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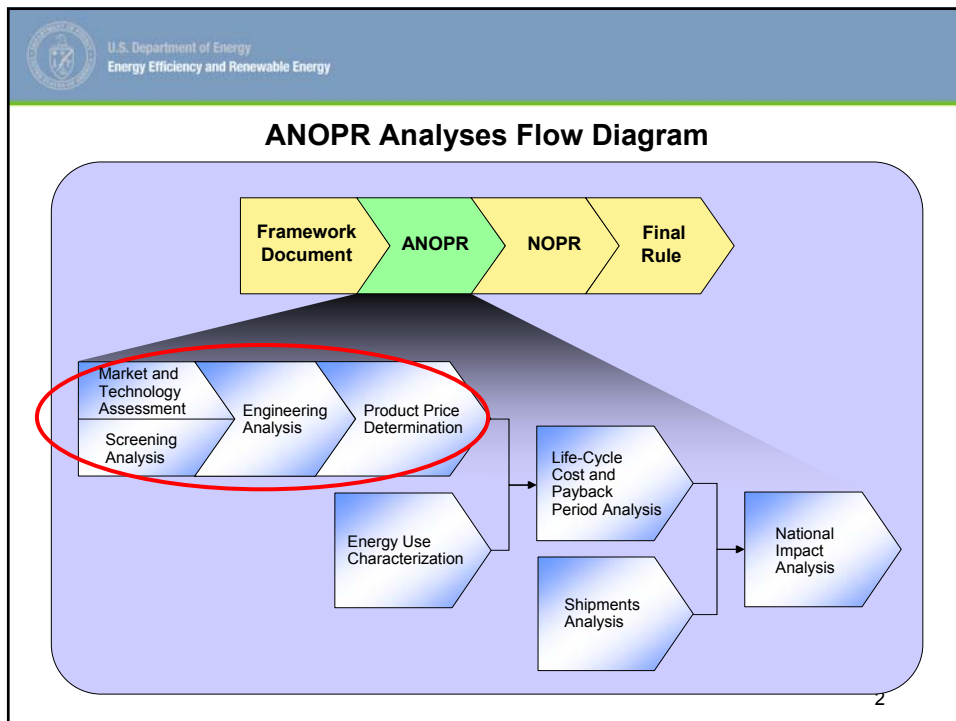
Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps


ANOPR Public Meeting

Engineering Analysis

Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

March 10-11, 2008




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Purpose

- **Market & Technology Assessment**
 - Characterize the fluorescent and incandescent reflector lamp market and industry, identify the measures to improve efficacy, and establish product classes.
- **Screening Analysis**
 - Screen out technology options that DOE will not consider in the engineering analysis for fluorescent and incandescent lamps.
- **Engineering Analysis**
 - Identify baseline lamps or lamp-and-ballast systems and their higher-efficacy alternatives.
- **Product Price Determination**
 - Establish end-user prices for lamps and ballasts identified in the engineering analysis.

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Market and Technology Assessment

General Service Fluorescent Lamp Product Classes

- EPCA established efficacy and CRI standards for 8 separate categories of fluorescent lamps based on four lamp types and two wattage bins per lamp type. 42 U.S.C. 6295(i)(1)

Lamp Type	Nominal Lamp Wattage <i>W</i>	Minimum CRI	Minimum Average Lamp Efficacy <i>lm/W</i>
Four-Foot Medium Bipin	> 35 W	69	75.0
	≤ 35 W	45	75.0
Two-Foot U-Shaped	> 35 W	69	68.0
	≤ 35 W	45	64.0
Eight-Foot Slimline	> 65 W	69	80.0
	≤ 65 W	45	80.0
Eight-Foot High Output	> 100 W	69	80.0
	≤ 100 W	45	80.0

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Market and Technology Assessment

Characteristics Used to Establish GSFL Product Classes

- **DOE divides covered product into classes by:**
 - The type of energy used
 - Capacity of the product or other performance-related features that justify different standard levels, such as features affecting consumer utility (42 U.S.C. 6295(q))
- **DOE used the following criteria to subdivide GSFL product classes:**
 - Physical constraints of the lamp
 - Lumen package
 - Correlated color temperature
- **DOE did not use the following criteria to subdivide the GSFL product classes:**
 - Lamp diameter
 - Ballast interoperability
 - Lamp wattage

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GSFL Product Classes: Physical Constraints of Lamps

- **Physical constraints of the lamp refer to the ability of lamp to use a particular fixture.**
- **The ability of a lamp to use a particular fixture affect the utility of the lamp.**
- **The efficacy of the product is also affected (e.g., 4-foot and 8-foot exhibit different efficacies).**
- **Result: Subdivide product classes by:**
 - Straight-shaped,
 - U-shaped lamps,
 - 4-foot length lamps, and
 - 8-foot length lamps.

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GSFL Product Classes: Lumen Package of Fluorescent Lamps

- Lumen package refers to the quantity of light a lamp-and-ballast system provides to the consumer.
- Notable differences in standard lumen output lamps and high lumen output lamps indicate differences in utility.
- 8-foot single pin slimline vs. 8-foot recessed double contact high output lamps
 - High output systems have approximately 50% higher lumen output than slimline systems
 - Efficacy differential can be as much as 10% between comparable slimline and high output systems
- Result: Different product classes for 8-foot single pin slimline lamps and 8-foot recessed double contact high output lamps.

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Market and Technology Assessment

GSFL Product Classes: Correlated Color Temperature

The line graph shows Relative Sensitivity on the y-axis (0 to 1.2) and Wavelength (nanometers) on the x-axis (400 to 750). The curve peaks at approximately 1.0 at 550 nm. The bar chart shows Efficacy (lm/watt) on the y-axis (78 to 92) and Lamp CCT on the x-axis (6500K and 4100K). The 6500K bar has an efficacy of approximately 84 lm/watt, and the 4100K bar has an efficacy of approximately 88 lm/watt.

- Correlated color temperature (CCT) is a measure of the perceived color of the white light emitted from the lamp.
- CCT is a performance related feature that affects consumer utility.
- Higher CCT lamps emit less radiation in the visible part of the spectrum, resulting in relatively lower efficacies.
- DOE considers setting separate efficacy standards for lamps with CCT \leq 4500K and lamps with CCT $>$ 4500K.

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GSFL Product Classes

- **DOE does not subdivide product classes by lamp diameter (e.g., T12 vs. T8)**
 - These are not properties that affect lamp utility.
 - Manufacturer product literature and market trends show that T8 lamps are currently being offered as T12 product replacements
- **DOE does not subdivide product classes by ballast interoperability.**
 - The economics of the ballast can be taken into account in the analyses.
- **DOE does not subdivide product classes by lamp wattage (e.g., 40W vs. 34W)**
 - Lamp wattage is not a property that necessarily affects lamp utility (e.g., 34W lamps are considered as a replacement for 40W lamps)

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Setting CRI standards

- **DOE is proposing to not subdivide product classes by wattage.**
- **However, EPCA established minimum CRI requirements for fluorescent lamps based on wattage.**
 - Higher wattage lamps have a minimum CRI of 69
 - Lower wattage lamps have a minimum CRI of 45
- **DOE believes that it does not have the authority to change the minimum CRI standard.**
- **DOE can not maintain the current minimum CRI requirements within the new product class structure.**

DOE invites comment on the possible approaches to handling the issue of CRI in setting GSFL efficacy standards

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GSFL Product Classes Used in ANOPR Analyses

Lamp Type	For CCT \leq 4,500K, Minimum Lamp Efficacy <i>lm/W</i>	For CCT $>$ 4,500K, Minimum Lamp Efficacy <i>lm/W</i>
4-Foot Medium Bipin	Product Class #1	Product Class #5
2-Foot U-Shaped	Product Class #2	Product Class #6
8-Foot Single Pin Slimline	Product Class #3	Product Class #7
8-Foot Recessed Double Contact HO	Product Class #4	Product Class #8

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General Service Fluorescent Lamp Product Classes

DOE invites comments on GSFL product classes.

Specifically, DOE invites comment on whether T12 and T8 fluorescent lamps should be in the same product class.

DOE also invites comments on whether there should be a CCT divider, how many groupings of CCT are appropriate, and what the CCT divider or dividers should be.

(Issue #3)

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Market and Technology Assessment

Incandescent Reflector Lamp Product Classes

- EPCA set efficacy standards for 6 different wattage bins
- DOE believes wattage, though it affects efficacy, is not a direct measure of utility (e.g., a high efficacy 55W lamp can deliver the same amount of light as a lower efficacy 75W lamp)
- Therefore, DOE is establishing a product class that encompasses the entire wattage range (40W-205W)
- To take into account the effect of wattage on efficacy, the candidate standard level for incandescent reflector lamps would be an equation that depends on wattage.

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Incandescent Reflector Lamp Product Classes

$Lm / W \geq \alpha * (W^\beta)$
where α and β are constants.

The graph plots Efficacy (lumens / watt) on the vertical axis against Lamp wattage (watts) on the horizontal axis. Three curves, labeled CSL1, CSL2, and CSL3, represent candidate standard levels. These curves show that efficacy increases as wattage increases, with CSL3 being the highest and CSL1 the lowest. A fourth curve, labeled EPCA, represents the current standard, which is a step function where efficacy is constant within each wattage bin but increases in discrete steps between bins.

Efficacy (lumens / watt)

Lamp wattage (watts)

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Modified-Spectrum Incandescent Reflector Lamps

- EISA 2007 defines a “colored incandescent lamp” such that some IRL (e.g., lamps containing > 5% neodymium) are no longer excluded from coverage
- These lamps may fall under the definition for “modified-spectrum” IRL:
 - A lamp whose color point with (x,y) chromaticity coordinates lies below the black-body locus and at least 4 MacAdam steps from the color point of a similar clear lamp.
- Modified-spectrum IRL offer different light output (and utility) by absorbing a portion of the visible light emission emitted by the filament, thereby reducing efficacy.
- DOE considers a separate product class for modified-spectrum lamps.

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IRL Product Classes

Lamp Category	Standard-Spectrum Minimum Lamp Efficacy <i>lm/W</i>	Modified-Spectrum Minimum Lamp Efficacy <i>lm/W</i>
IRL	Product Class #9	Product Class #10

DOE invites comment on the creation of product classes that encompass the full range of IRL wattages and the creation of a separated product class for modified spectrum lamps. (Issue #3)

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Screening Analysis

Screening Analysis Method

- **Design options were screened using the following criteria:**
 - Technological feasibility
 - Practicability to manufacture, install and service
 - Adverse impacts on product utility or product availability
 - Adverse impacts on health or safety

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Screening Analysis

Design Options Selected for Further Consideration

- **General Service Fluorescent Lamp Design Options**
 - Highly emissive electrode coatings
 - Higher-efficiency lamp fill gas composition
 - Higher-efficiency phosphors
 - Glass coatings
 - Higher-efficiency lamp diameter
- **Incandescent Reflector Lamp Design Options**
 - Higher-temperature operation
 - Thinner filaments
 - Efficient filament coiling
 - Efficient filament orientation
 - Higher-efficiency inert fill gas
 - Tungsten-halogen lamps
 - Higher-pressure tungsten halogen lamps
 - Infrared glass coatings (thin-film)
 - Higher-efficiency reflector coatings
 - Efficient filament placement

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Engineering Analysis

Engineering Analysis: Purpose

- The purpose of the engineering analysis and the product price determination is to determine the relationship between fluorescent an incandescent lamps and end-user price.
- The engineering analysis identifies baseline lamps or lamp-and-ballast systems and their higher-efficacy alternatives.

The diagram shows two blue boxes on the left: 'Engineering Analysis' and 'Product Price Determination'. A large purple arrow points from these two boxes to a larger box on the right titled 'Downstream Rulemaking Analyses'. This box contains two bullet points: 'Life-Cycle Cost and Payback Period Analysis' and 'National Impact Analysis'.

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Engineering Analysis

Engineering Analysis Methodology

The methodology is presented as a vertical sequence of five yellow chevron-shaped boxes on the left, each pointing to a corresponding description on the right. The steps are: 1. Choose Representative Product Classes, 2. Define Baseline Models, 3. Select Efficient Substitutes, 4. Develop Candidate Standard Levels, and 5. Scale to Product Classes Not Analyzed.

- ↩ Choose product classes to be analyzed in the engineering and life-cycle cost analysis.
- ↩ Define characteristics of models in each representative product class which will serve as reference points to assess changes due to energy conservation standards.
- ↩ Identify more-efficient substitutes from a database of commercially-available lamps. Substitutes will maintain similar light output and save energy.
- ↩ Develop candidate standard levels that span the range of efficacy from the baseline to the maximum technologically feasible.
- ↩ Scale results to other product classes not analyzed.

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Engineering Analysis

Representative Product Classes

- **DOE chose a subset of product classes to analyze in the engineering analysis and life-cycle cost analysis to concentrate its analytical effort. These are called “representative product classes.”**
- **DOE based its selection on those product classes with the highest volume of shipments.**
- **General Service Fluorescent Lamps**
 - Of the 8 product classes, DOE analyzed three:
 - 4-foot medium bipin; CCT ≤ 4500K
 - 8-foot single pin slimline; CCT ≤ 4500K
 - 8-foot recessed double contact HO; CCT ≤ 4500K
- **Incandescent Reflector Lamps**
 - DOE analyzed the standard-spectrum product class and is scaling its findings to the modified-spectrum product class.

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Engineering Analysis

Baseline Models

- **DOE selected baseline lamps from each representative product class.**
- **Typically a baseline lamp just meets the existing energy conservation standard.**
- **DOE selected specific attributes like light output, wattage, and operating lifetimes that are typical of the most common lamp on the market for that product class.**
- **DOE selected multiple baseline lamps in each product class to ensure consideration of different high-volume lamps and their associated consumer economics.**

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Engineering Analysis

Baseline Models: General Service Fluorescent Lamps

- **4-Foot Medium Bipin, ≤ 4500K Product Class:**
 - Wattage: 40W T12, 34W T12, 32W T8
 - Operating lifetime: 20,000 hrs
 - CCT: 4100K
 - Phosphor: 40W T12 and 32W T8: 700 series, 34W T12: 600 series
- **8-Foot Single Pin Slimline, ≤ 4500K Product Class:**
 - Wattage: 75W T12, 60W T12, 59W T8
 - Operating lifetime: 12,000 and 15,000 hrs
 - CCT: 4100K
 - Phosphor: 75W T12 and 59W T8: 700 series, 60W T12: 600 series
- **8-Foot Recessed Double Contact High Output, ≤ 4500K Product Class:**
 - Wattage: 110W T12, 95W T12
 - Operating lifetime: 12,000 hrs
 - CCT: 4100K
 - Phosphor: 110W T12: 700 series, 95W T12: 600 series

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Engineering Analysis

Select Efficacious Fluorescent Lamp Substitutes

- Based on commercially-available lamps
- Example of 4-Foot Medium Bipin higher efficacy lamps

	Lamp Diameter	Nominal Wattage <i>W</i>	Rated Efficacy <i>lm/W</i>	CRI
Baseline	T12	40	80.0	70
	T12	40	82.5	80
	T12	40	85.0	80
	T12	40	90.0	85
Baseline	T12	34	77.9	62
	T12	34	82.4	70
	T12	34	85.3	80
	T12	34	91.2	85
Baseline	T8	32	86.2	75
	T8	32	90.8	82
	T8	32	92.3	85
	T8	32	95.4	82
	T8	30	95.0	82
	T8	28	97.3	82
	T8	25	96.0	85
	T8	25	96.0	85

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Fluorescent Lamp Systems Approach

- For GSFL, lamps must be operated on ballasts. DOE takes a “systems approach” that considers both reduced-wattage and equal-wattage lamps operated by different ballasts
- The ballast influences the light output and energy consumption of the lamp
- Each lamp is paired with one or more ballasts → “system”
- Systems are chosen to have similar mean lumen output as the baseline system
- Energy savings from the baseline system can be obtained by using either:
 1. A more efficacious reduced-wattage lamp on the same ballast; or
 2. A more efficacious same or reduced wattage lamp on a different ballast so it operates the lamp at a lower power level.

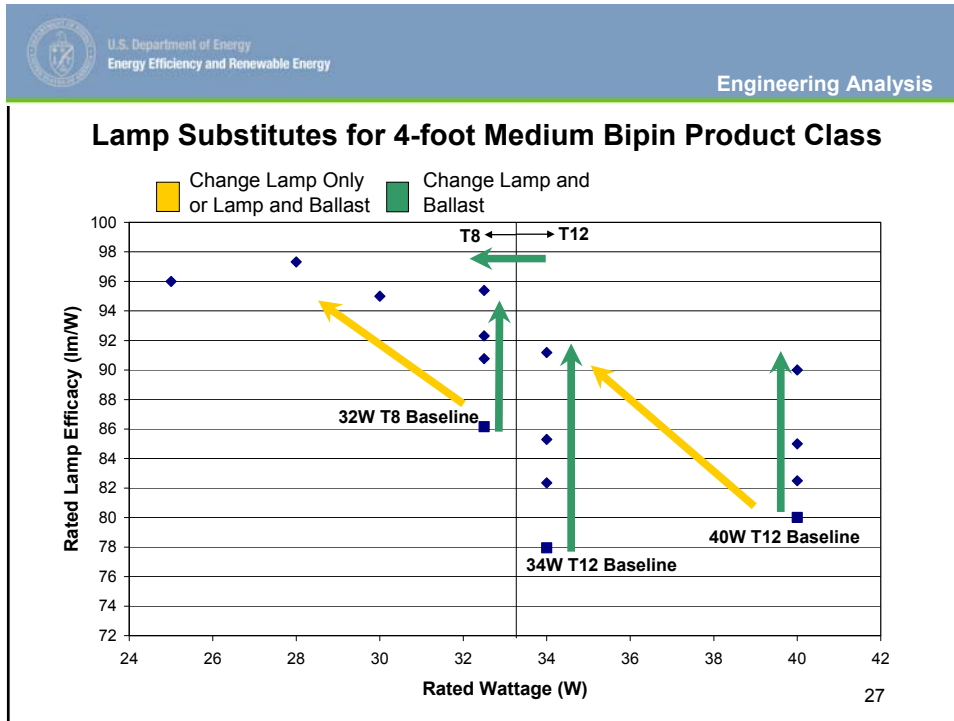
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Fluorescent Lamp Systems Introduction

- **System mean lumen output = number of lamps per ballast x ballast factor x mean lumen output of lamp**
 - For example, given a 3-lamp ballast with a 0.9 BF and lamps that emit 2,000 mean lumens each the system mean lumen output is equal to $3 \times 0.9 \times 2,000$ or 5,400 lumens.
- **System power is dependent on lamp wattage and the ballast factor of the ballast.**
 - As ballast factor decreases, system power decreases.
 - As lamp wattage decreases, system power decreases.

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- ### Fluorescent Lamp-and-Ballast Systems: Baselines and Substitutes
- **4-Foot Medium Bipin: 3-Lamp System**
 - Baseline systems
 - T12 system: magnetic ballast or a 0.88 ballast factor (BF) electronic ballast
 - T8 system: 0.88 BF electronic ballast
 - Additional electronic ballasts used for higher efficacy systems
 - T12 system: 0.87 and 0.86 BF; T8 system: 1.18, 1.00, 0.78, and 0.75 BF
 - **8-Foot Single Pin Slimline: 2-Lamp System**
 - Baseline systems
 - T12 system: magnetic ballast or a 0.88 BF electronic ballast
 - T8 system: 0.88 BF electronic ballast
 - Additional electronic ballasts used for higher efficacy systems
 - T12 system: 0.85 BF; T8 system: 0.78, 0.85, and 1.18 BF
 - **8-Foot Recessed Double Contact HO: 2-Lamp System**
 - Baseline systems
 - T12 system: 0.88 BF electronic ballast
 - Additional electronic ballasts
 - T12 system: 0.90 and 0.89 BF; T8 system: 0.81 BF
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Engineering Analysis

Fluorescent Lamp CSL Summary

- **Candidate standard levels based on several design options (primarily phosphor series) and commercially available lamps.**
- **Phosphor Series**
 - 600 series cool white halophosphor
 - Lower efficacy, reduced-wattage baselines; CRI between 60 and 69
 - 700 series rare earth phosphor
 - Higher-wattage baselines and higher-efficacy lamps; CRI between 70 and 79
 - 800 series rare earth phosphor
 - Higher efficacy lamps; CRI between 80 and 89
- **Other Possible Design Options Incorporated to meet CSLs**
 - Highly emissive electrode coatings, higher efficiency lamp fill gas composition, thicker phosphor coating, glass coatings, or higher efficiency lamp diameter
- **Some CSLs in each product class eliminate all T12 lamps**

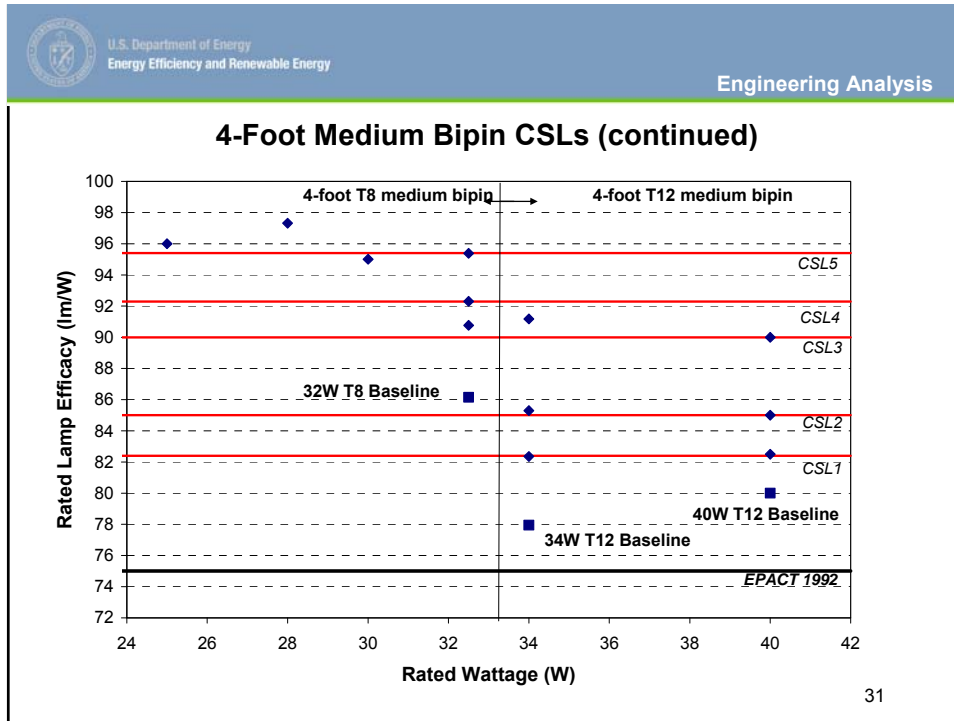
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Engineering Analysis

4-Foot Medium Bipin CSLs

CSL	Efficacy	Design Option for Each Baseline		
		40W T12	34W T12	32W T8
CSL0	< 82.4 lm/W	700 series	600 series	-
CSL1	82.4 lm/W	Improved 700 series or 800 series	700 series	-
CSL2	85.0 lm/W	800 series	800 series	700 series
CSL3	90.0 lm/W	Improved 800 series	Improved 800 series	800 series
CSL4	92.3 lm/W			Improved 800 series – 30W lamp available
CSL5	95.4 lm/W			Improved 800 series – 28W and 25W available

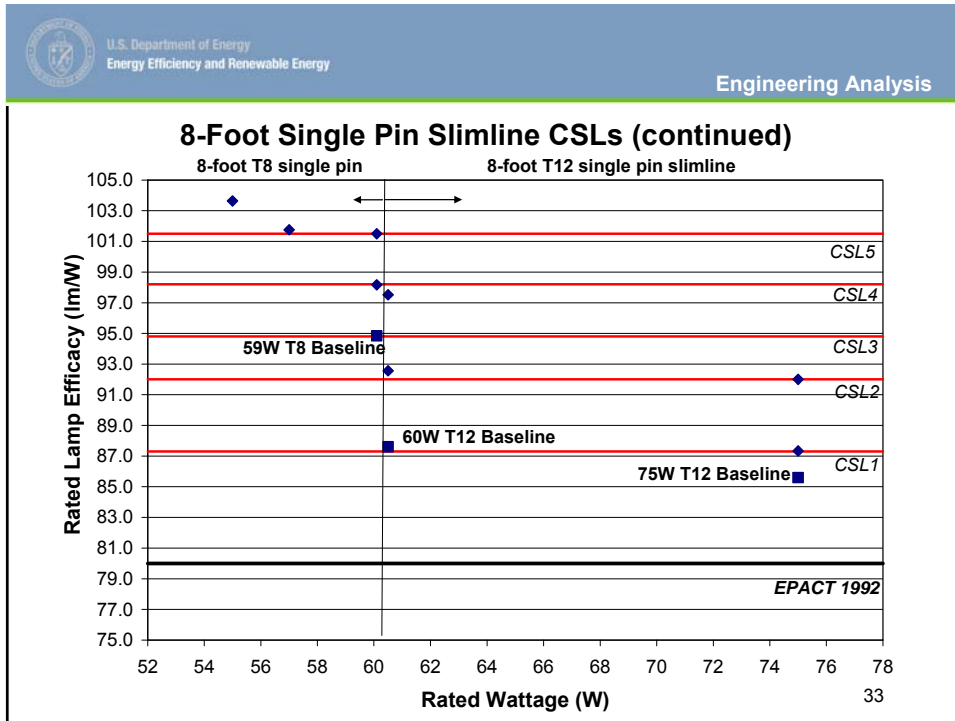
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8-Foot Single Pin Slimline CSLs

CSL	Efficacy	Design Option for Each Baseline		
		75W T12	60W T12	59W T8
CSL0	< 87.3 lm/W	700 series	-	-
CSL1	87.3 lm/W	800 series	600 series	-
CSL2	92.0 lm/W	Improved 800 series	700 series	-
CSL3	94.8 lm/W	Improved 800 series	Improved 700 series	700 series
CSL4	98.2 lm/W			800 series
CSL5	101.5 lm/W			Improved 800 series – 57W and 55W available

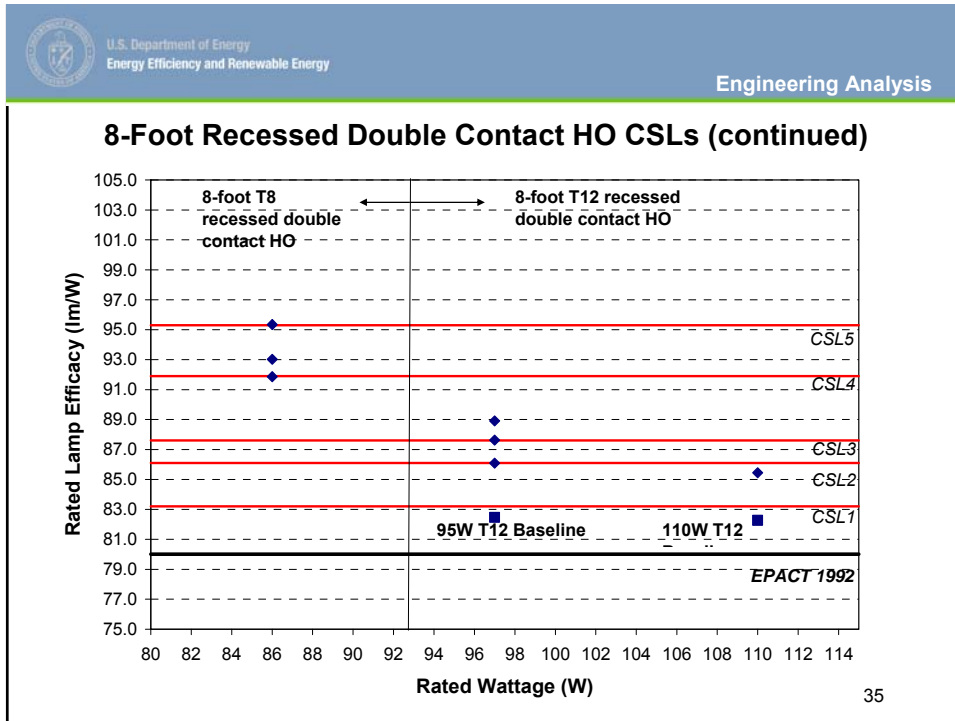
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8-Foot Recessed Double Contact HO CSLs

CSL	Efficacy	Design Option for Each Baseline		
		110W T12	95W T12	86W T8*
CSL0	< 83.2 lm/W	700 series	600 series	-
CSL1	83.2 lm/W	800 series	-	-
CSL2	86.1 lm/W		700 series	-
CSL3	87.6 lm/W		800 series	-
CSL4	91.9 lm/W			700 series
CSL5	95.3 lm/W			800 series

*Note: 86W T8 is not a baseline lamp



40W T12 Example Engineering Analysis System Results

	CSL	Lamp Diameter	Nominal Wattage	Rated Efficacy	Ballast Type	Ballast Factor	System Power	System Mean Light Output
			W	lm/W			W	lm
Lamp Only Replacement	CSL0	T12	40	80.0	Magnetic	0.95	129.0	8,208
	CSL3	T12	34	91.2	Magnetic	0.88	108.0	7,366
Lamp and Ballast Replacement	CSL0	T12	40	80.0	Electronic	0.88	107.7	7,603
	CSL1	T12	40	82.5	Electronic	0.88	107.7	7,920
	CSL1	T12	40	82.5	Electronic	0.87	107.0	7,830
	CSL2	T12	40	85.0	Electronic	0.87	107.0	7,987
	CSL2	T8	32	86.2	Electronic	1.18	114.5	8,921
	CSL3	T12	40	90.0	Electronic	0.87	107.0	8,483
	CSL3	T12	34	91.2	Electronic	0.88	91.7	7,366
	CSL3	T8	32	90.8	Electronic	1.00	98.3	8,130
	CSL4	T8	32	92.3	Electronic	0.88	87.5	7,524
	CSL4	T8	30	95.0	Electronic	1.00	90.2	8,040
	CSL5	T8	32	95.4	Electronic	0.88	87.5	7,696
	CSL5	T8	28	97.3	Electronic	1.00	80.5	7,680
	CSL5	T8	25	96.0	Electronic	1.18	93.0	8,071



Selection of Fluorescent Lamp-and-Ballast Designs and Candidate Standard Levels

DOE invites comments on the selection of GSFL lamp-and-ballast designs from baseline to max-tech as well as the selection of GSFL candidate standard levels.

Additional results can be found in Chapter 5 of the TSD.

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Scaling to Other Fluorescent Lamp Product Classes: Product Classes with CCT > 4500K

- Scale from corresponding fluorescent product class with CCT \leq 4500K
- Efficacies of commercially available T8 lamps at 6500K are approximately 4% to 7% lower than that of the 4,100K lamps
- To avoid overly penalizing current product offered in the market, DOE considers adopting the larger of the two scaling factors (7%)
- Example: If 82.4 lm/W (i.e., CSL1) were selected for the 4-foot medium bipin product class of 4,500K CCT and below, the scaled efficacy requirement for the product class greater than 4,500K CCT would be 76.6 lm/W.

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Scaling to Other Fluorescent Lamp Product Classes: 2-Foot U-shaped with CCT \leq 4500K

- Scale from 4-foot medium bipin product class with CCT \leq 4500K
- Efficacy differentials in commercially available products depend on lamp diameter and wattage – U-shaped are approximately 3-6% lower efficacy
- To avoid overly penalizing current product offered in the market, DOE considers adopting the larger of the two scaling factors (6%)

DOE invites comments on the method used to scale to product classes with CCT > 4100K and the 2-foot U-shaped product class. (Issue #4)



Baseline Models: Incandescent Reflector Lamps

- DOE has identified three common lumen packages that represent the most typical standard-spectrum IRL in the market
- These three lamps are currently regulated by EPCA and meet the EPCA standard.

Descriptor	Design Option	Wattage <i>W</i>	Efficacy <i>lm/W</i>	Initial Light Output <i>lm</i>	Lifetime <i>hr</i>
PAR30	Halogen	50	11.6	580	3,000
PAR38		75	14.0	1,050	2,500
PAR38		90	14.6	1,310	2,500



Select Efficacious IRL Substitutes

- **DOE chose IRL substitutes that save energy and achieve similar lumen output by increasing efficacy and using reduced-wattage lamps. e.g., 50W @ 12 lumens/watt \approx 44W @ 14 lumens/watt**
- **Used commercially available lamps when possible.**
- **Three basic design options available commercially:**
 - Improved Halogen (3,000 hr life)
 - Halogen Infrared (HIR) (3,000 hr life)
 - Improved HIR (4,000 hr life)
- **Improved Halogen and Improved HIR could be achieved using the following design options:**
 - Higher efficiency filaments, efficient filament coiling, filament configuration, capsule design, high pressure capsules, or higher efficiency reflector coating.

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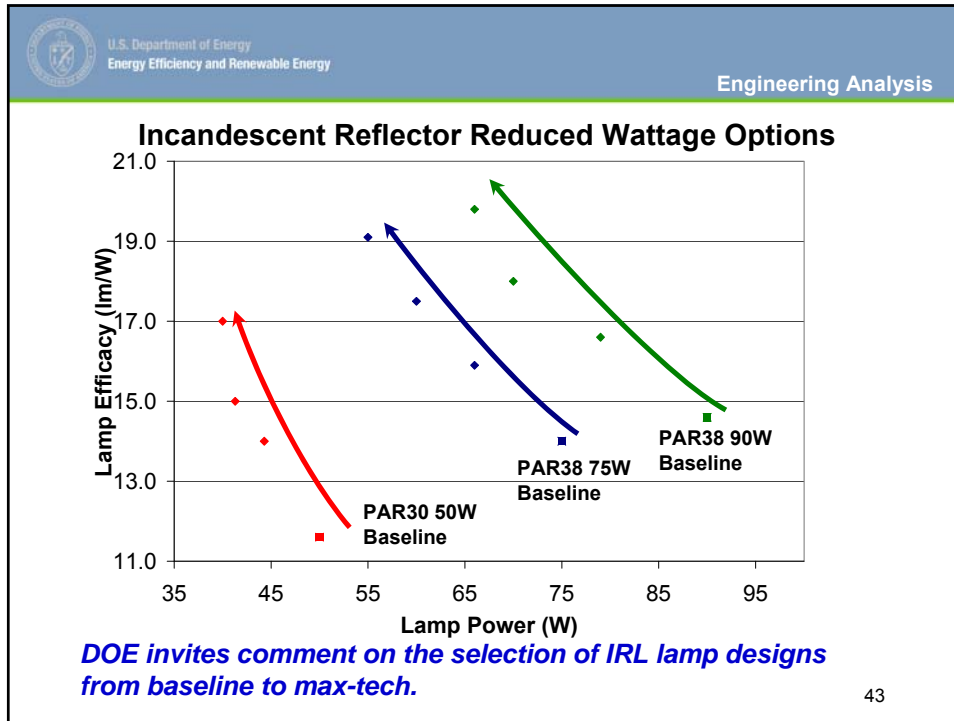
“Model” Incandescent Reflector Lamps

- **When commercially available lamps were not available, DOE developed model lamps to have a continuous range of lamp efficacies across the three lumen packages**
- **Model lamps were developed from technical literature and confidential information from manufacturers**
- **Model Lamps:**
 - 44.3W, 14.0 lm/W PAR30 lamp
 - 41.3W, 15.0 lm/W PAR30 lamp
 - 66.0W, 19.8 lm/W PAR38 lamp

} reduced-wattages of the 50W,
11.6 lm/W PAR 30 baseline

} reduced-wattage of 90W,
14.6 lm/W PAR38 baseline

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Engineering Analysis

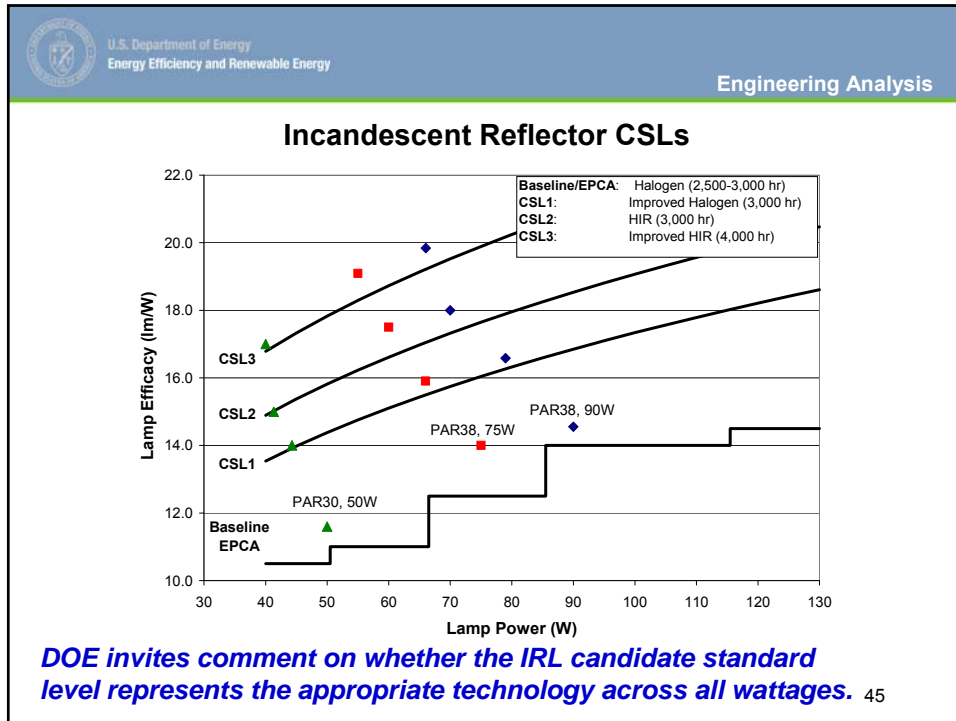
Incandescent Reflector CSLs

- DOE developed continuous equations that set a minimum efficacy requirement across all wattages.
- Each equation represents the same IRL design option across the wattage range of a product class.

Candidate Standard Level	Minimum Efficacy Requirement	Design Option
	lm/W	
CSL1	$5.0 \cdot P^{0.27}$	Improved Halogen
CSL2	$5.5 \cdot P^{0.27}$	HIR
CSL3	$6.2 \cdot P^{0.27}$	Improved HIR

P = rated wattage

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- ### Scaling to Modified Spectrum Incandescent Reflector Lamps
- DOE identified several IRL lamps with modified-spectrums and compared their performance with standard (i.e., non modified-spectrum) lamps.
 - The reduction in efficacy caused by the modified-spectrum ranged from 2% to 29% with an average reduction in efficacy of 15%.
 - DOE recognizes that those modified-spectrum lamps may have a distinct utility.
 - DOE wishes to establish a standard for modified-spectrum lamps that:
 - Does not eliminate modified-spectrum lamps which require a lower efficacy standard because of their distinct utility; and
 - Acknowledges the ranges of spectrum modification possible for IRL and their corresponding effects on efficacy
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Possible Scaling Method for Modified-Spectrum IRL

- Modified spectrum scaling could be based on the light output of the modified spectrum lamp and an equivalent reference standard-spectrum lamp
- Reference standard-spectrum lamp would be equivalent to the modified spectrum lamp except for the coating of neodymium (or other additive) that causes the lamp to emit a modified-spectrum.
- Equation:

$$CSL_{Modified-Spectrum} = \frac{lm_{Modified-Spectrum}}{lm_{Standard-Spectrum}} * CSL_{Standard-Spectrum}$$

DOE invites comments on the method used to scale from a standard-spectrum lamp to a modified-spectrum lamp. (Issue #4)

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Product Price Determination

Purpose

- Establish end-user prices for those lamps or lamp-and-ballast systems identified in the engineering analysis.

Method

- Product price determination is based on available pricing lists (e.g., manufacturer price lists, state procurement price lists).
- DOE discounted blue-book prices to develop high-range, medium-range, and low-range end-user retail prices to reflect variability in the market.
 - Medium-range prices are used as reference prices in life-cycle cost and national impact analysis
 - High and low-range prices are used as sensitivities in the life-cycle cost analysis.
- DOE developed a weighted-average sales tax data by region based on local data from Sales Tax Clearinghouse.
 - National average: 6.9%.

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Product Price Determination

General Service Fluorescent Lamp Methodology

- **Market Today**
 - Higher efficacy lamps received higher markups (*i.e.*, lower discounts off the blue book price schedule) than lower efficacy lamps in the market.
- **DOE mirrored State procurement contracts by applying a constant discount across all lamps to reflect the commoditization of the product in marketplace after a standard.**
- **Low-Range Prices (high discount off “blue book”)**
 - Consistent with prices found in State procurement contracts and other sources which have a single high-volume discount (typically between 70-90%) for all products.
- **Medium-Range Prices (medium discount off “blue book”)**
 - Consistent with the typical discount provided by distributors for commercial and institutional consumers on high-volume lamps, incorporating a 13% contractor mark-up (2000 Ballast Rule).
- **High-Range Prices (low discount off “blue book”)**
 - Consistent with prices encountered by small quantity purchasers (e.g., internet prices, distributor quotes). These prices also incorporate a 13% contractor mark-up.

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Product Price Determination

General Service Fluorescent Lamp End-User Price Results

32W T8 4-foot Medium Bipin Results

Lamp Efficacy (lm/W)	High-Range Price (\$)	Medium-Range Price (\$)	Low-Range Price (\$)
86.0	2.4	1.7	1.0
90.5	3.8	2.7	1.6
92.5	4.0	2.8	1.7
95.5	4.6	3.3	2.0

DOE requests feedback on the approach for developing end-user GSFL prices.

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Incandescent Reflector Lamp Prices

- DOE did not observe significant variation in prices by lamp wattage.
- DOE did develop separate prices for PAR 38 and PAR 30 IRL.
- Research indicated that the PAR 38 IRL market was a more developed market than the PAR 30 IRL market.
- DOE developed discounts off of the blue-book prices for PAR 38 lamps. DOE then based the PAR 30 lamp prices off the PAR 38 analysis.

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PAR 38 Incandescent Reflector Lamp Prices

- DOE mirrored state procurement contracts by applying a constant discount off the “blue-book” over all halogen and HIR technology IRL to reflect commoditization of the product in the marketplace after the standard.
- **Low-Range Prices (high discount off “blue book”)**
 - Consistent with prices found in State procurement
- **Medium-Range Prices (medium discount off “blue book”)**
 - Consistent with shipment-weighted average prices paid by consumers for commonly available IRL.
- **High-Range Prices (low discount off “blue book”)**
 - Consistent with prices encountered by small quantity purchasers (e.g., internet prices).

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Product Price Determination

PAR30 Incandescent Reflector Lamp Prices

- Research indicates that the PAR 30 market is less developed
- Therefore, DOE developed modified list (“blue-book”) prices for PAR 30 lamps by applying the same incremental differences between incandescent (non-halogen) lamps and higher efficacy lamps from the PAR 38 lamps.

Developing PAR 30 “Blue Book” Prices

BR 40	Incandescent	BR 30
PAR 38	Halogen	PAR 30
PAR 38	Improved Halogen	PAR 30
PAR 38	HIR	PAR 30
PAR 38	Improved HIR	PAR 30

- DOE then applied the same discounts off of the modified “blue book” prices to develop low, medium and high-range prices.

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Product Price Determination

Incandescent Reflector Lamp End-User Prices

75W PAR38 Baseline Results

Lamp Efficacy (lm/W)	High-Range Price (\$)	Medium-Range Price (\$)	Low-Range Price (\$)
14.0	6.5	4.8	3.2
16.0	8.1	6.1	4.1
17.5	8.3	6.3	4.2
19.0	10.0	7.5	5.0

DOE requests feedback on the approach for developing end-user IRL prices.

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ANOPR Issues for Public Comment

- **Product Classes (Issue #3)**
- **Standards for Color Rendering Index**
- **Selection of Efficacious Lamp Substitutes and Candidate Standard Levels**
- **Scaling to Product Classes Not Analyzed (Issue #4)**
- **Approaches for Establishing End-user Prices**