WRR methodology vs Lumen range For A-Lamps

CALIFORNIA
TECHNICAL FORUM

ALINA ZOHRABIAN

IOU WRR WORKING GROUP: RICHARD GREENBURG(SCE), YUN HAN(SCE), JEFF COX (SDG&E), ADAM SCHEER(PG&E), SHAREGHE MEHRAEEN (PG&E), ALINA ZOHRABIAN (PG&E)

SEPTEMBER 22, 2016

Presentation Overview

Objective: Get CALTF feedback on switching to lumen equivalency method from the wattage reduction ratio (WRR) for calculating savings from LED A-Lamps

- Background on WRR
  - History of WRR and What is WRR?
  - Issues with WRR
- Why address issues now?
- New lumen equivalency method
- Issues/Challenges for the savings calculation
- Should lumen equivalency method be applied to other bulb types?

Measure Description
A-Lamps

- In CA How many engineers will take to calculate the savings for a light bulb?

Measure Description
A-Lamps

- One. But it takes 36 to review it

History of WRR

- WRR is the ratio of the baseline to measure wattage

Table 2 - Comparison of Lamp Savings

		Ba	
Lamp Description		ED Recommendation	
Type	Measure Wattage	Wattage Ratio	% Savings per Lamp
MR16	All	4.24	76%
PAR20	All	4.70	79%
PAR30	All	3.42	71%
PAR38	All	3.81	74%
A19	All	2.96	66%
Candelabra	All	7.35	86%
Globe	< 3W	7.47	87%
	>= 3W	4.94	80%

- In May of 2012 ED issued a disposition on Integral LED workpapers that gave the WRR value for each lamp type as shown in the left

History of WRR: Calculating WRR

SDG&E's 2010-2012 cycle, based on Lumen equivalency 40W incandescent = 8.7W LED

Savings Using original WP submission (assumes 100% Incandescent Baseline) =
40W-8.7W=**31.3** Watts

Minimum
Lumens
450

A19, 40 W
Incandescent

450-530
lumen Energy
Star(ES)=492
Lumens

A19, LED Wattage range allowed for rebate ≤9watts, ES average =8.7 W LED

ED also considered 50% CFL base case

The A19 Wattage Reduction Ratio (WRR)=((40W*0.5)+(40W/3.47)*0.5)/8.7=2.96

Savings Using WRR (assumes 50% CFL baseline): Calculate base case =8.7W LED *2.96= **25.74**, and savings = 25.75W-8.7W=**17.05** Watts

History of WRR: Disposition Directive for Conservative Savings

In ED's 2013-2014 disposition, ED suggested applying the WRR to the lowest LED wattage in the market.
Example: Lowest Energy Star for ≤9 watts:

6W*2.96=17.76, savings 17.76-6=11.76 watts

"If the savings are calculated based on a ratio of a measure to pre-existing wattage ratio, then the measure wattage shall be the wattage at the lowest end of the wattage range. In cases where the range does not have an upper or lower range, then the wattage shall be the lowest wattage of commercially available products within that range."

Issues with WRR

- **WRRs Out-of-Date as LED Efficacy Increases**: Current WRR out-of-date, even if updated, as LED efficiency increases, WRR will again be out-of-date (Navigant Study)

- **WRR Yields Incorrect Results** – for bulbs with the same lumen output, higher wattages yield higher savings – this is clearly not correct (see next slide).

- **Creates Need for Excessive Measure Codes to Get Accurate Savings, Complicating Administration and Increasing Costs:** Guidance to apply WRR to lowest end of wattage range results in creation of many individual measure codes to finely bin wattage ranges

- **Creates Incorrect Incentives – Higher Wattage in Same Lumen Bin Yields Greater Savings**, so PA incentive is to incent higher wattage bulbs to claim greater savings, even if lower wattage bulb would produce same lumens.

Using WRR Yields Illogical Results

AS LED wattages go up, the savings go up, within the same EISA lumen bins (example from current A-lamp WP).

- **Current measures for A-Lamp**
- < LED A-Lamp < 8 watts
- LED A-Lamp 8 to < 9 watts
- LED A-Lamp 9 to < 10 watts
- NOTE: For a 40W equivalent LED (within the same EISA lumen bin), savings increase as the LED bulb wattage increases using the WRR method. However, as wattages go up, savings should *decrease*. Application of the WRR yields incorrect results and creates the wrong incentives for PAs and implementers.

- **Current savings for A-Lamp**
- **(6 * 2.96) - 6= 11.68**
- (8 * 2.96) - 8 = 15.68
- (9 * 2.96) - 9 = **17.64**

WRR: Why Consider Alternate Now?

- Navigant Study:

The WRR method underestimates savings for more efficient lamps and overestimates savings for less efficient lamps, which provides a disincentive for programs to focus on more efficient products.

Additionally, existing WRR values do not accurately reflect the current baseline and LED efficacies in the non-residential market.

Navigant Study, Key Findings and Recommendations section (page 1-11)

WRR: Why Consider Alternate Now?

- ED Disposition
  - *CPUC Staff and PAs acknowledge that the WRR values may be encouraging incentives for higher wattage lamps as a way of increasing reported savings . .the WRR for lamps assigns greater savings to . . . [higher wattage lamps for similarly performing lamps].*
  - *The Navigant report highlights a potentially significant opportunity to promote higher efficacy lamps that would increase savings over the practices occurring under current programs.*
  - *CPUC staff is open to alternatives proposed by the PAs that are supported by additional research, analysis or program requirements.*

Navigant Recommendations for Alternatives to Wattage Reduction Ratio

Ideal "Best" Scenario

- Use single baseline for each product category (i.e. EISA Lumen bin) (requires collecting rated lumen output)
- Use Average Program LED wattage if possible for program savings or use web scraping to update the LED average wattages annually

Alternative "Better" Scenario

- Use single baseline for each product category
- Collect actual LED wattage and calculate savings by using the baseline watts minus the actual LED watts
- Since LED efficacy increases the program savings should be updated annually to reflect the appropriate EISA bin

Possible Improvements if Continuing with WRR Methodology

- Update average LED efficacy and wattage annually using web-scraped data
- Apply different WRRs to each EISA bin as determined by LED lumens (ideal) or wattage (possible)
- Update baseline technology mix and wattage regularly

Lumen Equivalency Method

- Determine Baseline Wattage
  - What mix is correct mix of halogens, CFLs and LEDs for baseline?
  - What stud(ies) represent “Best Available Data”
  - Fully exclude LEDs from baseline as the LEDs will be picked up in NTG ratio?
- Determine LED Measure Wattage that Yields Same Lumen Range As Baseline
  - For A-Lamps, lumen range determined by EISA

The New Lumen Method: EISA Lumen Ranges

- (EISA) Energy Independence Security Act

GENERAL SERVICE INCANDESCENT LAMPS

Rated Lumen Ranges	Maximum Rate Wattage
1490–2600	72
1050–1489	53
750–1049	43
310–749	29

These represent the common incandescent bulb types

- 100W
- 75W
- 60W
- 40W

Calculating the Baseline Wattage

	lumen range		Equivalent Incandescent	50% max wattage halogen	50% max wattage CFL	LED Wattage?	Calculation base wattage
4	1490	2600	100	72	23		47.5
3	1050	1489	75	53	18		35.5
2	750	1049	60	43	13		28
1	310	749	40	29	10		19.5

Various Data Sources for Base Wattage Calc

- **TRC memo presents summary of baseline studies in Table 1. Note that these results do not include the percent of LEDs available, because the net savings adjustment in the impact evaluation will account for participants that would have purchased LEDs in the absence of the program. In other words, TRC removed LEDs from the baseline analysis to avoid double counting LED free ridership. The TRC Appendix provides the raw data from each data source, including the fraction of lamps that are LEDs.**

		% of Avail A-Lamps (without LEDs)			
Source	Timeframe Data Represents	Incandesc	Halogen	Incandesc + Halogen	CFL
CLASS 2012 (DNV-GL 2014): Installed A-lamps	May – Nov 2012	50%	0.2%	50%	50%
CSS (Itron 2014): Installed Medium Screw Based (MSB) Lamps	Q1 2012 – Q4 2013	33%	10%	43%	57%
NEMA shipment data, average of last four quarters	Q2 2015 through Q1 2016	12%	57%	69%	31%
DNV-GL CA shelf survey data for A-lamps (winter 2015/16)	Late 2015/early 2016	17%	34%	51%	49%

Calculating the Measure Wattage: Range of Wattages for first EISA Lumen Bin (all Energy Star Products)

For Energy Star-rated products, the measure wattage ranges from 4.5W to 10W for the first bucket (40W equivalent, 310-749 lumens)

Wattage Equivalency (watts)	Energy Used (watts)	Efficacy (lumens/watt)	Brightness (lumens)
40	4.5	73.3	330
		100	450
		104.4	470
	4.9	91.8	450
	5	90	450
		92	460
		94	470
		100	500
		110	550
	5.2	90.4	470
	5.5	80	440
		81.8	450
		85.5	470
		87.3	480
		89.1	490
		92.7	510
	5.6	80	450
		80.3	450
		80.4	450
		83	465
		83.9	470
		85.7	480
		89.3	500
	5.7	82.5	470
	6	74.9	450
		75	450
		76.7	450
		78.3	470
		79	470
		80	480
		83.3	500
		85	510
		88.3	530
		89	470
		91.7	550
		93.3	560
		100	600

Calculating the Measure Wattage

- **Can't only consider Efficacy without looking at the wattage since if only the lumen increases the efficacy would be higher but would use the same energy**

Energy Used (watts)	Efficacy (lumens/watt)	Brightness (lumens)
6	74.9	450
	75	450
	76.7	450
	78.3	470
	79	470
	80	480
	83.3	500
	85	510
	88.3	530
	89	470
	91.7	550
	93.3	560
	100	600

The new Measure Savings for 40W Equivalent

LED Watts	base W	delta W based on new method	delta W based on Current WRR method	Measure Name
5	19.5	14.5	9.8	5-Watt LED A-Lamp 310-749 Lumens
6	19.5	13.5	11.76	6-Watt LED A-Lamp 310-749 Lumens
7	19.5	12.5	13.72	7-Watt LED A-Lamp 310-749 Lumens
8	19.5	11.5	15.68	8-Watt LED A-Lamp 310-749 Lumens
9	19.5	10.5	17.64	9-Watt LED A-Lamp 310-749 Lumens
10	19.5	9.5	19.6	10-Watt LED A-Lamp 310-749 Lumens

The New Measure Savings for 60W Equivalent

CALIFORNIA TECHNICAL FORUM

LED Watts	base W	delta W based on new method	delta W based on Current WRR method	Measure Name
7	28	21	13.72	7-Watt LED A-Lamp 750-1049 Lumens
8	28	20	15.68	8-Watt LED A-Lamp 750-1049 Lumens
9	28	19	17.64	9-Watt LED A-Lamp 750-1049 Lumens
10	28	18	19.6	10-Watt LED A-Lamp 750-1049 Lumens
11	28	17	21.56	11-Watt LED A-Lamp 750-1049 Lumens
12	28	16	23.52	12-Watt LED A-Lamp 750-1049 Lumens
13	28	15	25.48	13-Watt LED A-Lamp 750-1049 Lumens
14	28	14	27.44	14-Watt LED A-Lamp 750-1049 Lumens
15	28	13	29.4	15-Watt LED A-Lamp 750-1049 Lumens

The New Measure Codes Under the New Method: Still Requires Many Measure Codes to Capture Watts and Lumens for Each Bulb

5-Watt LED A-Lamp 310-749 Lumens	14-Watt LED A-Lamp 750-1049 Lumens
6-Watt LED A-Lamp 310-749 Lumens	14-Watt LED A-Lamp 1050-1489 Lumens
7-Watt LED A-Lamp 310-749 Lumens	14-Watt LED A-Lamp 1490-2600 Lumens
7-Watt LED A-Lamp 750-1049 Lumens	15-Watt LED A-Lamp 750-1049 Lumens
8-Watt LED A-Lamp 310-749 Lumens	15-Watt LED A-Lamp 1050-1489 Lumens
8-Watt LED A-Lamp 750-1049 Lumens	15-Watt LED A-Lamp 1490-2600 Lumens
9-Watt LED A-Lamp 310-749 Lumens	16-Watt LED A-Lamp 1050-1489 Lumens
9-Watt LED A-Lamp 750-1049 Lumens	16-Watt LED A-Lamp 1490-2600 Lumens
10-Watt LED A-Lamp 310-749 Lumens	17-Watt LED A-Lamp 1050-1489 Lumens
10-Watt LED A-Lamp 750-1049 Lumens	17-Watt LED A-Lamp 1490-2600 Lumens
10-Watt LED A-Lamp 1050-1489 Lumens	18-Watt LED A-Lamp 1490-2600 Lumens
11-Watt LED A-Lamp 750-1049 Lumens	19-Watt LED A-Lamp 1490-2600 Lumens
11-Watt LED A-Lamp 1050-1489 Lumens	20-Watt LED A-Lamp 1490-2600 Lumens
12-Watt LED A-Lamp 750-1049 Lumens	23-Watt LED A-Lamp 1490-2600 Lumens
12-Watt LED A-Lamp 1050-1489 Lumens	
13-Watt LED A-Lamp 750-1049 Lumens	
13-Watt LED A-Lamp 1050-1489 Lumens	

Advantages of Lumen Equivalency Method

- **Accurate Savings**: Lumen Equivalency method does not underestimate savings for more efficient or overestimate savings for less efficient lamps.
- **Does Not Yield Incorrect Results:** For bulbs with same lumen output, higher wattage bulbs yields lower savings, as expected.
- **Does Not Become Dated As LED Efficacy Improves**: Lumen Equivalency Method does not become out-of-date as LEDs become more efficient
  - Some LED measures might need to be added for the lower end of each EISA bin
- **Most Common Approach Used Nationwide (by far):** Lumen Equivalency Method is by far the most common approach to calculating savings from LEDs

Issues/Challenges for the Savings Calculation

- Balancing the savings accuracy and simplified implementation
- Making assumptions on what the appropriate percent and mix of base case should be for each bin (TRC Report looks at four data sources)
- After finalizing A-Lamp method, do we apply the same method to all other lamp types? But EISA Lumen bins are not defined for other lamp types, or should a different method be used for each lamp type? (R/BR, PAR, MR16, candelabra, globe)

CALTF Feedback

- Does the lumen method seem reasonable for the A-Lamps savings calculation?
  - What improvement could be done?
- What baseline mix and percentage bulb should be used?
- How often should the baseline should be updated?
- What about other bulb types?

Appendix

- Prior discussions with ED
- Measure savings comparison for lumen equivalency and WRR for 75W, and 100W equivalency
- Language from Navigant Study on Alternatives
- Citations to Studies

Summary of Presentation of IOU to ED

- Use Energy Star: Use the Energy Star list as the basis for choosing LED measure wattage, since IOU's don't incent the market and only incent Energy Star products.
- Apply the WRR that was originally created based on lumen equivalency to the lumen equivalent of the LED wattage not the lowest wattage in the range. This methodology is consistent with the "Integral LED Lamp replacement" disposition.
- Reconsider the fixed WRR method for the next cycle since not updating the WRR would mean: as LED's improve and get more efficient the IOU's claim less and less savings.
- Reconsider the calculation methodology for workpapers with wattage ranges (Use the lowest base wattage and highest measure wattage within the range), so IOU's are not claiming the least amount of savings possible but a more representative energy savings. Base the savings calculation on the most popular base wattage in the field and an average equivalent lumen wattage for the measure.

The new Measure Savings for 75W Equivalent

LED Watts	base W	delta W based on new method	delta W based on Current WRR method	Measure Name
10	35.5	25.5	19.6	10-Watt LED A-Lamp 1050-1489 Lumens
11	35.5	24.5	21.56	11-Watt LED A-Lamp 1050-1489 Lumens
12	35.5	23.5	23.52	12-Watt LED A-Lamp 1050-1489 Lumens
13	35.5	22.5	25.48	13-Watt LED A-Lamp 1050-1489 Lumens
14	35.5	21.5	27.44	14-Watt LED A-Lamp 1050-1489 Lumens
15	35.5	20.5	29.4	15-Watt LED A-Lamp 1050-1489 Lumens
16	35.5	19.5	31.36	16-Watt LED A-Lamp 1050-1489 Lumens
17	35.5	18.5	33.32	17-Watt LED A-Lamp 1050-1489 Lumens

The new Measure Savings for 100W Equivalent

LED Watts	base W	delta W based on new method	delta W based on Current WRR method	Measure Name
14	47.5	33.5	27.44	14-Watt LED A-Lamp 1490-2600 Lumens
15	47.5	32.5	29.4	15-Watt LED A-Lamp 1490-2600 Lumens
16	47.5	31.5	31.36	16-Watt LED A-Lamp 1490-2600 Lumens
17	47.5	30.5	33.32	17-Watt LED A-Lamp 1490-2600 Lumens
18	47.5	29.5	35.28	18-Watt LED A-Lamp 1490-2600 Lumens
19	47.5	28.5	37.24	19-Watt LED A-Lamp 1490-2600 Lumens
20	47.5	27.5	39.2	20-Watt LED A-Lamp 1490-2600 Lumens
23	47.5	24.5	45.08	23-Watt LED A-Lamp 1490-2600 Lumens

Navigant Study and Recommendation to improve WRR: Switch to Lumen Equivalency Method

- Ideal "Best" Method. The most accurate option is to determine a single baseline for each product category—i.e. EISA lumen bin—and determine which bin LEDs fall into by collecting actual lumen output for incented products. This is the recommended approach for A-line lamps in the residential lighting uniform methods protocol. Average program LED wattage per bin would determine the savings. In lieu of program LED wattage averages, average LED wattage for each bin could be updated annually with web-scraping data.
  - This approach would require programs to collect detailed records of incented LED products including wattage and efficacy or lumen output.

Navigant Study and Recommendation to improve WRR

- Alternative "Better" Method. If collecting lumen output is not possible, simply assigning a single baseline wattage for each product category and assigning product categories by LED wattage could be an improvement. In this case, savings should be the category baseline watts minus the actual LED watts. Programs would need to review the LED wattage bin mapping annually to account for increases in efficacy that will change the LED bounds of each EISA category.
  - This approach would require programs to collect the rated wattage of incented LED products.

Navigant Study and Recommendation to improve WRR

- Possible Improvements to WRR Method. If the WRR method cannot be changed, the following improvements to its application will improve accuracy:
  - Update average LED efficacy and wattage annually using web-scraped data
  - Apply different WRRs to each EISA bin as determined by LED lumens (ideal) or wattage (possible)
  - Update baseline technology mix and wattage regularly

Cited Studies

- Navigant Consulting, California LED Workpaper Update Study, Final Report (August 28, 2015)(Reference No. 169396).
- TRC, Memorandum on LED Baseline Assumptions (August 25, 2016).