from a decrease in lead presence in the waste resulting from reduced incandescent use could possibly compensate for the increase in mercury – especially since the average lifetime of CFLs can reach an order of magnitude longer than incandescents.

CLTC is at present researching the quantification of these issues.

Phasing of Incandescent Wattage Reduction

The lamp manufacturing industry has proposed, in the United States as well as in the European Union, to reduce the wattage of incandescent lamps by between 20% and 30%, depending on lamp wattage, while maintaining light output. The proposal is for this to happen in phases during the next decade, one lamp wattage at a time.

It is laudable that this is a voluntary initiative. That notwithstanding, significant issues can be raised about its effectiveness in actually reducing lighting energy consumption.

Even if all wattages were changed simultaneously, it is not clear that consumers would replace expired incandescents by new lamps of the same light output, rather than use the same wattage and rejoice in the higher light output. The phasing of wattages one by one introduces further uncertainties in this process, increasing the potential for consumer confusion.

Exemptions

In any standard or initiative that is aimed at removing the least efficient lamps from market, care must be taken not to leave loopholes that would allow the continued availability of those lamps under an alternative designation.

There are all categories that, if exempted, have loophole potential:

- Enhanced spectrum lamps
- Infra red lamps
- Reflector lamps
- Rough service lamps
- Shatter resistant lamps
- Sign service lamps

One way to avoid exploitation of exemptions is by capping them at a certain volume, or market share, beyond which the exemption is revoked.

Misapplication by Consumers

A significant concern with any new technology is misapplication by the user. The consumer will likely not be familiar with new technology as it advances, and without proper education, consumer misuse could have deleterious effects, especially if policy is not properly designed. For example, if restrictions on general service incandescent lamps led to mass replacement by incandescent reflector lamps, which are even less efficient, the end result could actually be an increase in energy consumption. As mentioned above, similar issues can be raised if incandescent lamp wattages are reduced but consumers keep using the same wattage.

Misapplication also extends to CFLs. If their use becomes more widespread, it is likely that more failures will occur from their use in enclosed fixtures, electronic devices, dimmers, etc.

All these possibilities point to the vital importance of consumer education programs for the effectiveness of any other policies directed at increasing residential lighting energy efficiency.

6. SCENARIOS FOR CALIFORNIA LIGHTING ENERGY CONSUMPTION 2001-2018

An important element for the formulation of successful policy is the quantification of the expected benefit of each option. This section includes ten-year projections for California residential lighting energy consumption, allowing for several different scenarios. This exercise is inspired by the lighting energy reduction targets prescribed in the July 7, 2007 version of the Huffman bill (AB 1109), namely to "reduce statewide electrical energy consumption by not less than 50% from the 2007 levels for indoor residential lighting and not less than 25% from the 2007 levels for indoor commercial and outdoor lighting by 2018". Please note that these projections are meant to be merely indicative of trends and magnitude in energy consumption, and that, with more time and data, more detailed and accurate projections are certainly possible. The present projections may nevertheless be useful in framing and directing discussion of policy options.

The number of households in California is projected to evolve as shown in Figure 3. Three levels of growth are shown. The highest assumes current trends persisting – approximately 1.2%, or 150,000 new households per year (from US Census data for 2000-2005). The middle trend assumes half of that growth rate and the lower line assumes no growth in the number of households. The number of homes that comply with Title 24 2005 is also shown, and it comprises new housing as well as retrofits at an annual rate of 1.4% [RLW 2005].

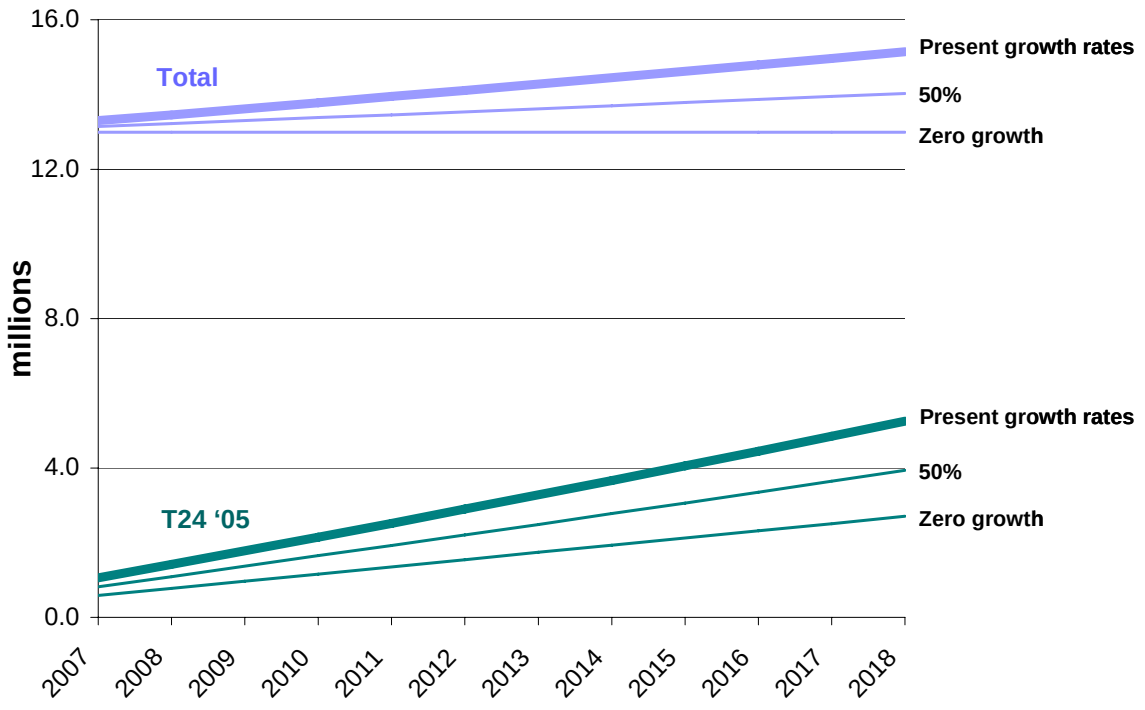


Figure 3 Number of households in California (projection)

The scenarios also include assumptions about growth in the number of lamps per household. According to the RLW study [RLW 2005], the average household had 39 lamps in 2000 and 46 in 2005 – a sizeable increase. After that, that number is assumed to grow at half that rate, to

reach the vicinity of 50 lamps per household in 2018. It was assumed that an increase in number of lamps per household implied a directly proportional increase in lighting energy consumption. Research is needed to ascertain whether that is, in fact, the case. It is also not known whether the increase in lamp numbers is primarily due to increases in household size or in lamp density.

No Action

If no action is taken, lighting energy consumption is projected to evolve as shown in Figure 4A. In 2007, residential lighting energy consumption is estimated to be in the vicinity of 14 billion kWh, equivalent to 3.9 million metric tons of CO_2, increasing to slightly over 20% more in 2018. On a per household basis, the evolution of lighting energy consumption is shown in Figure 4B. As new houses are added to the stock, and other houses are renovated, the consumption of the average house gradually approaches that of houses compliant with Title 24 2005.

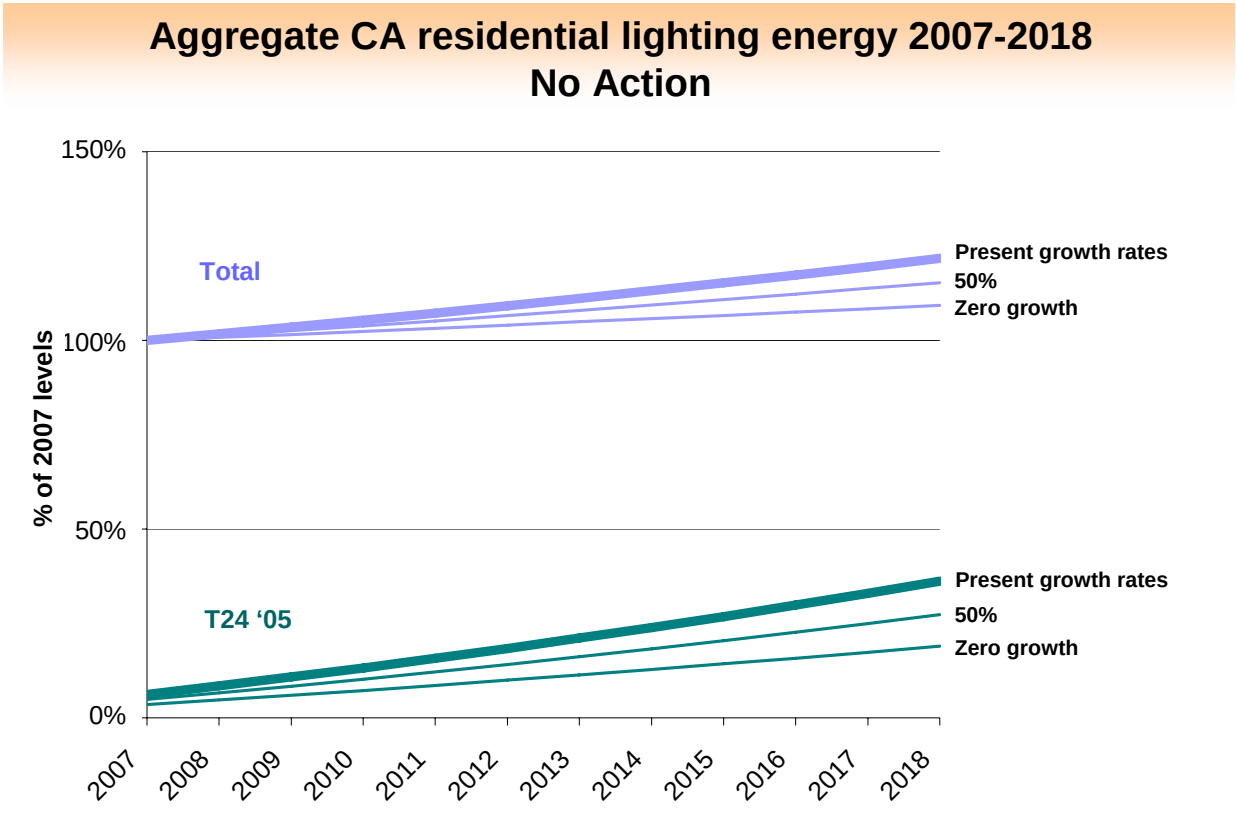


Figure 4A Aggregate lighting energy consumption by California households under current policy (projection)

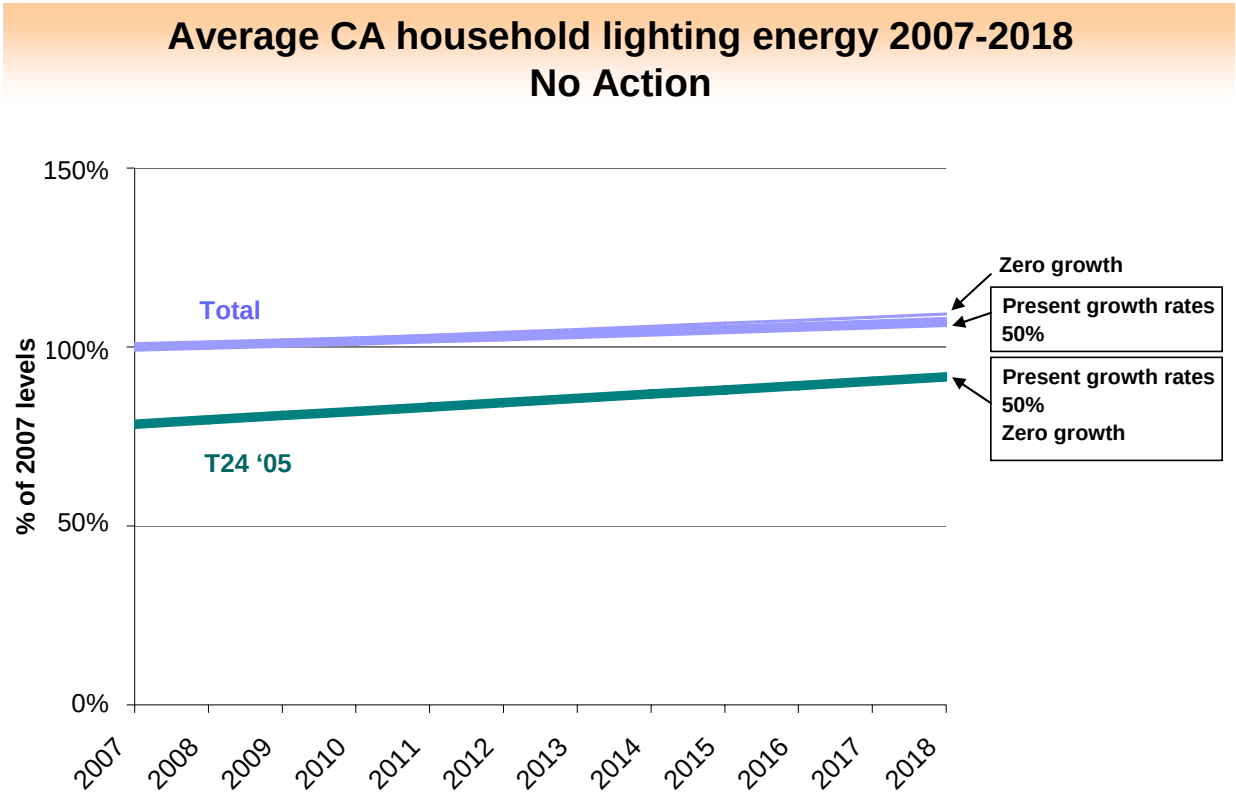


Figure 4B Lighting energy consumption per California household under current policy (projection)

Increased CFL Market Penetration

If a successful full ban on incandescents were to be enacted in 2010 and therefore all of those lamps were replaced by CFLs or other lamps of the same efficacy during that year, the effect on lighting energy consumption would be drastic, either in aggregate or at household level, as shown in Figures 5A and 5B. If that market penetration of high-efficacy lamps were achieved gradually between the present and 2018, the decrease in energy consumption would also be gradual, as shown in Figures 6A and 6B. Note that for both non-zero-growth scenarios (two uppermost curves), the increase in energy consumption would resume after 2018, this due to continued growth, both in number of houses and number of lamps per household. This also applies to all the following scenarios except the last one, where the effects of the building code are permanent. Figures 7A and 7B show the effects of achieving 50% CFL penetration gradually. As with Figures 6A and 6B, the effect is gradual, but rather less marked.

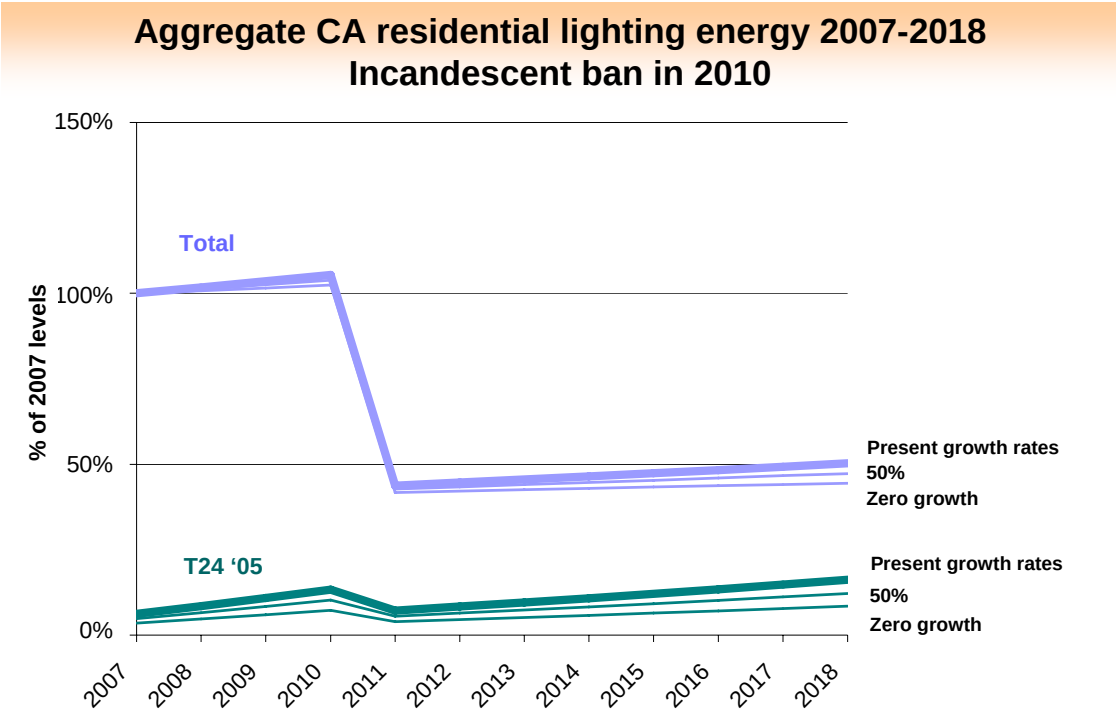


Figure 5A Aggregate lighting energy consumption by California households under 2010 incandescent ban (projection)

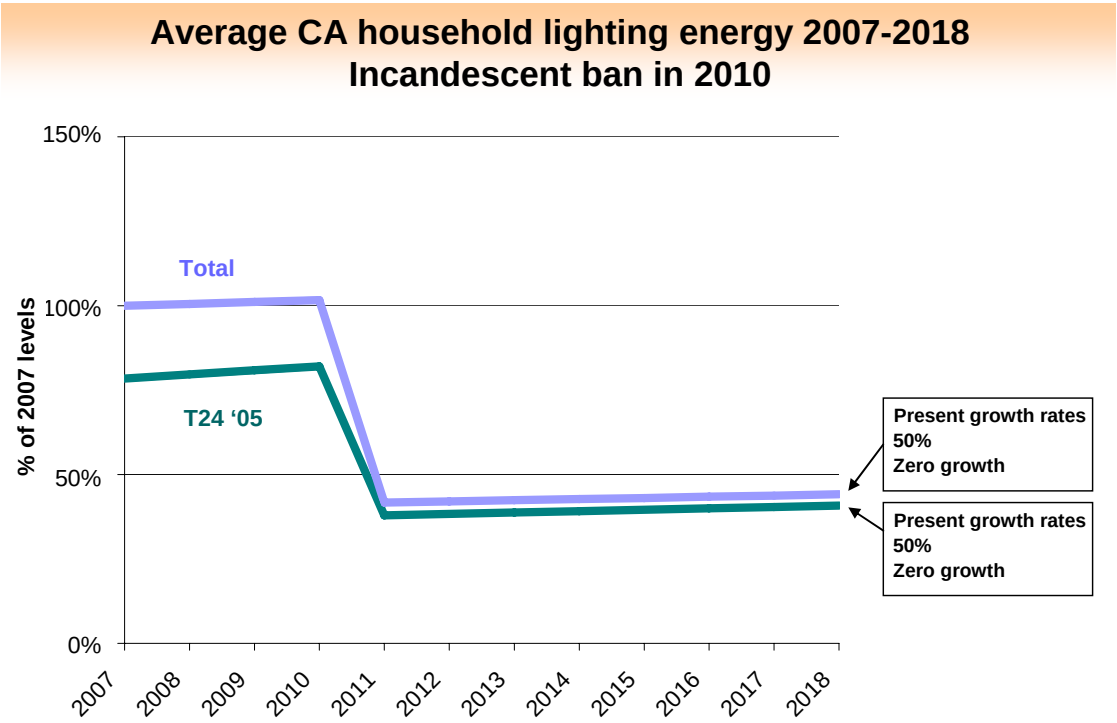


Figure 5B Average lighting energy consumption per California household under 2010 incandescent ban (projection)

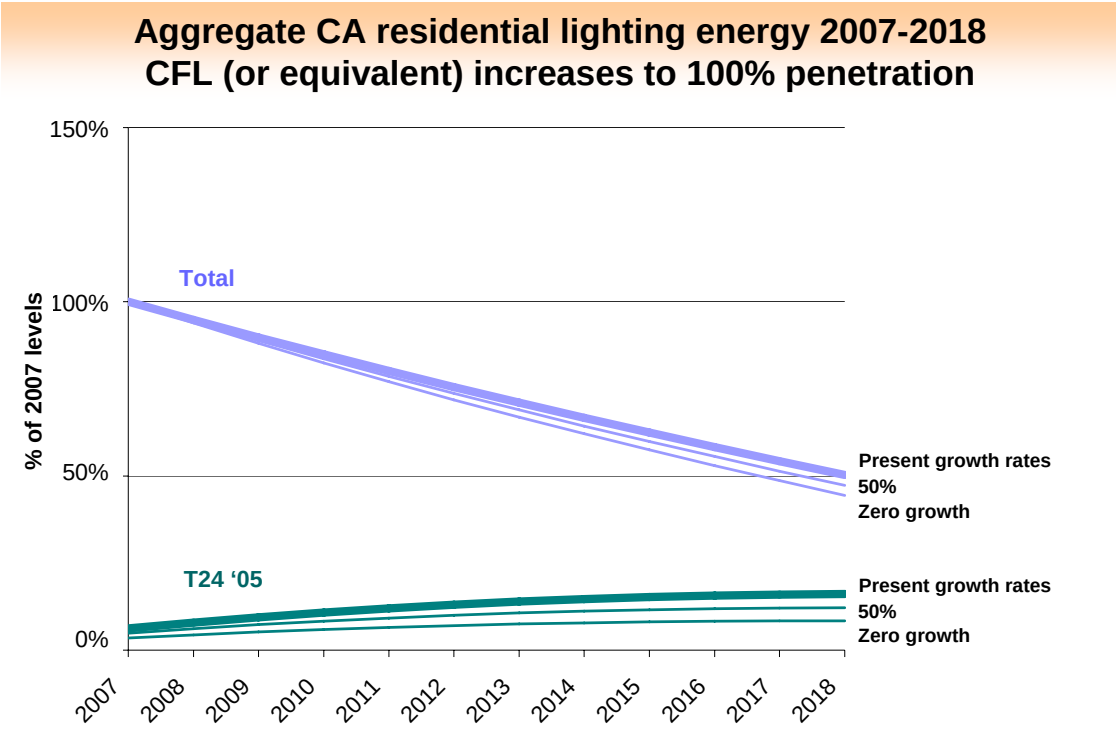


Figure 6A Aggregate lighting energy consumption by California households with gradual achievement of 100% CFL or equivalent market penetration (projection)

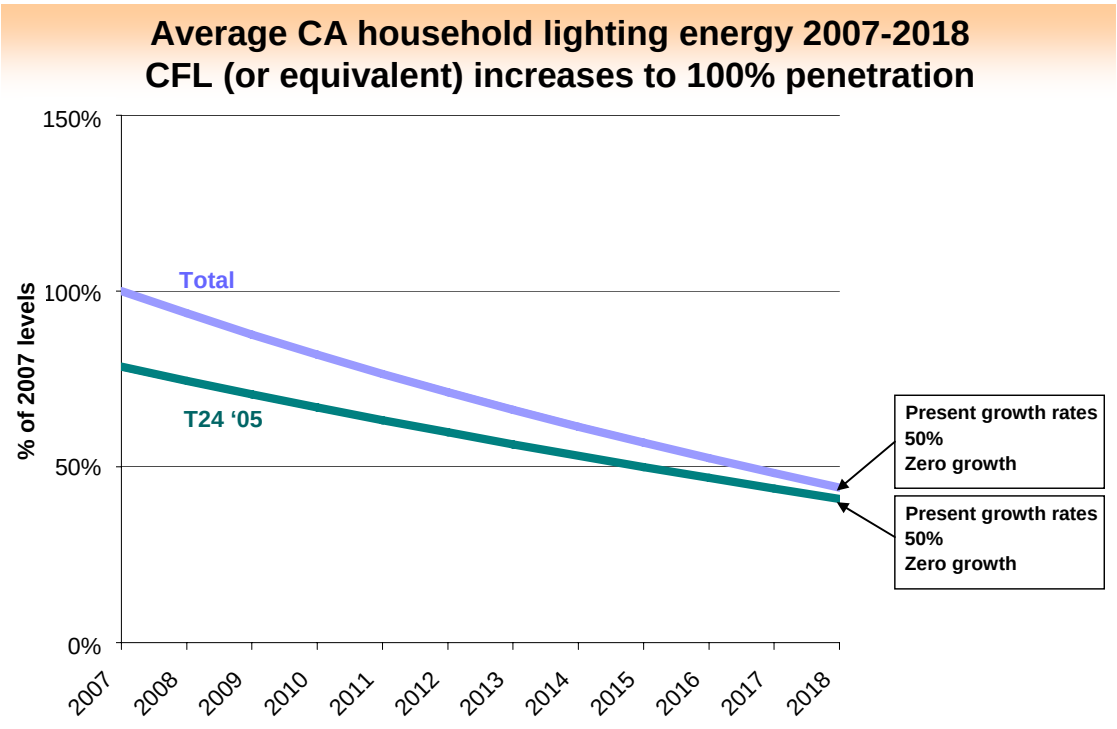


Figure 6B Average lighting energy consumption per California household with gradual achievement of 100% CFL or equivalent market penetration (projection)

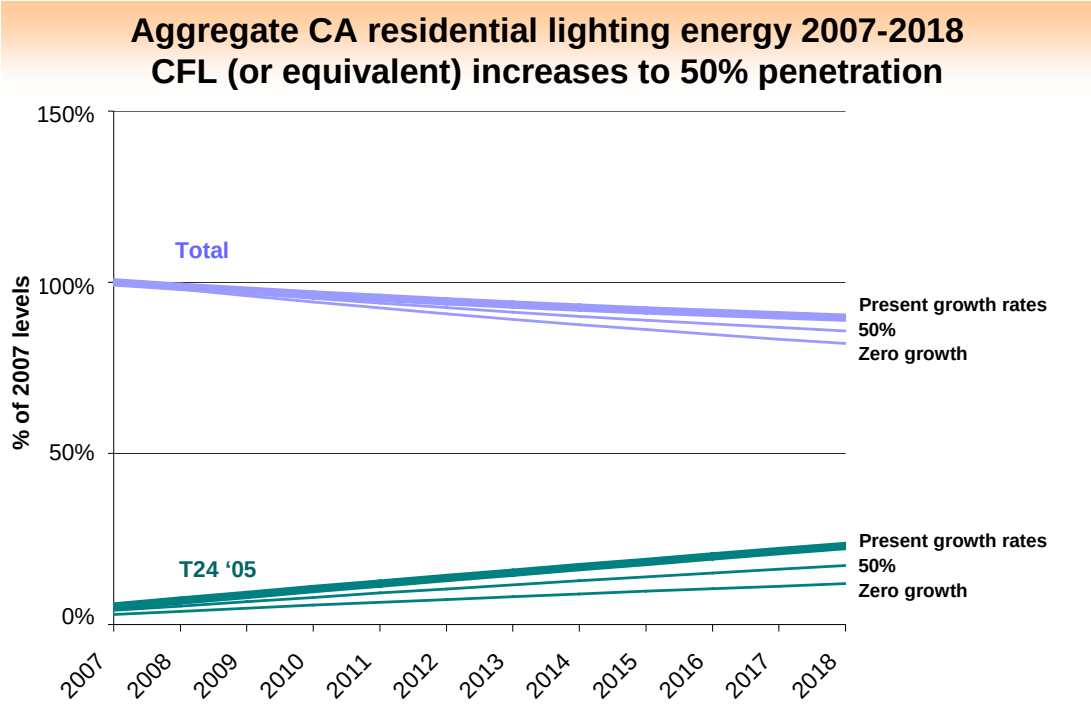


Figure 7A Aggregate lighting energy consumption by California households with gradual achievement of 50% CFL or equivalent market penetration (projection)

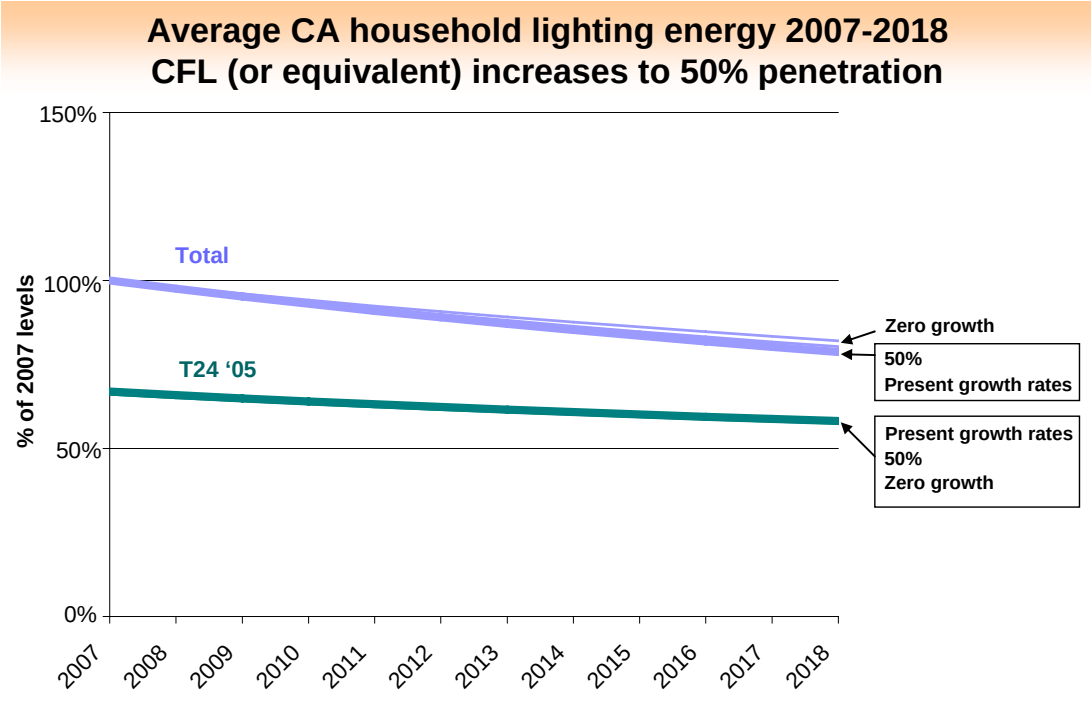


Figure 7B Average lighting energy consumption per California household with gradual achievement of 50% CFL or equivalent market penetration (projection)

Reduction in Incandescent Wattage (Industry Proposal)

If current policy is maintained and incandescent lamp wattages are reduced according to the current industry proposal, the effect in energy consumption is as shown in Figures 8A and 8B. Note that this assumes perfect consumer behavior: lamps are replaced with new lamps of the same light output. A first-order estimate of the effect on energy consumption of a wattage reduction along the lines of the European Union industry proposal is also shown.

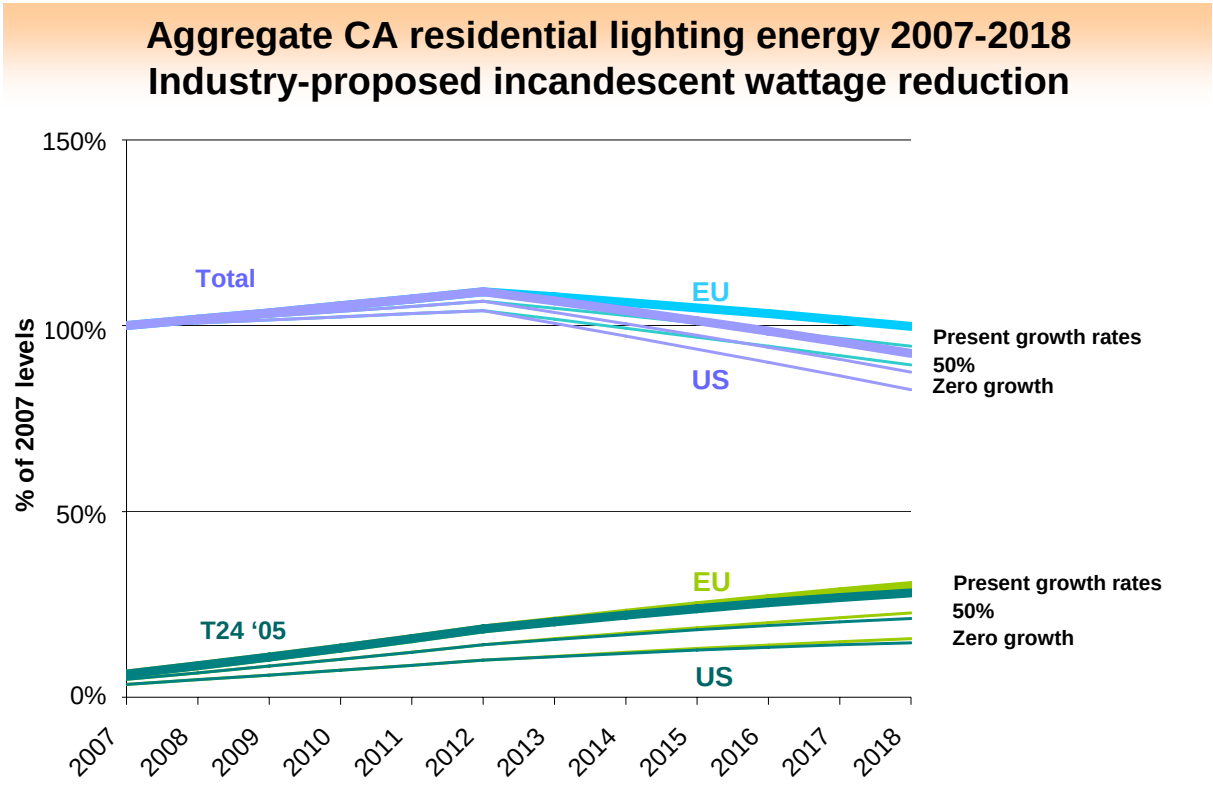


Figure 8A Aggregate lighting energy consumption by California households with gradual wattage reduction between 2012 and 2018, according to US and EU industry proposals (projection)

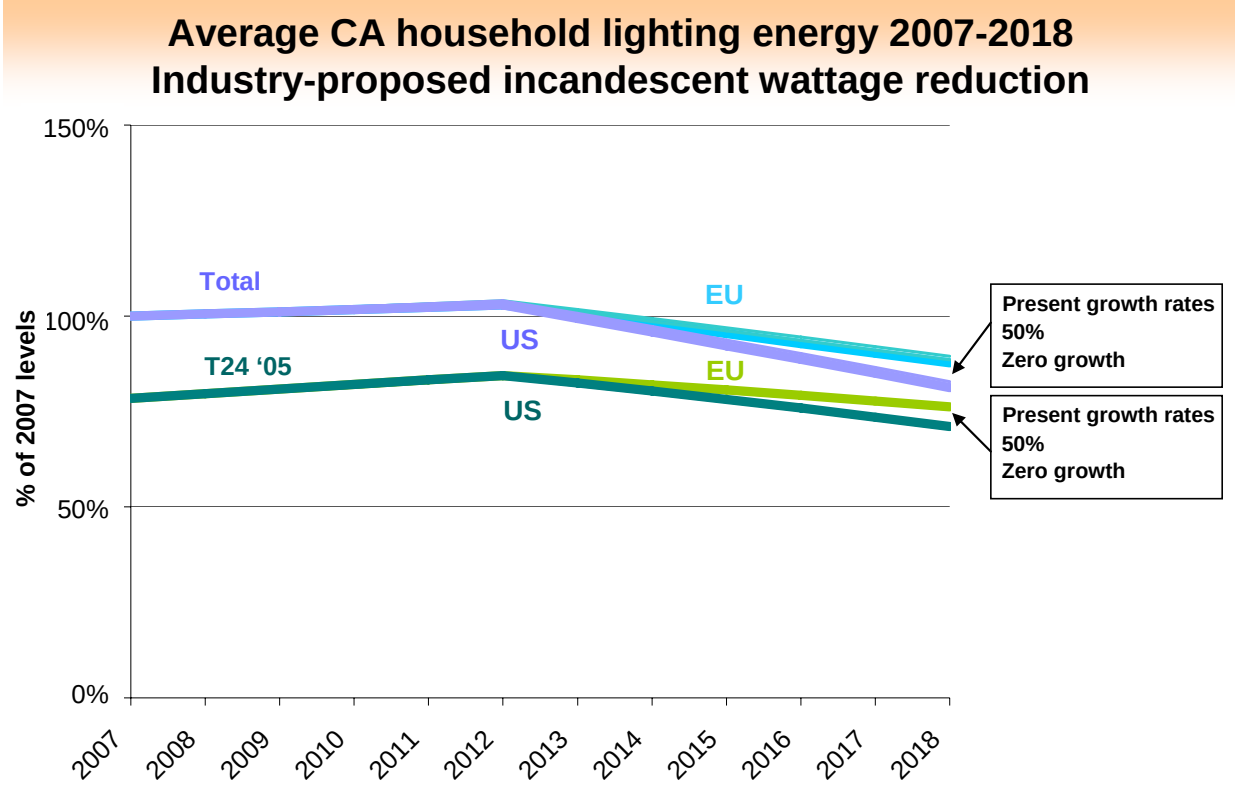


Figure 8B Average lighting energy consumption per California household with gradual wattage reduction between 2012 and 2018, according to US and EU industry proposals (projection)

Zero-Energy Building Code

This hypothetical scenario assumes that, from 2008 on, every new or retrofitted household does not consume any net energy with lighting – e.g. through the use of photovoltaic solar panels. This allows us to see what the maximum effect of building codes could be.

An important distinction, not adequately shown in these plots, between building codes and other measures, is in the time span of their effect. For all other measures studied here, the previous trends in growth are resumed after the time period during which they take place elapses. See for example figures 5A and 5B, where, for the positive growth cases, consumption keeps increasing after the ban, albeit from a much lower starting point. This is the case for all the other scenarios, although it is not shown in the plots because trends would resume in 2019. Building codes, however, have an effect in lighting energy consumption that can be considered permanent, even if less marked than in the example shown here.

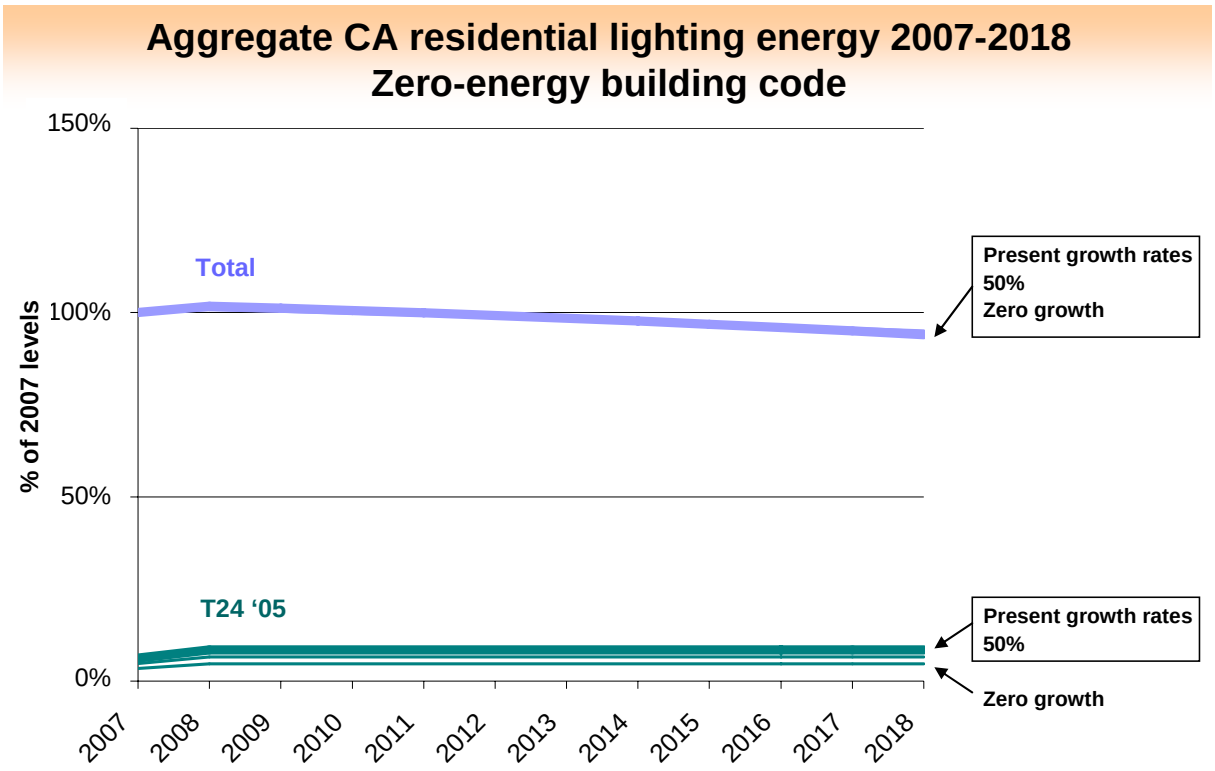


Figure 9A Aggregate lighting energy consumption by California households with zero-energy building code after 2008 (projection)

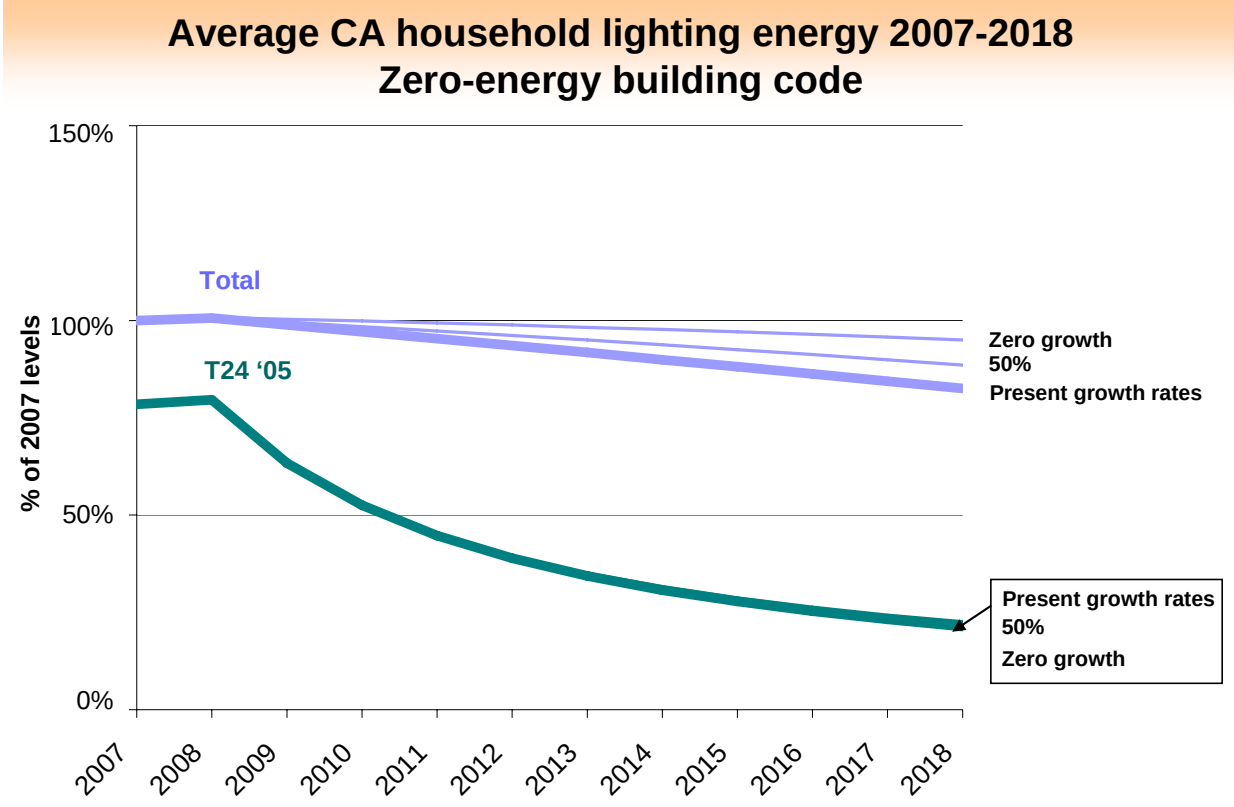


Figure 9A Aggregate lighting energy consumption by California households with zero-energy building code after 2008 (projection)

7. AN INTEGRATED POLICY

1. Consumer Education and Information

An educated and motivated consumer can only be an advantage, whatever the range of other tools deployed to reduce lighting energy consumption, so it could be argued that consumer education and information should be the first pillar of any successful policy, and should make the best use of the variety of information channels available today.

Labeling provides a powerful tool to build on consumer education, providing information clearly for consumer decision-making. Labeling by manufacturers may be voluntary or prescriptive. Labels must provide the information that consumers need to understand the energy and performance implications of their lamp purchase decisions. Labels should at least include light output (lumens), power (watts), efficacy (lumens per watt), life (hours), some measure of yearly energy expenditure (dollars) and color temperature. Color temperature can be a difficult concept to grasp but is an essential factor for combining different light sources harmoniously in the same space. It should be specified in a way that allows consumers to understand what color lamp they are buying. A very basic example, based on research carried out by the Lighting Research Center [Leslie 2006] is shown in Figure 10.

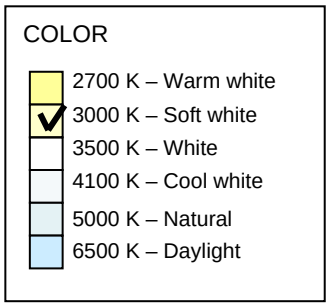


Figure 10 Example of color temperature label that includes the color temperatures, names, and colors indicative of the range of colors available.

2. Appliance Standards

A second pillar should be the removal from the market of the most inefficient products. Appliances standards could be put to very effective use here. With this type of instrument, several different approaches could be taken. As Australia and other countries are considering, the efficiency bar could be set so that conventional incandescent would be phased out, leaving the halogen incandescent as the only allowable technology. That bar could also be set higher, to a level approaching CFL efficiency, requiring then much more fundamental changes for incandescent technology to remain. The most appropriate level would most probably be found after extensive discussions between state regulators, utilities, industry and advocate groups.

A way to compound the effectiveness of this prescriptive measure – especially if it is found that the feasible efficiency bar is rather low – could be to combine it with an excise “green” tax on the more inefficient lamps, to reduce economic incentive for consumer purchase of

inefficient technology. This tax could be a source of funds for consumer education and information or for the incentives mentioned below.

3. Incentives for Best Technologies

A third pillar of a successful approach should be the promotion of the most efficient technologies available that also have high amenity quality (color, no flicker or noise, dimmability), with the objective of making them the consumers' default choice for a light source. This could include LEDs some time into the next decade, but for the present CFLs are the high-efficiency source of choice. Besides the fundamental consumer education efforts, several sorts of monetary incentives – rebates or tax breaks – for products that met certain quality specifications could be used to increase the market share of higher-quality products that addressed the barriers that have kept this technology from achieving wider consumer acceptance. It is very important that efforts to achieve higher market penetration of CFLs are combined with adequate infrastructure for their disposal, due to the presence of toxic metals in their composition. The effectiveness of this infrastructure could be increased by refunding part of the price of lamps upon appropriate disposal, analogously to California Refund Value for bottles.

4. Building Code

Finally, as shown in the previous section, building codes can be a very effective long-term tool – eventually all buildings in California will be touched by Title 24 – and periodic updates that incorporate the latest technological developments are likely to result in further reductions in lighting energy consumption.

8. CONCLUSIONS

Achieving a significant reduction in lighting energy consumption in California is beyond a merely technological challenge. Highly efficient technology already exists in the form of compact fluorescent lamps (CFLs) and the prospects for solid state (i.e. LED) lighting in the next decade are very promising. The real challenge lies in constructively achieving market transformation.

An integrated approach comprising four components is suggested here. The basic component is consumer education – a motivated and informed public increases the likelihood that any other components will be well received and function as intended. Secondly, appliance standards are necessary to reduce or end the availability of the least efficient lamps. Standards can be combined with measures such as an excise tax, and clear and informative labeling requirements. The third component is to promote the higher-quality high-efficiency lamps with the potential to become the consumers' preferred, and, in the long run, default choice. Useful tools here are monetary incentives for products that meet certain specifications. Finally, regularly updating building codes taking into account the latest technological developments addresses the longer term.

Besides the direct economic and environmental benefits, a successful integrated approach to ambitiously reduce lighting energy consumption could also serve as an example for energy efficiency initiatives in other areas and in the rest of the country.

APPENDIX A: LAMP SALES DATA

The data shown in this appendix complements the installed lamp data shown in Section 1.

Available data shows that US incandescent sales are just over a billion units per year, with about 1.1 billion units in 2000 and about 1.4 billion units in 2005, data for both the US and California is provided below. Available 2005 data is less detailed than what has been available in the past, due to some collection changes and retailer confidentiality issues. Note that sales data do not distinguish between residential and commercial/industrial sales. Industry experts suggest about 2/3 of lamps sales are destined for residential and small commercial use.

Table 1: California sales of included lamp types in 2000[7]

Watts	Soft White	Vibration Resistant	Standard Clear	Total
40	6,913,961	327,785	2,807,771	10,049,516
60	25,402,783	435,953	6,312,060	32,150,796
75	15,131,053		3,196,726	18,327,780
100	9,338,296		4,071,127	13,409,422
150	283,948	24,601	70,824	379,373
	57,070,041	788,339	16,458,507	74,316,888

Table 2: National sales of included lamp types in 2000[8]

Watts	Soft White	Vibration Resistant	Standard Clear	Total
40	104,756,984	5,471,256	42,037,158	152,265,398
60	384,890,653	6,605,354	95,637,271	487,133,278
75	229,258,382		48,435,249	277,693,631
100	141,489,328		61,683,736	203,173,064
150	4,302,245	372,746	1,073,085	5,748,076
	864,697,592	12,449,356	248,866,499	1,126,013,447

Reproduced from [Ecos 2004]

Figure 4: Incandescent Lamp Sales – by Type – 2005

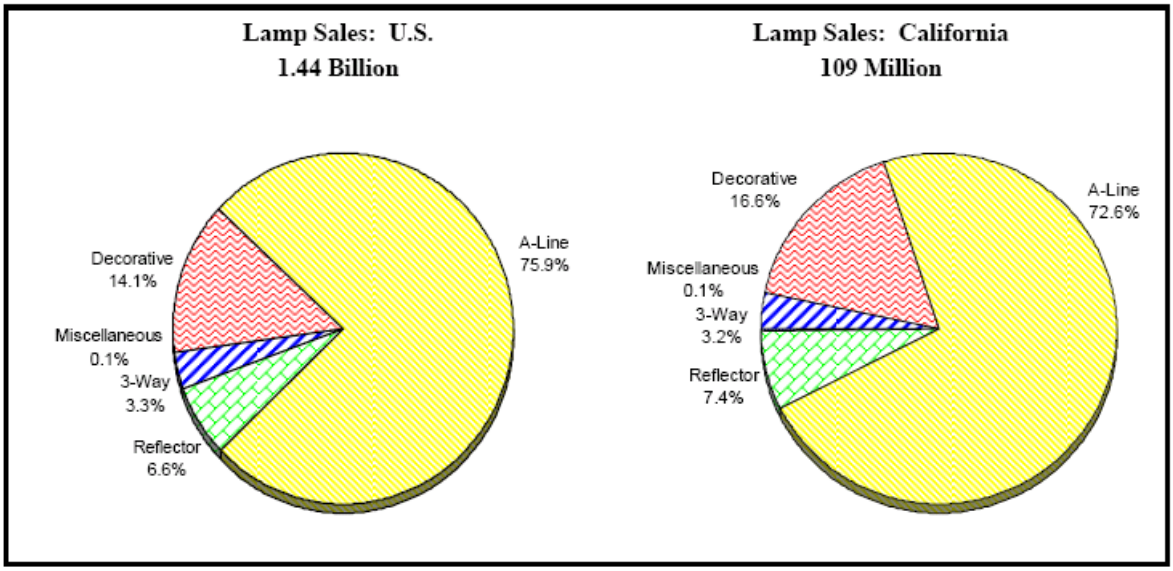
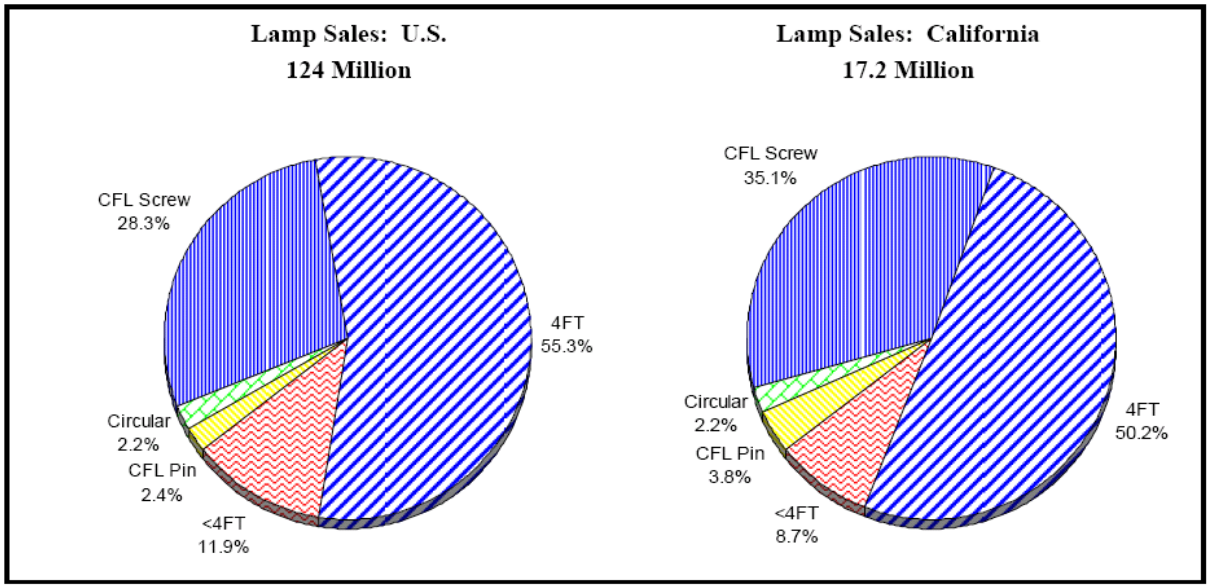
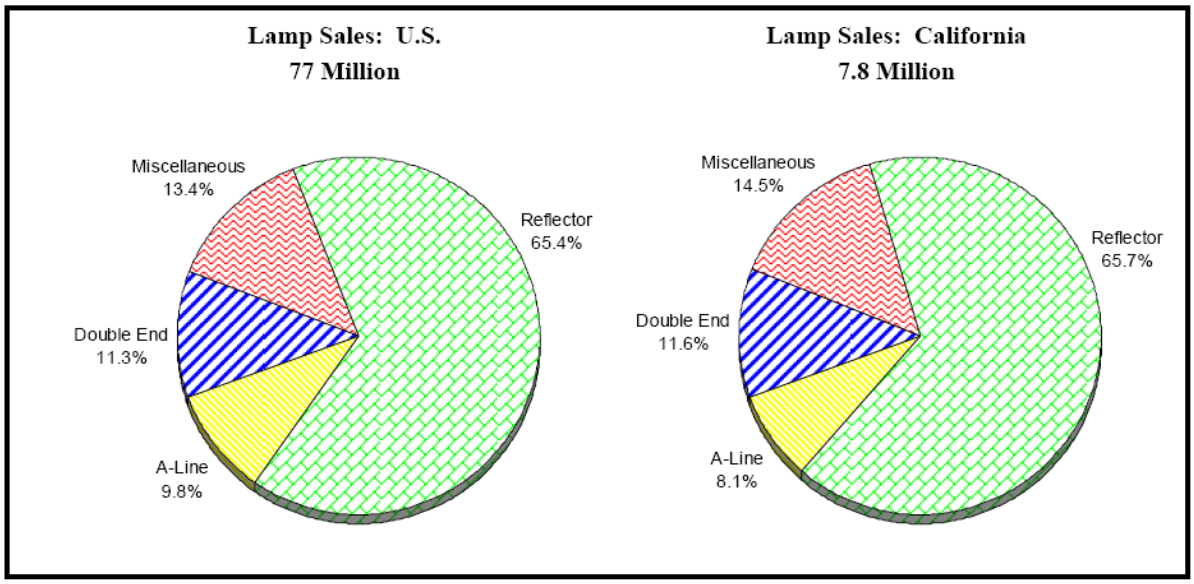


Figure 5: Fluorescent Lamp Sales – by Type – 2005



Reproduced from [Itron 2006]

Figure 6: Halogen Lamp Sales – by Type – 2005



Reproduced from [Itron 2006]

Newer data from consulting firms AC Nielsen and Activant indicates that, in terms of market dollar value, incandescent light bulb sales are estimated to be $3.29 billion in 2005. Market dollar value data also indicates that while there are some fluctuations in general service incandescent sales, the incandescent share of the overall lamp market remains significant in the past few years. Remarkably, there is still room for growth in the incandescent lamp market, mostly in the high-end and specialty areas. The recent introduction of higher-end and specialty bulbs, including decorative candelabras, halogen and incandescent bulbs, such as GE's Reveal bulb, marketed to enhance the natural color in a home's décor – have helped to fuel overall market growth.

“Upsell” halogen – specialty halogen lamps designed to be used in low-voltage, decorative fixtures such as track and spotlight – represents one of the fastest growing lamp category in the past five years. These lamps now represent about 17 percent of the overall lamp market in 2005. Also worth noting is the fact that fluorescent lamps (both linear and CFLs) also saw increased market share since 2000 and now occupies about 23 percent of the lamp market. General service incandescent lamps, which commanded 69 percent of dollar share in 2000, declined to 59 percent in 2005.

The market data also tracked sales in home centers since 2000. Within this sales channel, the product mix has remained steady with slightly more emphasis on halogen and fluorescent. Total home center market's dollar share in 2005 shows a breakdown by incandescent at 44 percent, fluorescent at 32 percent, halogen at 23 percent and all other at 1 percent. For the same period in 2000, incandescent had 48 percent dollar share; fluorescent 30 percent; halogen, 21 percent; and all others, 1 percent.

It is important to note that market share and adoption rates are two different things. Adoption rates basically refer to what fraction of the bulbs installed in homes and businesses are currently CFLs. Those numbers can become quite high after a few years of decent CFL

sales, because CFLs last so much longer than typical incandescents. Market share of light bulb sales will tend to be a much lower number, because of the differences in bulb life.

The two available main sources for CFL data differ significantly. Based on current numbers from Lawrence Berkeley National Laboratory [Atkinson 2007], the national market share of CFLs might have already moved past 10%. LBNL estimates that about 200 million CFLs were sold in the U.S. in 2006, of which about 1/3 (66 million CFLs) were purchased by commercial and industrial concerns, and the remaining 2/3 (133 million CFLs) were sold through retail stores, which primarily serve the residential and small business market. This data tracks well with the dollar value reported by other data sources cited above (at about 18% of the market). Based on these data sources, US CFL sales are about 18% to 23% of lamp sales in 2006.

Itron's projection for 2005, on the other hand, came in at 124 million units total, with CFLs making up 28.3%, or 35 million units, with only 6 million units in California. Since 2006 data is not yet available from Itron, it is difficult to believe that the CFL market can grow 400 percent in 12 months.

Table ES-2. Average Number of Lamps per Building and Total Lamps, 2001

Technologies	Residential	Commercial	Industrial	Total Lamps in US	Percent of Lamps
Incandescent	39	91	33	4,397,000,000	63%
Fluorescent	6	324	1,340	2,473,000,000	35%
HID	0.04	7	67	105,357,000	2%
Solid State	-	0.4	0.3	1,840,000	0.03%
Total	45	422	1,440	6,977,197,000	100%
Number of Buildings	106,989,000	4,657,000	227,000	n/a	n/a

Table 8-4. Percentage of Installed Lamps in Average Buildings by Sector, 2001

Lamp Type	Residential (% lamps)	Commercial (% lamps)	Industrial (% lamps)	Outdoor (% lamps)	National Avg. (% lamps)
Incandescent	86%	22%	2%	22%	63%
Fluorescent	14%	77%	93%	3%	35%
HID	0%	2%	5%	75%	2%
Solid State	0%	0%	0%	0%	0%
Totals	100%	100%	100%	100%	100%

Reproduced from [Navigant 2002]

APPENDIX B: SCENARIO DATA

California households (millions)

	Present growth				
	Total	Renovated	New	T24 2005	Prev codes
2007	13.30	0.20	0.16	1.05	12.25
2008	13.46	0.20	0.16	1.41	12.04
2009	13.62	0.20	0.16	1.78	11.84
2010	13.78	0.20	0.16	2.15	11.63
2011	13.94	0.21	0.17	2.52	11.42
2012	14.11	0.21	0.17	2.90	11.21
2013	14.28	0.21	0.17	3.28	11.00
2014	14.45	0.21	0.17	3.66	10.78
2015	14.62	0.22	0.17	4.06	10.56
2016	14.79	0.22	0.18	4.45	10.34
2017	14.97	0.22	0.18	4.85	10.11
2018	15.14	0.23	0.18	5.26	9.89

	50% growth				
	No houses	Renovated	New	T24 2005	Prev codes
2007	13.14	0.20	0.08	0.82	12.33
2008	13.22	0.20	0.08	1.09	12.13
2009	13.30	0.20	0.08	1.37	11.93
2010	13.38	0.20	0.08	1.65	11.73
2011	13.46	0.20	0.08	1.93	11.53
2012	13.54	0.20	0.08	2.21	11.33
2013	13.62	0.20	0.08	2.49	11.13
2014	13.70	0.20	0.08	2.78	10.92
2015	13.78	0.20	0.08	3.06	10.72
2016	13.86	0.21	0.08	3.35	10.51
2017	13.95	0.21	0.08	3.64	10.31
2018	14.03	0.21	0.08	3.93	10.10

	Zero growth				
	No houses	Renovated	New	T24 2005	Prev codes
2007	12.99	0.19	0.00	0.58	12.41
2008	12.99	0.19	0.00	0.77	12.22
2009	12.99	0.19	0.00	0.97	12.02
2010	12.99	0.19	0.00	1.16	11.83
2011	12.99	0.19	0.00	1.35	11.64
2012	12.99	0.19	0.00	1.54	11.44
2013	12.99	0.19	0.00	1.74	11.25
2014	12.99	0.19	0.00	1.93	11.06
2015	12.99	0.19	0.00	2.12	10.87
2016	12.99	0.19	0.00	2.32	10.67
2017	12.99	0.19	0.00	2.51	10.48
2018	12.99	0.19	0.00	2.70	10.29

California residential lighting energy consumption (aggregate)

No Action

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total			Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total
	MWh/a		*MWh/a*		*MWh/a*			*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*
2007	0.88	6%	13.23	94%	14.11	100%	2007	0.68	5%	13.32	95%	14.00	100%	2007	0.48	3%	13.41	97%	13.89	100%
2008	1.20	8%	13.16	93%	14.36	102%	2008	0.92	7%	13.26	95%	14.18	101%	2008	0.65	5%	13.35	96%	14.00	101%
2009	1.53	11%	13.08	93%	14.61	104%	2009	1.17	8%	13.19	94%	14.36	103%	2009	0.83	6%	13.29	96%	14.11	102%
2010	1.87	13%	13.00	92%	14.87	105%	2010	1.43	10%	13.11	94%	14.54	104%	2010	1.01	7%	13.22	95%	14.23	102%
2011	2.23	16%	12.91	91%	15.13	107%	2011	1.70	12%	13.03	93%	14.73	105%	2011	1.19	9%	13.15	95%	14.34	103%
2012	2.60	18%	12.81	91%	15.40	109%	2012	1.98	14%	12.95	92%	14.92	107%	2012	1.38	10%	13.07	94%	14.46	104%
2013	2.98	21%	12.70	90%	15.68	111%	2013	2.26	16%	12.85	92%	15.12	108%	2013	1.58	11%	13.00	94%	14.58	105%
2014	3.38	24%	12.59	89%	15.97	113%	2014	2.56	18%	12.76	91%	15.32	109%	2014	1.78	13%	12.92	93%	14.69	106%
2015	3.79	27%	12.47	88%	16.26	115%	2015	2.86	20%	12.66	90%	15.52	111%	2015	1.98	14%	12.83	92%	14.81	107%
2016	4.22	30%	12.34	87%	16.56	117%	2016	3.17	23%	12.55	90%	15.72	112%	2016	2.19	16%	12.74	92%	14.93	107%
2017	4.66	33%	12.21	86%	16.86	119%	2017	3.49	25%	12.44	89%	15.93	114%	2017	2.41	17%	12.65	91%	15.06	108%

100% CFL penetration (sudden)

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total			Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total
	MWh/a		*MWh/a*		*MWh/a*			*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*
2007	0.88	6%	13.23	94%	14.11	100%	2007	0.68	5%	13.32	95%	14.00	100%	2007	0.48	3%	13.41	97%	13.89	100%
2008	1.20	8%	13.16	93%	14.36	102%	2008	0.92	7%	13.26	95%	14.18	101%	2008	0.65	5%	13.35	96%	14.00	101%
2009	1.53	11%	13.08	93%	14.61	104%	2009	1.17	8%	13.19	94%	14.36	103%	2009	0.83	6%	13.29	96%	14.11	102%
2010	1.87	13%	13.00	92%	14.87	105%	2010	1.43	10%	13.11	94%	14.54	104%	2010	1.01	7%	13.22	95%	14.23	102%
2011	1.01	7%	5.16	37%	6.17	44%	2011	0.77	6%	5.21	37%	5.98	43%	2011	0.54	4%	5.26	38%	5.80	42%
2012	1.18	8%	5.12	36%	6.30	45%	2012	0.90	6%	5.17	37%	6.07	43%	2012	0.63	5%	5.23	38%	5.85	42%
2013	1.35	10%	5.08	36%	6.42	46%	2013	1.02	7%	5.14	37%	6.16	44%	2013	0.71	5%	5.19	37%	5.91	43%
2014	1.52	11%	5.03	36%	6.55	46%	2014	1.15	8%	5.10	36%	6.25	45%	2014	0.80	6%	5.16	37%	5.96	43%
2015	1.70	12%	4.98	35%	6.68	47%	2015	1.29	9%	5.06	36%	6.34	45%	2015	0.89	6%	5.12	37%	6.02	43%
2016	1.89	13%	4.93	35%	6.82	48%	2016	1.42	10%	5.01	36%	6.43	46%	2016	0.98	7%	5.09	37%	6.07	44%
2017	2.08	15%	4.87	35%	6.95	49%	2017	1.56	11%	4.96	35%	6.53	47%	2017	1.08	8%	5.05	36%	6.12	44%
2018	2.28	16%	4.81	34%	7.09	50%	2018	1.70	12%	4.92	35%	6.62	47%	2018	1.17	8%	5.01	36%	6.18	44%

Gradual 100% CFL penetration

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total			Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total
	MWh/a		*MWh/a*		*MWh/a*			*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*
2007	0.88	6%	13.23	94%	14.11	100%	2007	0.68	5%	13.32	95%	14.00	100%	2007	0.48	3%	13.41	97%	13.89	100%
2008	1.12	8%	12.26	87%	13.38	95%	2008	0.86	6%	12.35	88%	13.21	94%	2008	0.61	4%	12.43	89%	13.04	94%
2009	1.33	9%	11.33	80%	12.66	90%	2009	1.02	7%	11.42	82%	12.45	89%	2009	0.72	5%	11.51	83%	12.23	88%
2010	1.52	11%	10.45	74%	11.98	85%	2010	1.17	8%	10.54	75%	11.71	84%	2010	0.82	6%	10.63	77%	11.45	82%
2011	1.69	12%	9.62	68%	11.31	80%	2011	1.29	9%	9.71	69%	11.00	79%	2011	0.91	7%	9.80	71%	10.70	77%
2012	1.84	13%	8.82	63%	10.66	76%	2012	1.40	10%	8.92	64%	10.32	74%	2012	0.98	7%	9.01	65%	9.99	72%
2013	1.96	14%	8.07	57%	10.03	71%	2013	1.49	11%	8.16	58%	9.65	69%	2013	1.04	7%	8.25	59%	9.29	67%
2014	2.07	15%	7.35	52%	9.42	67%	2014	1.56	11%	7.45	53%	9.01	64%	2014	1.09	8%	7.54	54%	8.63	62%
2015	2.15	15%	6.67	47%	8.82	62%	2015	1.62	12%	6.77	48%	8.39	60%	2015	1.13	8%	6.86	49%	7.98	57%
2016	2.21	16%	6.02	43%	8.23	58%	2016	1.66	12%	6.12	44%	7.78	56%	2016	1.15	8%	6.21	45%	7.36	53%
2017	2.25	16%	5.40	38%	7.65	54%	2017	1.69	12%	5.50	39%	7.19	51%	2017	1.17	8%	5.59	40%	6.76	49%
2018	2.28	16%	4.81	34%	7.09	50%	2018	1.70	12%	4.92	35%	6.62	47%	2018	1.17	8%	5.01	36%	6.18	44%

Gradual 50% CFL penetration

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total			Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total
	MWh/a		*MWh/a*		*MWh/a*			*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*
2007	0.74	5%	13.23	95%	13.98	100%	2007	0.57	4%	13.32	96%	13.90	100%	2007	0.41	3%	13.41	97%	13.82	100%
2008	0.98	7%	12.82	92%	13.80	99%	2008	0.76	5%	12.91	93%	13.67	98%	2008	0.53	4%	13.00	94%	13.54	98%
2009	1.21	9%	12.42	89%	13.63	98%	2009	0.93	7%	12.52	90%	13.45	97%	2009	0.66	5%	12.61	91%	13.27	96%
2010	1.44	10%	12.03	86%	13.48	96%	2010	1.11	8%	12.14	87%	13.24	95%	2010	0.78	6%	12.24	89%	13.02	94%
2011	1.67	12%	11.66	83%	13.33	95%	2011	1.28	9%	11.77	85%	13.05	94%	2011	0.90	6%	11.88	86%	12.77	92%
2012	1.90	14%	11.30	81%	13.19	94%	2012	1.45	10%	11.42	82%	12.86	93%	2012	1.01	7%	11.53	83%	12.54	91%
2013	2.12	15%	10.94	78%	13.07	93%	2013	1.61	12%	11.08	80%	12.69	91%	2013	1.12	8%	11.20	81%	12.32	89%
2014	2.34	17%	10.60	76%	12.95	93%	2014	1.77	13%	10.74	77%	12.52	90%	2014	1.23	9%	10.88	79%	12.11	88%
2015	2.56	18%	10.27	73%	12.83	92%	2015	1.94	14%	10.42	75%	12.36	89%	2015	1.34	10%	10.56	76%	11.91	86%
2016	2.78	20%	9.94	71%	12.72	91%	2016	2.09	15%	10.11	73%	12.20	88%	2016	1.45	10%	10.26	74%	11.71	85%
2017	3.00	21%	9.62	69%	12.62	90%	2017	2.25	16%	9.81	71%	12.06	87%	2017	1.55	11%	9.97	72%	11.52	83%
2018	3.22	23%	9.31	67%	12.53	90%	2018	2.41	17%	9.51	68%	11.92	86%	2018	1.65	12%	9.69	70%	11.34	82%

Reduction in incandescent wattage (US industry proposal)

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	MWh/a		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*	
2007	0.88	6%	13.23	94%	14.11	100%	0.68	5%	13.32	95%	14.00	100%	0.48	3%	13.41	97%	13.89	100%
2008	1.20	8%	13.16	93%	14.36	102%	0.92	7%	13.26	95%	14.18	101%	0.65	5%	13.35	96%	14.00	101%
2009	1.53	11%	13.08	93%	14.61	104%	1.17	8%	13.19	94%	14.36	103%	0.83	6%	13.29	96%	14.11	102%
2010	1.87	13%	13.00	92%	14.87	105%	1.43	10%	13.11	94%	14.54	104%	1.01	7%	13.22	95%	14.23	102%
2011	2.23	16%	12.91	91%	15.13	107%	1.70	12%	13.03	93%	14.73	105%	1.19	9%	13.15	95%	14.34	103%
2012	2.60	18%	12.81	91%	15.40	109%	1.98	14%	12.95	92%	14.92	107%	1.38	10%	13.07	94%	14.46	104%
2013	2.87	20%	12.18	86%	15.05	107%	2.18	16%	12.33	88%	14.51	104%	1.52	11%	12.46	90%	13.98	101%
2014	3.13	22%	11.56	82%	14.69	104%	2.37	17%	11.71	84%	14.08	101%	1.65	12%	11.86	85%	13.50	97%
2015	3.36	24%	10.94	78%	14.30	101%	2.54	18%	11.10	79%	13.64	97%	1.76	13%	11.25	81%	13.02	94%
2016	3.58	25%	10.32	73%	13.91	99%	2.70	19%	10.50	75%	13.19	94%	1.87	13%	10.66	77%	12.52	90%
2017	3.78	27%	9.71	69%	13.49	96%	2.84	20%	9.89	71%	12.73	91%	1.96	14%	10.06	72%	12.02	86%
2018	3.96	28%	9.10	65%	13.06	93%	2.96	21%	9.30	66%	12.26	88%	2.04	15%	9.47	68%	11.51	83%

Reduction in incandescent wattage (EU industry proposal)

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	MWh/a		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*	
2007	0.88	6%	13.23	94%	14.11	100%	0.68	5%	13.32	95%	14.00	100%	0.48	3%	13.41	97%	13.89	100%
2008	1.20	8%	13.16	93%	14.36	102%	0.92	7%	13.26	95%	14.18	101%	0.65	5%	13.35	96%	14.00	101%
2009	1.53	11%	13.08	93%	14.61	104%	1.17	8%	13.19	94%	14.36	103%	0.83	6%	13.29	96%	14.11	102%
2010	1.87	13%	13.00	92%	14.87	105%	1.43	10%	13.11	94%	14.54	104%	1.01	7%	13.22	95%	14.23	102%
2011	2.23	16%	12.91	91%	15.13	107%	1.70	12%	13.03	93%	14.73	105%	1.19	9%	13.15	95%	14.34	103%
2012	2.60	18%	12.81	91%	15.40	109%	1.98	14%	12.95	92%	14.92	107%	1.38	10%	13.07	94%	14.46	104%
2013	2.90	21%	12.31	87%	15.21	108%	2.20	16%	12.46	89%	14.66	105%	1.53	11%	12.60	91%	14.13	102%
2014	3.19	23%	11.82	84%	15.01	106%	2.41	17%	11.98	86%	14.39	103%	1.68	12%	12.12	87%	13.80	99%
2015	3.47	25%	11.32	80%	14.79	105%	2.62	19%	11.49	82%	14.11	101%	1.82	13%	11.65	84%	13.47	97%
2016	3.74	27%	10.83	77%	14.57	103%	2.82	20%	11.01	79%	13.83	99%	1.95	14%	11.18	80%	13.12	94%
2017	4.00	28%	10.33	73%	14.34	102%	3.00	21%	10.53	75%	13.53	97%	2.07	15%	10.71	77%	12.78	92%
2018	4.25	30%	9.84	70%	14.09	100%	3.18	23%	10.05	72%	13.23	94%	2.18	16%	10.24	74%	12.42	89%

Zero-energy building code

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	MWh/a		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*		*MWh/a*	
2007	0.88	6%	13.23	94%	14.11	100%	0.68	5%	13.32	95%	14.00	100%	0.48	3%	13.41	97%	13.89	100%
2008	1.20	8%	13.16	93%	14.36	102%	0.92	7%	13.26	95%	14.18	101%	0.65	5%	13.35	96%	14.00	101%
2009	1.20	8%	13.08	93%	14.28	101%	0.92	7%	13.19	94%	14.11	101%	0.65	5%	13.29	96%	13.94	100%
2010	1.20	8%	13.00	92%	14.19	101%	0.92	7%	13.11	94%	14.03	100%	0.65	5%	13.22	95%	13.87	100%
2011	1.20	8%	12.91	91%	14.10	100%	0.92	7%	13.03	93%	13.95	100%	0.65	5%	13.15	95%	13.80	99%
2012	1.20	8%	12.81	91%	14.00	99%	0.92	7%	12.95	92%	13.87	99%	0.65	5%	13.07	94%	13.73	99%
2013	1.20	8%	12.70	90%	13.90	98%	0.92	7%	12.85	92%	13.78	98%	0.65	5%	13.00	94%	13.65	98%
2014	1.20	8%	12.59	89%	13.79	98%	0.92	7%	12.76	91%	13.68	98%	0.65	5%	12.92	93%	13.57	98%
2015	1.20	8%	12.47	88%	13.67	97%	0.92	7%	12.66	90%	13.58	97%	0.65	5%	12.83	92%	13.48	97%
2016	1.20	8%	12.34	87%	13.54	96%	0.92	7%	12.55	90%	13.47	96%	0.65	5%	12.74	92%	13.39	96%
2017	1.20	8%	12.21	86%	13.40	95%	0.92	7%	12.44	89%	13.36	95%	0.65	5%	12.65	91%	13.30	96%
2018	1.20	8%	12.06	85%	13.26	94%	0.92	7%	12.32	88%	13.24	95%	0.65	5%	12.55	90%	13.20	95%

California residential lighting energy consumption (average per household)

No Action

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	832.67	78%	13.23	94%	1061.07	100%	832.67	78%	13.32	95%	1065.35	100%	832.67	78%	13.41	97%	1069.67	100%
2008	845.30	80%	13.16	93%	1066.77	101%	845.30	79%	13.26	95%	1072.37	101%	845.30	79%	13.35	96%	1078.07	101%
2009	857.94	81%	13.08	93%	1072.72	101%	857.94	81%	13.19	94%	1079.59	101%	857.94	80%	13.29	96%	1086.62	102%
2010	870.61	82%	13.00	92%	1078.88	102%	870.61	82%	13.11	94%	1086.98	102%	870.61	81%	13.22	95%	1095.32	102%
2011	883.30	83%	12.91	91%	1085.25	102%	883.30	83%	13.03	93%	1094.53	103%	883.30	83%	13.15	95%	1104.14	103%
2012	896.01	84%	12.81	91%	1091.79	103%	896.01	84%	12.95	92%	1102.22	103%	896.01	84%	13.07	94%	1113.08	104%
2013	908.74	86%	12.70	90%	1098.50	104%	908.74	85%	12.85	92%	1110.03	104%	908.74	85%	13.00	94%	1122.12	105%
2014	921.48	87%	12.59	89%	1105.36	104%	921.48	86%	12.76	91%	1117.96	105%	921.48	86%	12.92	93%	1131.25	106%
2015	934.23	88%	12.47	88%	1112.35	105%	934.23	88%	12.66	90%	1125.98	106%	934.23	87%	12.83	92%	1140.45	107%
2016	947.00	89%	12.34	87%	1119.48	106%	947.00	89%	12.55	90%	1134.10	106%	947.00	89%	12.74	92%	1149.73	107%
2017	959.79	90%	12.21	86%	1126.72	106%	959.79	90%	12.44	89%	1142.31	107%	959.79	90%	12.65	91%	1159.06	108%

100% CFL penetration (sudden)

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	832.67	78%	13.23	94%	1061.07	100%	832.67	78%	13.32	95%	1065.35	100%	832.67	78%	13.41	97%	1069.67	100%
2008	845.30	80%	13.16	93%	1066.77	101%	845.30	79%	13.26	95%	1072.37	101%	845.30	79%	13.35	96%	1078.07	101%
2009	857.94	81%	13.08	93%	1072.72	101%	857.94	81%	13.19	94%	1079.59	101%	857.94	80%	13.29	96%	1086.62	102%
2010	870.61	82%	13.00	92%	1078.88	102%	870.61	82%	13.11	94%	1086.98	102%	870.61	81%	13.22	95%	1095.32	102%
2011	402.08	38%	5.16	37%	442.79	42%	402.08	38%	5.21	37%	444.66	42%	402.08	38%	5.26	38%	446.60	42%
2012	406.43	38%	5.12	36%	446.35	42%	406.43	38%	5.17	37%	448.47	42%	406.43	38%	5.23	38%	450.69	42%
2013	410.82	39%	5.08	36%	449.94	42%	410.82	39%	5.14	37%	452.32	42%	410.82	38%	5.19	37%	454.81	43%
2014	415.26	39%	5.03	36%	453.56	43%	415.26	39%	5.10	36%	456.18	43%	415.26	39%	5.16	37%	458.95	43%
2015	419.73	40%	4.98	35%	457.21	43%	419.73	39%	5.06	36%	460.08	43%	419.73	39%	5.12	37%	463.12	43%
2016	424.23	40%	4.93	35%	460.88	43%	424.23	40%	5.01	36%	463.99	44%	424.23	40%	5.09	37%	467.31	44%
2017	428.76	40%	4.87	35%	464.57	44%	428.76	40%	4.96	35%	467.92	44%	428.76	40%	5.05	36%	471.51	44%
2018	433.32	41%	4.81	34%	468.29	44%	433.32	41%	4.92	35%	471.86	44%	433.32	41%	5.01	36%	475.73	44%

Gradual 100% CFL penetration

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	832.67	78%	13.23	94%	1061.07	100%	832.67	78%	13.32	95%	1065.35	100%	832.67	78%	13.41	97%	1069.67	100%
2008	790.15	74%	12.26	87%	993.89	94%	790.15	74%	12.35	88%	999.04	94%	790.15	74%	12.43	89%	1004.28	94%
2009	749.20	71%	11.33	80%	930.00	88%	749.20	70%	11.42	82%	935.78	88%	749.20	70%	11.51	83%	941.70	88%
2010	709.69	67%	10.45	74%	869.14	82%	709.69	67%	10.54	75%	875.34	82%	709.69	66%	10.63	77%	881.72	82%
2011	671.49	63%	9.62	68%	811.08	76%	671.49	63%	9.71	69%	817.49	77%	671.49	63%	9.80	71%	824.14	77%
2012	634.51	60%	8.82	63%	755.62	71%	634.51	60%	8.92	64%	762.07	72%	634.51	59%	9.01	65%	768.79	72%
2013	598.65	56%	8.07	57%	702.57	66%	598.65	56%	8.16	58%	708.89	67%	598.65	56%	8.25	59%	715.51	67%
2014	563.81	53%	7.35	52%	651.77	61%	563.81	53%	7.45	53%	657.80	62%	563.81	53%	7.54	54%	664.16	62%
2015	529.93	50%	6.67	47%	603.07	57%	529.93	50%	6.77	48%	608.67	57%	529.93	50%	6.86	49%	614.61	57%
2016	496.92	47%	6.02	43%	556.34	52%	496.92	47%	6.12	44%	561.38	53%	496.92	46%	6.21	45%	566.76	53%
2017	464.74	44%	5.40	38%	511.45	48%	464.74	44%	5.50	39%	515.81	48%	464.74	43%	5.59	40%	520.50	49%
2018	433.32	41%	4.81	34%	468.29	44%	433.32	41%	4.92	35%	471.86	44%	433.32	41%	5.01	36%	475.73	44%

Gradual 50% CFL penetration

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	703.50	67%	13.23	95%	1050.83	100%	703.50	67%	13.32	96%	1057.33	100%	703.50	66%	13.41	97%	1063.91	100%
2008	692.71	66%	12.82	92%	1025.29	98%	692.71	66%	12.91	93%	1033.69	98%	692.71	65%	13.00	94%	1042.25	98%
2009	682.54	65%	12.42	89%	1001.05	95%	682.54	65%	12.52	90%	1011.24	96%	682.54	64%	12.61	91%	1021.67	96%
2010	672.95	64%	12.03	86%	978.02	93%	672.95	64%	12.14	87%	989.89	94%	672.95	63%	12.24	89%	1002.10	94%
2011	663.88	63%	11.66	83%	956.10	91%	663.88	63%	11.77	85%	969.53	92%	663.88	62%	11.88	86%	983.45	92%
2012	655.29	62%	11.30	81%	935.19	89%	655.29	62%	11.42	82%	950.10	90%	655.29	62%	11.53	83%	965.64	91%
2013	647.14	62%	10.94	78%	915.23	87%	647.14	61%	11.08	80%	931.52	88%	647.14	61%	11.20	81%	948.60	89%
2014	639.39	61%	10.60	76%	896.13	85%	639.39	60%	10.74	77%	913.73	86%	639.39	60%	10.88	79%	932.28	88%
2015	632.03	60%	10.27	73%	877.85	84%	632.03	60%	10.42	75%	896.66	85%	632.03	59%	10.56	76%	916.63	86%
2016	625.01	59%	9.94	71%	860.32	82%	625.01	59%	10.11	73%	880.27	83%	625.01	59%	10.26	74%	901.59	85%
2017	618.32	59%	9.62	69%	843.49	80%	618.32	58%	9.81	71%	864.52	82%	618.32	58%	9.97	72%	887.11	83%
2018	611.93	58%	9.31	67%	827.31	79%	611.93	58%	9.51	68%	849.35	80%	611.93	58%	9.69	70%	873.17	82%

Reduction in incandescent wattage (US industry proposal)

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	832.67	78%	13.23	94%	1061.07	100%	832.67	78%	13.32	95%	1065.35	100%	832.67	78%	13.41	97%	1069.67	100%
2008	845.30	80%	13.16	93%	1066.77	101%	845.30	79%	13.26	95%	1072.37	101%	845.30	79%	13.35	96%	1078.07	101%
2009	857.94	81%	13.08	93%	1072.72	101%	857.94	81%	13.19	94%	1079.59	101%	857.94	80%	13.29	96%	1086.62	102%
2010	870.61	82%	13.00	92%	1078.88	102%	870.61	82%	13.11	94%	1086.98	102%	870.61	81%	13.22	95%	1095.32	102%
2011	883.30	83%	12.91	91%	1085.25	102%	883.30	83%	13.03	93%	1094.53	103%	883.30	83%	13.15	95%	1104.14	103%
2012	896.01	84%	12.81	91%	1091.79	103%	896.01	84%	12.95	92%	1102.22	103%	896.01	84%	13.07	94%	1113.08	104%
2013	874.94	82%	12.18	86%	1054.30	99%	874.94	82%	12.33	88%	1065.20	100%	874.94	82%	12.46	90%	1076.63	101%
2014	852.79	80%	11.56	82%	1016.58	96%	852.79	80%	11.71	84%	1027.80	96%	852.79	80%	11.86	85%	1039.64	97%
2015	829.57	78%	10.94	78%	978.59	92%	829.57	78%	11.10	79%	989.99	93%	829.57	78%	11.25	81%	1002.09	94%
2016	805.28	76%	10.32	73%	940.29	89%	805.28	76%	10.50	75%	951.74	89%	805.28	75%	10.66	77%	963.97	90%
2017	779.92	74%	9.71	69%	901.66	85%	779.92	73%	9.89	71%	913.02	86%	779.92	73%	10.06	72%	925.24	86%
2018	753.50	71%	9.10	65%	862.66	81%	753.50	71%	9.30	66%	873.83	82%	753.50	70%	9.47	68%	885.90	83%

Reduction in incandescent wattage (EU industry proposal)

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	832.67	78%	13.23	94%	1061.07	100%	832.67	78%	13.32	95%	1065.35	100%	832.67	78%	13.41	97%	1069.67	100%
2008	845.30	80%	13.16	93%	1066.77	101%	845.30	79%	13.26	95%	1072.37	101%	845.30	79%	13.35	96%	1078.07	101%
2009	857.94	81%	13.08	93%	1072.72	101%	857.94	81%	13.19	94%	1079.59	101%	857.94	80%	13.29	96%	1086.62	102%
2010	870.61	82%	13.00	92%	1078.88	102%	870.61	82%	13.11	94%	1086.98	102%	870.61	81%	13.22	95%	1095.32	102%
2011	883.30	83%	12.91	91%	1085.25	102%	883.30	83%	13.03	93%	1094.53	103%	883.30	83%	13.15	95%	1104.14	103%
2012	896.01	84%	12.81	91%	1091.79	103%	896.01	84%	12.95	92%	1102.22	103%	896.01	84%	13.07	94%	1113.08	104%
2013	883.39	83%	12.31	87%	1065.35	100%	883.39	83%	12.46	89%	1076.41	101%	883.39	83%	12.60	91%	1088.00	102%
2014	869.96	82%	11.82	84%	1038.77	98%	869.96	82%	11.98	86%	1050.34	99%	869.96	81%	12.12	87%	1062.54	99%
2015	855.74	81%	11.32	80%	1012.03	95%	855.74	80%	11.49	82%	1023.99	96%	855.74	80%	11.65	84%	1036.68	97%
2016	840.71	79%	10.83	77%	985.09	93%	840.71	79%	11.01	79%	997.33	94%	840.71	79%	11.18	80%	1010.41	94%
2017	824.89	78%	10.33	73%	957.92	90%	824.89	77%	10.53	75%	970.35	91%	824.89	77%	10.71	77%	983.70	92%
2018	808.27	76%	9.84	70%	930.51	88%	808.27	76%	10.05	72%	943.02	89%	808.27	76%	10.24	74%	956.54	89%

Zero-energy building code

	Present growth						50% growth						Zero growth					
	Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total		Title 24 2005		Previous codes		Total	
	kWh/a		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*		*kWh/a*	
2007	832.67	78%	13.23	94%	1061.07	100%	832.67	78%	13.32	95%	1065.35	100%	832.67	78%	13.41	97%	1069.67	100%
2008	845.30	80%	13.16	93%	1066.77	101%	845.30	79%	13.26	95%	1072.37	101%	845.30	79%	13.35	96%	1078.07	101%
2009	672.22	63%	13.08	93%	1048.46	99%	674.23	63%	13.19	94%	1060.71	100%	676.24	63%	13.29	96%	1073.12	100%
2010	556.85	52%	13.00	92%	1030.00	97%	560.19	53%	13.11	94%	1048.80	98%	563.53	53%	13.22	95%	1067.94	100%
2011	474.46	45%	12.91	91%	1011.36	95%	478.73	45%	13.03	93%	1036.65	97%	483.03	45%	13.15	95%	1062.50	99%
2012	412.67	39%	12.81	91%	992.54	94%	417.64	39%	12.95	92%	1024.24	96%	422.65	40%	13.07	94%	1056.80	99%
2013	364.62	34%	12.70	90%	973.53	92%	370.13	35%	12.85	92%	1011.54	95%	375.69	35%	13.00	94%	1050.82	98%
2014	326.19	31%	12.59	89%	954.33	90%	332.13	31%	12.76	91%	998.57	94%	338.12	32%	12.92	93%	1044.54	98%
2015	294.76	28%	12.47	88%	934.92	88%	301.03	28%	12.66	90%	985.30	92%	307.38	29%	12.83	92%	1037.97	97%
2016	268.57	25%	12.34	87%	915.30	86%	275.12	26%	12.55	90%	971.73	91%	281.77	26%	12.74	92%	1031.08	96%
2017	246.41	23%	12.21	86%	895.47	84%	253.20	24%	12.44	89%	957.86	90%	260.09	24%	12.65	91%	1023.87	96%
2018	227.43	21%	12.06	85%	875.43	83%	234.41	22%	12.32	88%	943.67	89%	241.51	23%	12.55	90%	1016.33	95%

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