

**POTENTIAL
APPLIANCE EFFICIENCY REGULATIONS
FOR GENERAL SERVICE AND
REFLECTOR INCANDESCENT LAMPS
AND FOR METAL HALIDE LUMINAIRES**

CALIFORNIA
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STAFF REPORT

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-Disclaimer-

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Background

Since 1975, Section 25402 (c) of the Public Resources Code has required the California Energy Commission (Energy Commission) to adopt standards for the energy efficiency of appliances. New and upgraded standards must be feasible and attainable, and cannot “result in any added total costs to the consumer over the designed life of the appliance.” This added total cost is determined by comparing the costs and performance of a typical model with the proposed standard in effect to a typical model without the proposed standard in effect.

On December 15, 2004, the Energy Commission adopted amendments to the Energy Commission’s Appliance Efficiency Regulations (California Code of Regulations, Title 20, Sections 1601-1608). The proposed amendments, known as 15 day language, were published on November 30, 2004, containing two proposals (Alternative 1 and Alternative 2) for provisions in 1605.3(k) (2), Table K-3 (Energy Efficiency Standards for State-Regulated General Service Incandescent Lamps), 1605 (k) (3), Table K-4 (Energy Efficiency Standards for State-Regulated Incandescent Reflector Lamps), and 1605.3 (n) (3), Table N-1 (Energy Efficiency Standards for Metal Halide Luminaires).

The Energy Commission decided to adopt Alternative 2. The adoption of Alternative 2 had broad support from affected stakeholders (they were less stringent than Alternative 1), and the Commission wanted the staff to continue working on concerns related to Alternative 1.

The 15 day language, showing Alternatives 1 and 2 for Table K-3 (Standards for State-Regulated General Service Incandescent Lamps), K-4 (Standards for State-Regulated Incandescent Reflector Lamps), and N-1 (Standards for Metal Halide Luminaires) is available on the Energy Commission website at:

http://www.energy.ca.gov/appliances/2004rulemaking/documents/2004-11-30_EXPRESS_TERMS.PDF

A Committee Workshop was held on July 18, 2005 to receive public comment on potential revisions to the Regulations for incandescent lamps and metal halide luminaires that were detailed in a document titled “Draft Staff Report; Potential Appliance Efficiency Regulations for General Service and Reflector incandescent Lamps and for Metal Halide Luminaires,” dated July 2005. At that workshop, the Energy Efficiency Committee directed staff to continue working with the National Electrical Manufacturers Association (NEMA) and its constituent members on clarifications to provisions that were adopted on December 15, 2004, to work toward reaching a consensus on the Alternative 1 provisions, and to be prepared to make decisions related to the provisions at a workshop in October 2005. This Staff Report contains the revised potential revisions to the Regulations for incandescent lamps and metal halide luminaires.

Directives to the Energy Efficiency Committee

In the Order Adopting Regulations and Directing Additional Rulemaking Activities (see: http://www.energy.ca.gov/appliances/2004rulemaking/notices/2004-12-22_ORDER_ADOPT.PDF), the Energy Commission directed the Energy Efficiency Committee to continue this rulemaking to consider possible efficiency standards for full-spectrum or enhanced spectrum general service incandescent lamps. The order also directed the Committee to explore the possibility of making efficiency standards for general service incandescent lamps, incandescent reflector lamps, and non-vertical metal halide luminaires more stringent than those adopted in Alternative 2, and ordered appropriate action to be taken as soon as possible.

The Order also said,

Alternative 1 of the 15-Day Language, which we are not adopting today, contained proposed standards for these types of equipment. Today, we are adopting Alternative 2, which eliminates some of those standards, after discussions with the National Electrical Manufacturers Association (NEMA) and several of its constituent manufacturers. One of the issues [that was] raised concerns the likely responses of consumers to (and thus the likely levels of energy savings from) standards for general service incandescent bulbs. We invite NEMA and its members to discuss actively that issue and other matters associated with the proposed lighting equipment standards listed above, including but not limited to creation, funding, and implementation of a consumer education and marketing program for energy-efficient general service incandescent lamps.

Potential Standards

Since the December 15, 2004 adoption, the Energy Commission staff has discussed these issues with the National Electrical Manufacturers Association (NEMA) and several of its constituent members, Flex Your Power staff (California's statewide energy efficiency marketing and outreach campaign; see: <http://www.fypower.org/>), and the California Lighting Technology Center (see: <http://cltc.ucdavis.edu/>). A revised incandescent lamp study, Proposed Energy Efficiency Specifications for General Service Incandescent Lamps, has been written by Ecos Consulting, a consultant for the Pacific Gas and Electric (PG&E) Company.

This report is available on the Energy Commission web site at:

http://www.energy.ca.gov/appliances/lamps/documents/2005-07-13_REVISIED_PG+E_PROPOSED_INCANDESCENT.PDF

Based on these follow-up meetings and the additional PG&E study, the Energy Efficiency Committee considered potential revisions to the Appliance Efficiency Regulations for incandescent lamps and metal halide luminaires at a Committee Workshop held on July 18, 2005. At that workshop, the Energy Efficiency Committee directed staff to continue working with NEMA and its members toward reaching a consensus on the Alternative 1 provisions, and to be prepared to make decisions related to the provisions at a second workshop, which was held on October 26, 2005. The following pages contain revised Alternative 1 provisions proposed by staff.

Potential Standards for State-Regulated General Service Incandescent Lamps

Alternative 2 for Table K-3 (Energy Efficiency Standards for State-Regulated General Service Incandescent Lamps) was adopted by the Energy Commission on December 15, 2004. Alternative 2 included standards to be effective on January 1, 2006 for Frost or Clear and Soft White lamps. Alternative 1 for Table K-3 was not adopted. Alternative 1 had the same requirements as Alternative 2 and in addition included standards for enhanced spectrum and vibration service lamps, and increased efficiency standards to be effective on January 1, 2007.

Standards for Soft White lamps were modified and adopted by the Commission on October 19, 2005 as shown in Table K-3.

The potential standards the Efficiency Committee is now considering are shown in Table K-3 on page 5. In Table K-3, column 2 shows the standards for January 1, 2006 for Frost or Clear lamps as adopted by the Commission on December 15, 2004, and for Soft White lamps as adopted by the Commission on October 19, 2005. Column 3 shows the potential standards for January 1, 2008, and column 4 shows the potential standards for January 1, 2009, for State-regulated general service

incandescent lamps. The standards for January 1, 2008 and January 1, 2009 are revised from the original proposal in Alternative 1 for Table K-3 to establish the Maximum Power Use (watts) as a function of lumens. The proposed standards are equations that apply to specified ranges of lumens.

(k) Lamps (2) Energy Efficiency Standards for State-Regulated General Service Incandescent Lamps.

The lamp electrical power input of state-regulated general service incandescent lamps manufactured on or after the applicable dates shown in Table K-3 shall be no greater than the applicable values shown in Table K-3.

Graphic presentations of the Table K-3 equations

The equations for columns 3 and 4 of Table K-3 are shown graphically in Figures 1, 2 and 4 on the pages 7, 8 and 10 of this report.

Table K-3

Standards for State-Regulated General Service Incandescent Lamps

| Lumens (L) | Maximum Power Use (Watts) | | |
|-----------------------|---------------------------------------|---|---|
| | January 1, 2006 (Adopted 12/15/04) | Potential Standards for January 1, 2008 | Potential Standards for January 1, 2009 |
| Frost or Clear | | | |
| $L \leq 300$ | $(0.0500 * \text{Lumens}) + 21$ | $(0.0500 * \text{Lumens}) + 21$ | $0.05\text{Lumens} + 20$ |
| $300 < L \leq 700$ | $(0.0500 * \text{Lumens}) + 21$ | 35 | 35 |
| $700 < L \leq 740$ | $(0.0500 * \text{Lumens}) + 21$ | $\frac{11}{20}\text{Lumens} - 350$ | $\frac{11}{20}\text{Lumens} - 350$ |
| $740 < L \leq 950$ | $(0.0500 * \text{Lumens}) + 21$ | 57 | 57 |
| $950 < L \leq 1020$ | $(0.0500 * \text{Lumens}) + 21$ | $\frac{1}{5}\text{Lumens} - 133$ | $\frac{1}{5}\text{Lumens} - 133$ |
| $1020 < L \leq 1300$ | $(0.0500 * \text{Lumens}) + 21$ | 71 | 71 |
| $1300 < L \leq 1350$ | $(0.0500 * \text{Lumens}) + 21$ | $\frac{33}{100}\text{Lumens} - 358$ | $\frac{33}{100}\text{Lumens} - 358$ |
| $1350 < L \leq 1500$ | $(0.0500 * \text{Lumens}) + 21$ | $0.05\text{Lumens} + 20$ | $0.05\text{Lumens} + 20$ |
| $1500 < L \leq 1850$ | $(0.0500 * \text{Lumens}) + 21$ | 95 | 95 |
| $1850 < L \leq 1900$ | $(0.0500 * \text{Lumens}) + 21$ | $(0.0500 * \text{Lumens}) + 21$ | $\frac{2}{5}\text{Lumens} - 645$ |
| $1900 < L \leq 2500$ | $(0.0500 * \text{Lumens}) + 21$ | $(0.0500 * \text{Lumens}) + 21$ | $0.05\text{Lumens} + 20$ |
| $2500 < L \leq 3000$ | $(0.0500 * \text{Lumens}) + 21$ | $(0.0500 * \text{Lumens}) + 21$ | 145 |
| Soft White | | | |
| $L \leq 270$ | $(0.0500 * \text{Lumens}) + 22.5$ | $(0.0500 * \text{Lumens}) + 22.5$ | $0.05\text{Lumens} + 21.5$ |
| $270 < L \leq 670$ | $(0.0500 * \text{Lumens}) + 22.5$ | 35 | 35 |
| $670 < L \leq 725$ | $(0.0500 * \text{Lumens}) + 22.5$ | $\frac{2}{5}\text{Lumens} - 233$ | $\frac{2}{5}\text{Lumens} - 233$ |
| $725 < L \leq 925$ | $(0.0500 * \text{Lumens}) + 22.5$ | 57 | 57 |
| $925 < L \leq 1000$ | $(0.0500 * \text{Lumens}) + 22.5$ | $\frac{7}{100}\text{Lumens} - \frac{31}{4}$ | $\frac{7}{100}\text{Lumens} - \frac{31}{4}$ |
| $1000 < L \leq 1250$ | $(0.0500 * \text{Lumens}) + 22.5$ | 71 | 71 |
| $1250 < L \leq 1300$ | $(0.0500 * \text{Lumens}) + 22.5$ | $\frac{31}{100}\text{Lumens} - \frac{633}{2}$ | $\frac{31}{100}\text{Lumens} - \frac{633}{2}$ |
| $1300 < L \leq 1470$ | $(0.0500 * \text{Lumens}) + 22.5$ | $0.05\text{Lumens} + 21.5$ | $0.05\text{Lumens} + 21.5$ |
| $1470 < L \leq 1800$ | $(0.0500 * \text{Lumens}) + 22.5$ | 95 | 95 |
| $1800 < L \leq 1850$ | $(0.0500 * \text{Lumens}) + 22.5$ | $(0.0500 * \text{Lumens}) + 22.5$ | $W = \frac{19}{50}L - 589$ |
| $1850 < L \leq 2470$ | $(0.0500 * \text{Lumens}) + 22.5$ | $(0.0500 * \text{Lumens}) + 22.5$ | $0.05\text{Lumens} + 21.5$ |
| $2470 < L \leq 3000$ | $(0.0500 * \text{Lumens}) + 22.5$ | $(0.0500 * \text{Lumens}) + 22.5$ | 145 |

(k) Lamps (3) Energy Efficiency Standards for State-Regulated Enhanced Spectrum Incandescent Lamps.

The lamp electrical power input of state-regulated enhanced spectrum incandescent lamps manufactured on or after the applicable dates shown in Table K-4 shall be no greater than the applicable values shown in Table K-4.

Graphic presentations of the Table K-4 equations

The equations for Table K-4 are shown graphically in Figures 3 and 4 on the pages 9 and 10 of this report.

Table K-4
Standards for State-Regulated Enhanced Spectrum Incandescent Lamps

| Lumens (L) | Maximum Power Use (Watts) Potential Standards for January 1, 2009 |
|----------------------------|---|
| Spectrally Enhanced | |
| $L \leq 270$ | $0.05Lumens + 21.5$ |
| $270 < L \leq 455$ | 35 |
| $455 < L \leq 595$ | $\frac{4}{25}(Lumens - 600) + 57.5$ |
| $600 < L \leq 695$ | 57 |
| $695 < L \leq 790$ | $\frac{3}{20}(Lumens - 800) + 72.5$ |
| $790 < L \leq 1090$ | 71 |
| $1090 < L \leq 1195$ | $\frac{9}{40}(Lumens - 1200) + 95$ |
| $1195 < L \leq 1450$ | 95 |
| $1450 < L$ | $\frac{2}{15}Lumens - \frac{295}{3}$ |

Figure 1: Frost and Clear Bulbs

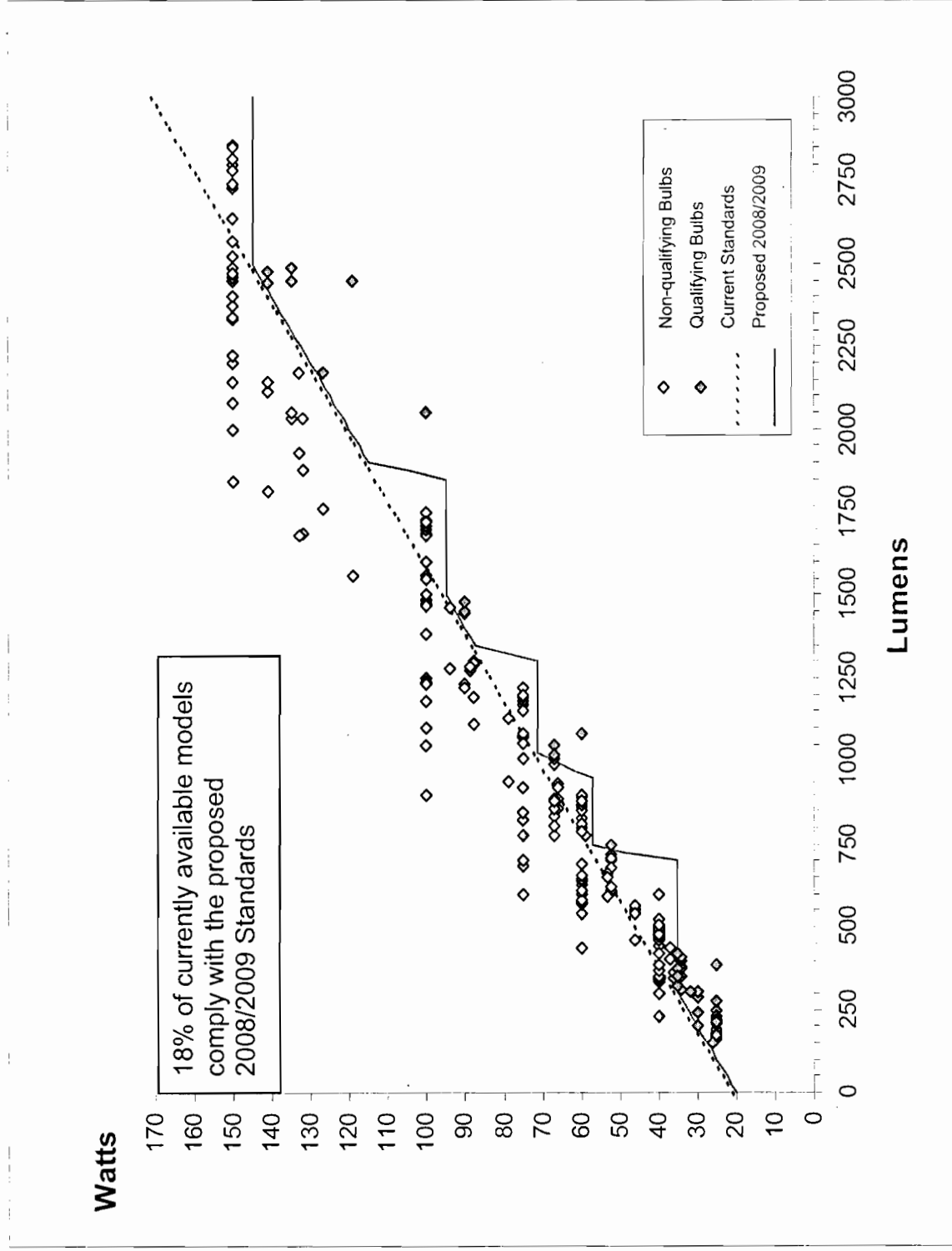


Figure 2: Soft White Light Bulbs

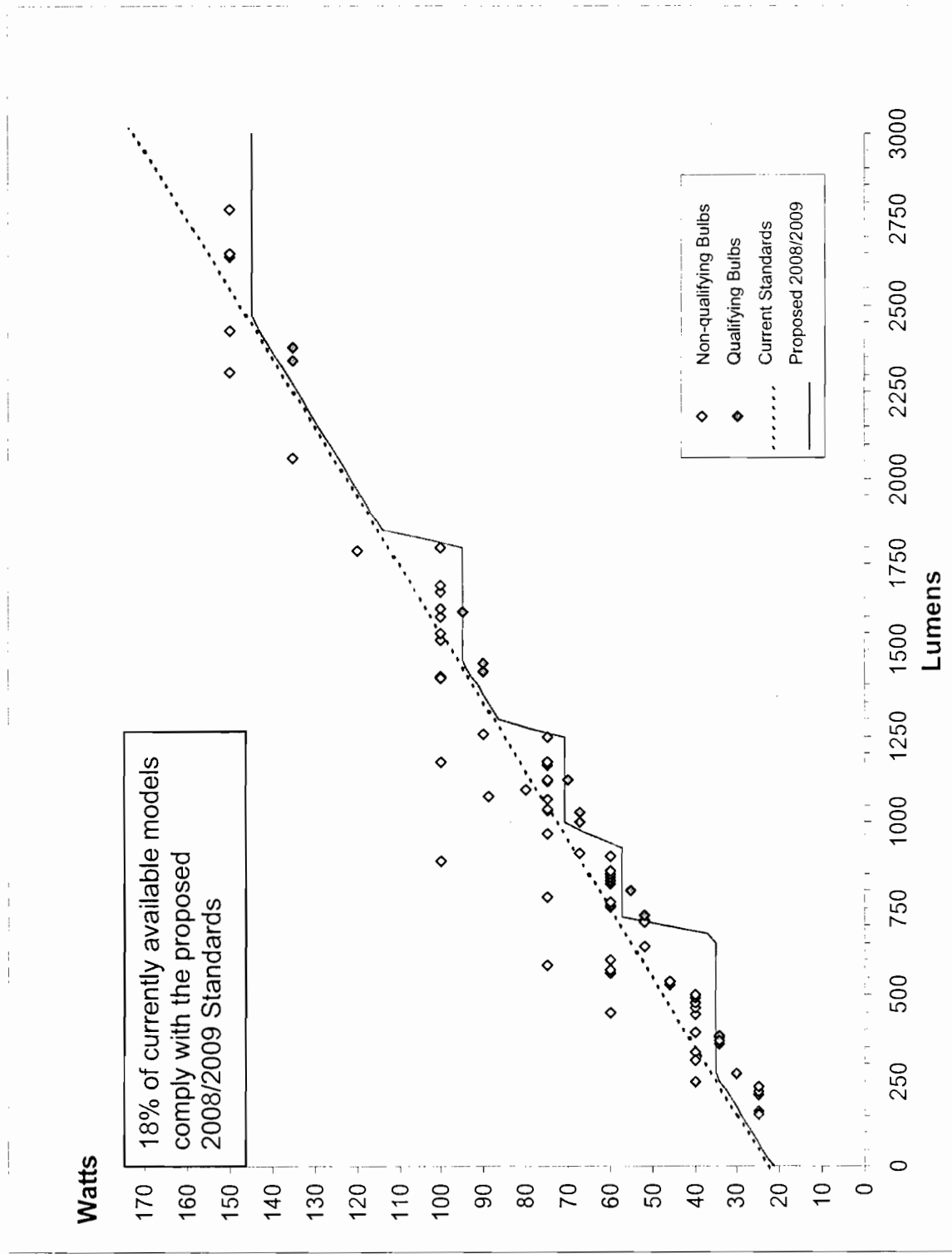


Figure 3: Enhanced Spectrum Light Bulbs

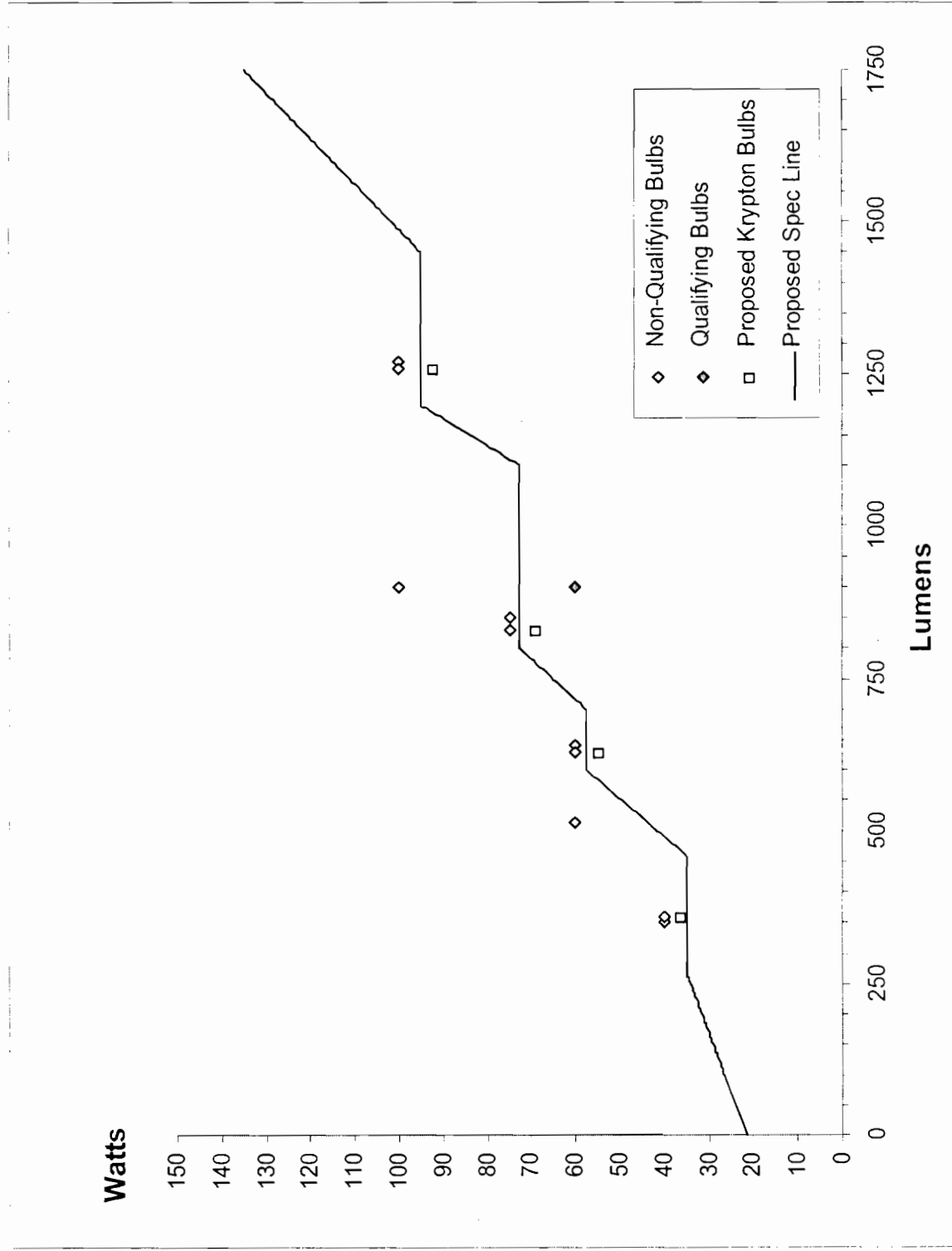
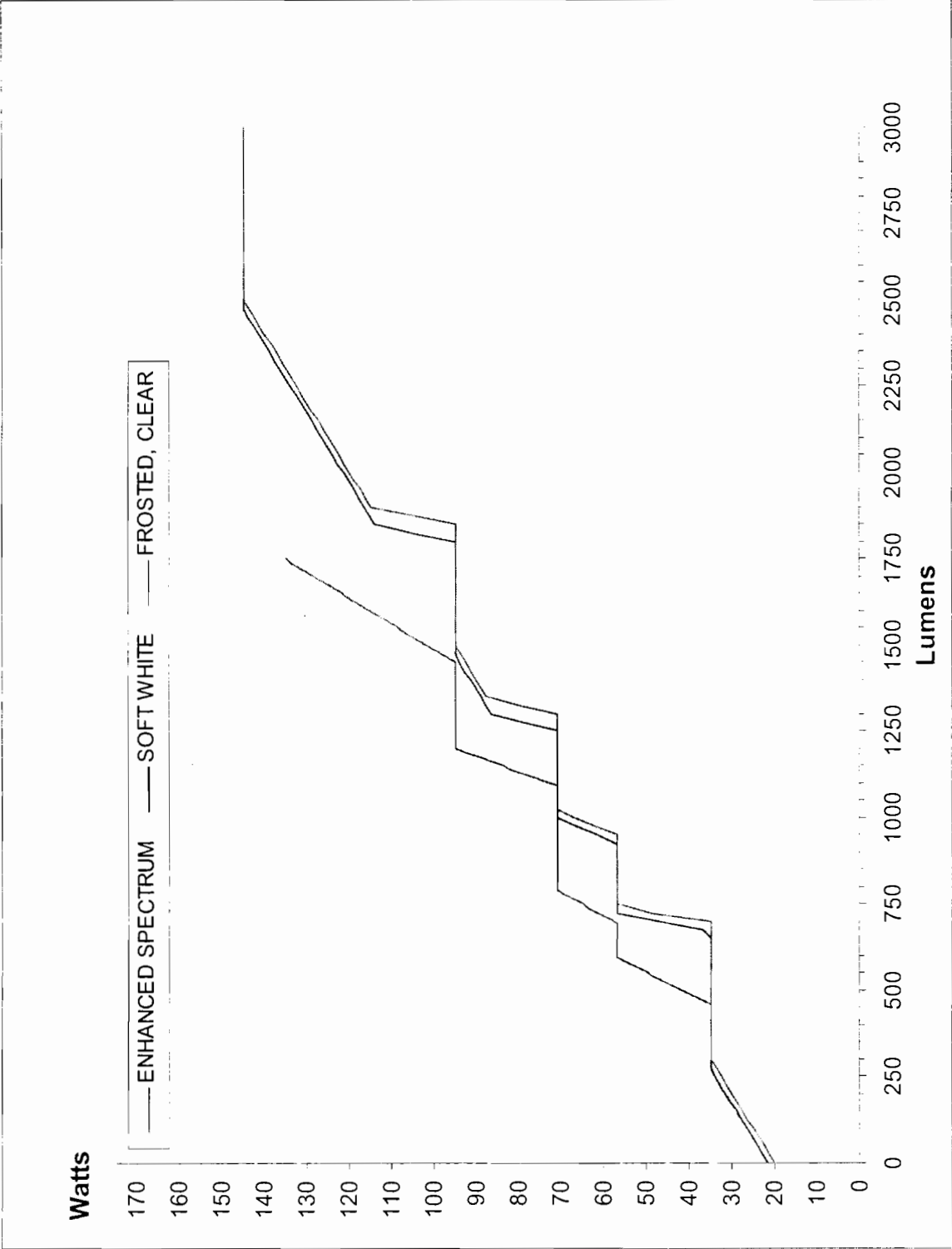


Figure 4: Proposed Specification Lines in All General Service Categories



Potential Standards for State-Regulated Incandescent Reflector Lamps

Alternative 2 for Table K-5 (Energy Efficiency Standards for State-Regulated Incandescent Reflector Lamps) was adopted by the Energy Commission on December 15, 2004. Alternative 2 deleted Table K-5 as it was shown in Alternative 1; thus new standards were not adopted for state-regulated incandescent reflector lamps.

The potential standards the Energy Efficiency Committee is considering are shown in Table K-5 below. Table K-5 shows the standards for reflector lamps as originally proposed in Alternative 1 for Table K-5, except for the following changes: 1) the effective date is delayed from January 1, 2006 to June 1, 2007, 2) specific ellipsoidal reflector (ER) and bulge reflector (BR) lamps were exempted.

(K) Lamps (4) Standards for State-Regulated Incandescent Reflector Lamps

The average lamp efficacy of state-regulated incandescent reflector lamps manufactured on or after July 1, 2007 shall be not less than the applicable values shown in Table K-5. The average lamp efficacy of state-regulated incandescent reflector lamps that have a bulb classification of R-20 and have rated lamp wattage of 45 watts or less manufactured on or after January 1, 2008 shall comply with Table K-5

Table K-5
Standards for State-Regulated Incandescent Reflector Lamps

| Rated Lamp Wattage | Minimum Average Lamp Efficacy (LPW) |
|---------------------------|--|
| 40-50 | 10.5 |
| 51-66 | 11.0 |
| 67-85 | 12.5 |
| 86-115 | 14.0 |
| 116-155 | 14.5 |
| 156-205 | 15.0 |

LAMP EXEMPTIONS

- ≤ 50 watt ER 30 (ellipsoidal reflector, 3.75" diameter)
- ≤ 50 watt ER 40 (ellipsoidal reflector, 5.00" diameter)
- 65 watt ER 40 (ellipsoidal reflector, 5.00" diameter)
- ≤ 50 watt BR 30 (bulge reflector, 3.75" diameter)
- ≤ 50 watt BR 40 (bulge reflector, 5.00" diameter)
- 65 watt BR 30 (bulge reflector, 3.75" diameter)
- 65 watt BR 40 (bulge reflector, 5.00" diameter)

Potential Standards for Metal Halide Luminaires

Alternative 2 for Table N-1 (Energy Efficiency Standards for Metal Halide Luminaires) was adopted by the Energy Commission on December 15, 2004.

Alternative 2 included only standards for metal halide luminaires designed for 150 to 500 watt vertically mounted lamps, to be effective on January 1, 2006. The standards for metal halide luminaires were modified to separately address base-up and base-down vertically mounted lamps, and adopted by the Energy Commission on October 19, 2005. Alternative 1 for Table N-1 was not adopted. Alternative 1 had the same requirements as Alternative 2, and in addition included standards for metal halide luminaires designed for 150 to 500 watt horizontally mounted lamps, to be effective on January 1, 2008, and increased efficiency requirements for all lamp orientations, to be effective on January 1, 2008.

The potential standards the Energy Efficiency Committee is considering are shown in Table N-1 on page 13. Table N-1 shows the requirement for metal-halide luminaires that disallows probe-start ballasts for vertical base-up lamps on January 1, 2006 and all vertically mounted lamps (base-up and base-down) on January 1, 2008, as amended by the Energy Commission on October 19, 2005. In addition Table N-1 proposes to disallow probe-start ballasts for all lamp orientations from 150 to 500 watts on January 1, 2008. Also, the requirement for minimum lamp/ballast efficiency has been changed from Alternative 1, and has been separated into two wattage categories, with the requirement for 150-200 watts going into effect on January 1, 2008, and the requirement for 201-500 watts being delayed one year to have an effective date of January 1, 2009.

(n)(2) Energy Efficiency Standard for Metal Halide Luminaires.

Metal halide luminaires, manufactured on or after the effective dates shown in Table N-1, shall meet the requirements shown in Table N-1.

Table N-1
Standards for Metal Halide Luminaires

| Lamp Position | Lamp Rating | Effective Date | Requirements |
|-------------------------|----------------------|--|---|
| <i>Vertical base-up</i> | <i>150-500 Watts</i> | <i>January 1, 2006</i> <i>[Adopted 12/15/04- modified to exclude base-down 10/19/05].</i> | <i>Luminaires shall not contain a probe-start metal halide ballast</i> |
| <i>Vertical</i> | <i>150-500 Watts</i> | <i>January 1, 2008</i> <i>[Adopted 10/19/05].</i> | <i>Luminaires shall not contain a probe-start metal halide ballast</i> |
| <i>All</i> | <i>150-500 Watts</i> | <i>January 1, 2008</i> | <i>Luminaires shall not contain a probe-start metal halide ballast.</i> |
| <i>All</i> | <i>150-200 Watts</i> | <i>January 1, 2008</i> | <i>Luminaires (except "exempted outdoor luminaries" and luminaries operating at 480V) shall contain a metal halide ballast with minimum ballast efficiency = $(0.00016 \times \text{Lamp Watts}) + 0.86$</i> |
| <i>All</i> | <i>201-500 Watts</i> | <i>January 1, 2009</i> | <i>Luminaires (except "exempted outdoor luminaries" and luminaries operating at 480V) shall contain a metal halide ballast with minimum ballast efficiency = $(0.00016 \times \text{Lamp Watts}) + 0.86$</i> |

Notes: Fixtures are covered if they are capable of operating lamps that fall within the range of included lamp wattages. Vertical base-up includes products rated for use within 15° of vertical base-up. Vertical includes both base-up and base-down products. Vertical includes products rated for use within 15° of vertical.

Graphic presentations of the Table N-1 equations

The American Council for an Energy-Efficient Economy (ACEEE) has collected and analyzed readily available public data, and data provided by the National Electric Manufacturer's Association (NEMA) on a sample of electronic ballasts for pulse-start metal halide lamps including many products that have been introduced to the market since an earlier analysis was completed by them in March 2004. In general, ballasts with the maximum input wattage will have the lowest efficiency.

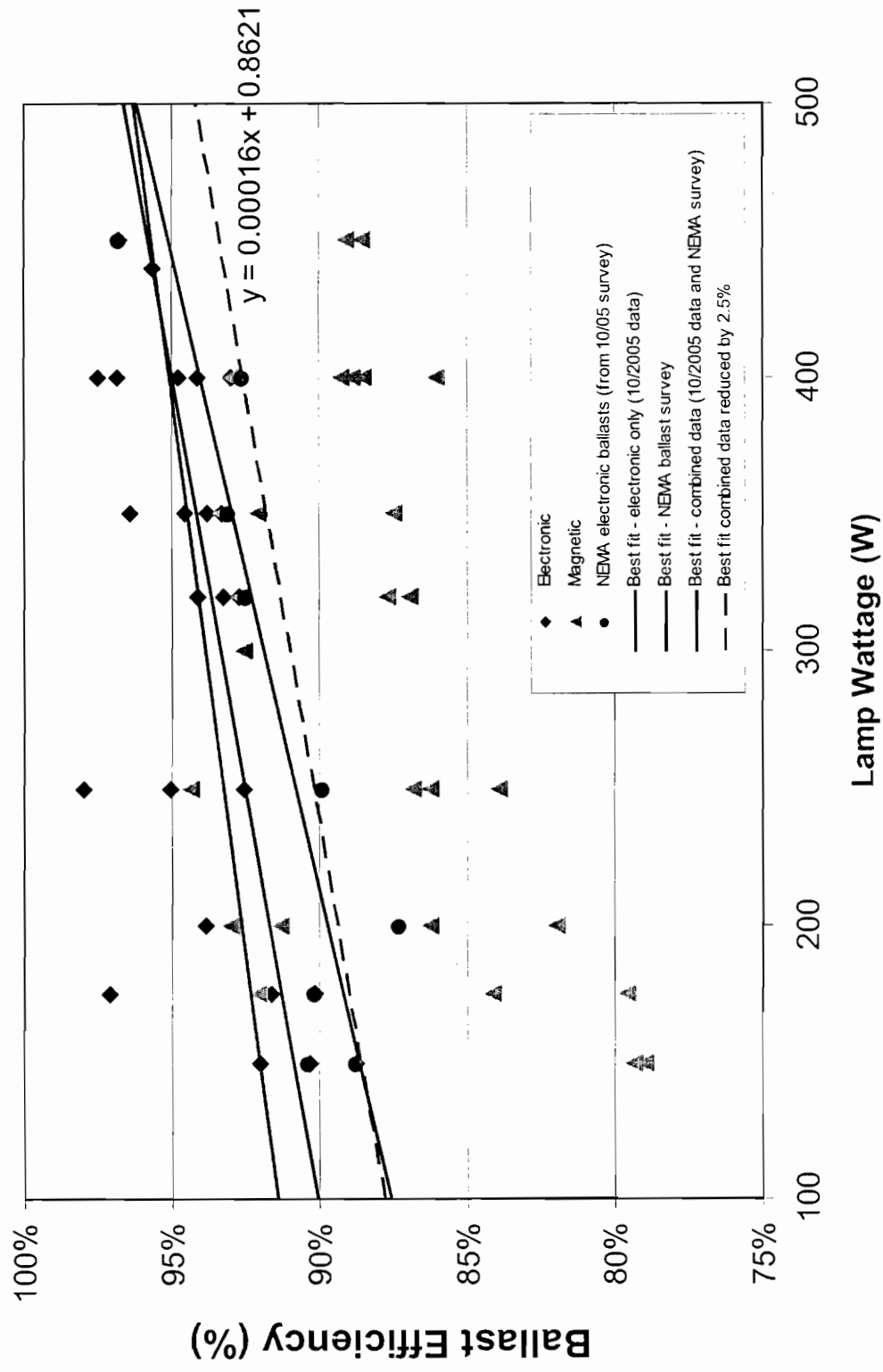
In the fall of 2005, ACEEE collected data on electronic ballasts from six manufacturers. The ACEEE data was provided to ENERGY COMMISSION just prior to the October 26, 2005 workshop and discussed at the workshop.

In order to provide a useful foundation for making recommendations, ACEEE combined its dataset (as presented at the Oct. 26, 2005 workshop) with the additional electronic ballast data provided by NEMA. ACEEE then plotted a best-fit line for the different data sets – ACEEE's, NEMA's, and the combined data set. Finally, these products were modified to develop the combined best fit line to produce a line that allows most, but not all electronic products to be in compliance. Specifically, ACEEE took the best fit line for the combined data set and multiplied by 97.5% (reduced the slope and intercept each by 2.5%). This analysis is shown in the graph on page 15. Based on this analysis, the recommend efficiency requirement for metal halide fixture ballast performance is as follows:

$$\text{Minimum ballast efficiency} = (0.00016 * \text{Lamp Watts}) + 0.86$$

This standard will take effect Jan. 1, 2008 for fixtures rated for lamps of 150-200 Watts, and Jan. 1, 2009 for fixtures rated for lamps of 201-500 Watts.

Figure 5: 2005 Analysis of Pulse-Start Metal Halide Ballasts



Proposed New Efficiency Equations for Metal Halide Ballasts

Dec. 12, 2005

Earlier this week NEMA provided information on metal halide ballast efficiencies. This included information from six companies, including four who currently sell electronic ballasts for metal halide lamps. NEMA does not report data on all products but instead, according to NEMA, “the figures are based on the product having the maximum input wattage as submitted by the ballast companies.” In general, ballasts with the maximum input wattage will have the lowest efficiency, hence the NEMA data will generally provide information on ballasts that are at or near the lowest efficiency for a given lamp wattage.

In the fall of 2005, ACEEE collected data on electronic ballasts from six manufacturers, including three not in the NEMA compilation. The ACEEE data was provided to CEC just prior to the Oct. 26, 2005 CEC workshop and discussed at this workshop. Thus, while there is some overlap between the NEMA and ACEEE data, there are also some data points unique to each dataset.

In order to provide a useful foundation for making recommendations, ACEEE combined its dataset (as presented at the Oct. 26, 2005 workshop) with the NEMA electronic ballast data. We then plotted a best-fit line for the different data sets – ACEEE’s, NEMA’s, and the combined data set. Finally, as was done in the 2004 CASE study on these products, we modified the combined best fit line to produce a line that allows most but not all electronic products to be in compliance. Specifically, we took the best fit line for the combined data set and multiplied by 97.5% (i.e. we reduced the slope and intercept each by 2.5%). This analysis is shown in the graph below. Based on this analysis, we recommend that the standard for metal halide fixture ballast performance be as follows:

$$\text{Minimum ballast efficiency} = (0.00016 * \text{Lamp Watts}) + .86$$

As with the CEC proposal presented at the Oct. 26, 2005 workshop, this standard would take effect Jan. 1, 2008 for fixtures rated for lamps of 150-200 Watts, and Jan. 1, 2009 for fixtures rated for lamps of 201-500 Watts.

