

The “2X Lamp” – A Proposal to Harvest Additional Near Term Energy Savings

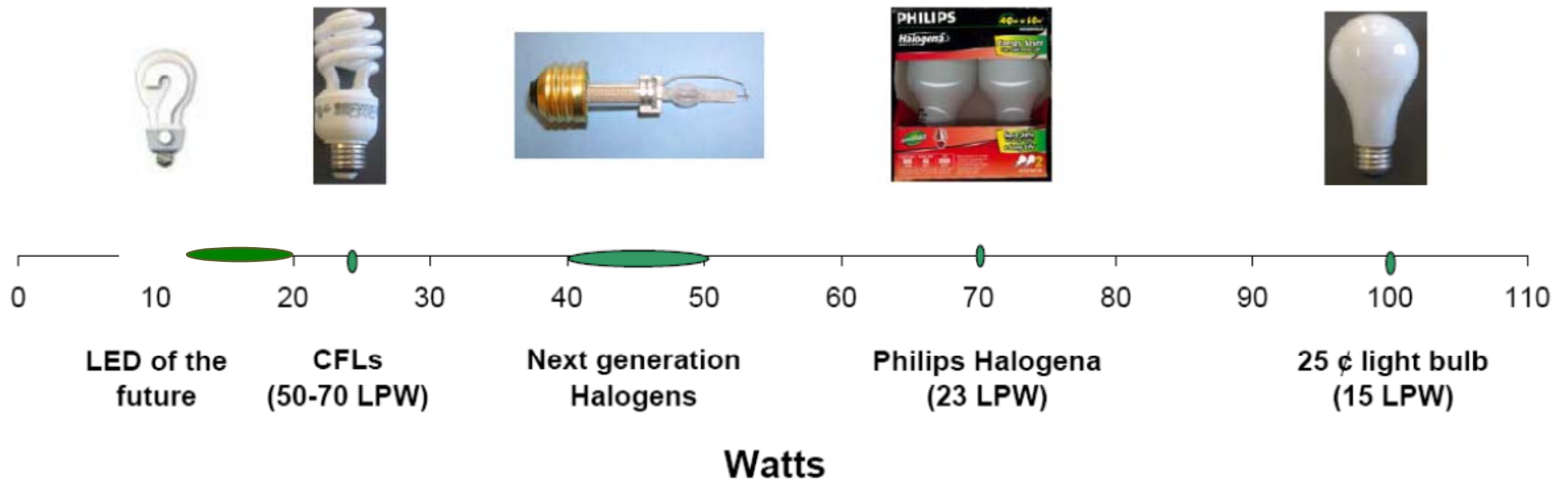


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Research by Ecos Consulting

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The 100 watt Replacement



What Will Consumers Buy Post EISA?

- a) incandescent/halogens - that just meet the standard – life only 1000 hours, cost likely to be between \$1 and \$2+ per bulb.
- b) CFL - much longer life and energy savings **BUT** : cost \$2 - \$5 per bulb, may not dim/dim well, slow run up time, exaggerated concerns about mercury, and 100W replacement may not fit. Most cost effective option today.
- c) LEDs – still very expensive to buy, can't get them yet in high light outputs

Likely Outcome

- Many consumers will opt for the new “normal” and
- Near term, potential that only a small fraction of *available* sockets (those without a CFL today) will get the more efficient CFL or LED inserted.
- “...it is quite possible that when USA minimum efficiency regulations come into effect in 2014 **there will be very little switching of lamp purchases to CFLs** as seen in much of Europe, Korea and Australia.” (IEA July 2011)

The “2X” Opportunity

- Pull to the market and promote significantly
 - Omni directional (every day bulb)
 - Directional (spot lights, reflectors)

Harvest some of the savings that would not be achieved otherwise without cannibalizing savings from CFL and LED programs.

Create a “2X” Specification

- Compared to old incandescent, 2X bulbs:
 - Last twice as long
 - Twice the efficiency (uses $\frac{1}{2}$ the power)
and do everything the old bulb did – fit, dim, quick startup, just as bright, etc.
- Opportunity to generate significant incremental near term energy and CO2 savings

What is a 2X Specification?

A 2x specification sets a near-term goal for lamps that behave in every way like incandescents but use half the power

Today's lamp



800 lumens of light for
60 watts
or
1600 lumens of light
for **100 watts**

EISA compliant lamp



800 lumens of light
for **43 watts**
or
1600 lumens of
light for **72 watts**

2x lamp



800 lumens of light
for **30 watts**
or
1600 lumens of
light for **50 watts**

Strawman General Service Lamp 2X Specification

Criteria Item	Proposed	Reasoning	IES Testing Std
Minimum Efficacy Maximum Power	$\text{Efficacy} = 7.05 \ln(\lambda) - 20.4$ $\text{Power} = 0.025(\lambda) + 9.25$ (λ = light output in <i>lumens</i>)	Twice as efficient as today's incandescents	IESNA LM-78
Correlated Color Temperature	$\leq 3200\text{K}$	Mimics incandescent	CIE 13.3-1995
Color Rendering Index	Min of 90	Mimics incandescent	CIE 13.3-1995
Run-up Time/Restrike	Very fast (TBD)	Mimics incandescent	TBD
Minimum Lifetime	<i>2,000 hours (perhaps lower for brighter bulbs)</i>	Twice as long as today's incandescent	LM-49-01
Dimming	Must dim continuously down to 5% light output; Minimal or no color shift when dimmed, no visible flicker or audible noise	Mimics incandescent	na
Flicker	No visible flicker	Mimics incandescent	IEC 61000-4-15 ed2.0
Compatibility	Must properly function with all types of dimmers, photo/occupancy sensors		na
Wattage Equivalency Claims	Follow E* guidelines	Industry standard	IESNA LM-45-09
Power Factor	≥ 0.9		IESNA LM-45-09
Dimensions	No larger than replacement ($\pm 3\%$)	Must directly replace	na
Light Distribution	Follow E* LED omnidirectional spec	Ensure even light output, not spot light	IESNA LM-77
Lumen Maintenance	Needed?	Mimic incandescent	?
Toxicity	RoHS compliance	Becoming universal -	IEC 62321:2008

Strawman Directional Lamp 2X Specification

Criteria Item	Proposed	Reasoning	IES Testing Std
Minimum Efficacy Maximum Power	Efficacy = $3.22 \ln(\lambda) - 8.678$ Power = $\lambda / (3.22 \ln(\lambda) - 8.678)$ (λ = beam light output in <i>lumens</i>)	Twice as efficient as today's incandescents	TBD
Correlated Color Temperature	$\leq 3200K$	Mimics incandescent	CIE 13.3-1995
Color Rendering Index	Min of 90	Mimics incandescent	CIE 13.3-1995
Run-up Time/Restrike	Very fast (TBD)	Mimics incandescent	TBD
Minimum Lifetime	3,000 hrs	50% greater than today's incandescent	LM-49-01
Dimming	Must dim continuously down to 5% light output; Minimal or no color shift when dimmed, no visible flicker or audible noise	Mimics incandescent	na
Flicker	No visible flicker	Mimics incandescent	IEC 61000-4-15 ed2.0
Compatibility	Must properly function with all types of dimmers, photo/occupancy sensors		na
Wattage Equivalency Claims	Follow E* guidelines	Industry standard	IESNA LM-45-09
Power Factor	≥ 0.9		IESNA LM-45-09
Dimensions	No larger than replacement ($\pm 3\%$)	Must directly replace	na
Lumen Maintenance	Needed?	TBD	?
Toxicity	RoHS compliance	Becoming universal	IEC 62321:2008

Example Prototype_L amp that Would Meet “2X”



TCP Generation 2 Hybrid Halogen

TCP exclusive Hybrid Halogen technology

Highest efficacy ratings (50% more energy efficient) with a max efficacy_{rating} = 32 LPW

Full range of products

50W = 100W @ 1600 lumens

40W – 75W @ 1150 lumens

30W = 60W @ 850 lumens

2,000 hour life rating

TCP Generation 2 Hybrid Halogen

TCP's newest halogen product is highly-engineered to be a low-cost alternative to LED products, yet with the same features of an incandescent

Precision filament

Re-crystallized for rigidity

Optimized capsule

Smaller 'legs' = reduced end losses

Improved Halogen gas

Correct filament geometry

Advanced thin-film coatings

Better coating increases efficacy

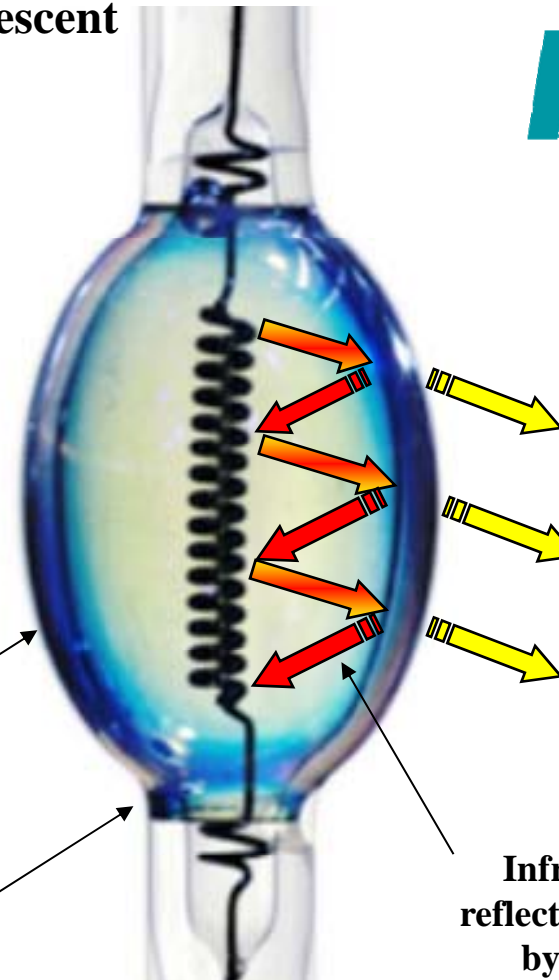


Ultra-thin *PIRL*TM
film coatings

Reduced end
losses

Infrared light
reflected, absorbed
by filament

Visible light
transmitted



General Service 2X Lamp Market Status

- Prototypes have demonstrated that the concept is viable
- TCP expects to bring a bulb to market in early 2012
- Initial pricing for product is expected to be about \$3
- As with past versions of HIR, the technology will likely be available for licensing to multiple companies

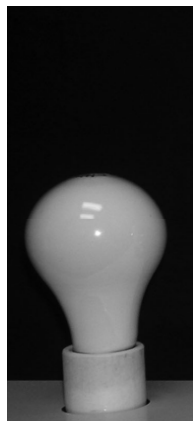


Largest General Purpose 2X Opportunity: 100 W and 150 W Replacements

Today	EISA	2x	Delta W Saved
100 W	72 W	50 W	22 W
150 W	N/A	75 W	75 W

- EISA/T20 takes effect for 100 W first
- CFL replacements for 100 W bulbs are bulky
- LEDs not available as 100 W and 150 W replacements at this time
- 150 W (>2,600 lumens) not covered by standards; sales likely to increase due to low price and familiar wattage

100 W
Incandescent



72 W
Halogen



24 W
CFL



LED



Strategy – Expand Lighting Program Savings by Adding 2X Lamps

- **Standardized 2X Specifications – GSL and Reflectors**
 - Single 2X specification used by multiple utility incentive programs will encourage more manufacturers to develop 2X lamps
- **Near-term Pilots**
 - Pilot 2X general service concept in 2012 with initial production samples from TCP. Full scale programs possible later in 2012.
 - Some 2x reflector lamps(IR halogen MR16s) already available for commercial sector pilots
- **Program Timing**
 - 2X programs can run throughout EISA/T20 phase in dates (2012 – 2014), then re-evaluate
- **Consumer Education**
 - Critical program element– ensure incandescent buyers migrate to 2X, but CFL and LED buyers continue buying CFLs and LEDs

Adding 2X Incentives to Lighting Programs

- Reserve smallish portion of overall lighting program budget for 2X lamps
- Meant to compliment existing programs for CFLs and LEDs, not replace them
- Cost of Rebates: Lifetime kWh savings for utilities at $\leq \$0.04/\text{kWh}$ ($<$ national avg. for residential programs)
- NTG should be 1 since no current 2x penetration

(See appendix for potential rebate levels and cost effectiveness calculations)

**WHO'S READY TO INVESTIGATE
“2X”
FURTHER?**

General Service Lamp 2x Specification Impact



Average Home

Nationally (Res Only)

Global Warming Pollution Benefits

780 lbs of CO₂ per year –
equivalent to driving **900
fewer miles each year**

13 million metric tons of
CO₂ per year – equivalent
to taking **2.5 million** cars
off the road

Energy Savings

500 kWh savings per year
– more than the annual
energy use of a new
refrigerator

19,000 GWh per year –
more than the energy
generated by **6 large
power plants**

Dollar Savings

\$60 per year

\$2.2 billion per year – the
annual income of **44,000
average families**

Additional Benefits

- Pulls advanced halogen lamp technology toward providing more service while using less energy

Acknowledgements

- Ecos Consulting – Chris Calwell Eric

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- TCP Lighting – Jim Crowcroft
- Venture Lighting – Steve Stockdale

APPENDICES

EISA Tier 1 Basics

Today's Bulbs	Lumens	➔	After the Standard
100 W	1490-2600		≤ 72 W
75 W	1050-1489		≤ 53 W
60 W	750-1049		≤ 43 W
40 W	310-749		≤ 29 W

Also Lamps must have:

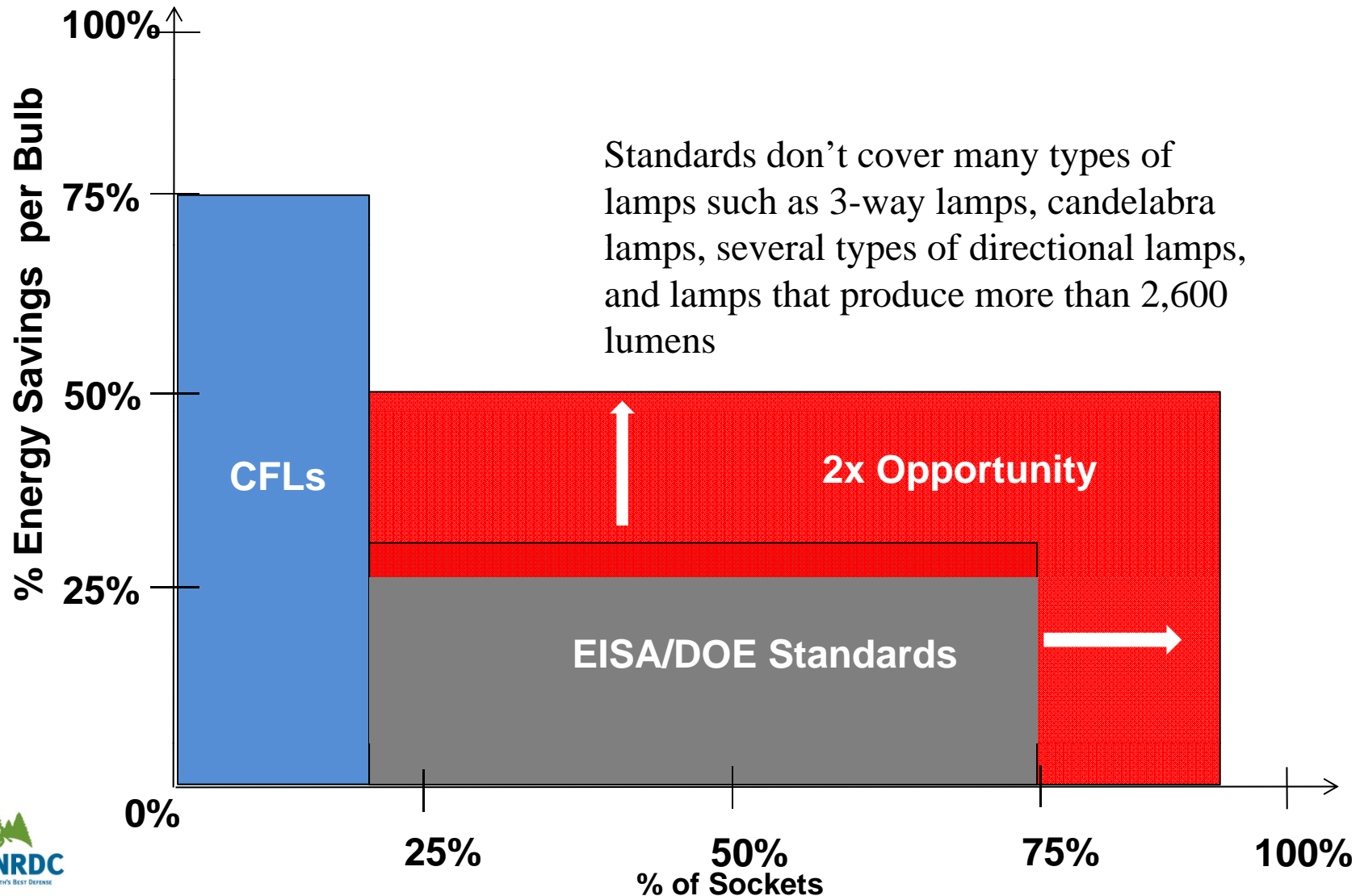
a) Minimum rated life 1,000 hours

b) CRI ≥ 80

Ensure Light Output of “2X” ≥ Today’s Bulbs

Baseline Wattage		2x Wattage		ENERGY STAR Min Light Output		2x Efficacy
40		20		450 lm		22.5 lm/W
60		30		800 lm		26.6 lm/W
75	➡	37.5	+	1100 lm	➡	29.3 lm/W
100		50		1600 lm		32.0 lm/W
150		75		2600 lm		34.6 lm/W

A 2x Specification Could Generate Significant Savings in The Near-term



General Service Lamp Utility Program Cost Effectiveness Comparison

(assume upstream rebate multiplier of of 1 – 1.5x)

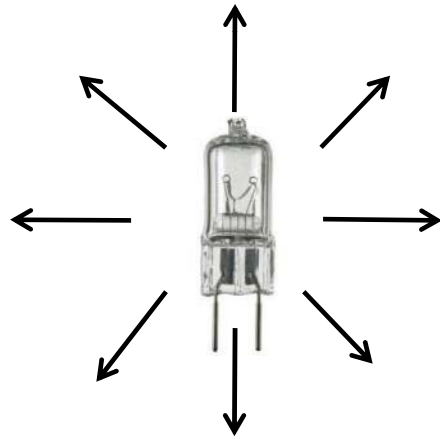
Description	Wattage	Lifetime (hrs)	Delta W (Post-EISA)	Net to Gross Ratio	Lifetime Savings (kWh)	Lamp Cost (\$)	Low Level Rebates			Aggressive Rebates		
							Rebate Amount (\$/lamp)	Lamp Cost Post Rebate (\$/lamp)	Utility cost (\$/kWh)	Rebate Amount (\$/lamp)	Lamp Cost Post Rebate (\$/lamp)	Utility cost (\$/kWh)
Today's	60	1000	n/a	n/a	n/a	\$0.25	n/a	\$0.25	n/a	n/a	\$0.25	n/a
Today's	75	750	n/a	n/a	n/a	\$0.25	n/a	\$0.25	n/a	n/a	\$0.25	n/a
Today's	100	750	n/a	n/a	n/a	\$0.50	n/a	\$0.50	n/a	n/a	\$0.50	n/a
Today's	150	750	n/a	n/a	n/a	\$0.75	n/a	\$0.75	n/a	n/a	\$0.75	n/a
EISA	43	1,000	n/a	n/a	n/a	\$1.00	n/a	\$1.00	n/a	n/a	\$1.00	n/a
EISA	53	1,000	n/a	n/a	n/a	\$1.00	n/a	\$1.00	n/a	n/a	\$1.00	n/a
EISA	72	1,000	n/a	n/a	n/a	\$1.00	n/a	\$1.00	n/a	n/a	\$1.00	n/a
2x	30	2,000	13	1	26	\$3.00	\$0.50	\$2.25-\$2.50	\$0.027	\$1.00	\$1.50-2.00	\$0.046
2x	37.5	2,000	16	1	31	\$3.00	\$0.50	\$2.25-\$2.50	\$0.023	\$1.00	\$1.50-\$2.00	\$0.039
2x	50	2,000	22	1	44	\$3.00	\$0.50	\$2.25-\$2.50	\$0.016	\$1.00	\$1.50-\$2.00	\$0.027
2x	75	2,000	75	1	150	\$3.00	\$1.00	\$1.50-\$2.00	\$0.008	\$1.50	\$0.75-\$1.50	\$0.011
CFL	13	8,000	30	0.6	144	\$2.99	\$1.00	\$1.49-\$1.99	\$0.008	\$2.00	\$0.00-\$0.99	\$0.015
CFL	27	8,000	45	0.6	216	\$3.99	\$1.00	\$2.49-\$2.99	\$0.006	\$2.00	\$0.99-\$1.99	\$0.010
LED	12	25,000	31	1	775	\$35.00	\$10.00	\$20-\$25	\$0.013	\$20.00	\$5-\$15	\$0.026
LED	21	25,000	51	1	1275	\$40.00	\$10.00	\$25-\$30	\$0.008	\$20.00	\$10-\$20	\$0.016

Directional 2x Lamp Utility Program Cost Effectiveness Comparison

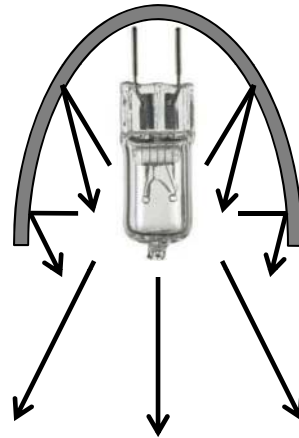
(assume 1-1.5x upstream rebate multiplier)

Description	Wattage	Lifetime (hrs)	Delta W (Replace BR40)	Lifetime Energy Savings (kWh)	Lamp Cost (\$)	Low Level Rebates			Aggressive Rebates		
						Rebate Amount (\$/lamp)	Lamp Cost Post Rebate (\$/lamp)	Utility cost (\$/kWh)	Rebate Amount (\$/lamp)	Lamp Cost Post Rebate (\$/lamp)	Utility cost (\$/kWh)
Today's BR40	100	2,000	n/a	n/a	\$4.25	n/a	\$4.25	n/a	n/a	\$4.25	n/a
Today's PAR38	90	2,500	n/a	n/a	\$4.85	n/a	\$4.85	n/a	n/a	\$4.85	n/a
DOE Compliant PAR38	78	2,500	n/a	n/a	\$9.00	n/a	\$9.00	n/a	n/a	\$9.00	n/a
2x PAR 38	45	3,000	55	165	\$9.00	\$2.00	\$6 - \$7	\$0.013	\$4.00	\$3- \$5	\$0.025
CFL	13	8,000	87	696	\$10.00	\$3.00	\$5.50 - \$7	\$0.005	\$6.00	\$1 - \$4	\$0.009
LED	18	25,000	82	2050	\$40.00	\$10.00	\$25 - \$30	\$0.005	\$20.00	\$10- \$20	\$0.010

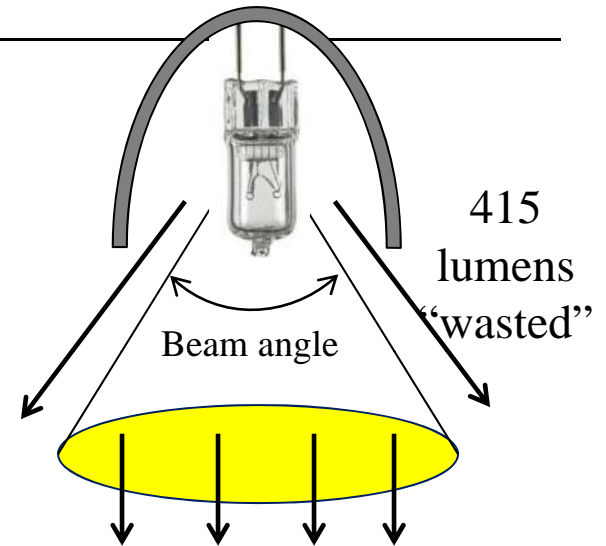
Measuring Useful Light From Directional Lamps is Not Very Straightforward



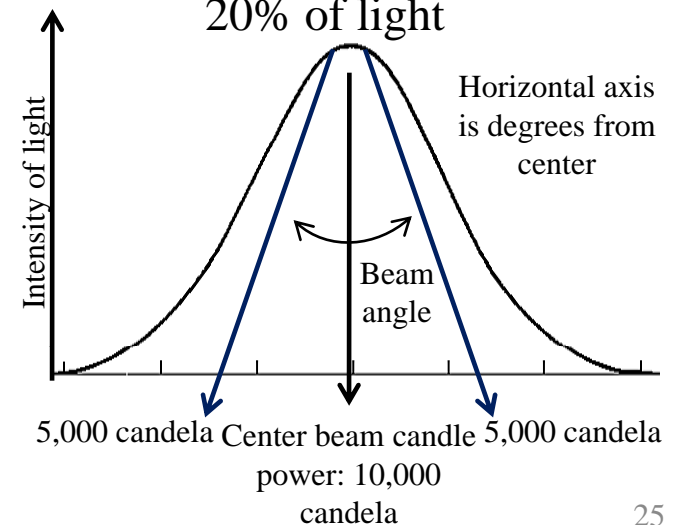
Capsule light:
620 lumens
100% of light



Lamp light:
560 lumens
90% of light



Beam light: 145 lumens
20% of light



What is beam angle?