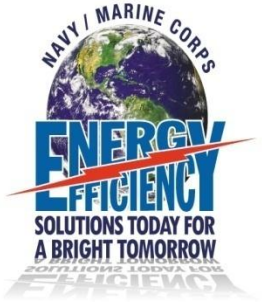
Navy Techval Program



Techval

FUPWG

October 20, 2010

Rapid City, SD

Paul Kistler, PE CEM
NAVFAC Engineering Service Center
Port Hueneme CA

Navy Techval Program

Technologies

- **Work Station Specific Lighting**
- **CO2 HVAC control**
  - What is it, how does it work?
  - Data from projects
  - Where does it work best?

Work Station Specific Lighting

What Is It?

1. Pendant light used mainly in open cubicles
2. Each cubicle has own dedicated fixture
3. One up light
4. Two down lights
5. Down light dimmed by the occupant
6. Up light on time clock
7. Occupancy sensor
8. Day light sensor
9. T5 5000K
10. Does not replace task lighting

Work Station Specific Lighting

Projected Savings

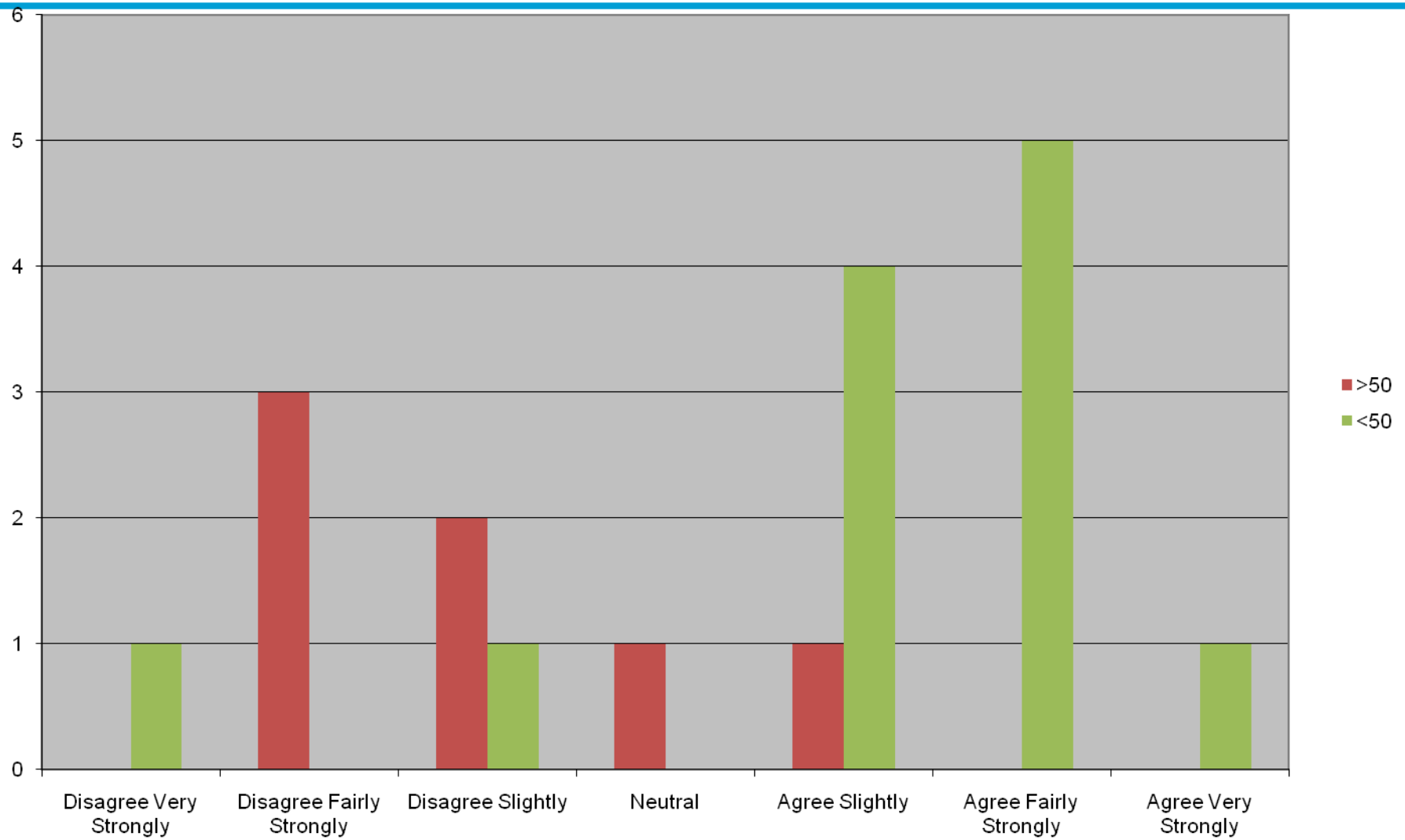
1. Projected payback is 17 years
2. Projected pay back on incremental cost is 3 to 4 years
3. Recent projects indicate a total savings of 70% lighting energy use
4. Most of the savings due to occupancy sensor

Work Station Specific Lighting

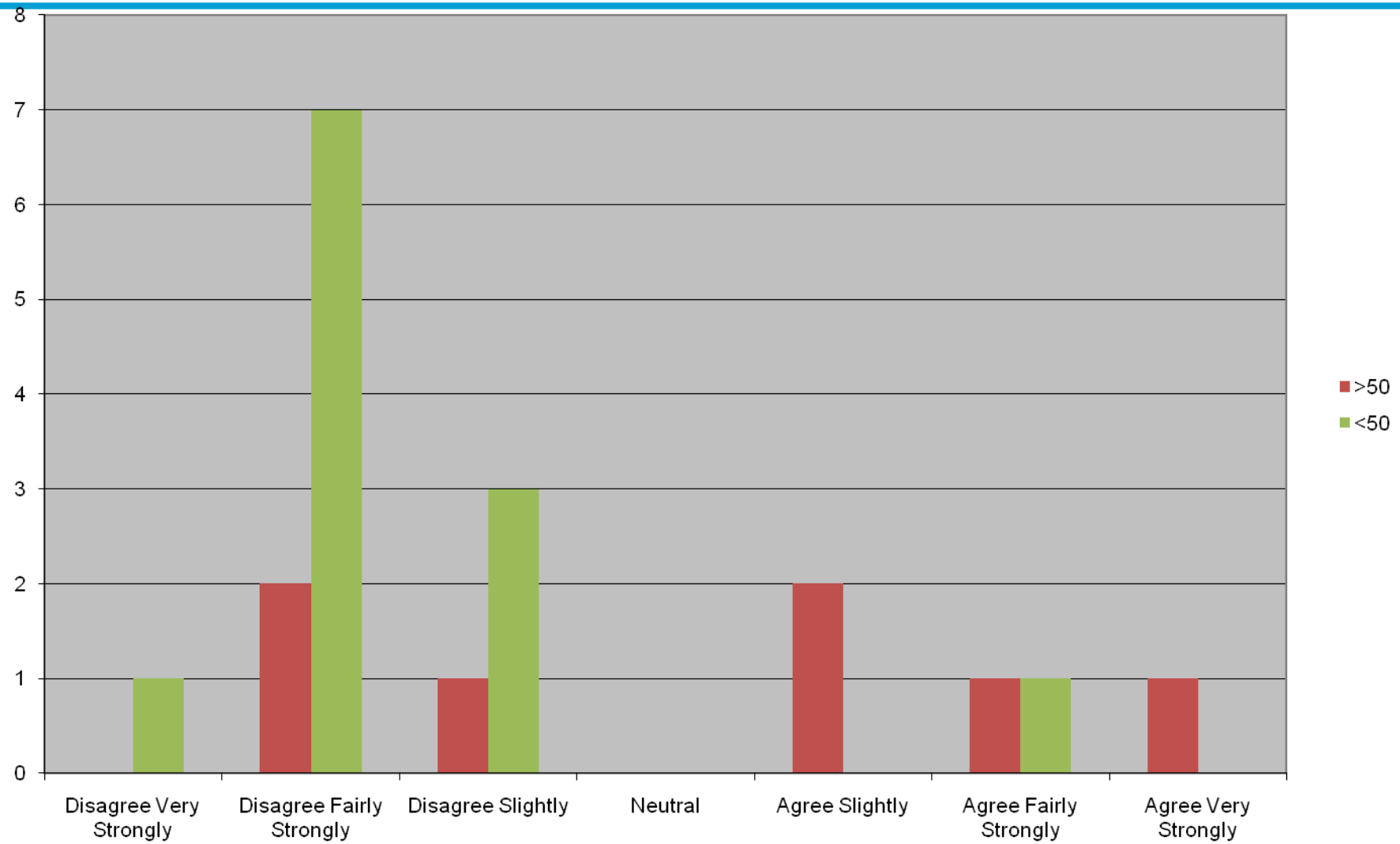
Challenges

1. Building new in 1996.
2. Originally 3 lamp T8 2 X 4 recessed troffer, est. 50 FC
3. Nine foot ceilings
4. During California energy crises, severely delamped
   a) 21 fixtures with 0 lamps
   b) 23 fixtures with 1 lamp
   c) 10 fixtures with 2 lamps
   d) 0 fixtures with 3 lamps
   e) Average 12 FC, 0.4 min, 42 max
5. New occupants relamped their area and changed cubicle spaces and heights
6. Timeclock, on 0600, off 1800. Reset 2 hours.
7. Two banks of lights per circuit

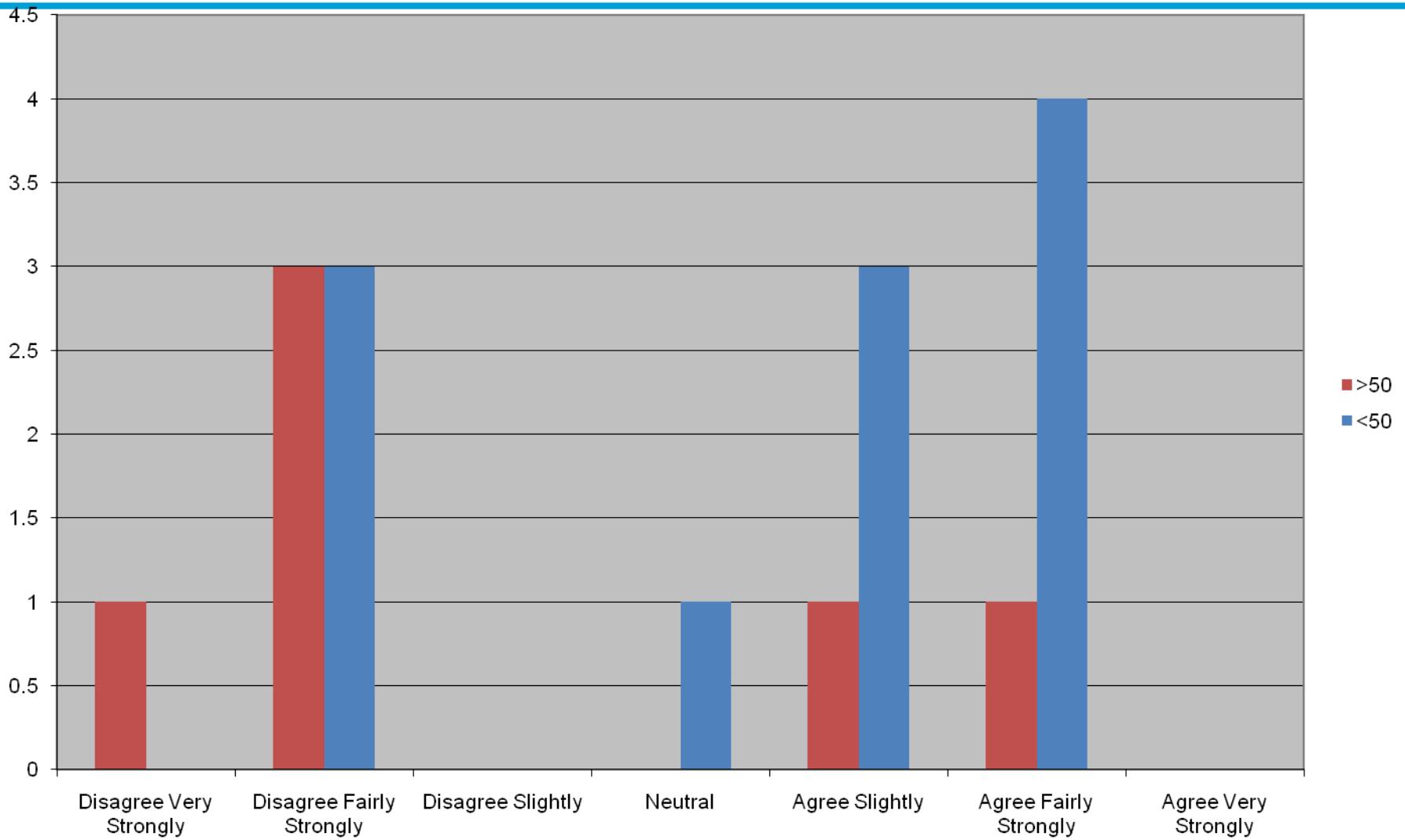
The lighting level is set at the preferred level for the work that I do



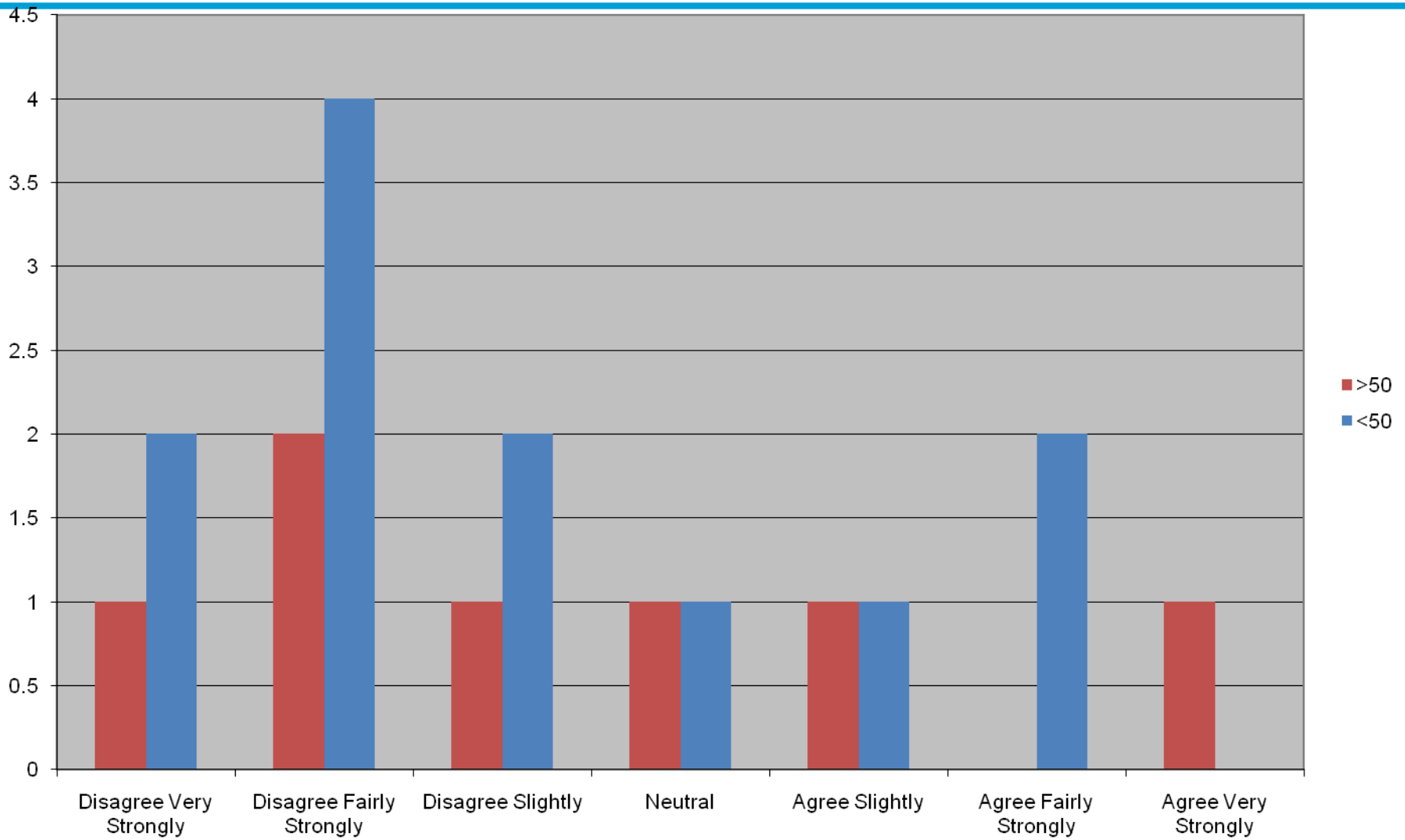
The overhead lighting makes it difficult for me to read printed material



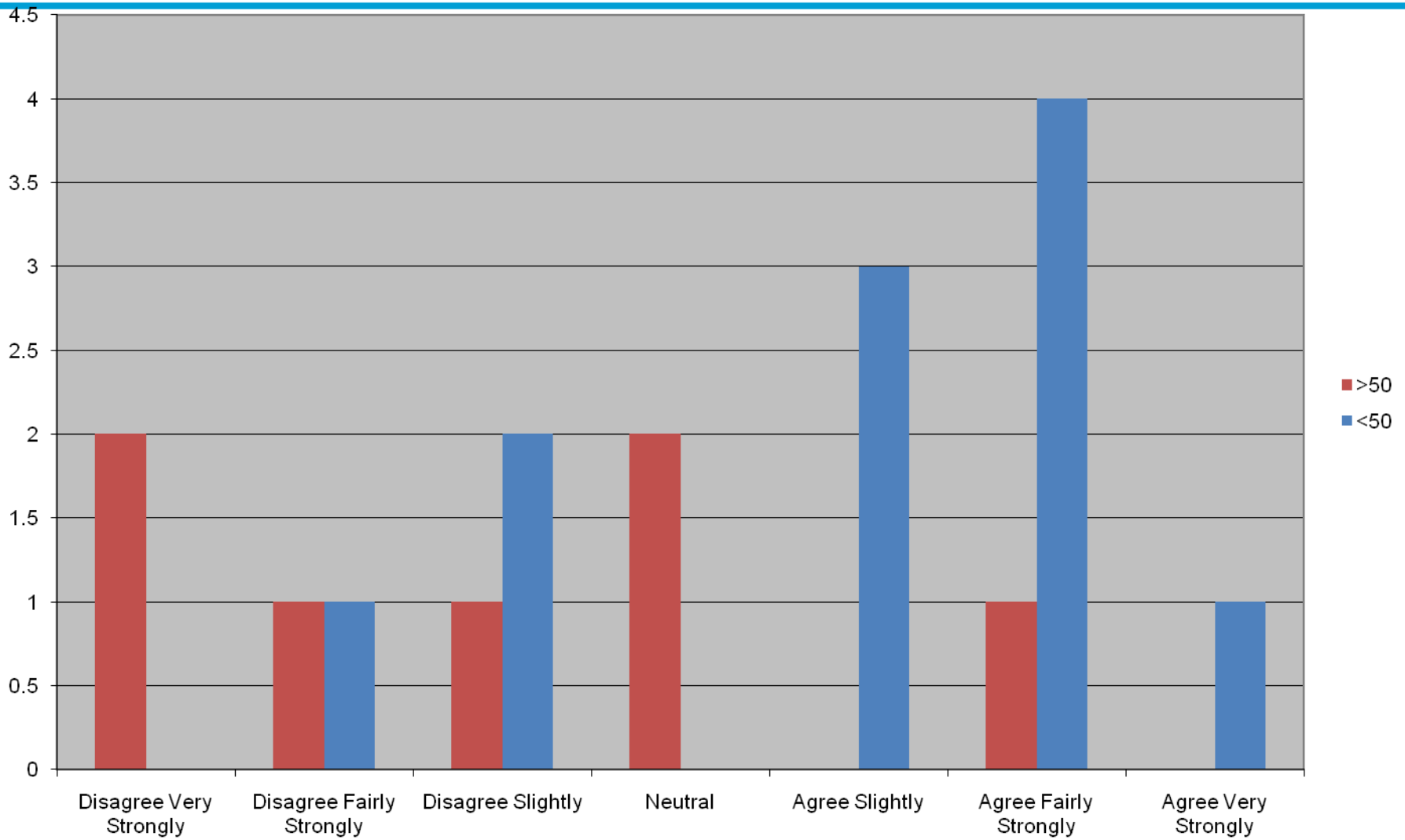
The overhead lighting is acceptable



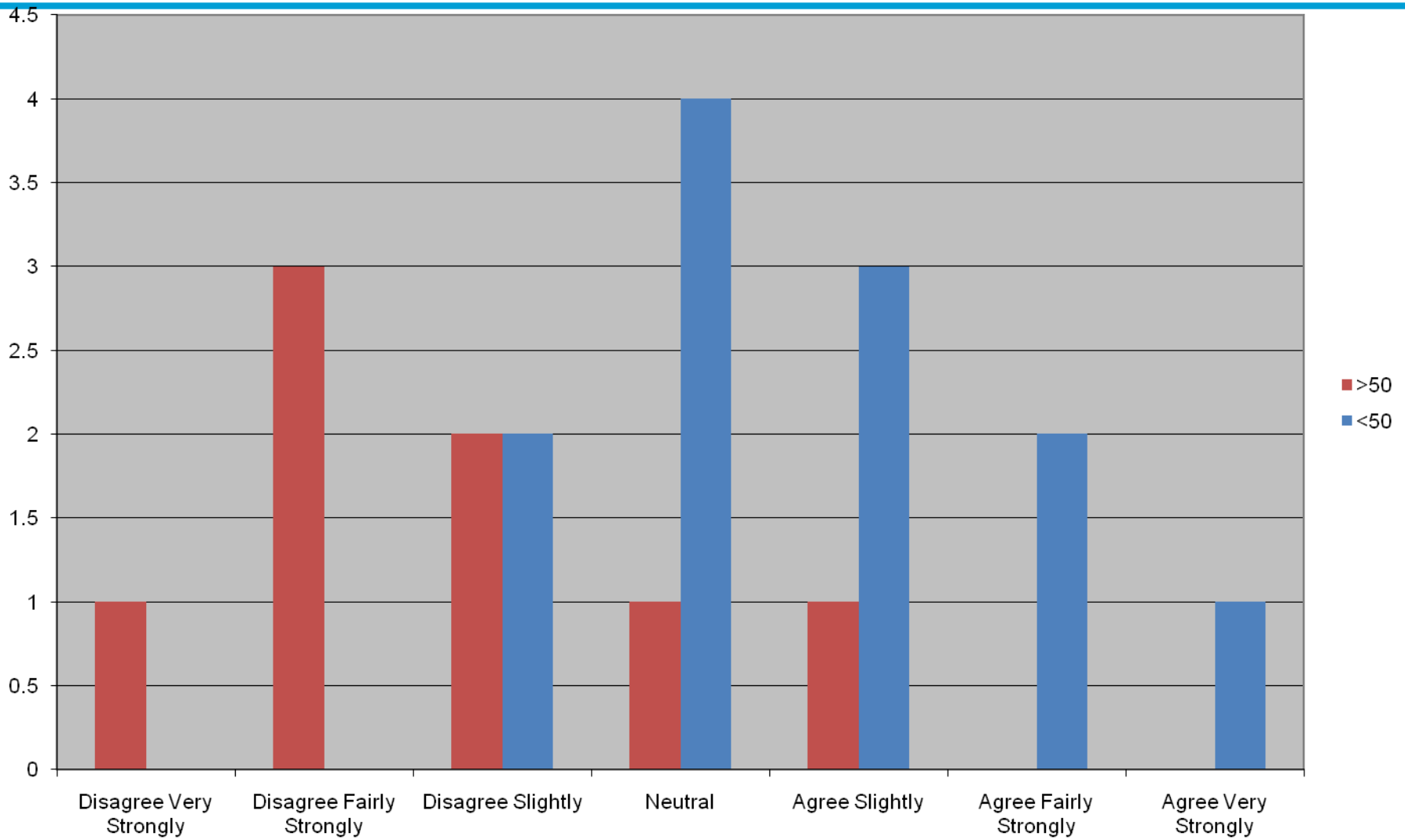
The overhead lighting is too dim for the work that I do



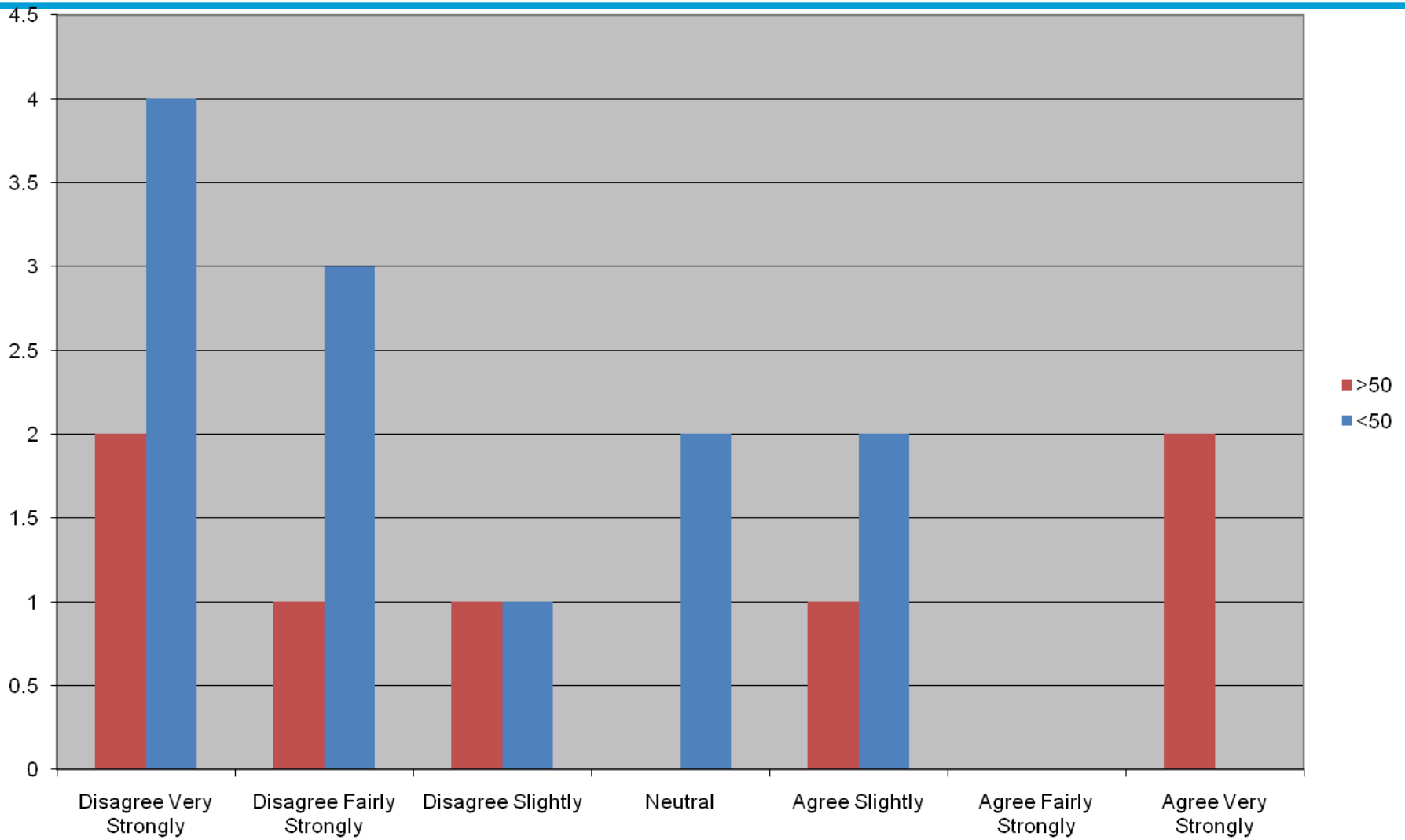
The overhead lighting allows me to see comfortably



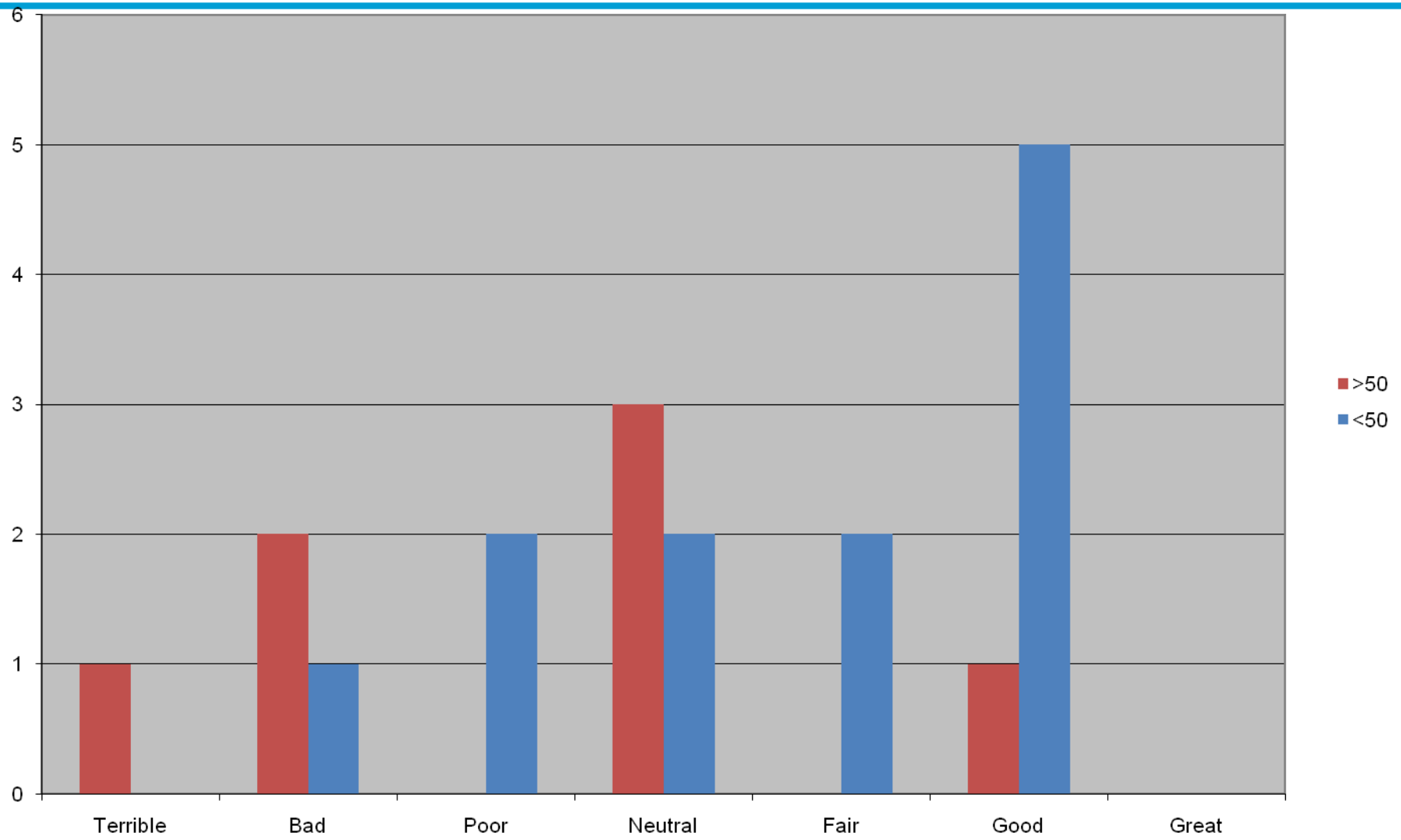
The overhead lighting is pleasant to work under



The overhead lighting is too high for the work that I do



Overall, how would you rate the existing overhead lighting?

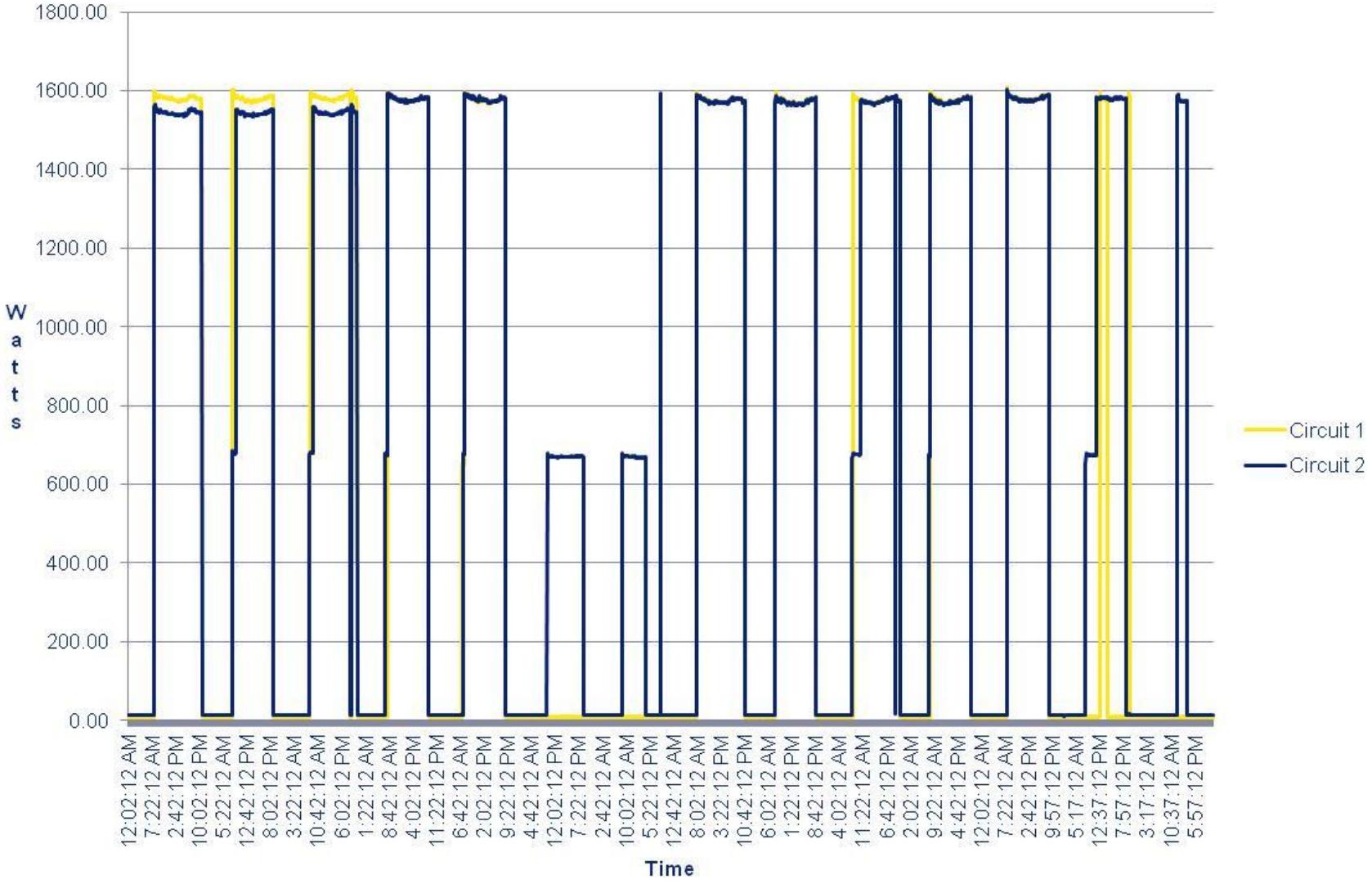


Work Station Specific Lighting

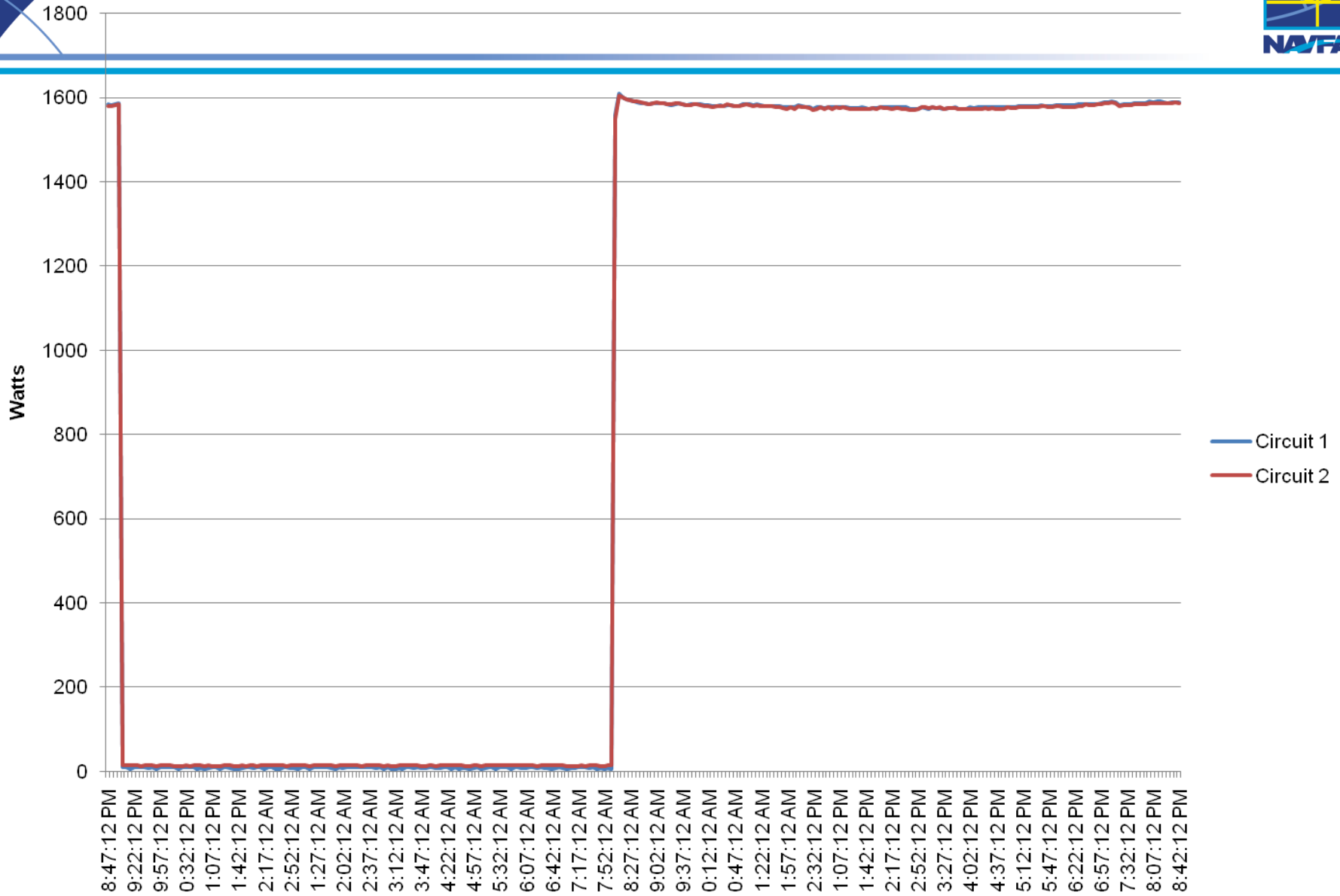
Issues

- **Mounting height**
  - 20” from ceiling to top of fixture
  - 7’1” from floor to bottom of fixture
  - Hot spots on ceiling
  - Fire sprinklers
- **Uniformity in passageways**
- **Shadows on work area**
- **Commissioning**
  - Not a DIY
- **Uplight**
  - Hot spots
  - Glare
- **Navy IT security**
- **Change out remaining lighting to 5000K**

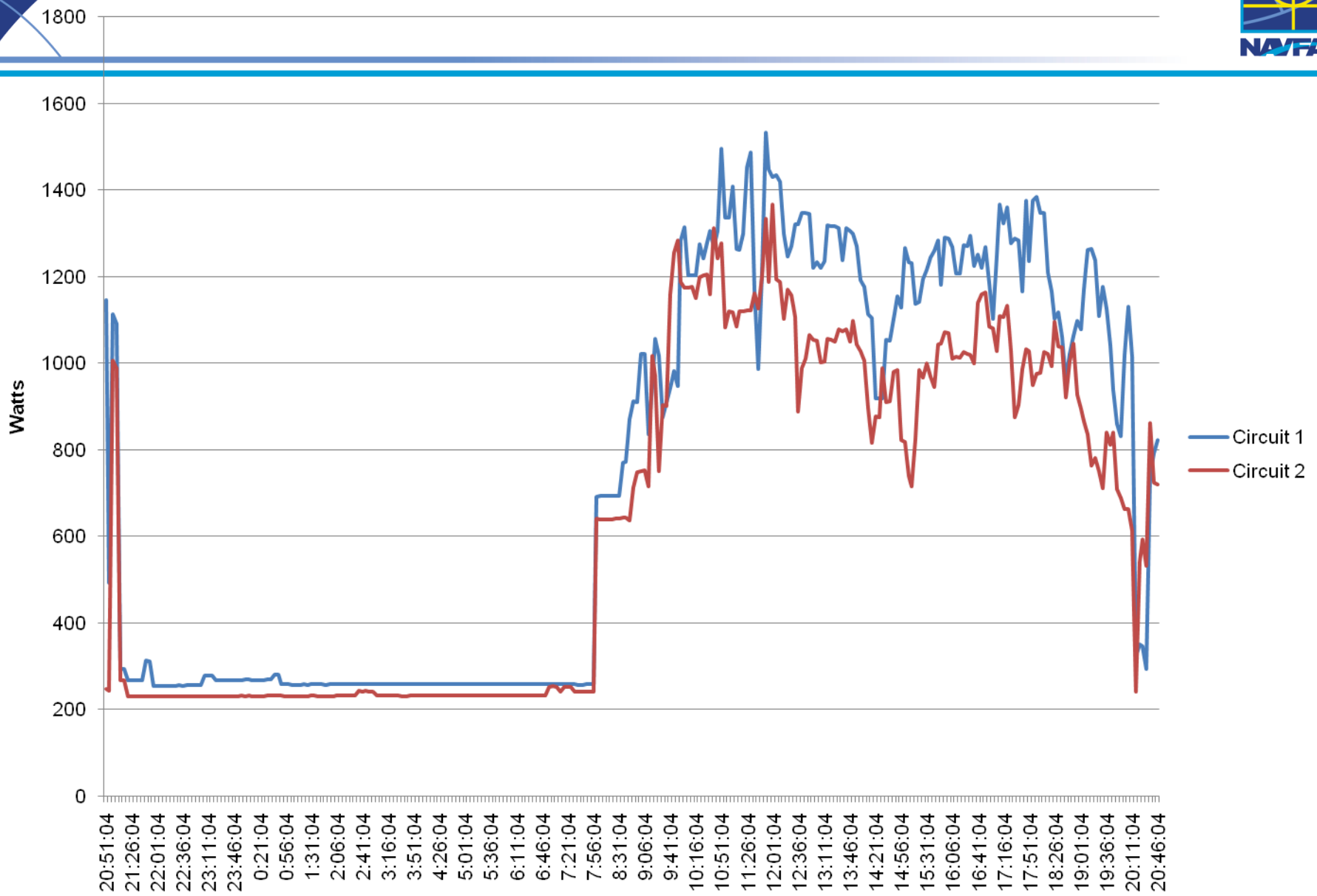
Lighting Circuits 1 & 2 Power Use Monday, 6/7/10 - Sunday, 6/20/10

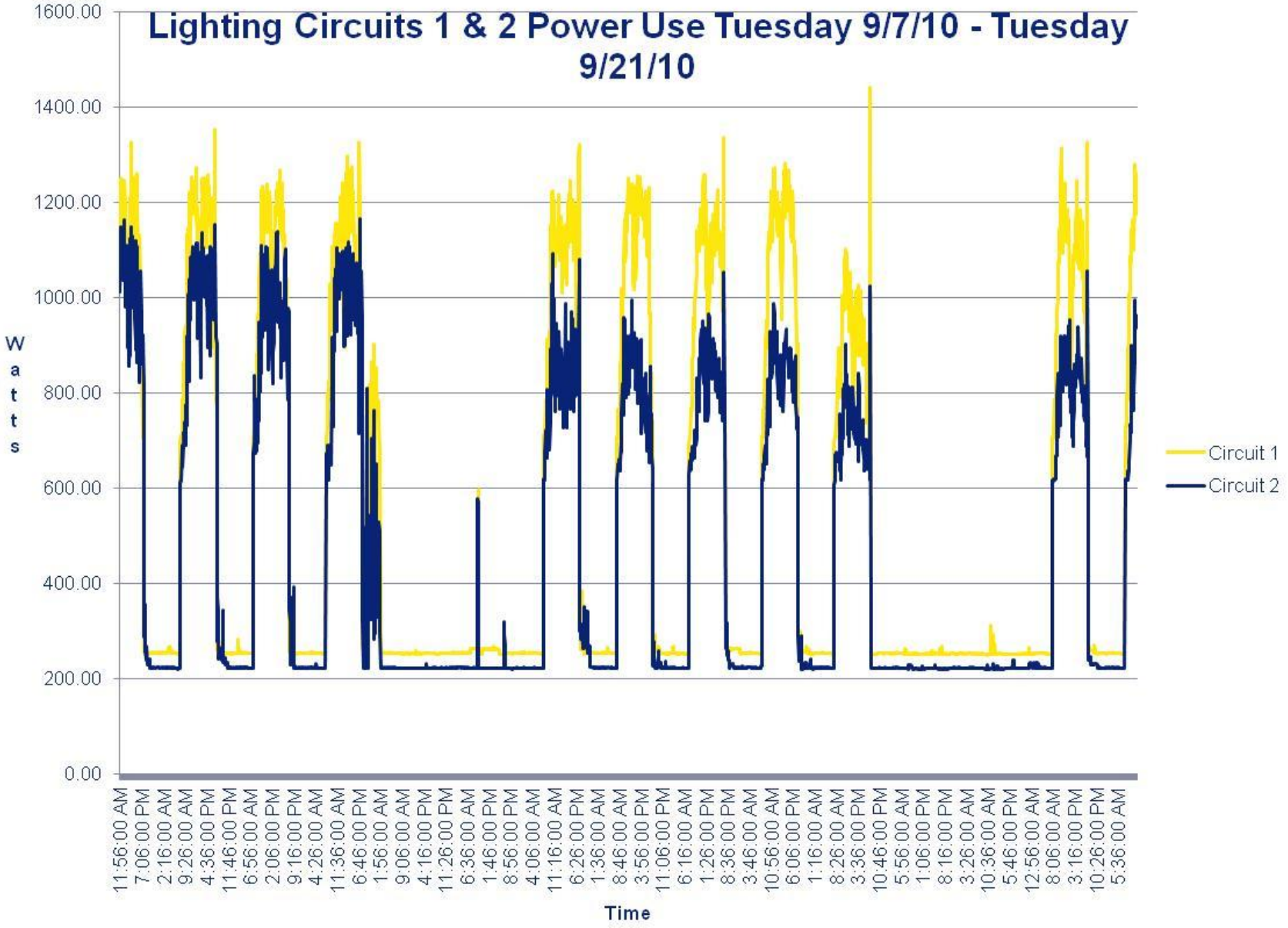


Lighting Circuits 1 & 2 Power Use 6/18/10



Lighting Circuits 1 & 2 Power Use 8/13/10

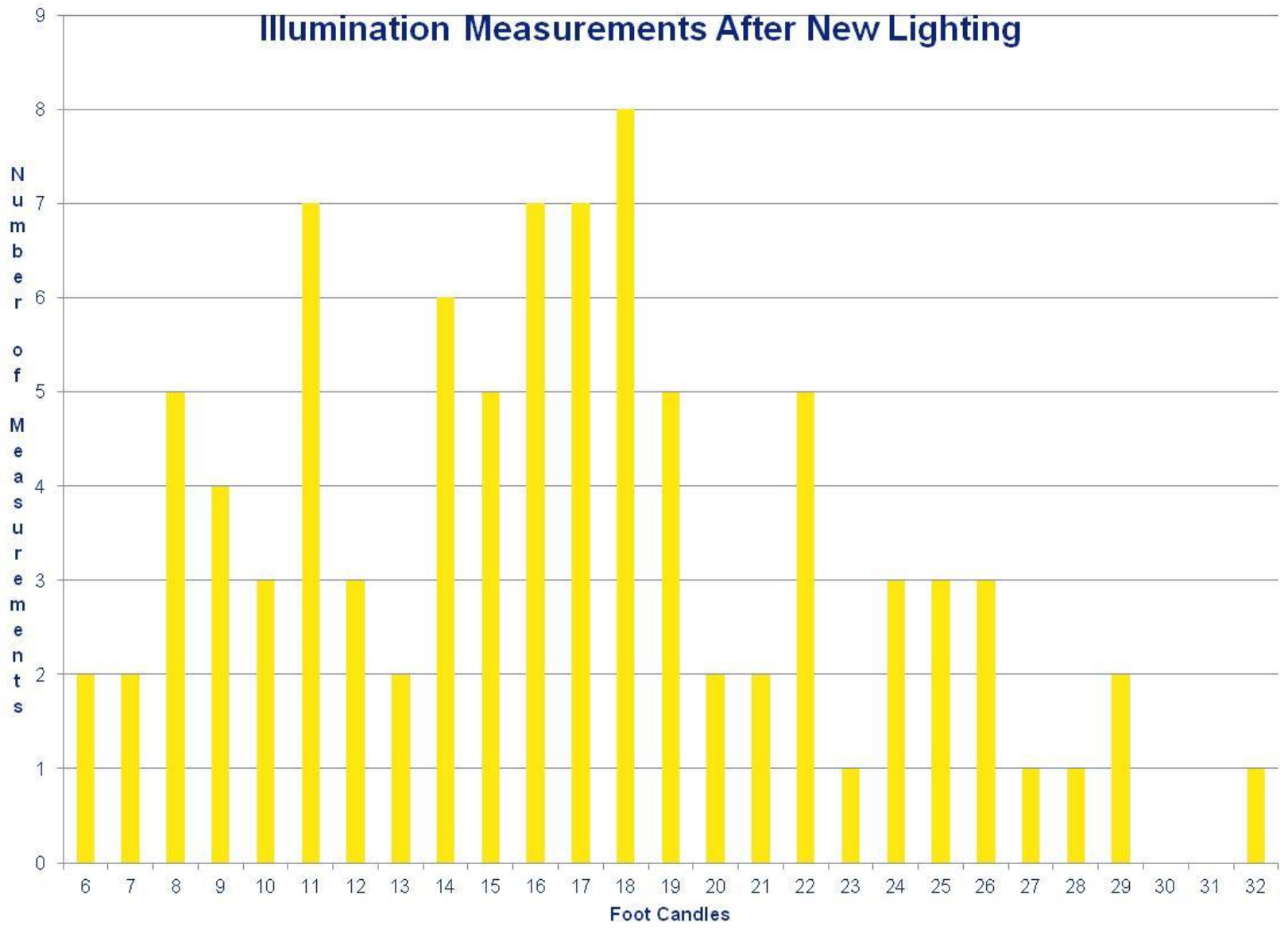



Lighting Circuits 1 & 2 Power Use Tuesday 9/7/10 - Tuesday 9/21/10
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
Watts
Time
Circuit 1
Circuit 2

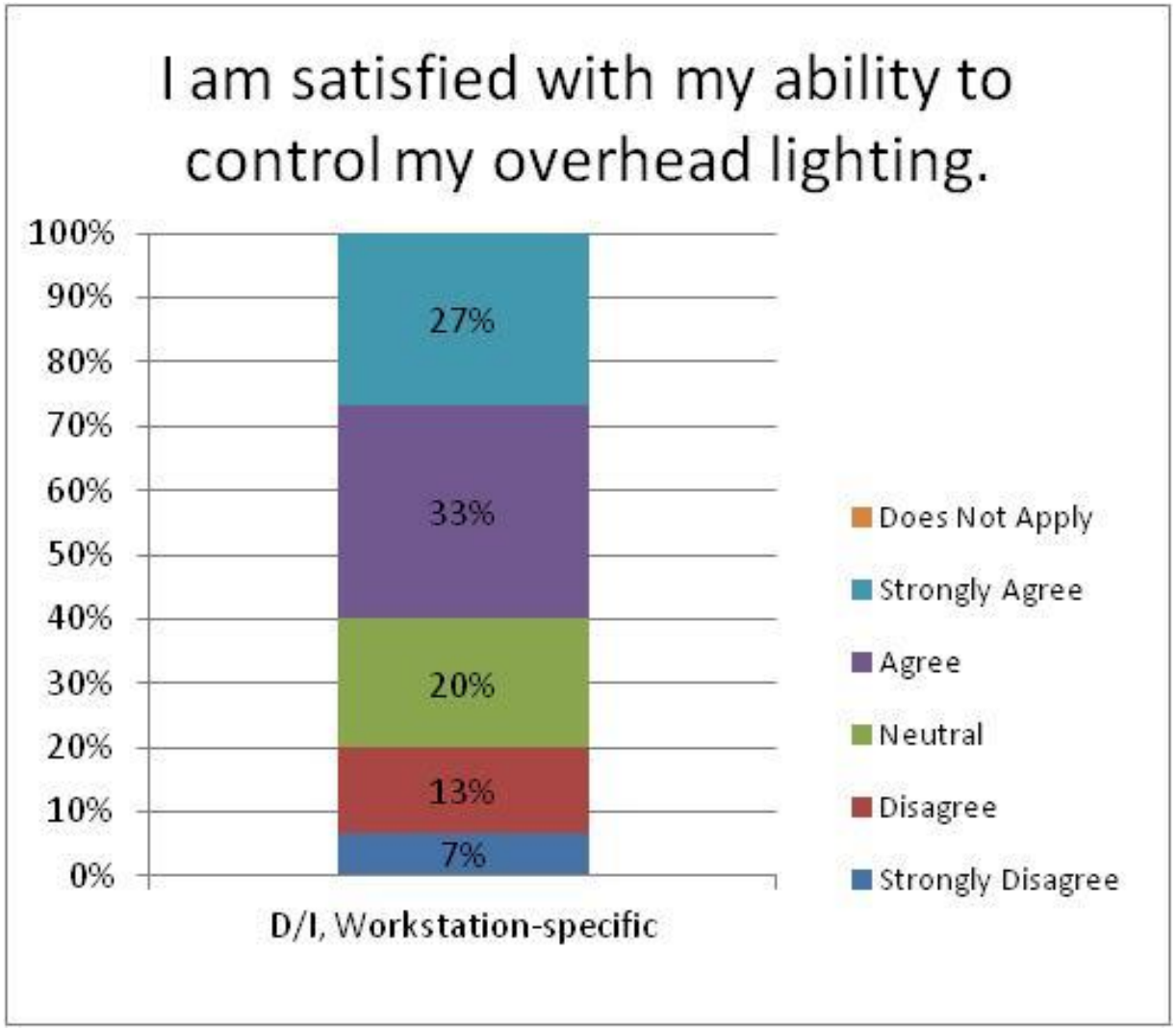
Tabulated Data

Original		
	Circuit 1	Circuit 2
Min W	6	12
Max W	1609	1605
Ave W	652	729
Post Install		
	Circuit 1	Circuit 2
Min W	248	219
Max W	1441	1165
Ave W	545	454

Tabulated Illumination Data After New Lighting Install	
Min	6 FC
Max	32 FC
Ave	16 FC


Illumination Measurements After New Lighting
Number of Measurements
0
1
2
3
4
5
6
7
8
9
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Foot Candles

Light Right Consortium
Lighting Satisfaction Survey Tool



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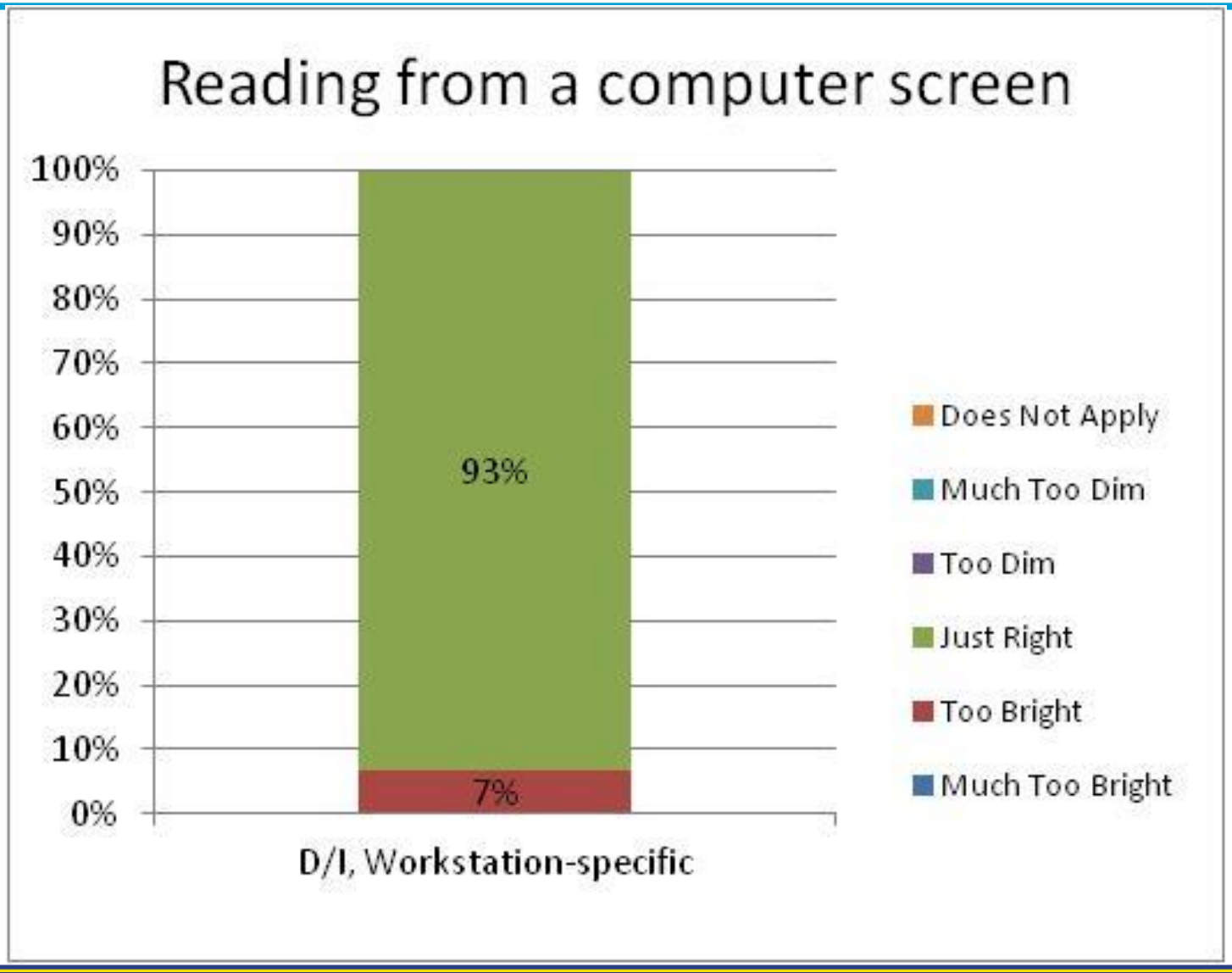
Lighting Satisfaction Survey Tool



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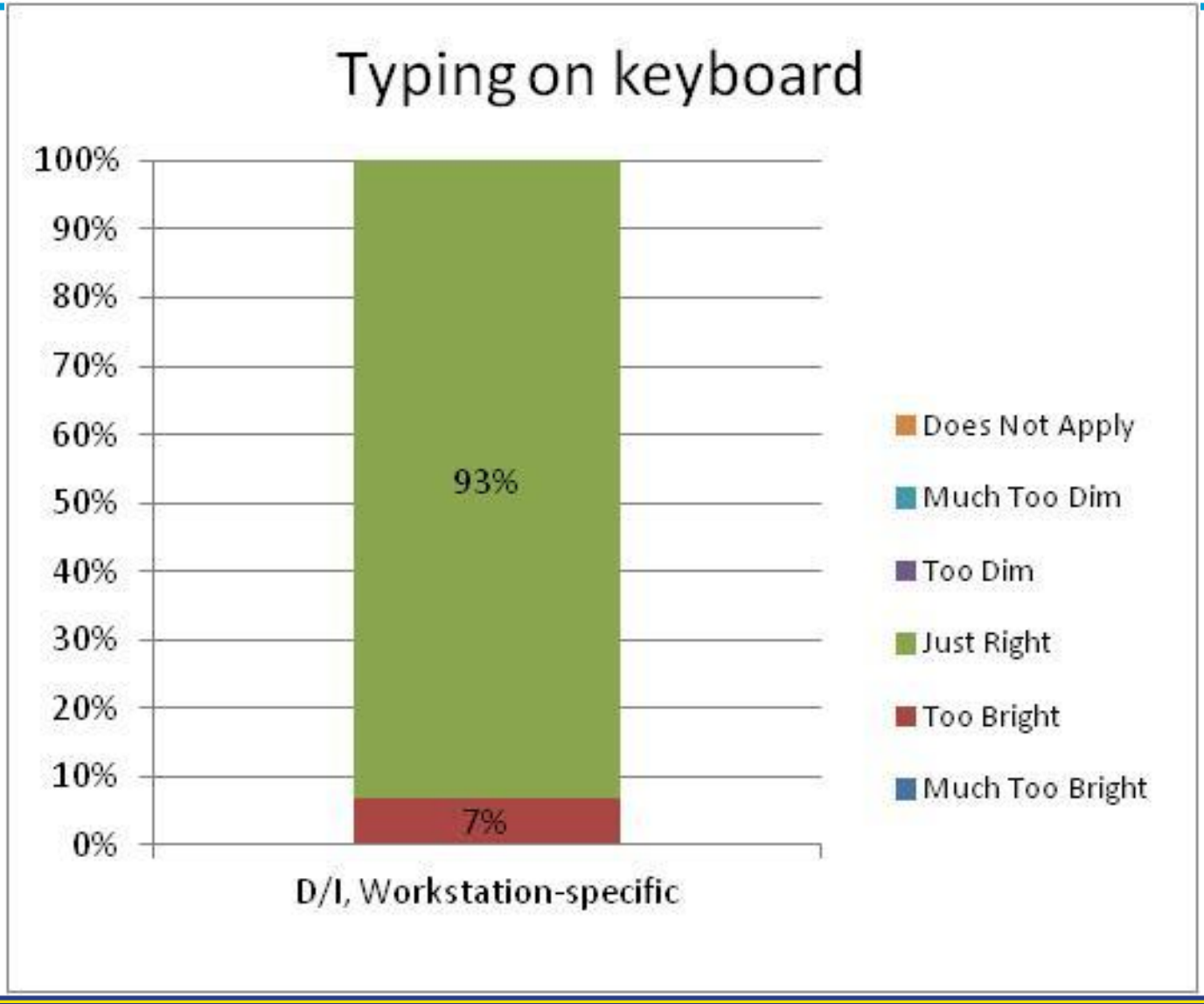

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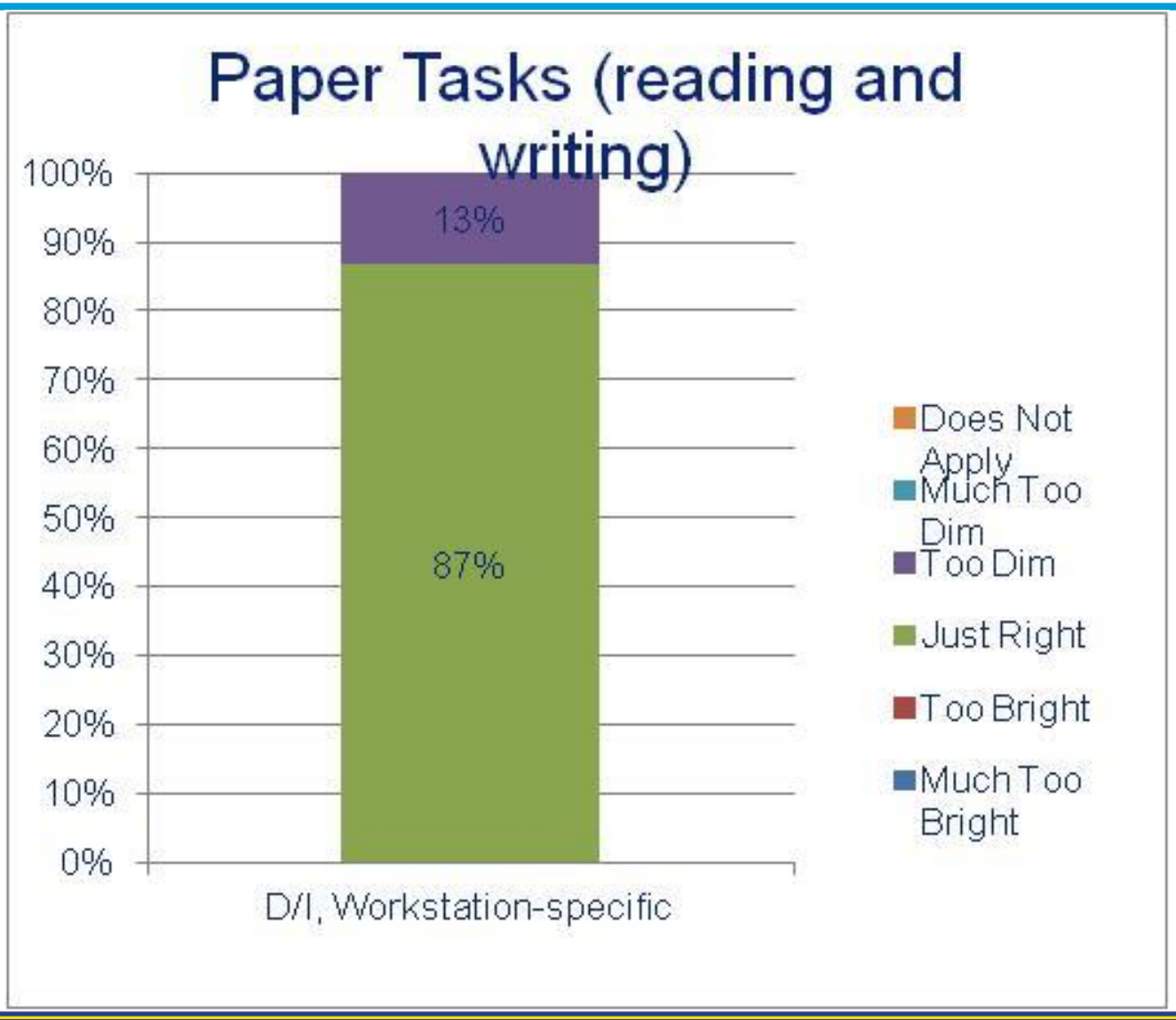

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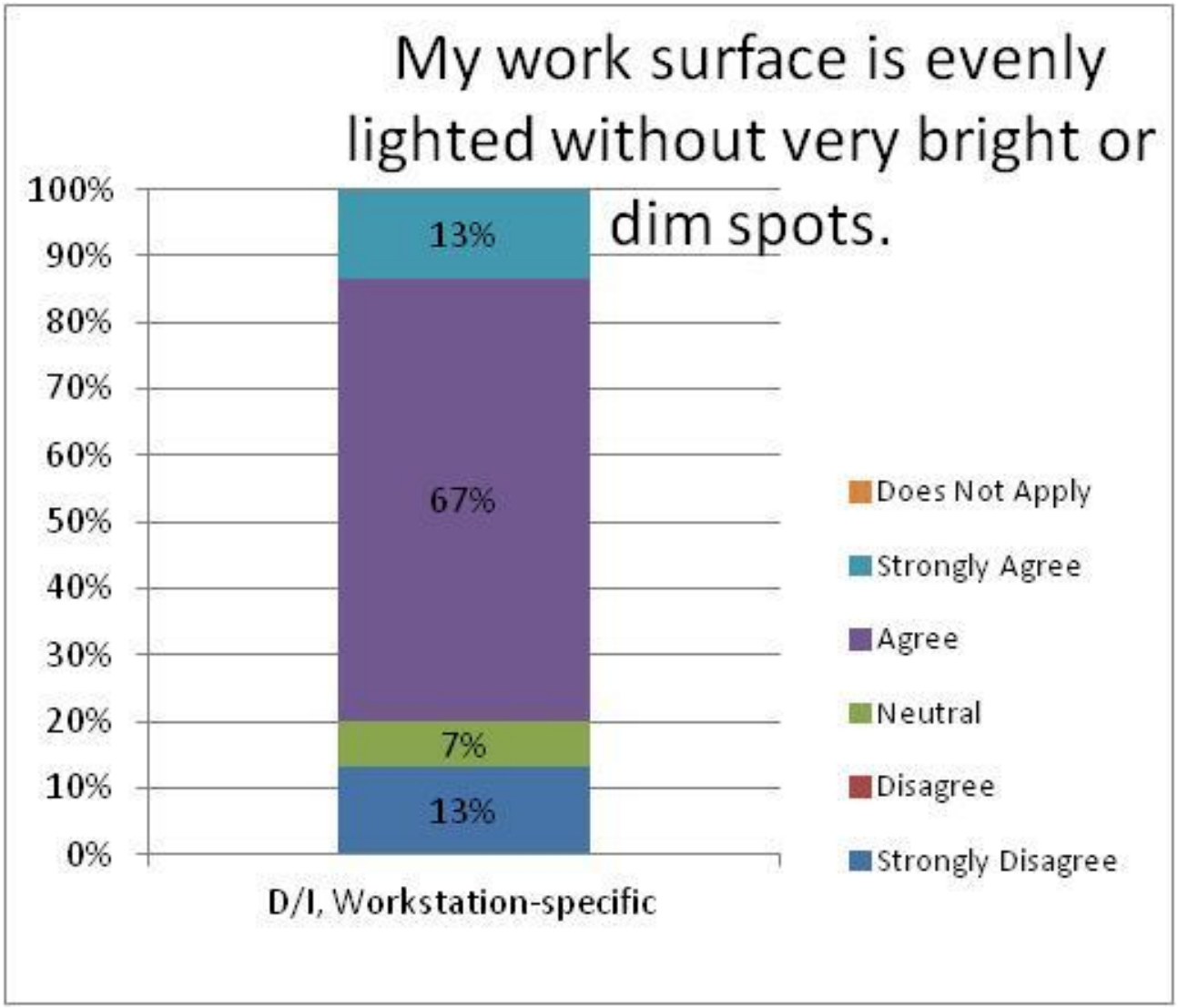

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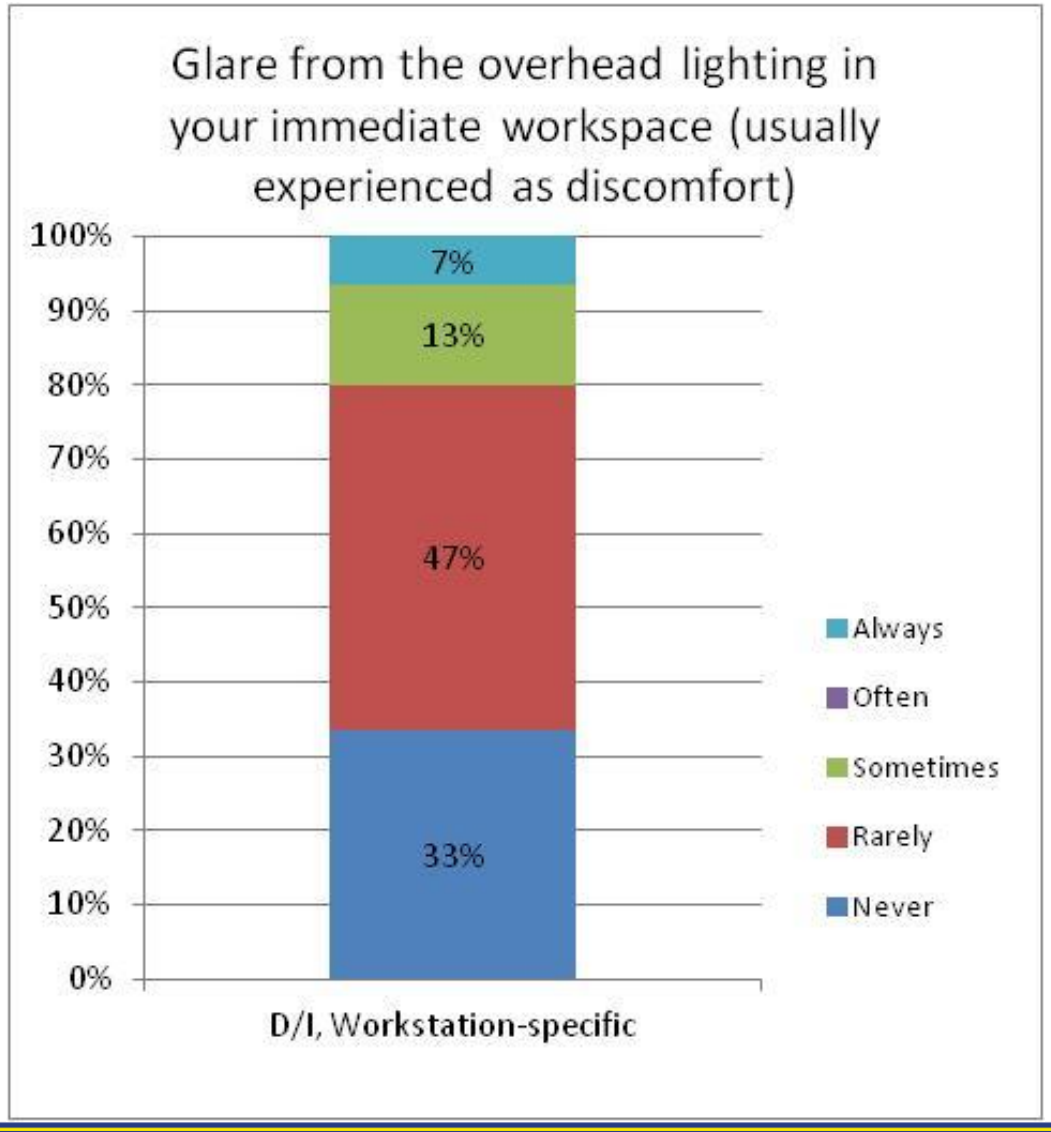

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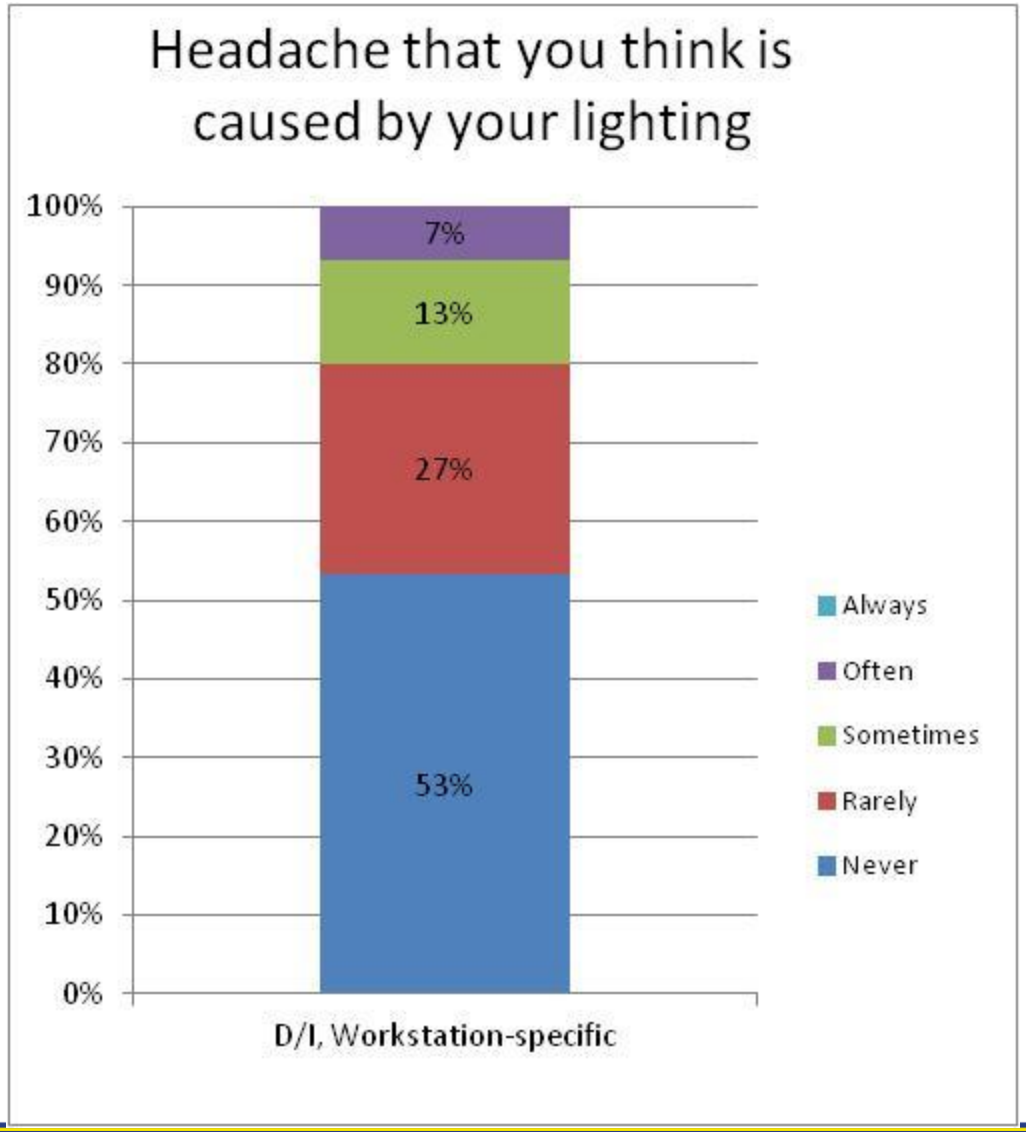

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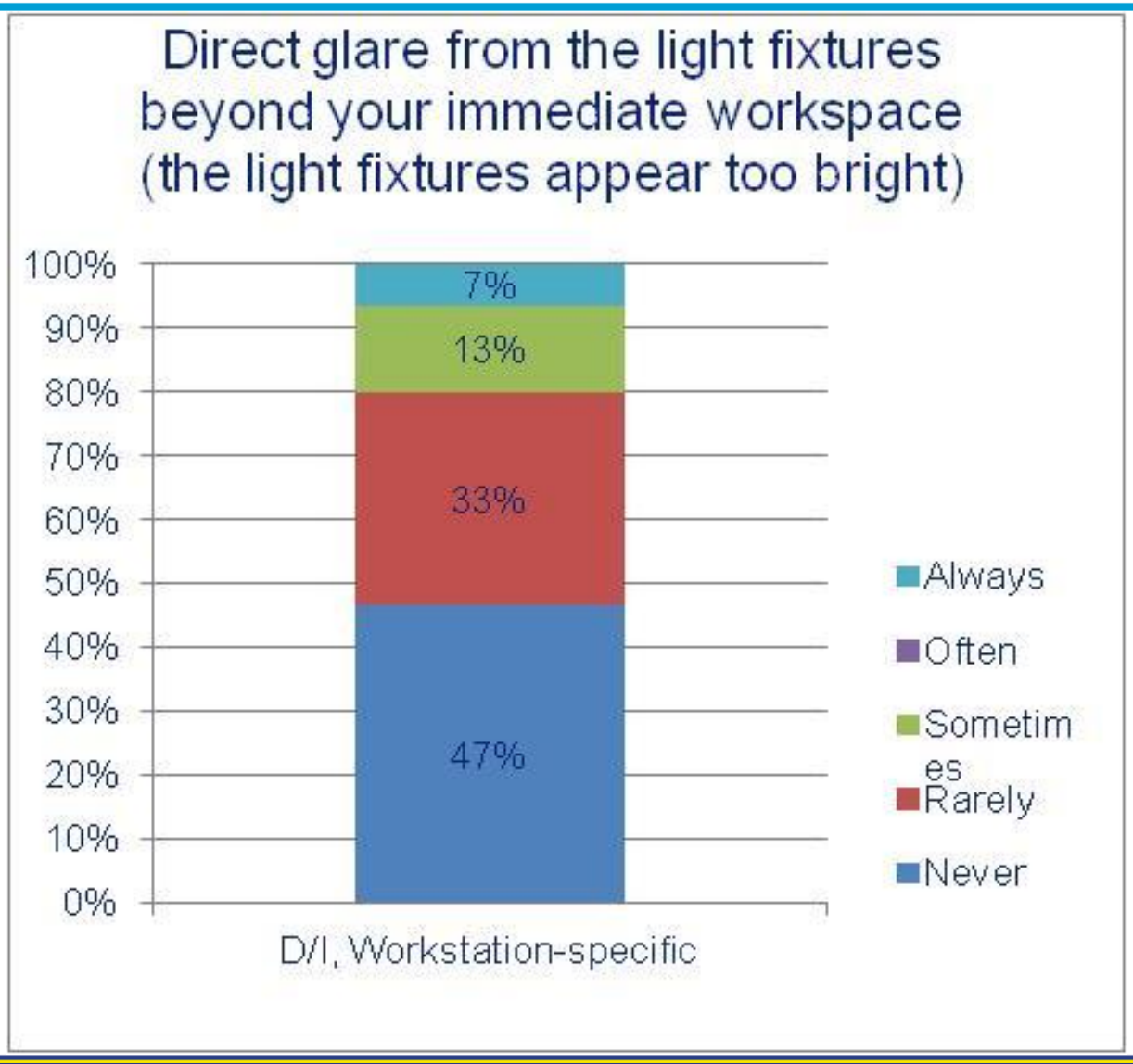

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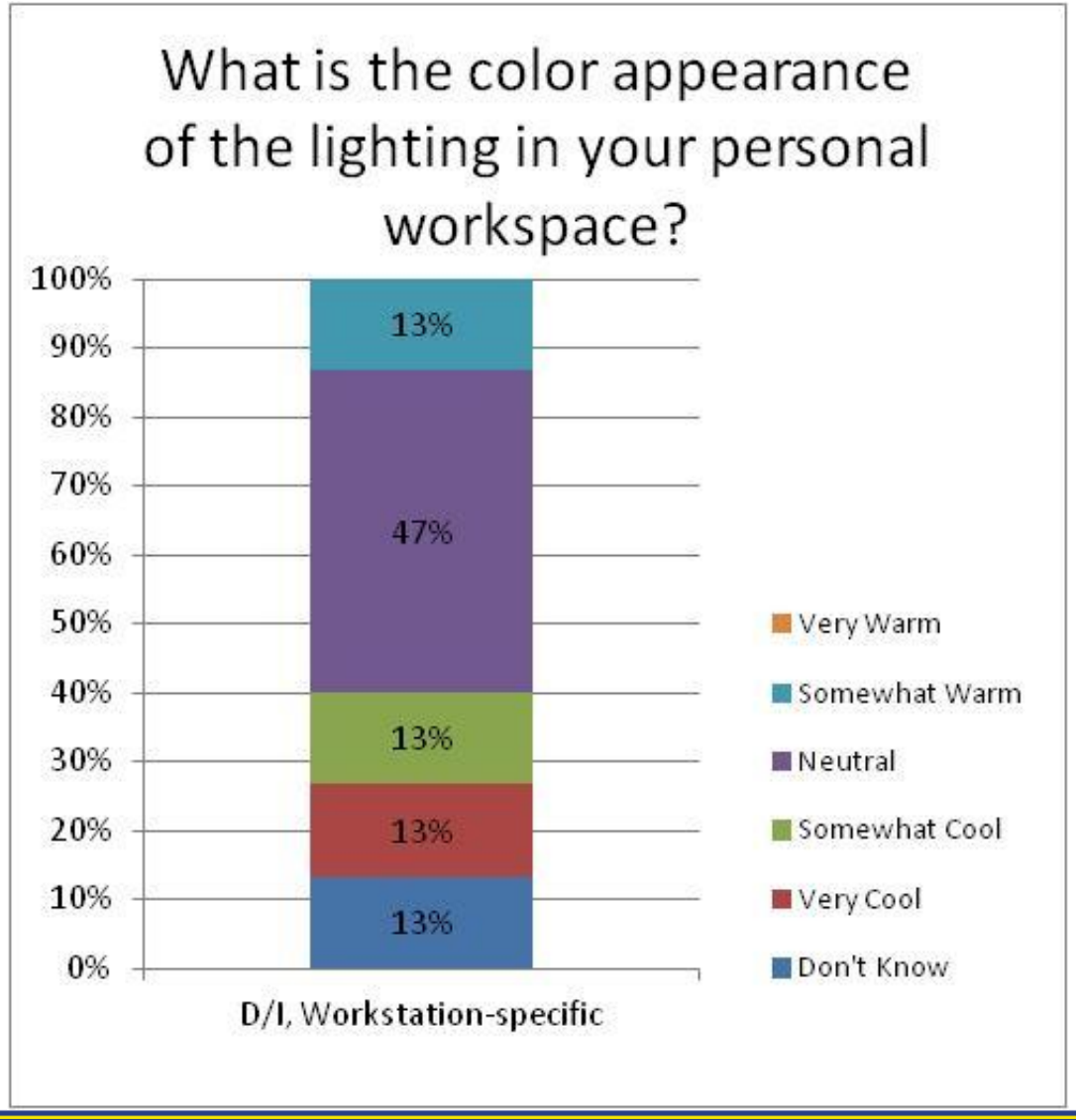

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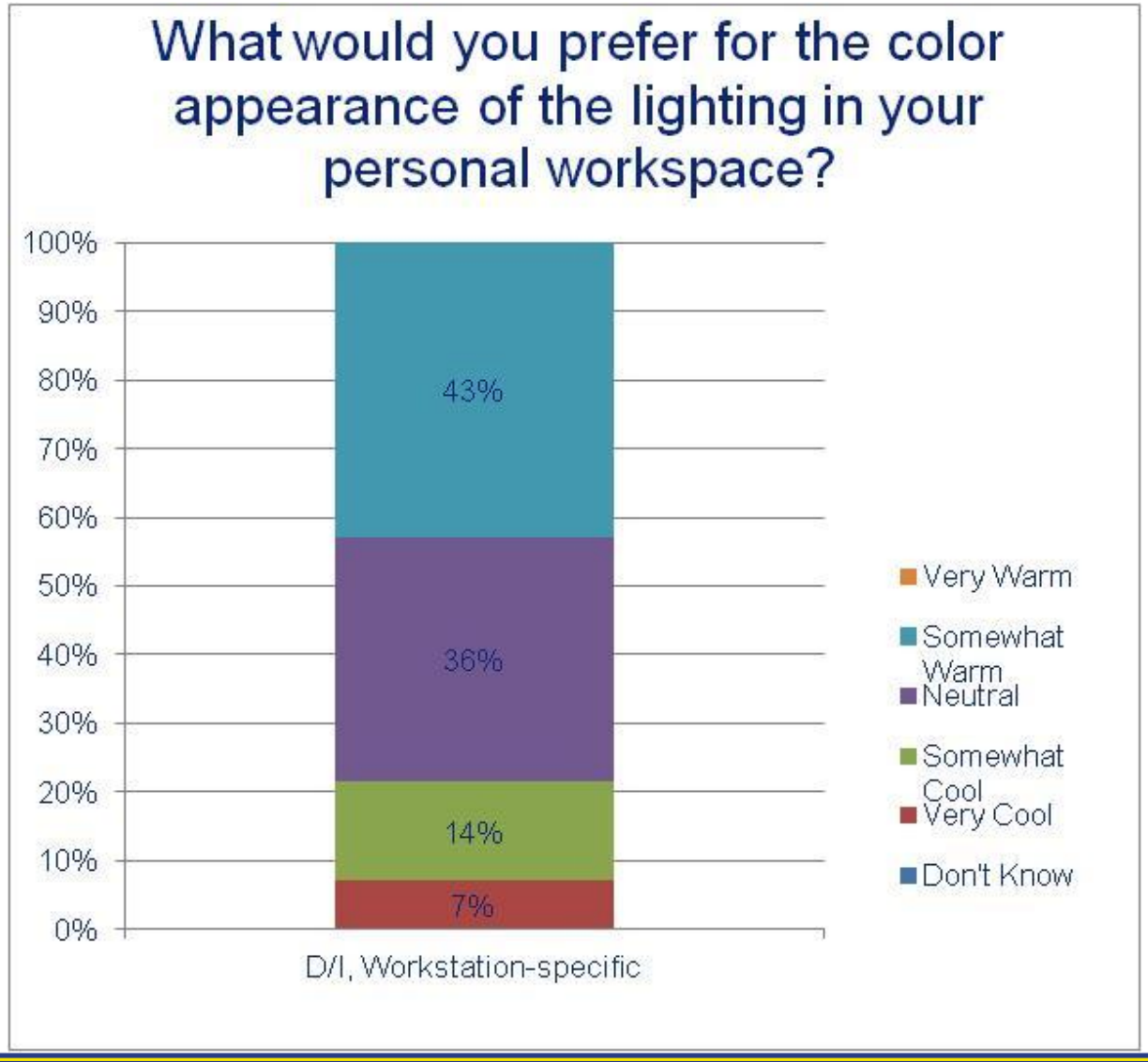


Light Right Consortium
Lighting Satisfaction Survey Tool

carol.jones@pnl.gov

www.lightright.org

www.lightingsolutions.energy.gov

Work Station Specific Lighting

Where to use

1. Open cubicles
2. Cubicles are frequently unoccupied
3. Daylight in outer zones
4. Large number of people that perform various visual tasks
5. Various age ranges

CO_2 HVAC Control

- How can you determine if active CO_2 control via your ventilation system is a legitimate option for your facility?
- What are the acceptable levels of ventilation and how are they determined?
- Why should you bother? – economic and energy incentives
- Three case studies – Virginia, Tennessee, Washington

CO_2 HVAC Control

What is it?

Reduces the amount of outside air brought into a building based on the CO2 level in the building.

Is CO_2 Control for You?

- Does your HVAC system incorporate an economizer control system?
- Do summertime temperatures get above 85 degrees?
- Do wintertime temperatures get below 45 degrees?
- Is the cost of heating fuel greater than $11.50/MBTU?
- Is the cost of electricity greater than $0.08/kWh?
- Is there less than 30 ft^2/person in the HVAC zone when fully occupied?
- Is the HVAC zone less than fully occupied 40% or more of the time?

Acceptable Levels of Ventilation

- ASHRAE Standard 62
  - Sets minimum outside air volumetric flow rates (cfm) based upon number of occupants within space, square footage of space, and effectiveness of the ventilation system serving the space
  - Outside air amounts target the amount necessary to maintain CO_2 levels within the space at no more than 700 ppm above outside air levels (Appendix C of Standard 62)
- UFC Guidelines - Federal
  - Primarily refer to ASHRAE standards
- State and Local Guidelines

Why bother? – economic and energy incentives

- Conditioning of ventilation air can account for as much as 50% of the energy requirements of HVAC systems in many climates
- Any reduction in the amount of ventilation air to be processed results in a decrease in energy consumption
- Any decrease in energy consumption results in an economic savings

Three Case Studies

- Virginia – Naval Amphibious Base Little Creek
  - Norfolk, VA
  - Building 3607, Galley
- Tennessee – Naval Support Activity, Mid-South
  - Millington, TN
  - Building 767, Conference Center
- Washington – Naval Base Kitsap
  - Bremerton, WA
  - Building 1017, Gymnasium

Virginia - Little Creek Building 3607 Galley

Outside Air Calculations per ASHRAE 62.1-2004

OUTSIDE AIR CALCULATIONS: ASHRAE 62-2004 AREA & PEOPLE

Utilization of Equation 11: Taylor, May 2006, "CO2 Based DVC Using 62.1-2004", ASHRAE Journal Article.

Total outside air flow at the air handler based on CO2 concentration difference

$$V'ot = \frac{Ra*Az}{Ez - \frac{Rp * (Cr-Coa)}{8400*m}} \quad \text{EQ 11}$$

Calulation of space CO2 levels and volumetric flowrate of OA at min and max occupancy.

To determine MAX CO2 use EQ. 13 Taylor, May 2006 ASHRAE Journal

$$Cr = Coa + \frac{8400*Ez*m}{Rp + \frac{Ra*Az}{Pz}} \quad \text{EQ 13}$$

Little Creek Bldg. 3607, Enlisted Dining, AHU-1 & AHU-2

	MIN	MAX	
INPUT VARIABLES			**Bold values with yellow highlight are inputs**
Ra	**0.18**	0.18	Room area ventilation rate, (cfm/ SF), ASHRAE 62, Table 2
Az	**1508**	1508	Occupied Square footage (SF)
Rp	**7.5**	7.5	Ventilation rate per person (cfm/person)., ASHRAE 62, Table 2
Pz	0	**100**	Number of people in the occupied space
Occupiable Square Feet		2250	14.25 Square foot per person
CONSTANTS			**Bold border:blue highlight = values based on site conditions**
Ez	1	1	Effectiness of the ventilation system, 1 = Ceiling supply diffusers
Coa	400	400	CO2 in outside air, (ppm), Actual measurement or estimate
constant	8400	8400	Conversion factor of 0.0084 cfm/met/person, (ppm*met*person/cfm).
met	1	1	Metabolic generation of CO2 per person, unit is (met), (1.0 for restful state.)
CALCULATED OUTPUTS			
V'ot	271	1021	Calculated by EQ. 11, OA volumetric flowrate, (CFM)
OA Space	271	271	OA required for the space square footage, (CFM)
OA People	0	750	OA required for the people occupying the space, (CFM)
Total OA	271	1021	Calculated OA volumetric flowrate, (CFM)
REPORTING VALUES			
	MIN	MAX	**These values are applied to both AHU-1 and AHU-2**
Cr, Room CO2	400	1222	Room CO2 concentrations, EQ. 13, Taylor, May 2006 ASHRAE Journal
Total OA	271	1021	Calculated OA volumetric flowrate, (CFM)

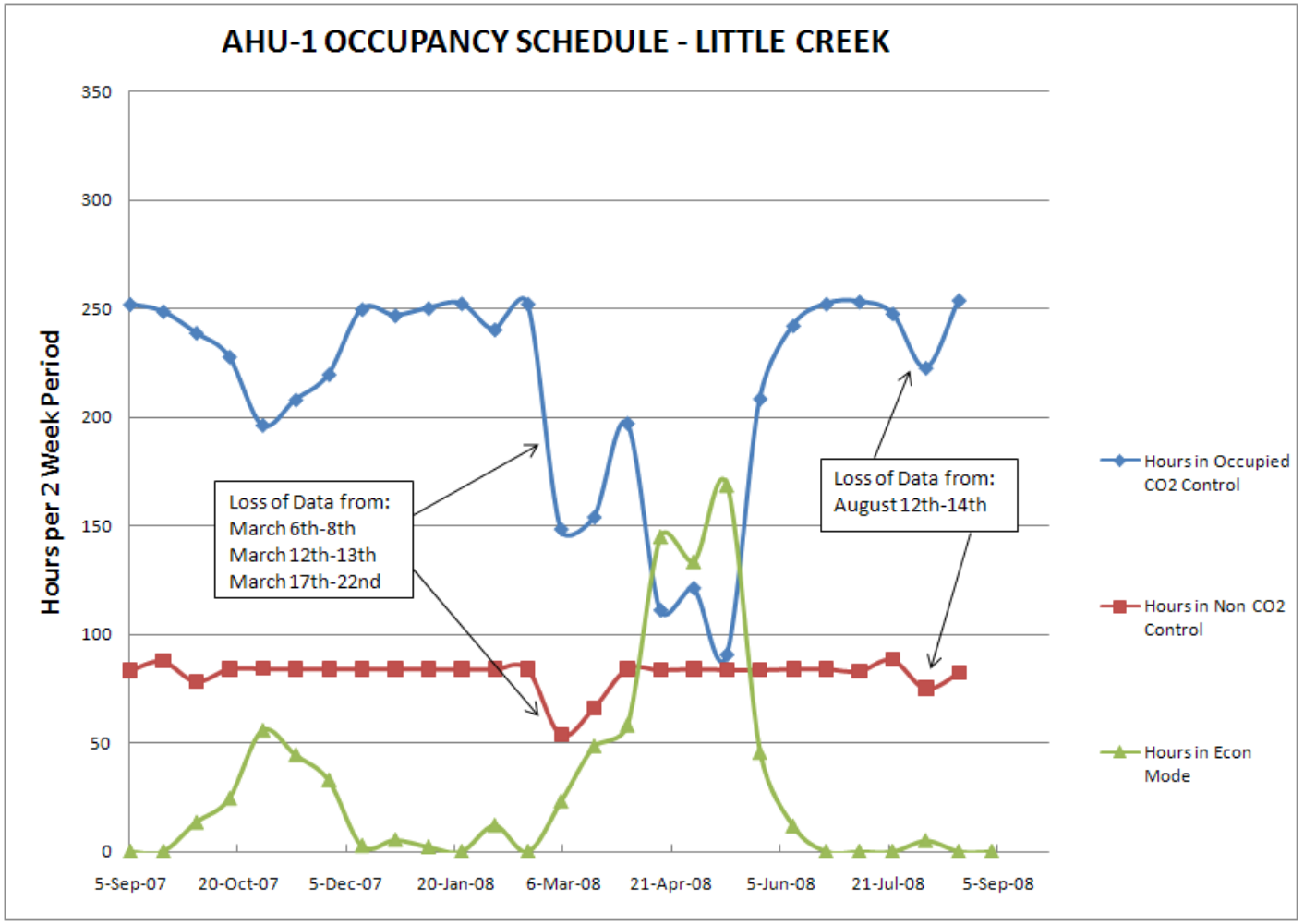
Total OSA for space with:

0 Occupants – 271 cfm
100 Occupants – 1021 cfm

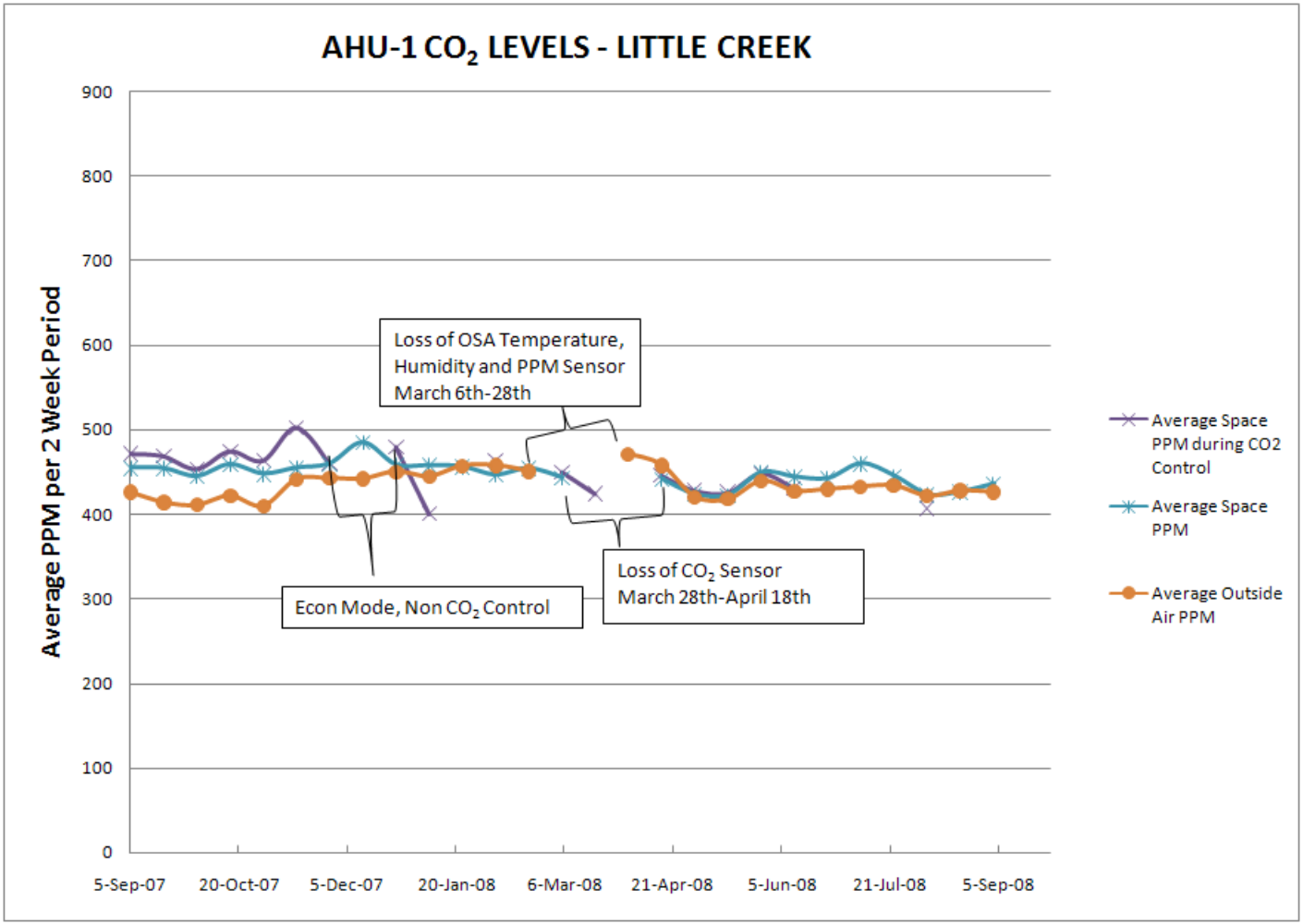
Performance Results - Virginia

- Occupancy Schedule
- CO2 Measured Concentration Levels
- Ventilation Air Cooling Load
- Ventilation Air Heating Load
- Ventilation Air Flow Rate

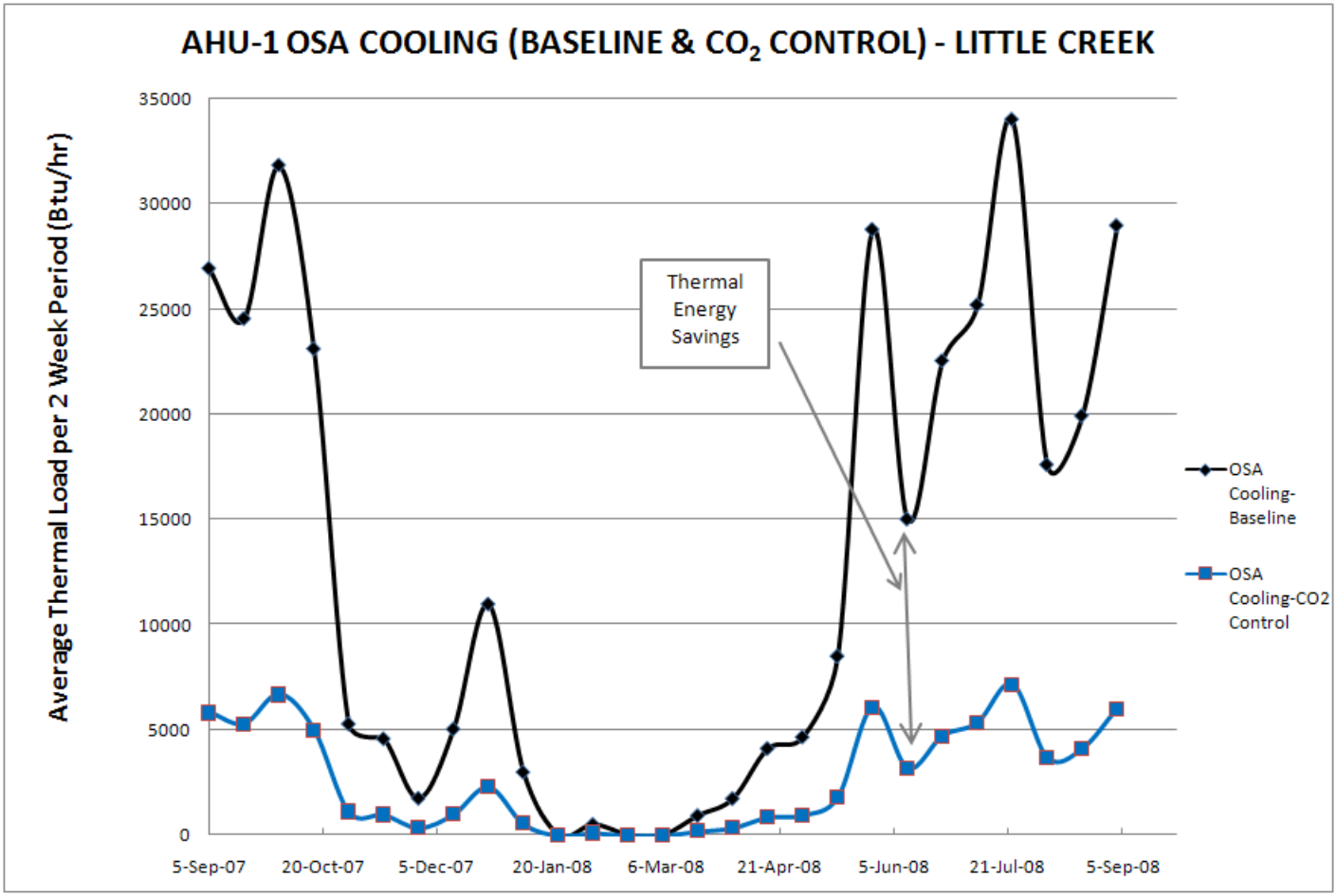
Occupancy Schedule - Virginia



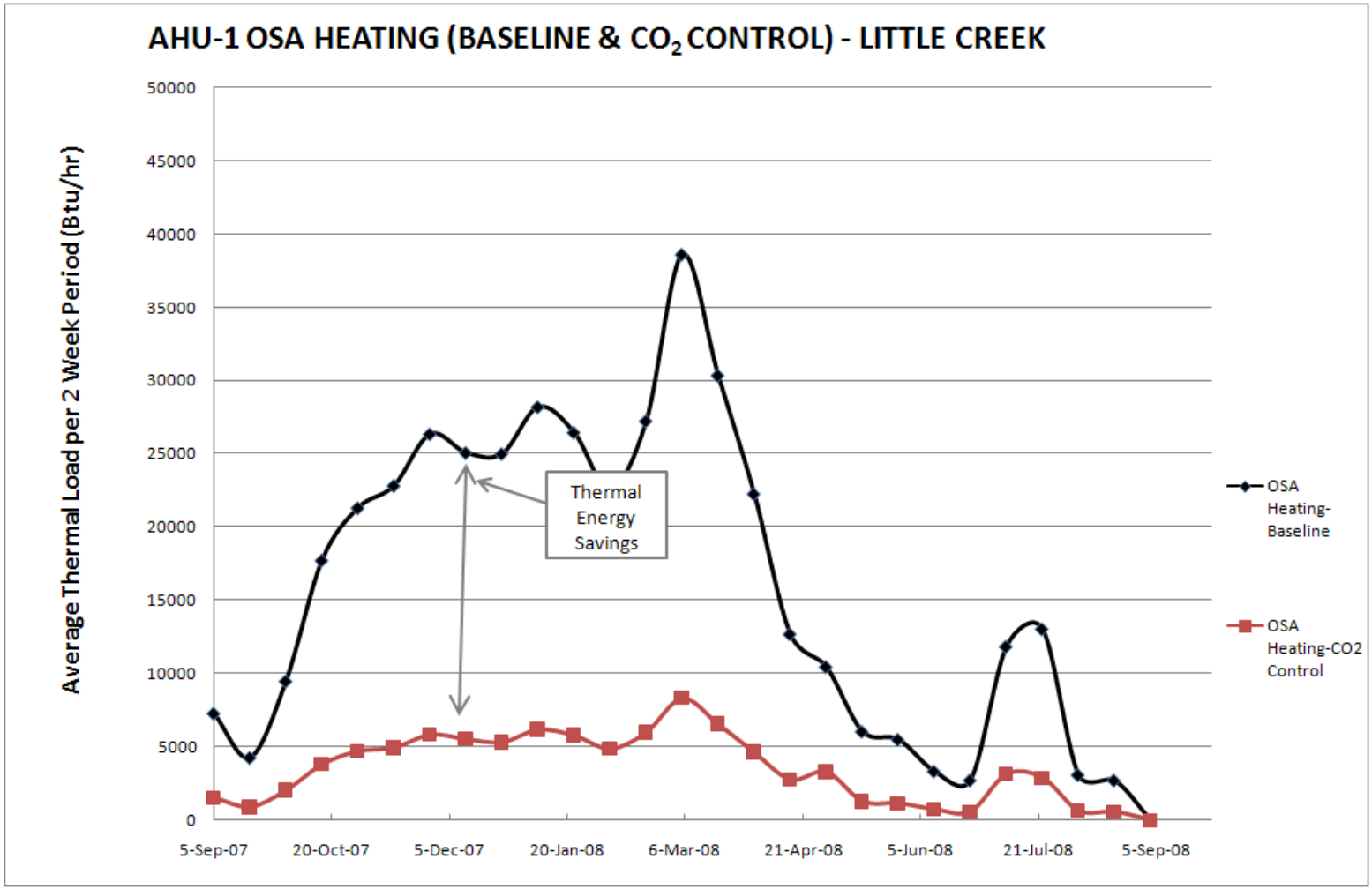
CO_2 Measured Concentration Levels - Virginia



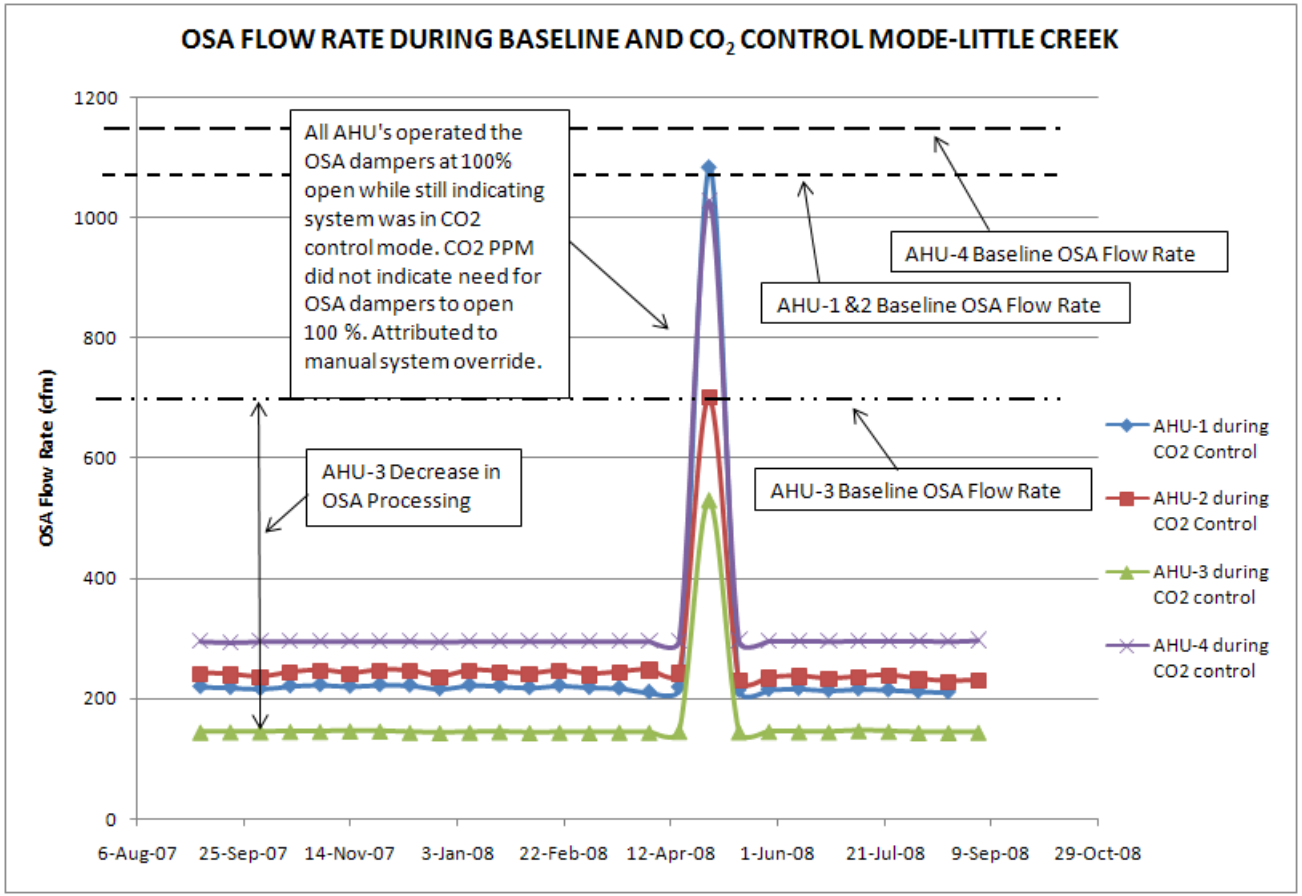
Ventilation Air Cooling Load - Virginia



Ventilation Air Heating Load - Virginia



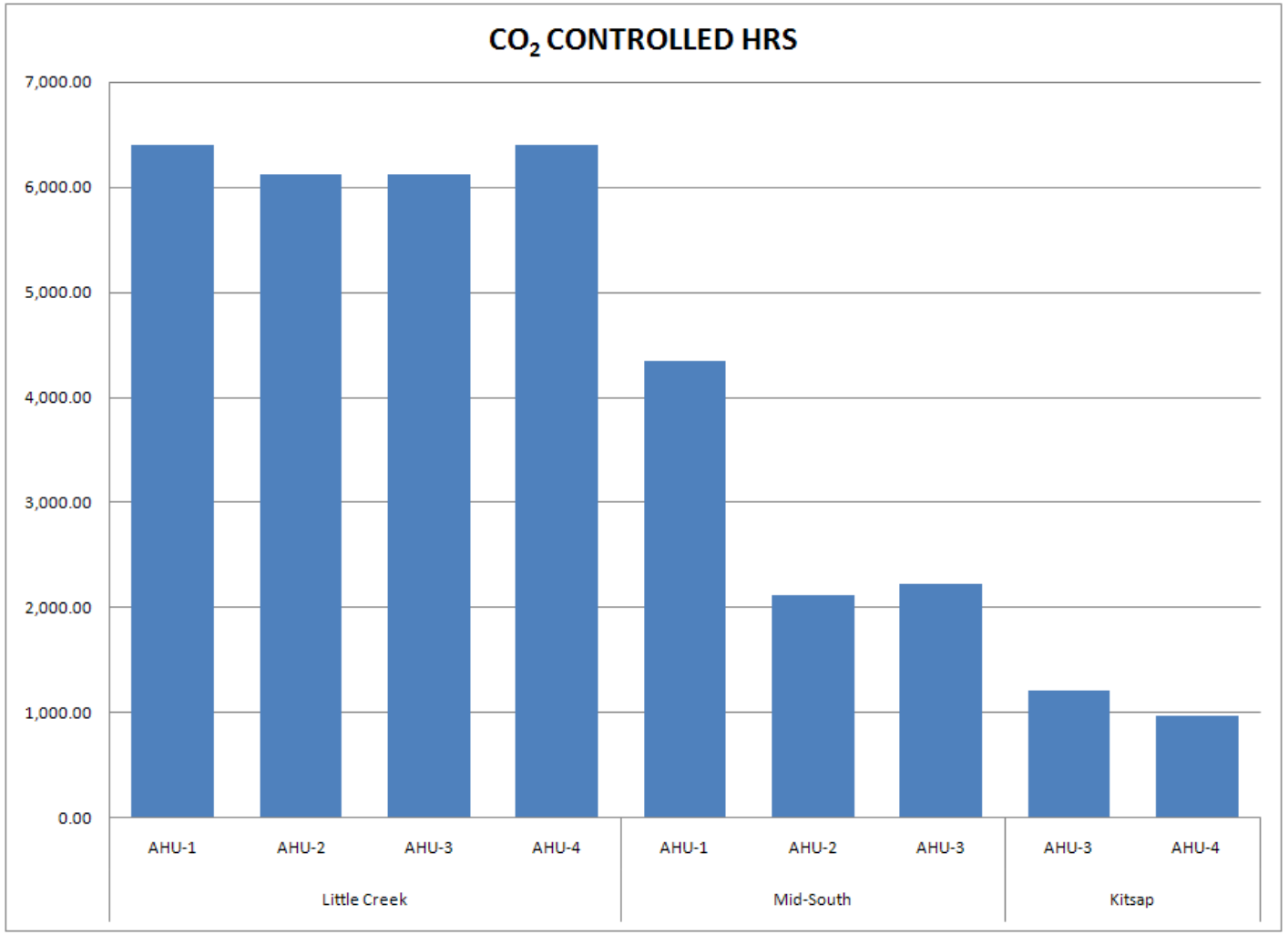
Ventilation Air Flow Rates - Virginia



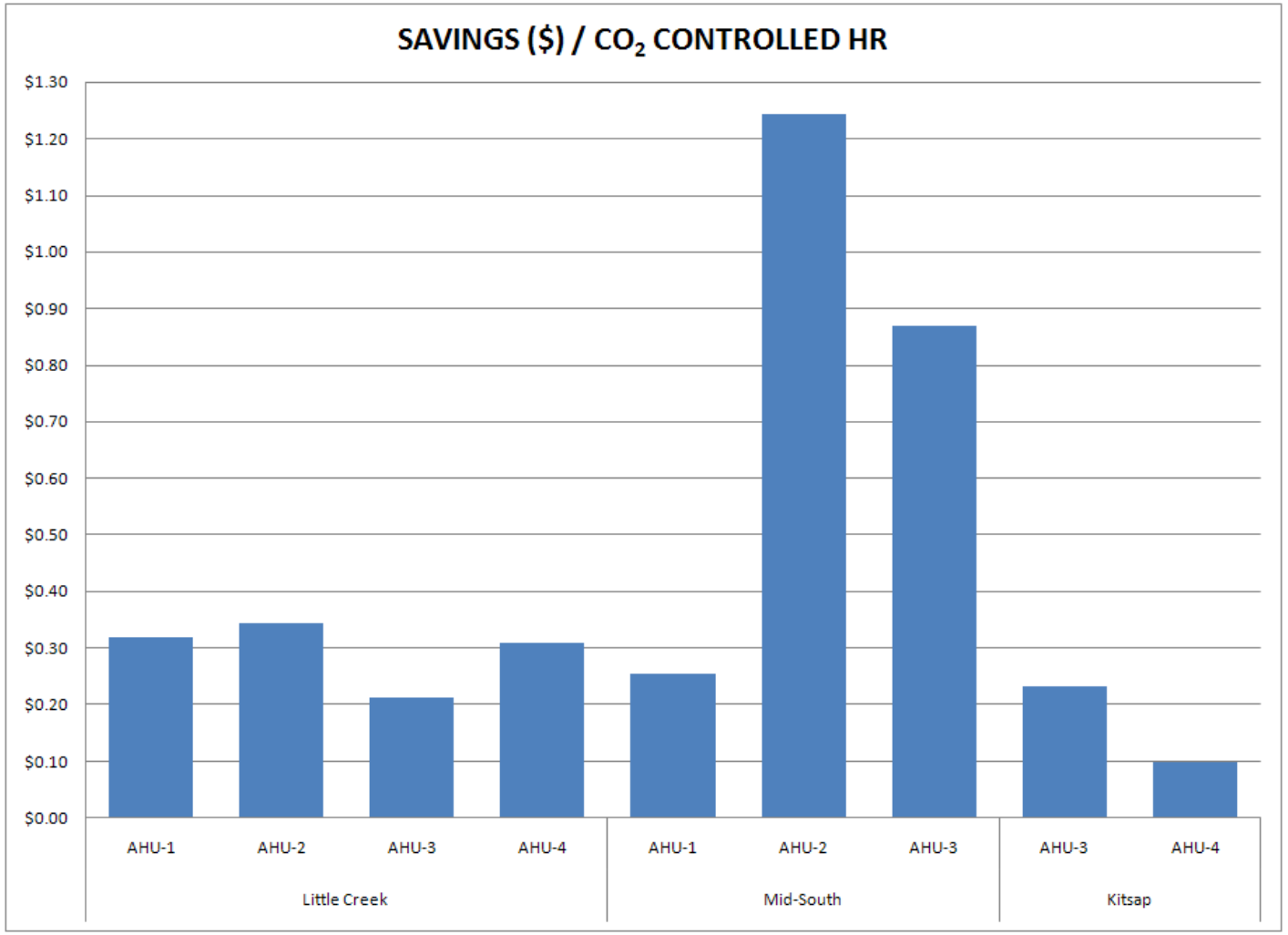
Performance Results – All Sites

- CO_2 Controlled Hours
- Savings per CO_2 Controlled Hour
- Annual Savings
- Payback in Years – non weather corrected
- Energy Manager Decision Calculator
- Test Site Evaluation Scores
- Payback based on Evaluation Scores

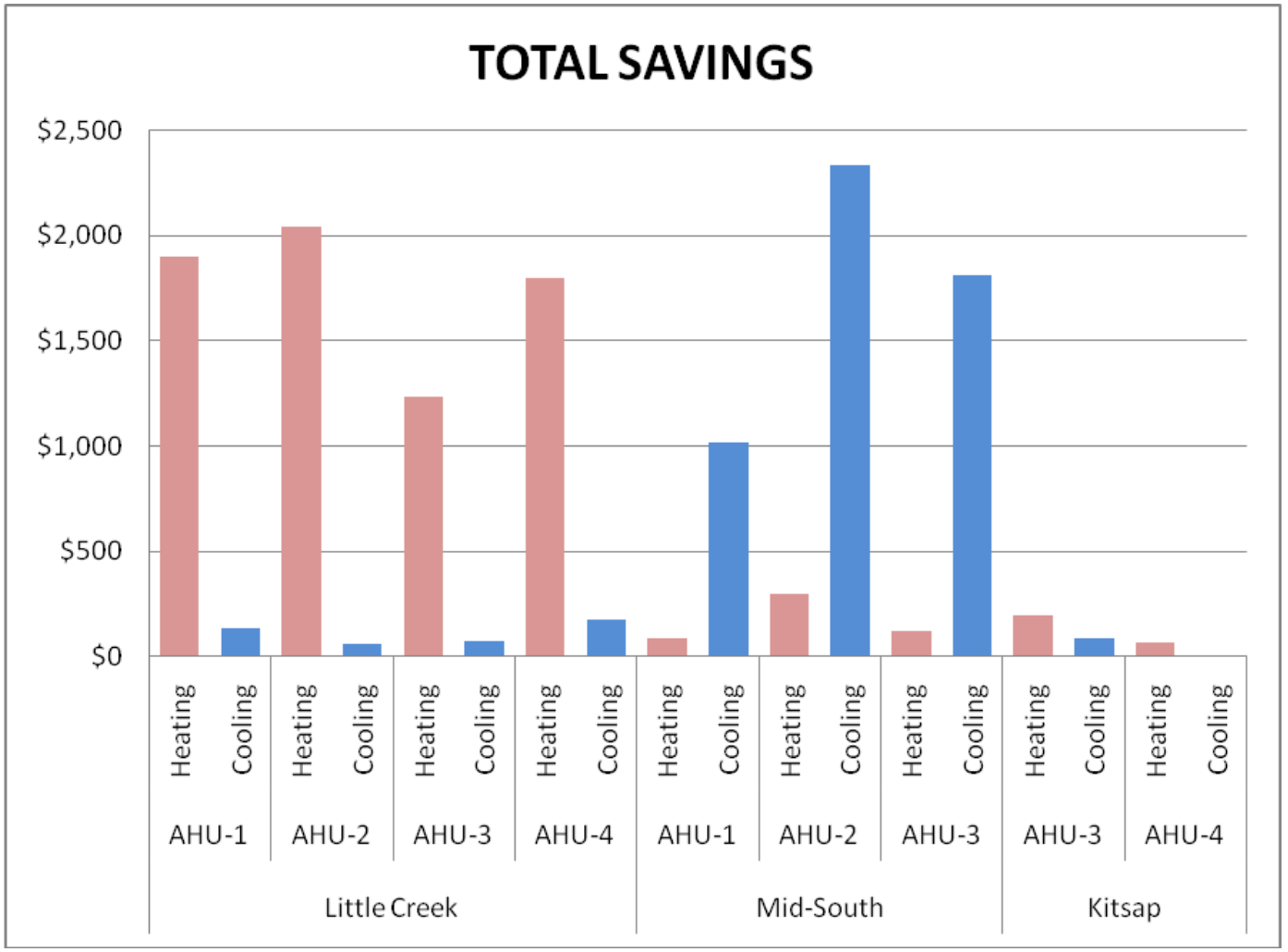
CO_2 Controlled Hours – All Sites



Savings per CO_2 Controlled Hour – All Sites



Annual Savings – All Sites



Payback in Years – All Sites Non Weather Corrected

	Total Installed Cost	Annual Total Savings	Payback (yrs)
Little Creek	$ 18,373	$ 7,427	2.5
Mid-South	$ 35,500	$ 5,682	6.3
Kitsap	$ 19,685	$ 348	56.6

Energy Manager Decision Calculator – Should I Install or Not?

CO_2 HVAC Controls Decision Calculator					
	Score				
Variable	**1**	**2**	**3**	**4**	**5**
CDD	<1000	1000 - 1250	1250 - 1750	1750 - 2000	>2000
HDD	<3000	3000 - 4000	4000 - 5000	5000 - 6000	>6000
Cost of heating fuel (per MBTU)	<$11	$11 - $11.50	$11.50 - $12	$12 - $12.50	>$12.50
Cost of Electricity (per kWh)	<5¢	5¢ - 6¢	8¢ - 9¢	7¢ - 10¢	>10¢
Efficiency of Heating System	>75%	65% - 75%	55% - 65%	45% - 55%	<45%
COP of Cooling System	>5	4 - 5	3 - 4	2 - 3	<2
Max SF/person in HVAC zone	>60	50 - 60	30 - 50	20 - 30	<20
% of time zone < 50% occupied	<25%	25% - 40%	40% - 55%	55% - 75%	>75%

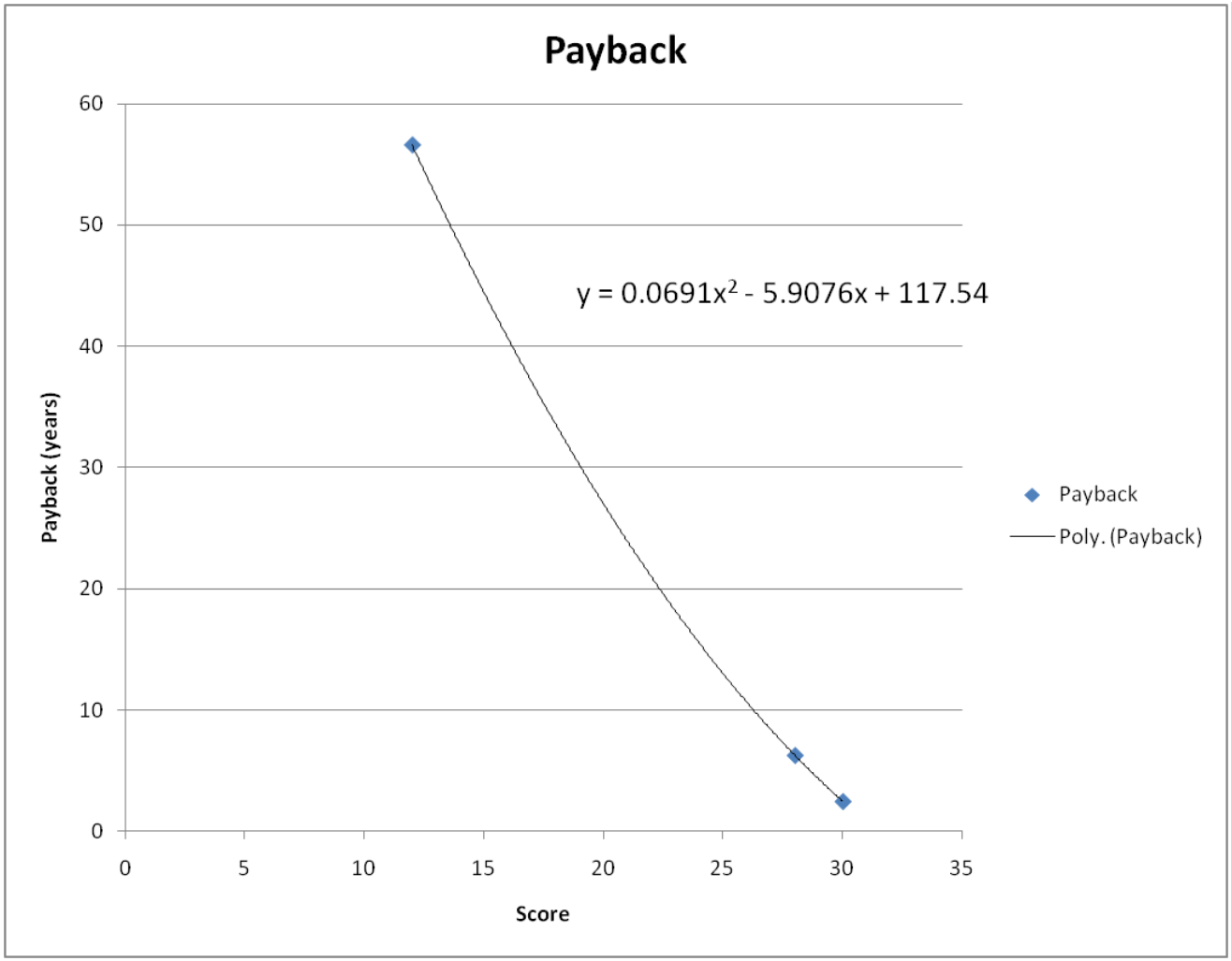
- **If the total score is <19, the candidate facility is not a good candidate for this technology.**
- **If the total score is 19 - 25, it is definitely worth further investigation.**
- **If the total score is > 26, it is a strong indicator of a good candidate for this technology.**

Test Site Evaluation Scores

- **For the three sites included in this evaluation, the scores are:**

Variable	Kitsap		Little Creek		Mid-South	
	Value	Score	Value	Score	Value	Score
CDD	393	1	2108	5	2094	5
HDD	4784	3	3066	2	3542	2
Cost of heating fuel (per MBTU)	$10.51	1	$12.08	4	$12.41	5
Cost of Electricity (per kWh)	$0.04	1	$0.03	1	$0.09	4
Efficiency of Heating System	0.8%	1	0.35%	5	0.8%	1
COP of Cooling System	3.5	3	3.5	3	3.5	3
Max SF/person in HVAC zone	100	1	15	5	20	4
% of time zone < 50% occupied	0.25%	1	0.8%	5	0.6%	4
Totals		**12**		**30**		**28**

Payback Based on Evaluation Score



Score	Payback
1	111.7
2	106.0
3	100.4
4	95.0
5	89.7
6	84.6
7	79.6
8	74.7
9	70.0
10	65.4
11	60.9
12	56.6
13	52.4
14	48.4
15	44.5
16	40.7
17	37.1
18	33.6
19	30.2
20	27.0
21	24.0
22	21.0
23	18.2
24	15.6
25	13.0
26	10.7
27	8.4
28	6.3
29	4.3
30	2.5
31	0.8
32	-0.7
33	-2.2
34	-3.4
35	-4.6
36	-5.6
37	-6.4
38	-7.2
39	-7.8
40	-8.2

CO2 HVAC Control Maintenance Issues

- Recalibrate every 5 years
- Internal algorithm in each sensor to minimize sensor drift between recalibrations
- $500 for recalibration kit

Contact Information

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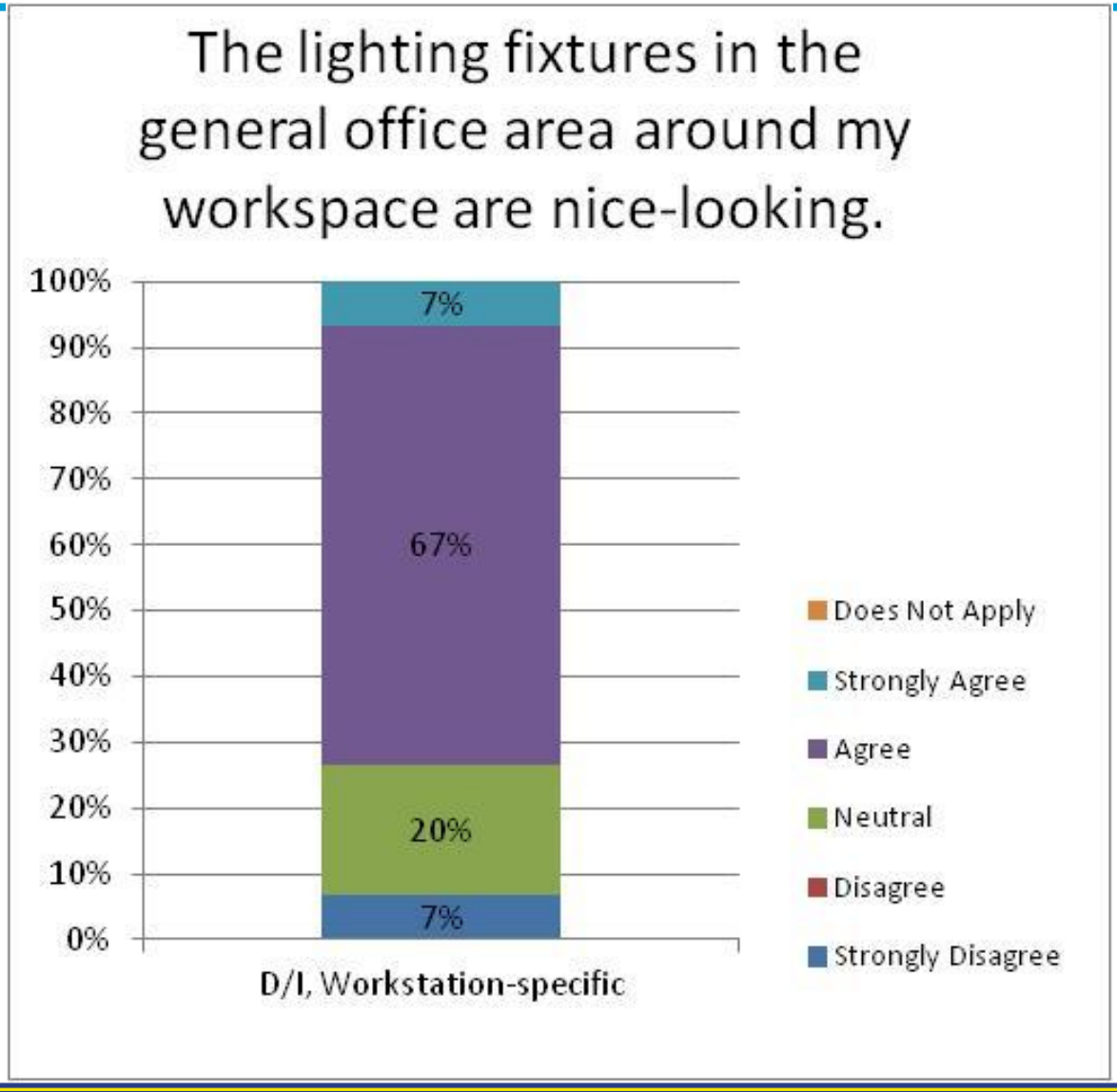
Light Right Consortium
Lighting Satisfaction Survey Tool



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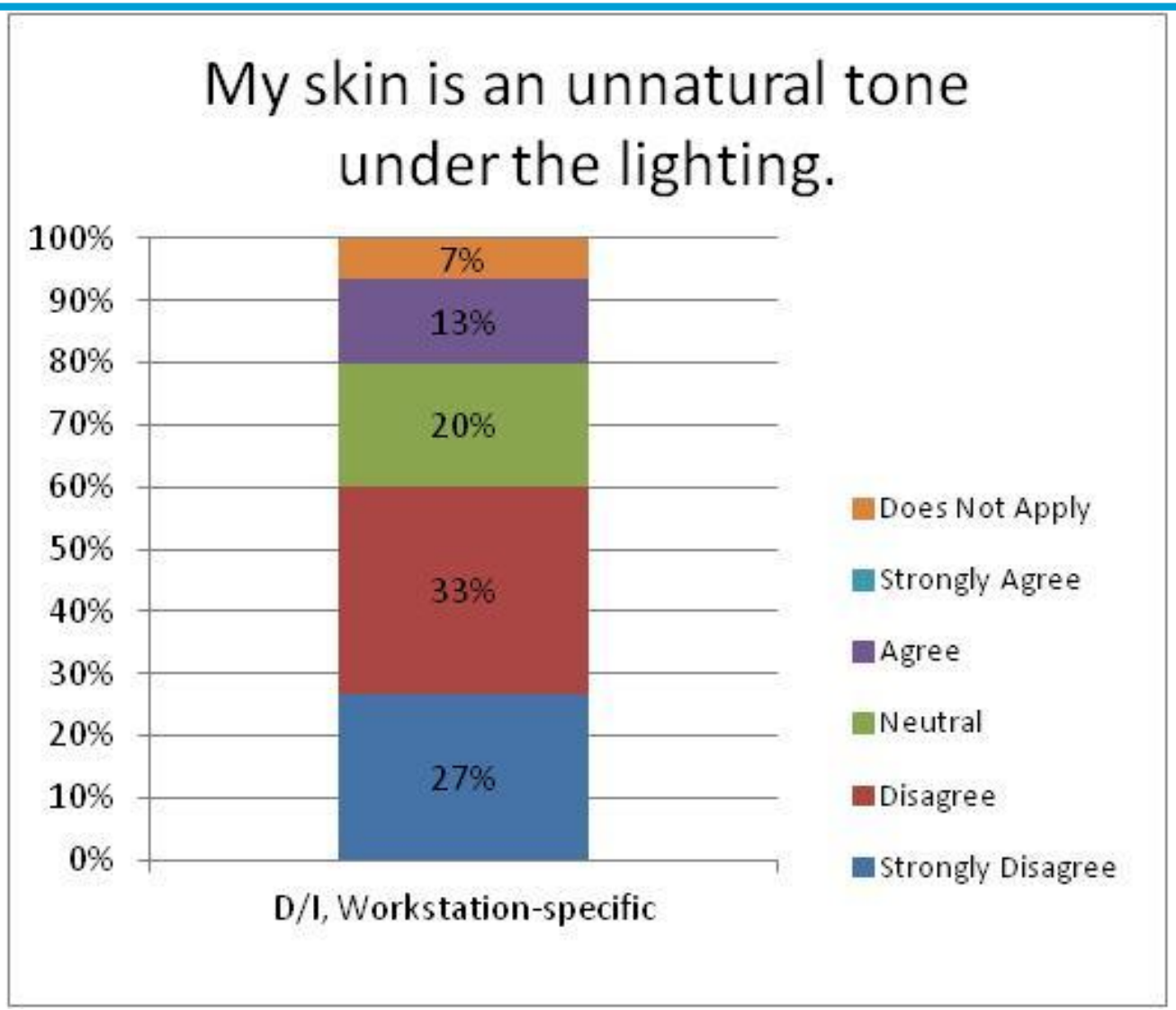

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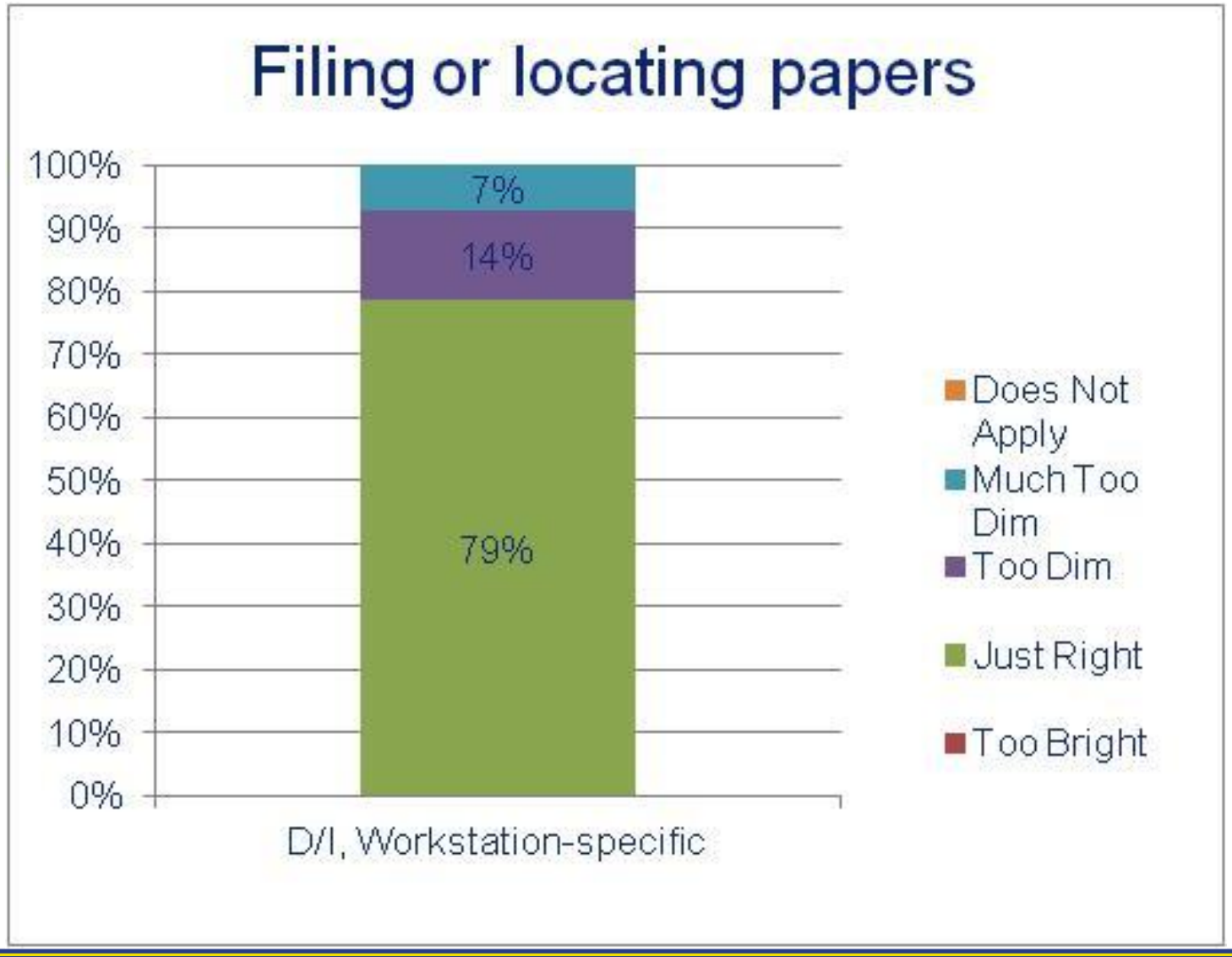

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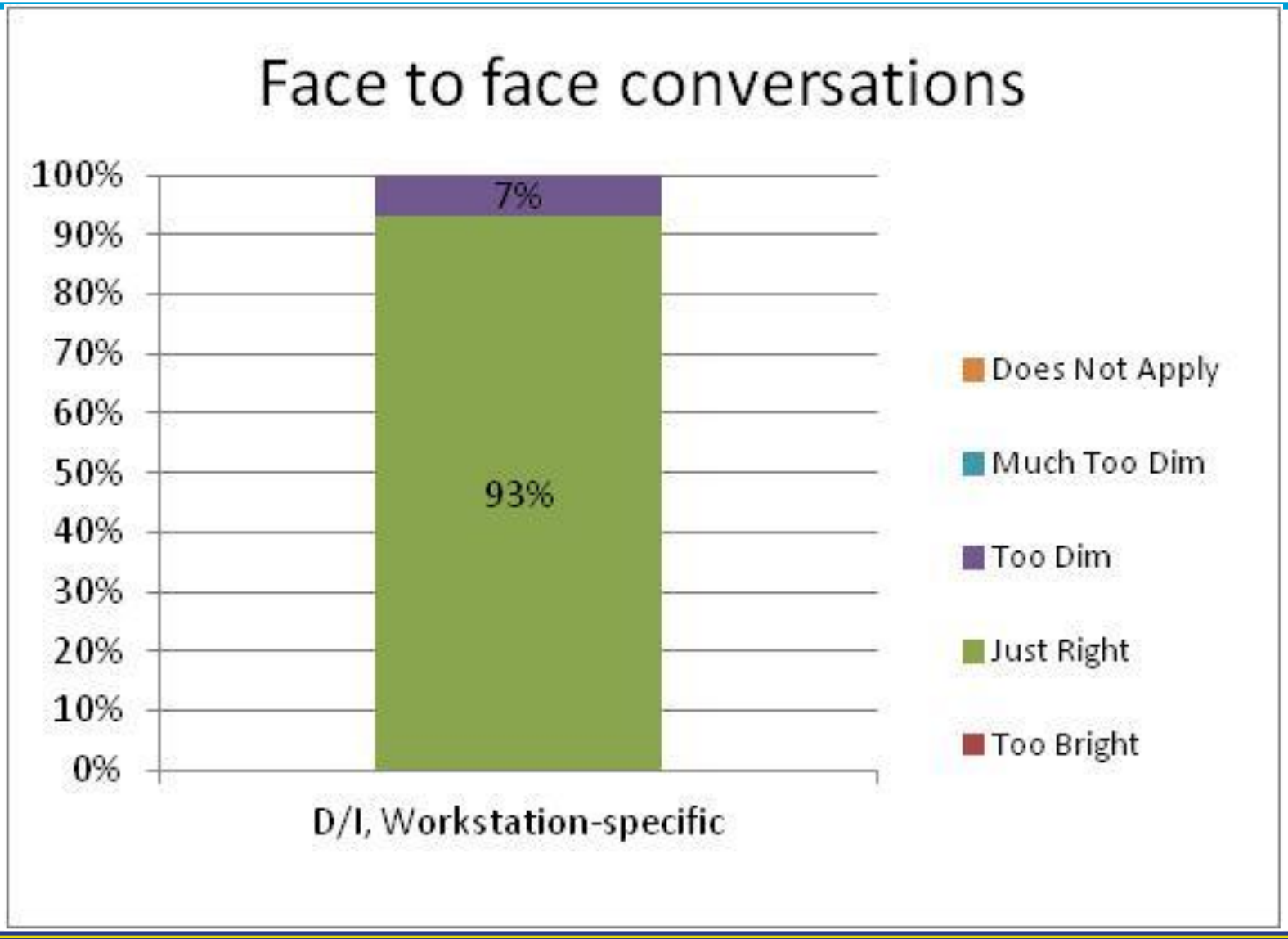

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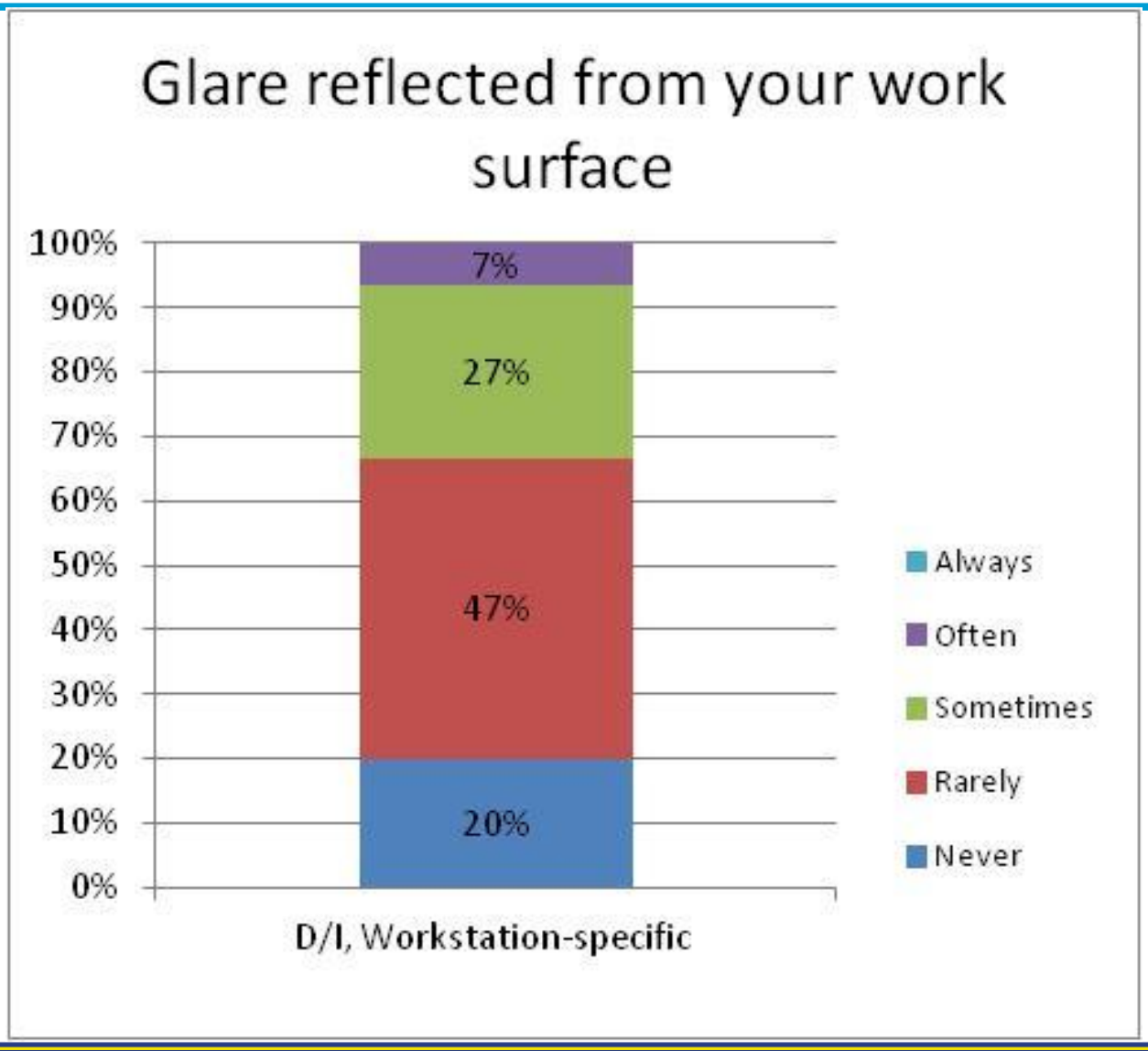

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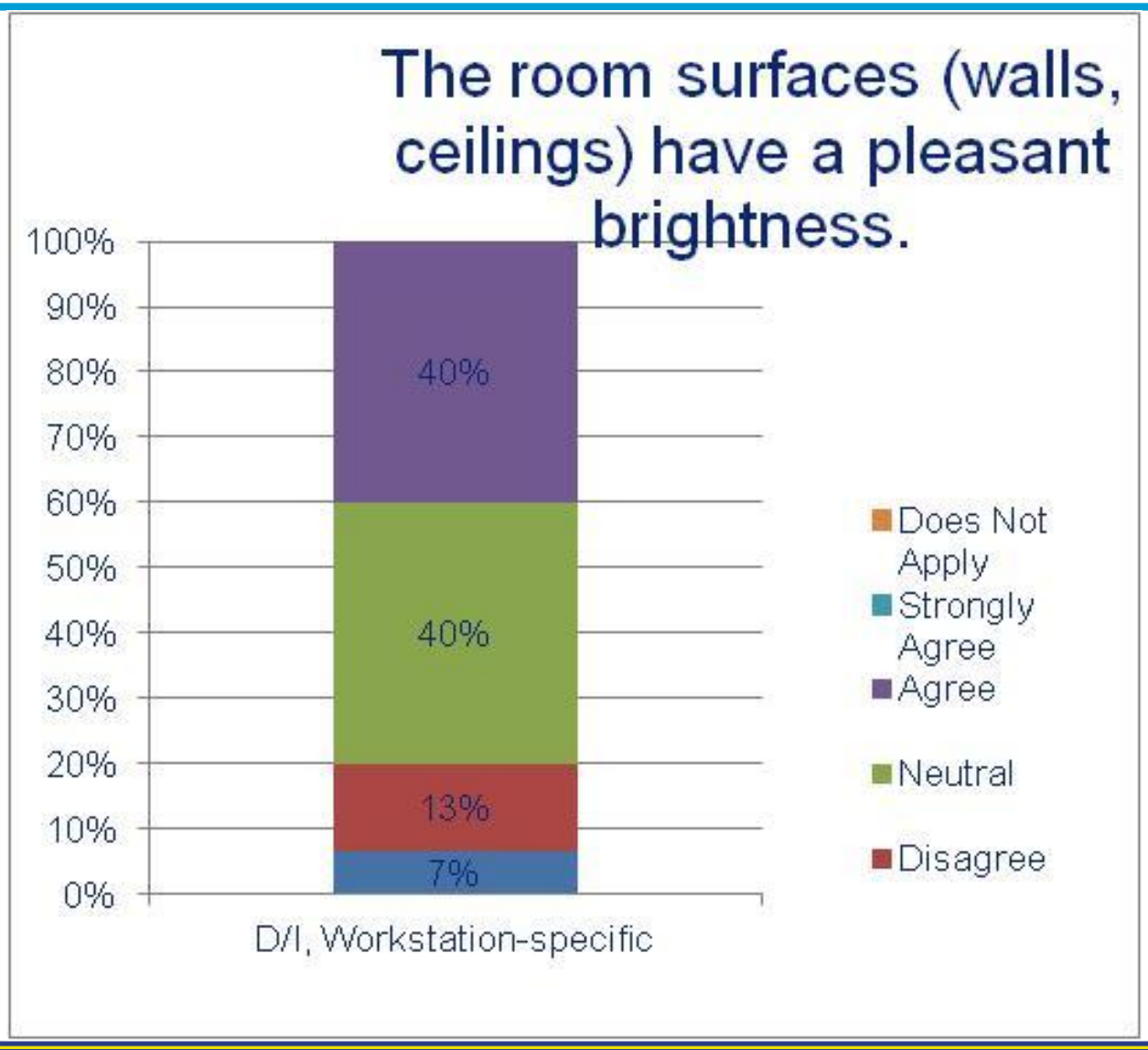

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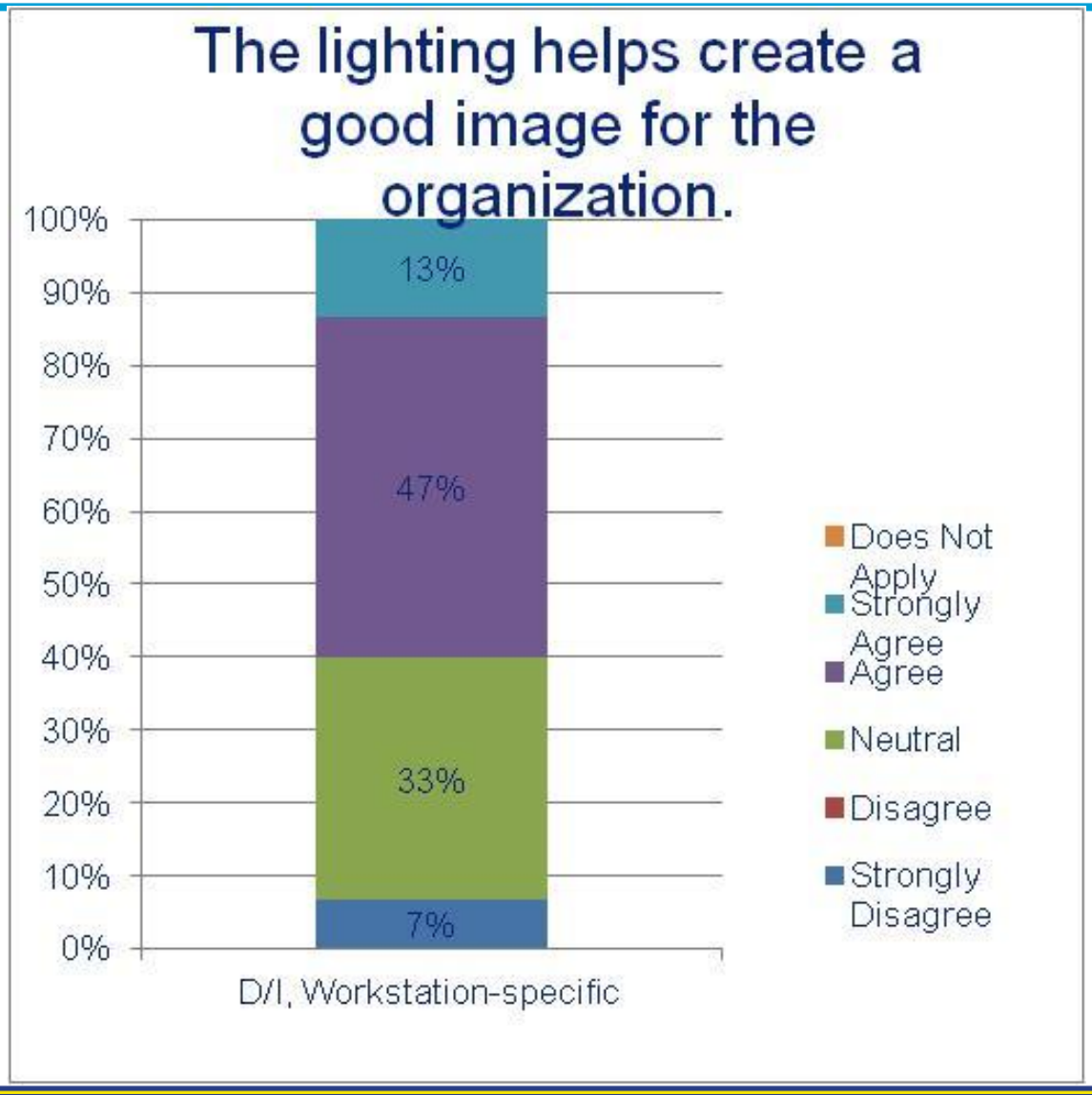

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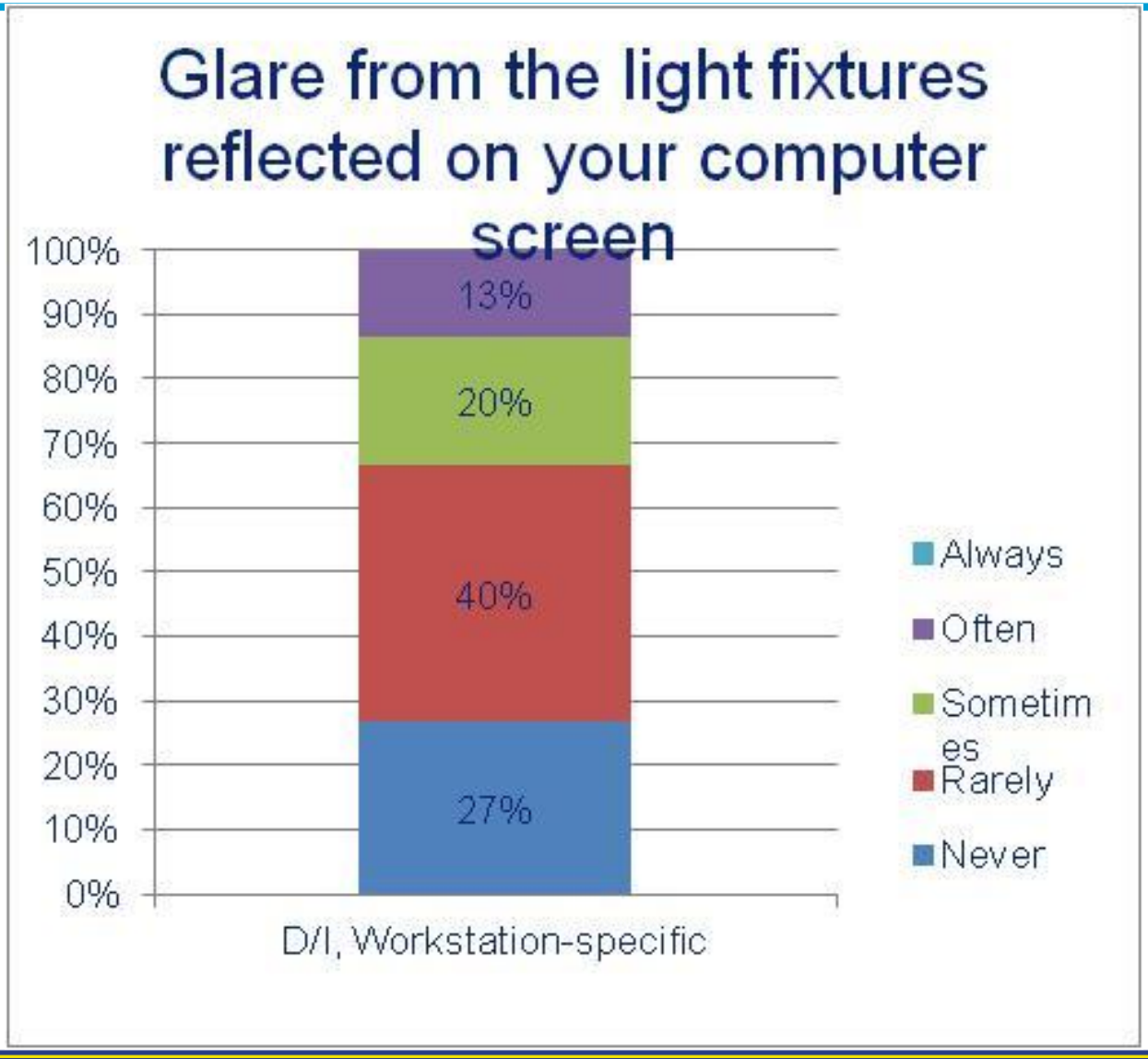

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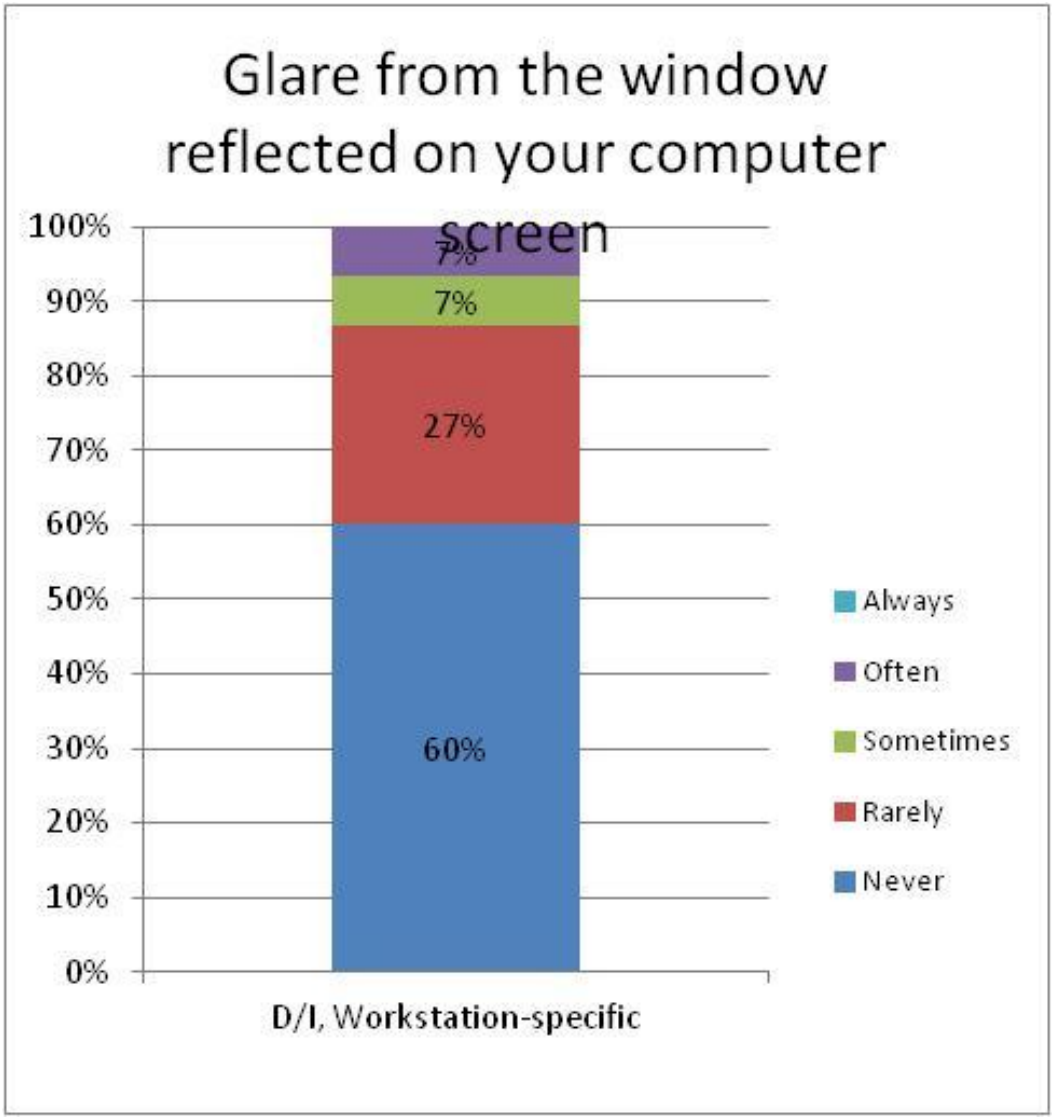

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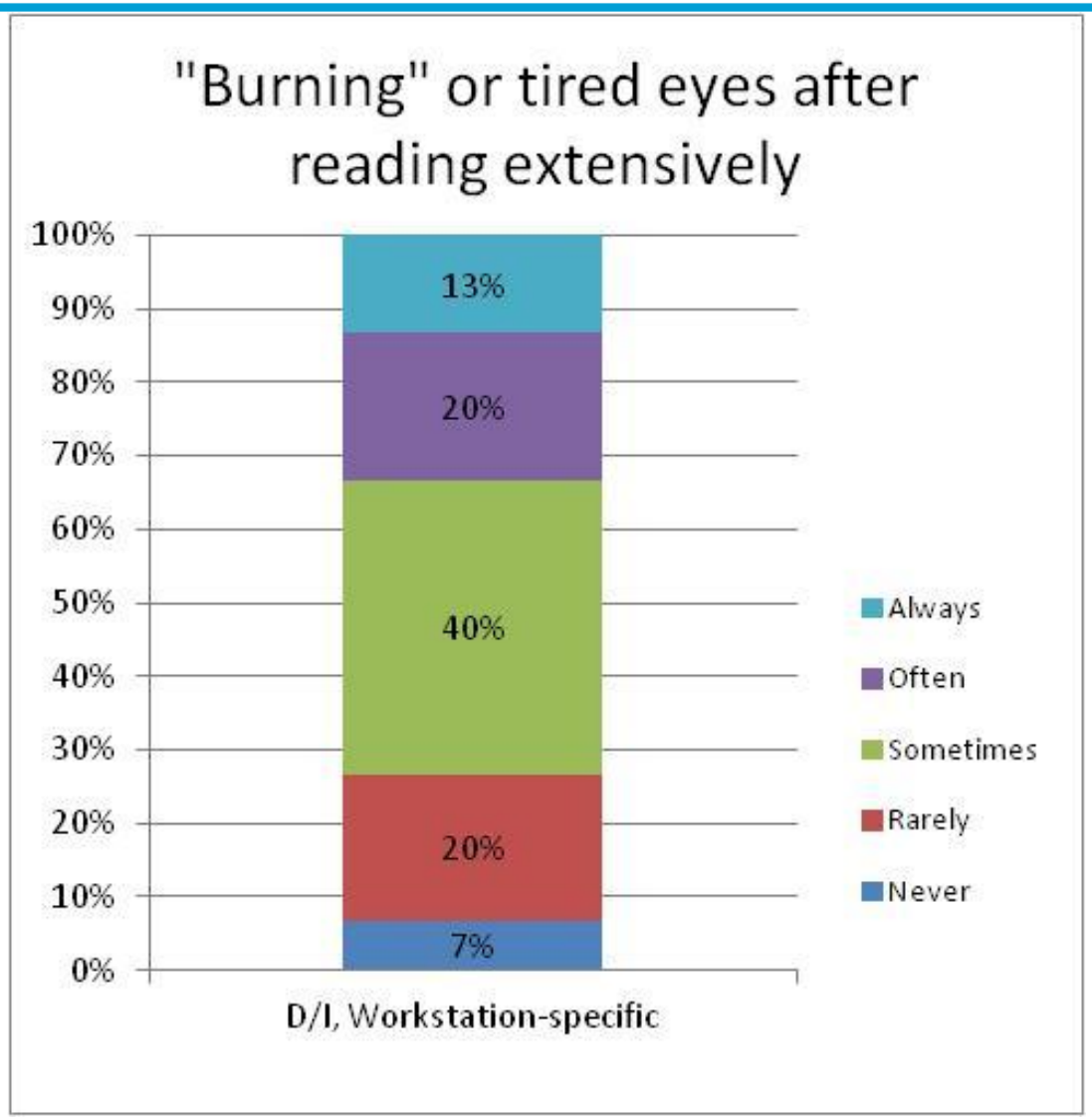

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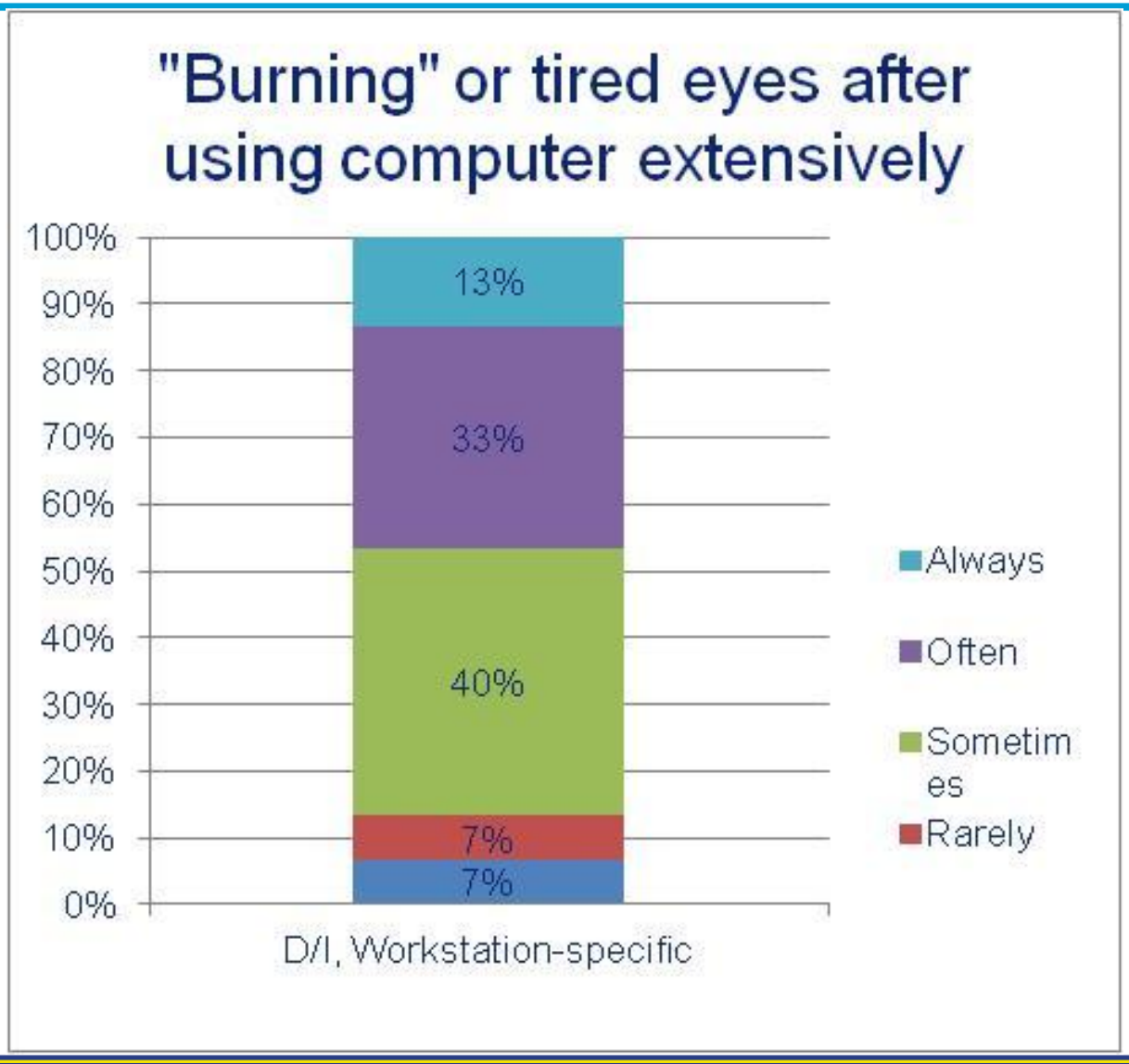

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