seventhwave

Hit the right note:
Task tuning for commercial lighting

Scott Schuetter and Jennifer Li

April 16, 2015

What are those little icons?

- **Polls** (pie chart)
- **Questions** (chat balloon)
- **Links** (chain links)
- **Mediasite help** (question mark)

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Minnesota Conservation Applied Research and Development (CARD) Grant Program

MINNESOTA DEPARTMENT OF
COMMERCE
DIVISION OF ENERGY RESOURCES

Our speakers

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Today’s topics

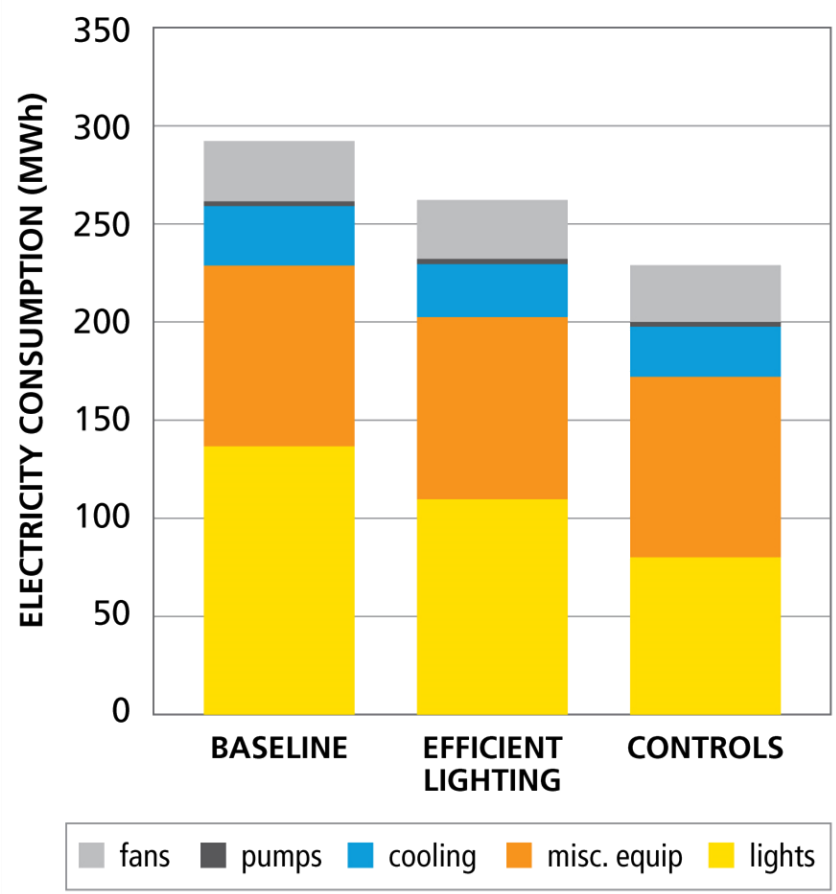
- Background
- How to task tune
- Our study
- Study results
- Program considerations

Background

PHOTO BY Rebecca Sadler, Seventhwave

Why is lighting efficiency important?

ENERGY SAVINGS



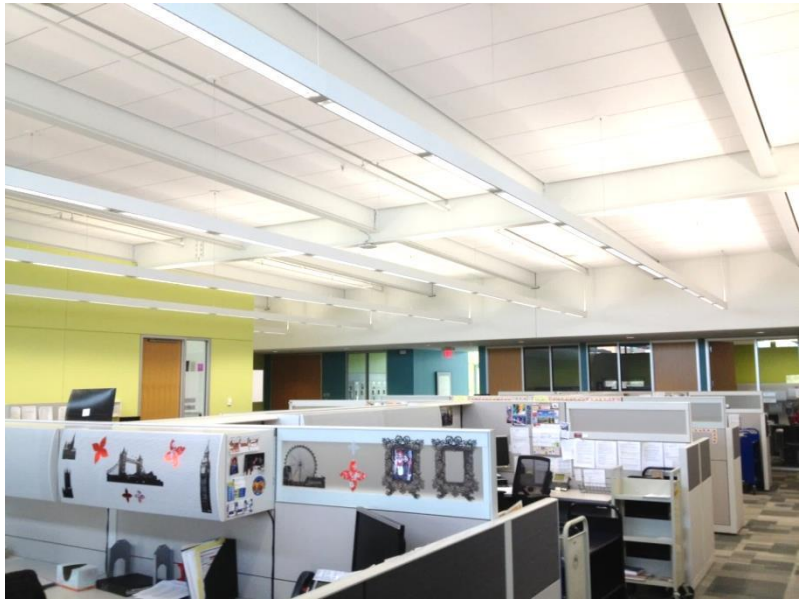
OCCUPANT COMFORT

COST SAVINGS

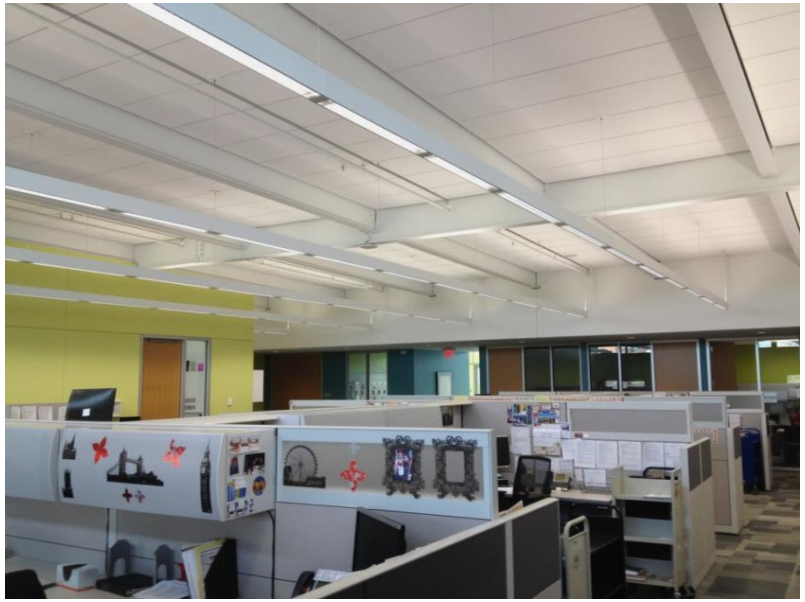
What is task tuning?

Dimming lights in commercial spaces so that the average light level is appropriate for the activities being performed

TOO BRIGHT

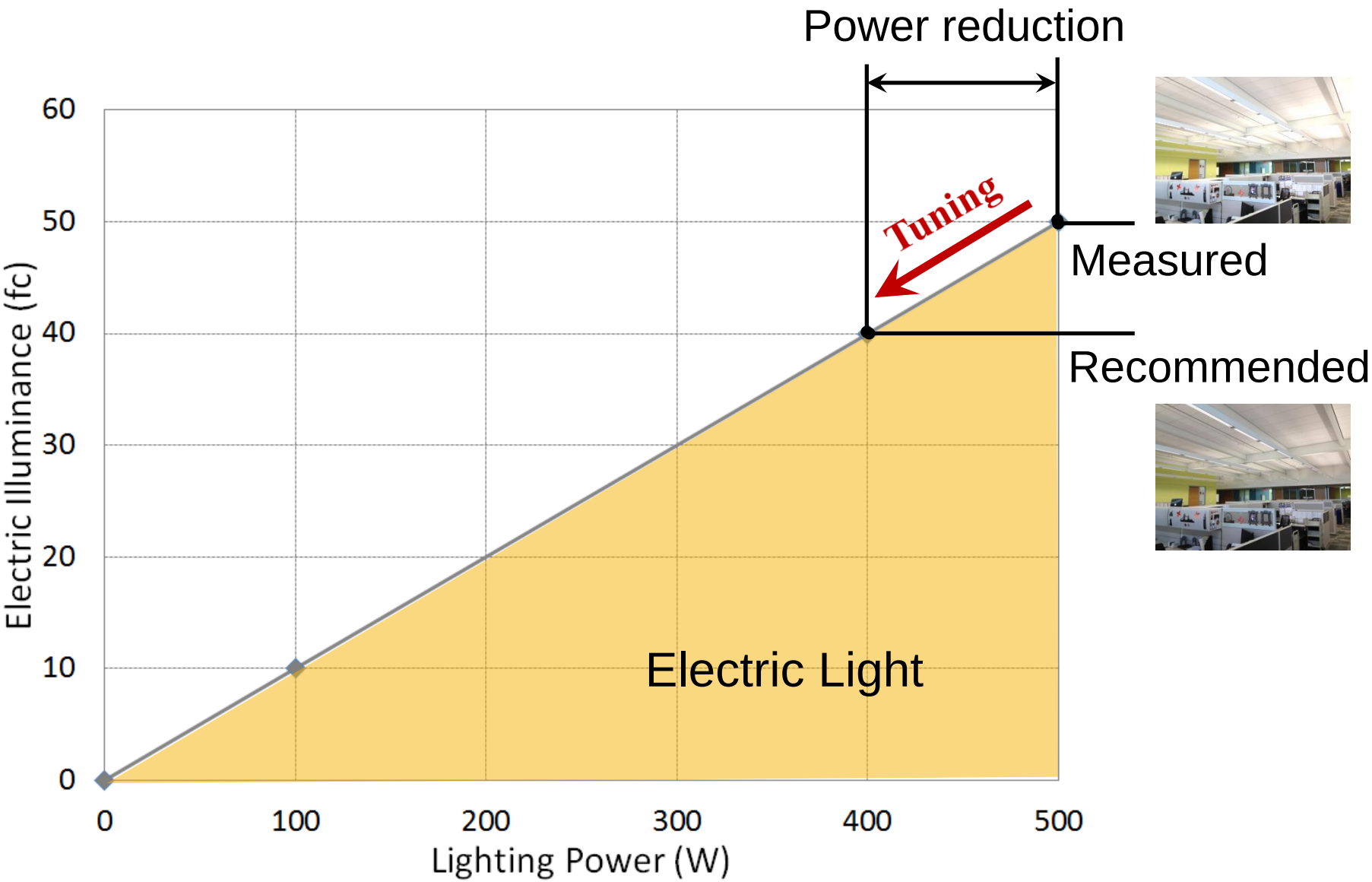


JUST RIGHT

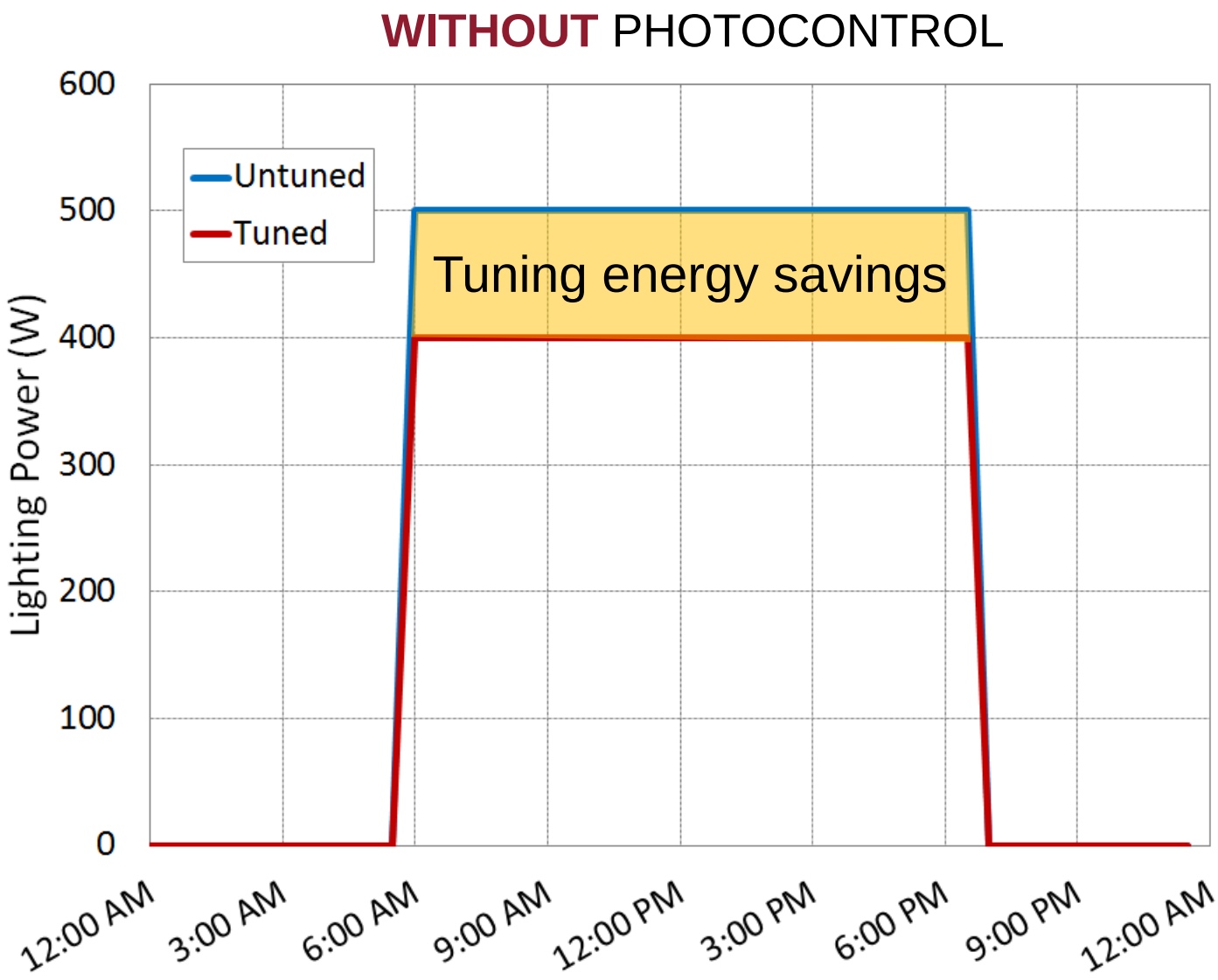


Tuning

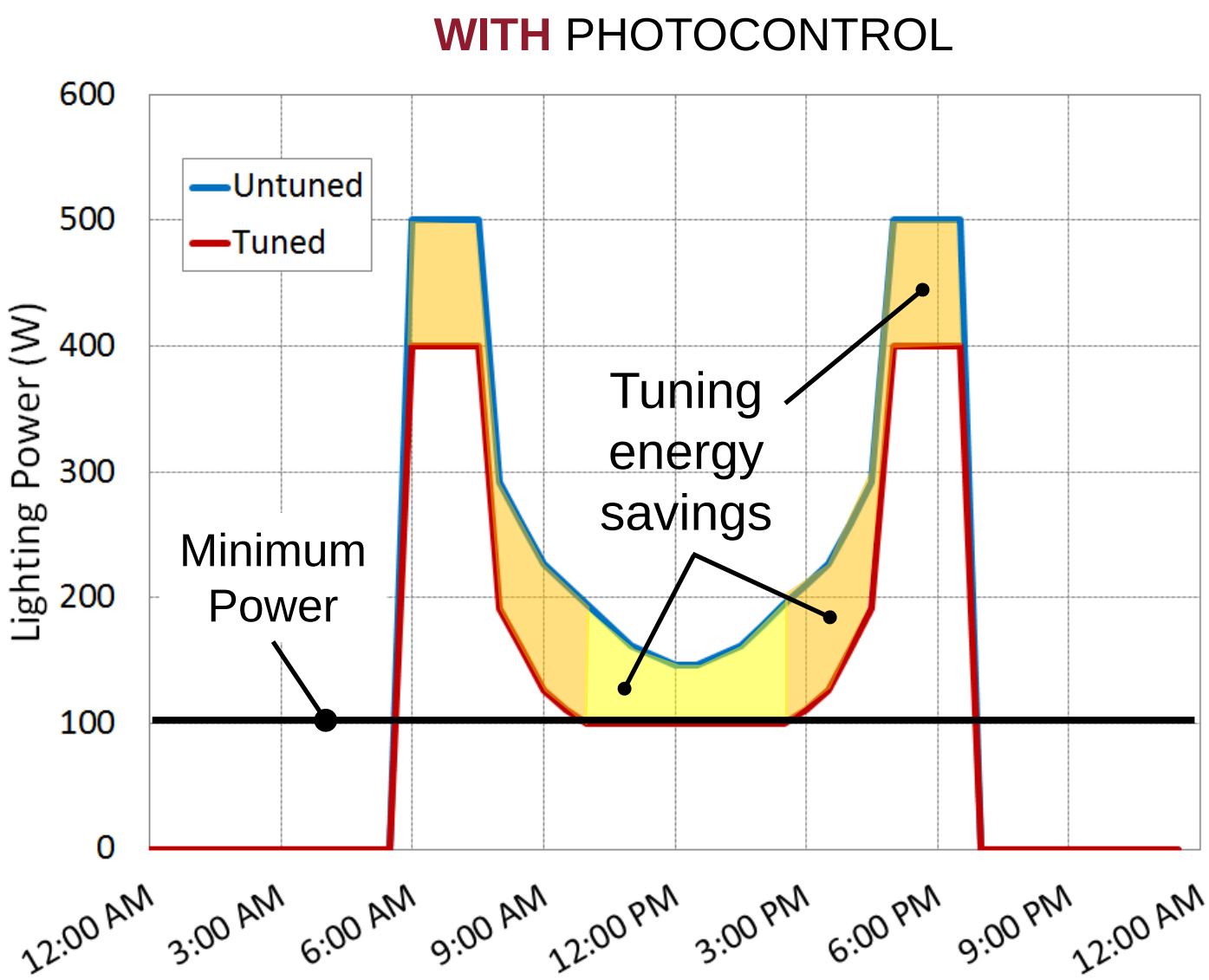
How does task tuning save power?



How does task tuning save energy?



What is task tuning?



How to task tune

General steps

Before visit

1. Gather information

During visit

2. Measure un-tuned light levels
3. Determine recommended light levels
4. Adjust controls
5. Confirm tuned light levels

After visit

6. Follow-up

NOTE: Step-by-step checklist included in final report

BUILDING DRAWINGS

Lighting plans

- What types of spaces will be tuned?
- What types of tasks will be occurring?
- How are the fixtures laid out in the spaces?

Fixture schedule

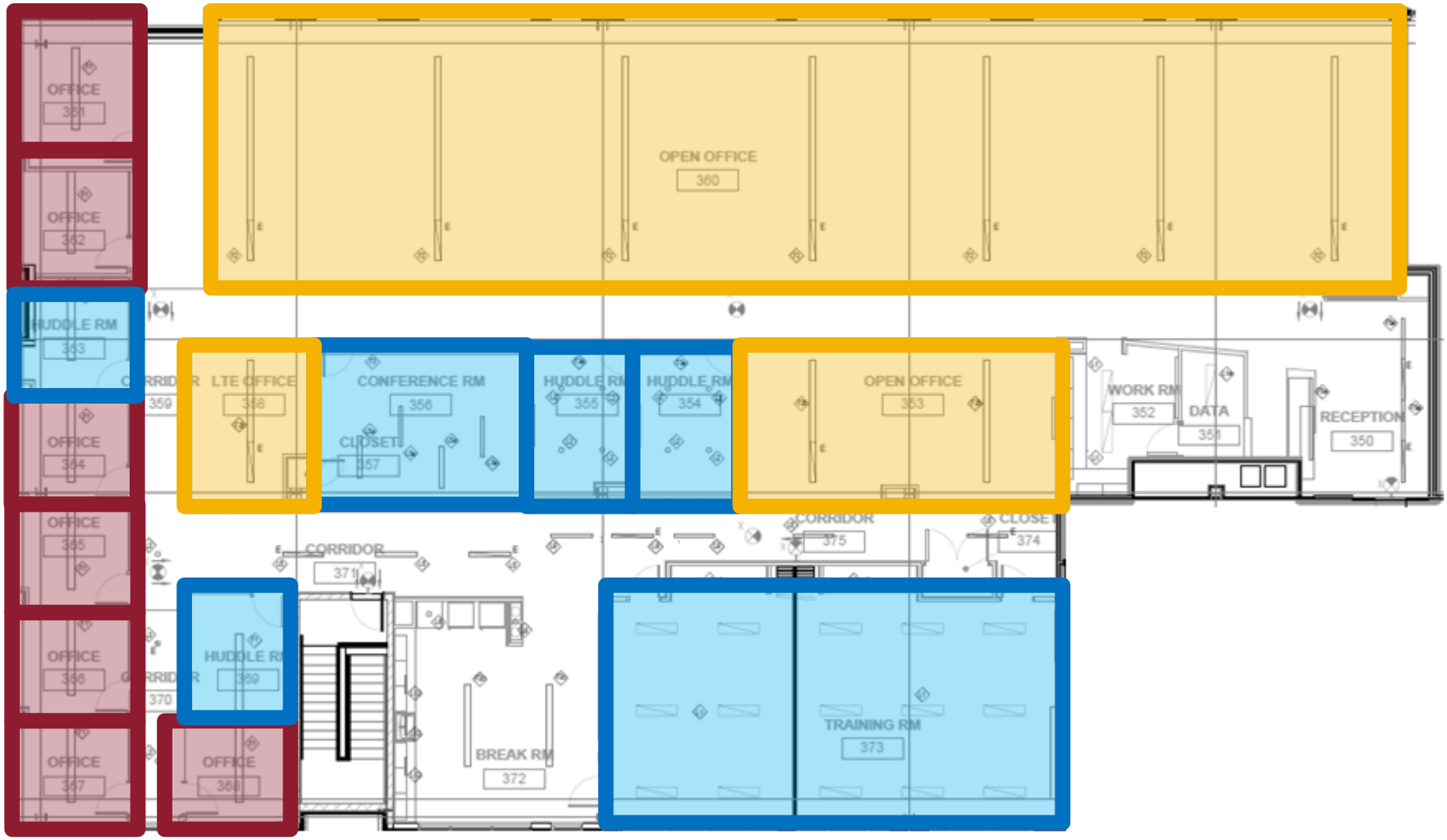
- What types of fixtures will be tuned?

Specifications

- What types of controls will be used to tune?

HOW-TO

Gather information



Open Office

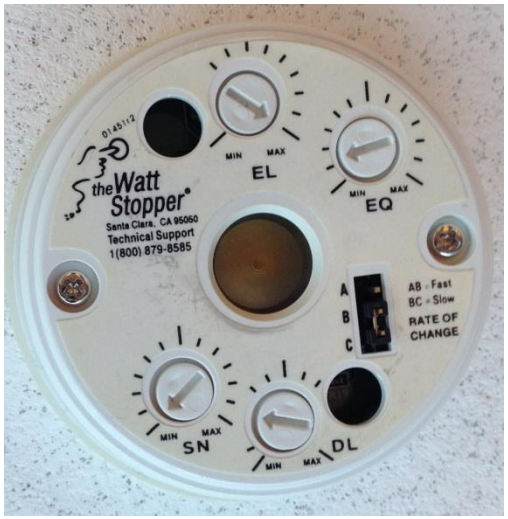
Conference

Private Office

Gather information

LIGHTING CONTROLS INFORMATION

- Where are the controls accessed?
- What menus need to be navigated? And how?
- Any log-in information?
- What settings need to be adjusted?
    - High end trim, photosensor setpoint



OCCUPANT COMFORT SURVEY

1. Please rank your level of satisfaction with the amount of light in your workspace:

   1 (very satisfied) 2 3 4 5 6 7 (very dissatisfied)

2. Please rank your level of satisfaction with the visual comfort of the lighting (glare, reflections, contrast):

   1 (very satisfied) 2 3 4 5 6 7 (very dissatisfied)

NOTE: Our survey instrument included in final report

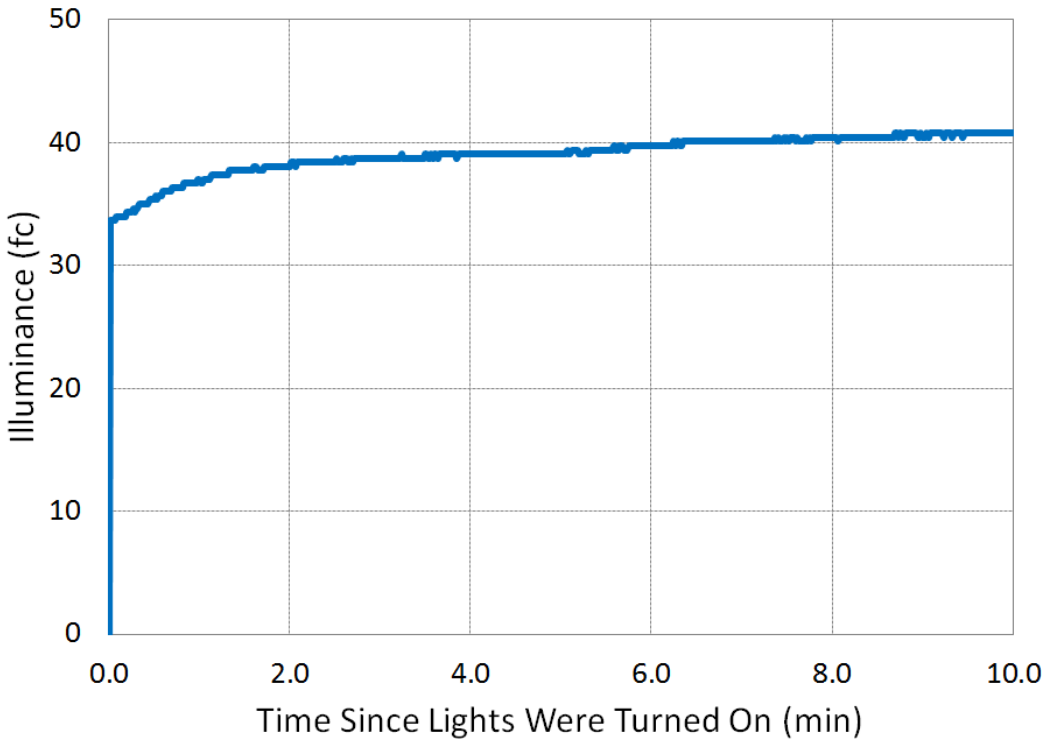
During the visit

TOUR THE BUILDING

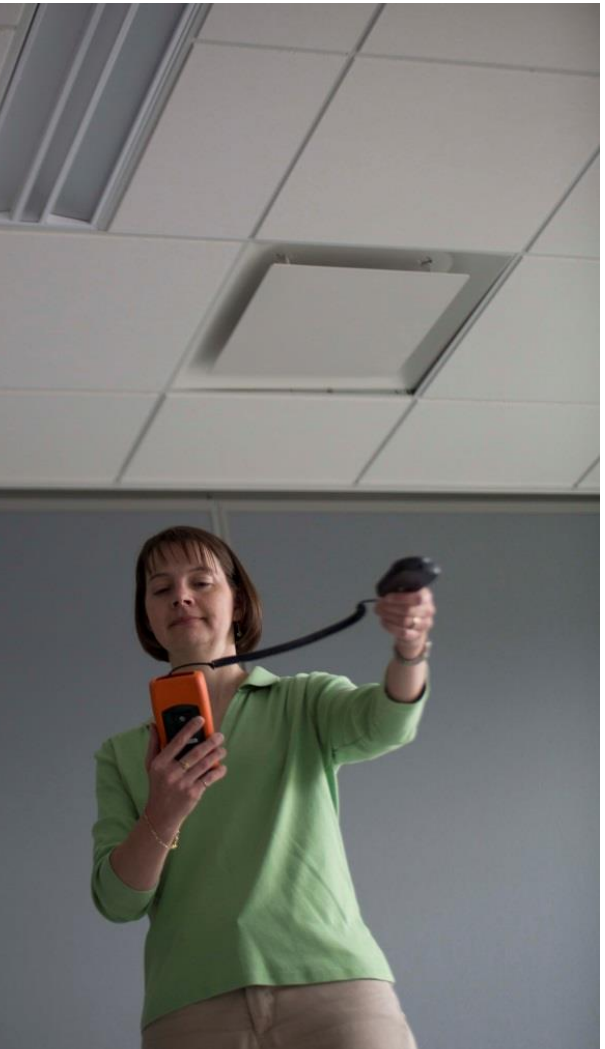
- Familiarize yourself with the spaces
- Talk to facility staff
- Introduce yourself to occupants

PROPERLY MEASURING LIGHT LEVELS

- Use a factory calibrated light meter
- Wait for the lights to warm up



PROPERLY MEASURING LIGHT LEVELS



Detector should be horizontal

Minimize your effect on readings

- Set the light meter on a surface and back away
- Hold it away from your body

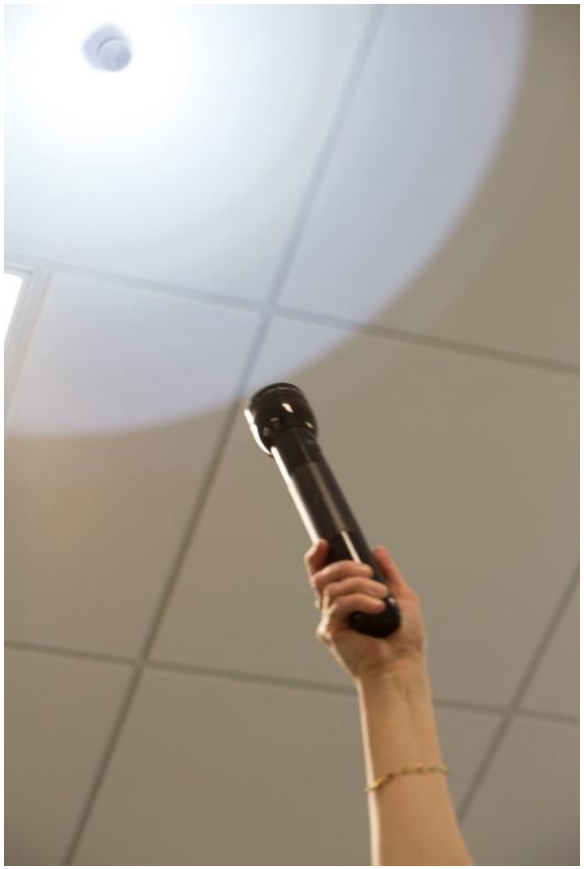
PROPERLY MEASURING LIGHT LEVELS

Minimize contribution of daylight

- Close blinds or shades
- Take measurements under overcast skies or night
- Take “lights on” measurements followed immediately by “lights off” measurements

PROPERLY MEASURING LIGHT LEVELS

If you need to force a lighting system with photocontrol to its maximum or minimum state:

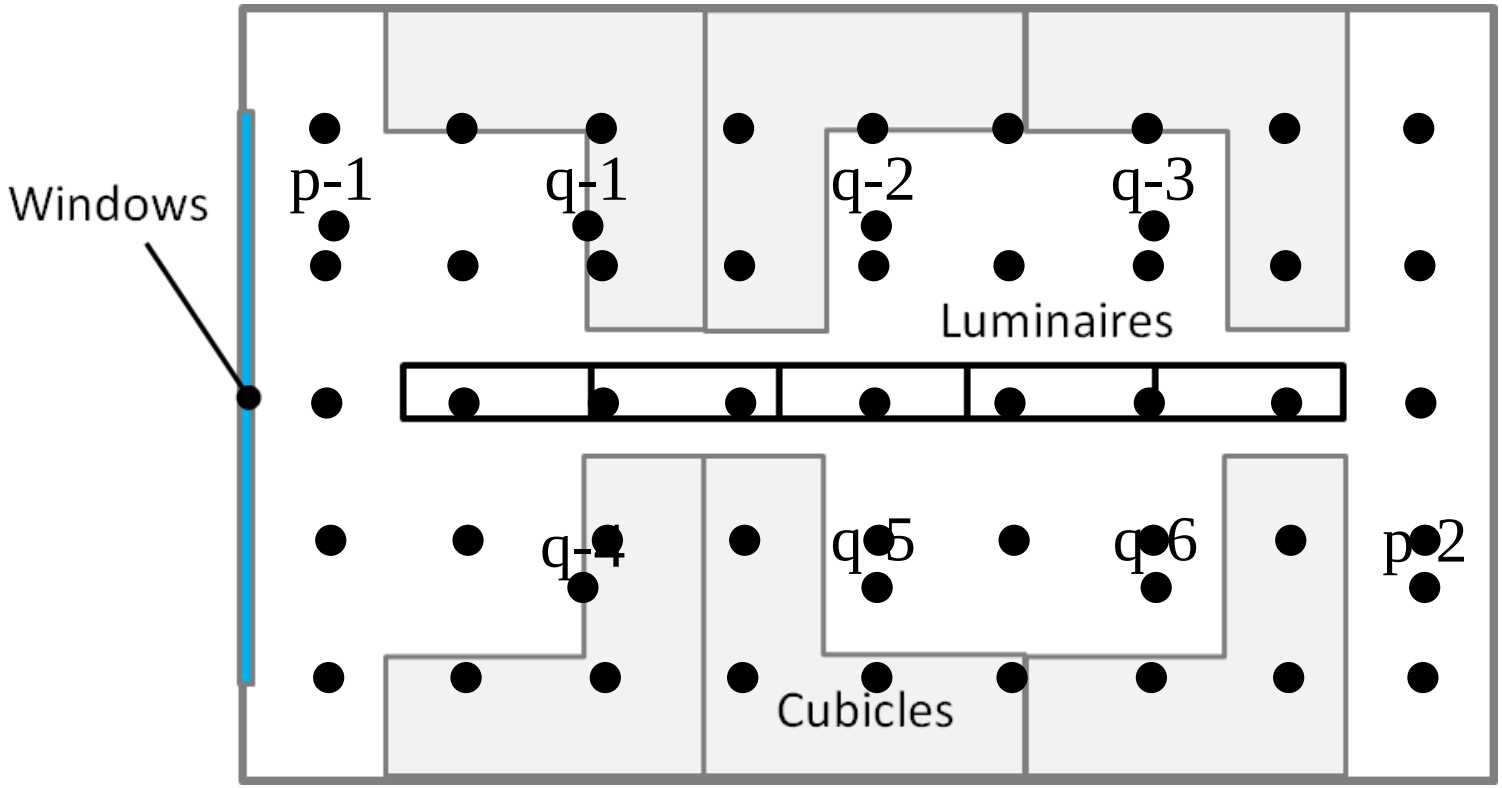


MINIMUM

MAXIMUM

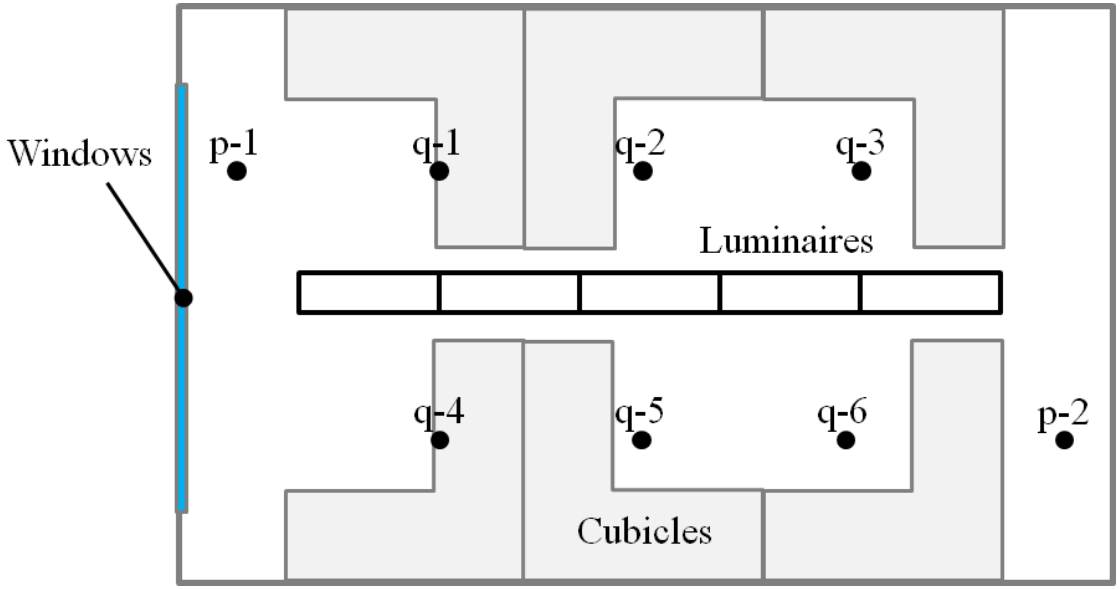
MEASURE UNTUNED AVERAGE ILLUMINANCE

- Select appropriate luminaire configuration type
- Identify measurement locations



MEASURE UNTUNED AVERAGE ILLUMINANCE

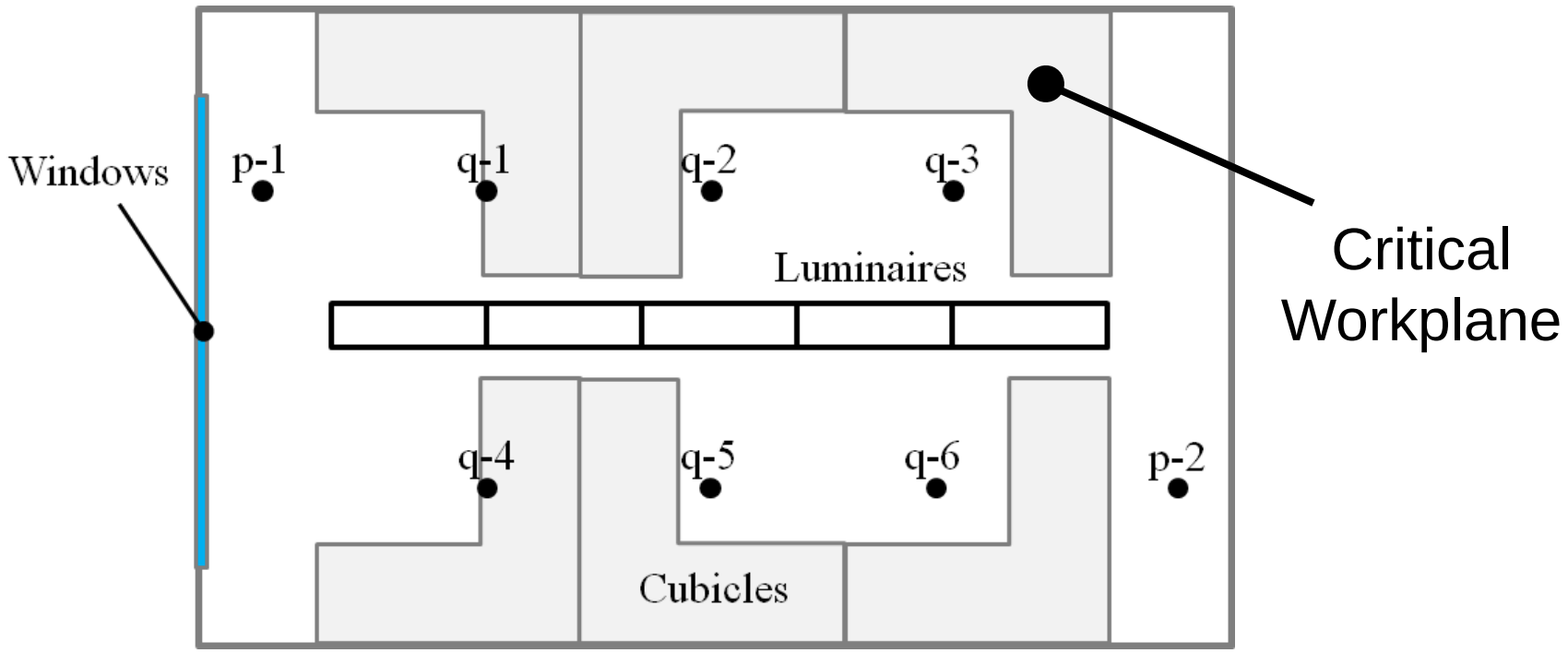
- Turn lights on, record light level at each location
- Calculate average light level



$$\text{Untuned Average} = \frac{Q(N-1)+P}{N} = 50 \text{ fc}$$

IDENTIFY CRITICAL WORKPLANE

- Location where someone will perform a visual task that receives the least amount of light
- Typically a desktop away from fixtures and windows



MEASURE UNTUNED CRITICAL ILLUMINANCE

- Turn lights on
- Record light level at critical workplane

Untuned Critical = 30 fc

DETERMINE RECOMMENDED ILLUMINANCE

Sources

- IES Handbook
- Basis of Design
- Owner Project Requirements

Consider

- Type of visual task
- Age of occupant
- Occupant survey results
- Presence of task lighting

Recommended Average = 40 fc

Example recommended illuminances

SPACE DESCRIPTION	TASK DESCRIPTION	RECOMMENDED ILLUMINANCE (FC)
Classroom	Writing, reading	40
Open office	Computer work	***30***
Conference	Note taking	30
Library stacks	General	20
Bar	General	7.5

CALCULATE CRITICAL WORKPLANE TUNED ILLUMINANCE

Target that you want the light meter to read as you adjust controls

$$\text{Tuned Critical} = \text{Untuned Critical}\left(\frac{\text{Recommended Ave.}}{\text{Untuned Ave.}}\right)$$

Tuned Critical = 30 fc × (40 fc / 50 fc)

Tuned Critical = 24 fc

CALCULATE PERCENT REDUCTION

Approximate amount by which the setpoints need to be reduced in controls program

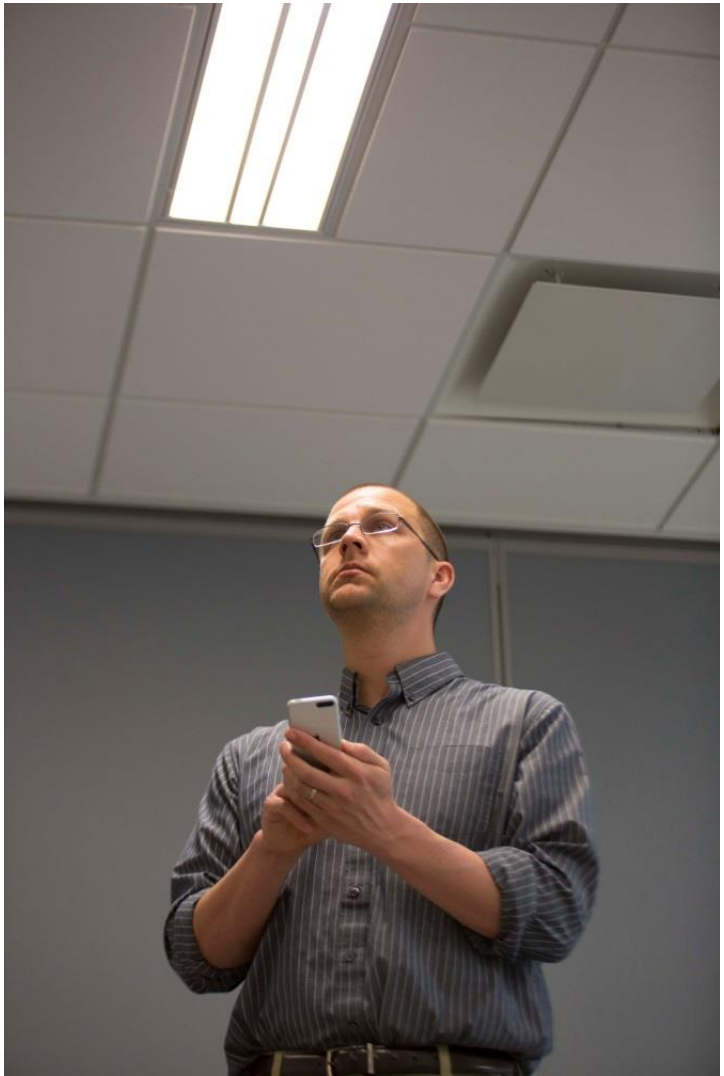
$$\text{Percent Reduction} = \frac{\text{Untuned} - \text{Recommended}}{\text{Untuned}}$$

$$\text{Percent Reduction} = \frac{50\ \text{fc} - 40\ \text{fc}}{50\ \text{fc}} = 20\%$$

Implement task tuning

NO DAYLIGHT PRESENT, NO PHOTOCONTROL

- Light meter at critical working plane
- Adjust ***high end trim*** until reading equals calculated critical illuminance
- Consider asking occupants for their feedback on new light levels



Implement task tuning

DAYLIGHT PRESENT, NO PHOTOCONTROL

- If possible, close blinds
- Turn off lights
- Take reading of ambient natural illuminance
- Turn on lights
- Adjust ***high end trim*** until reading equals:

Total Critical = **Tuned** Critical + Ambient Natural

Total Critical = 24 fc + 5 fc = 29 fc

Implement task tuning

DAYLIGHT PRESENT, PHOTOCONTROL

If possible, close blinds

With lights on, adjust ***photosensor setpoint*** until reading equals calculated critical illuminance

Tuned Critical = 24 fc

If system has additional ***high end trim*** setting

- Turn off lights
- Take reading of ambient natural illuminance
- Adjust high end trim until reading equals:

Total Critical = 29 fc

Implement task tuning

TOO MUCH DAYLIGHT PRESENT, PHOTOCONTROL

- Cannot confirm tuned light levels or occupant feedback
- Can you return some other time?
- If not, you can adjust the settings by the calculated percent reduction.

After the visit

FOLLOW UP

- After a month, follow up with facility manager to gauge satisfaction with new light levels
- Potentially, re-administer occupant survey
- If you obtained real-time feedback while tuning, this is less critical.

Our study

Research hypothesis and goal

HYPOTHESIS

Significant opportunity for lighting energy savings through task tuning of overlit commercial spaces.

GOAL

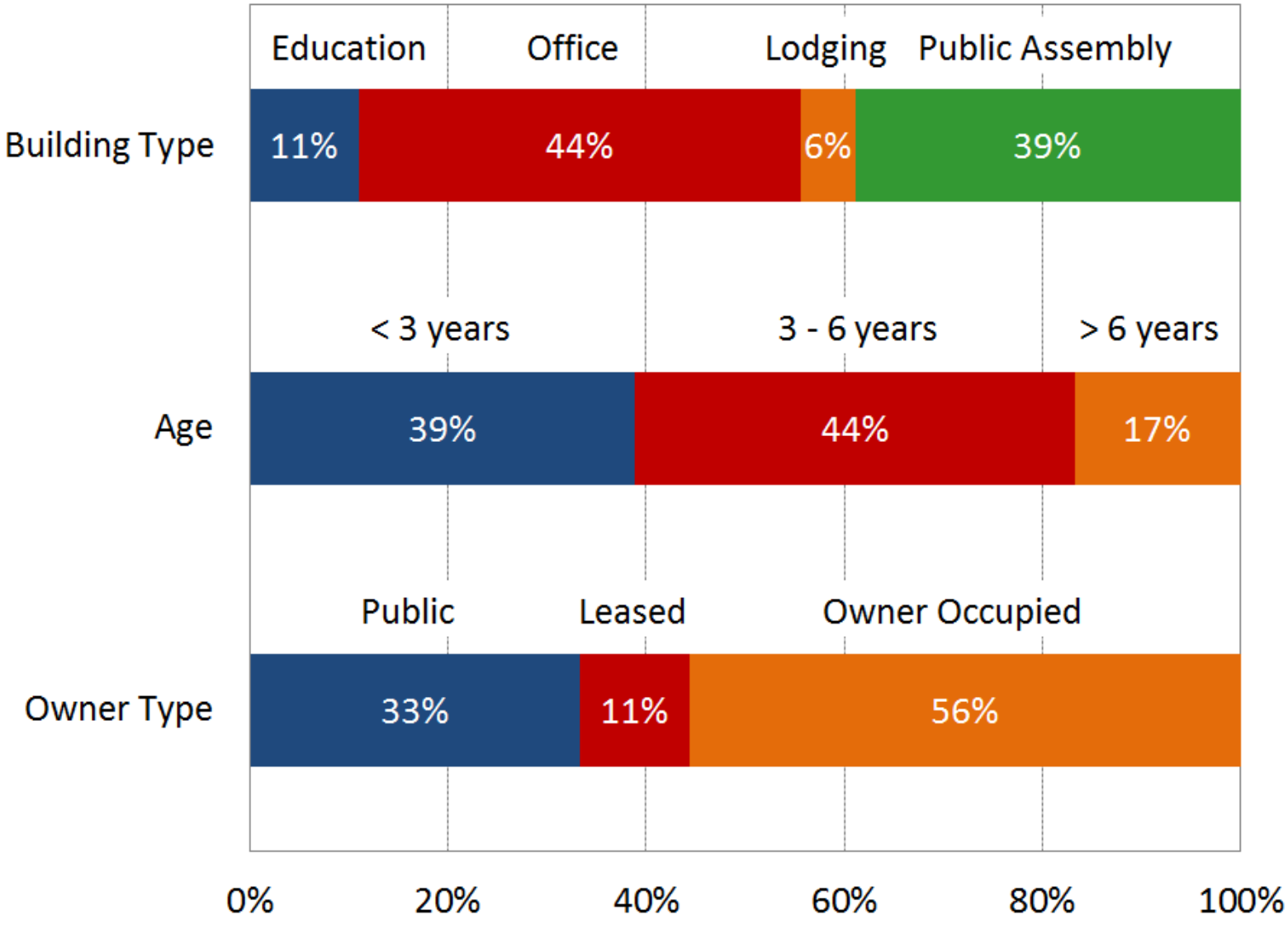
Quantify the magnitude of energy savings from task tuning by field monitoring commercial lighting systems in Minnesota.

Document best practices and lessons learned along the way.

Methodology

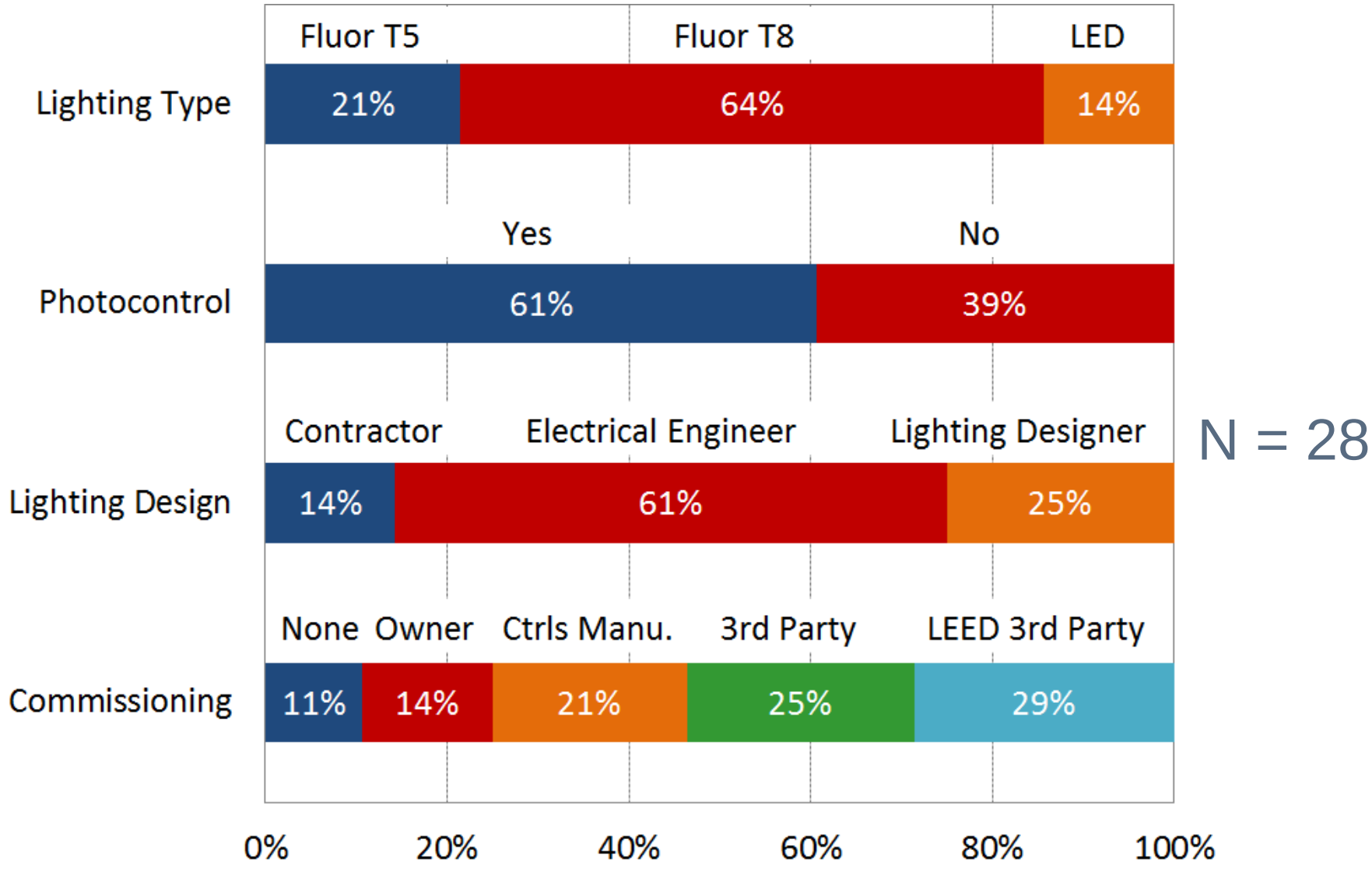
1. Identify projects with dimmable lighting systems
   - Characterization
2. Select subset of spaces to monitor
3. Install monitoring equipment in each space
4. Monitor system performance under 2 conditions
   - Period 1: untuned
   - Period 2: tuned
5. Calculate energy savings
6. Extrapolate to full year
7. Extrapolate to state of Minnesota

Building characterization

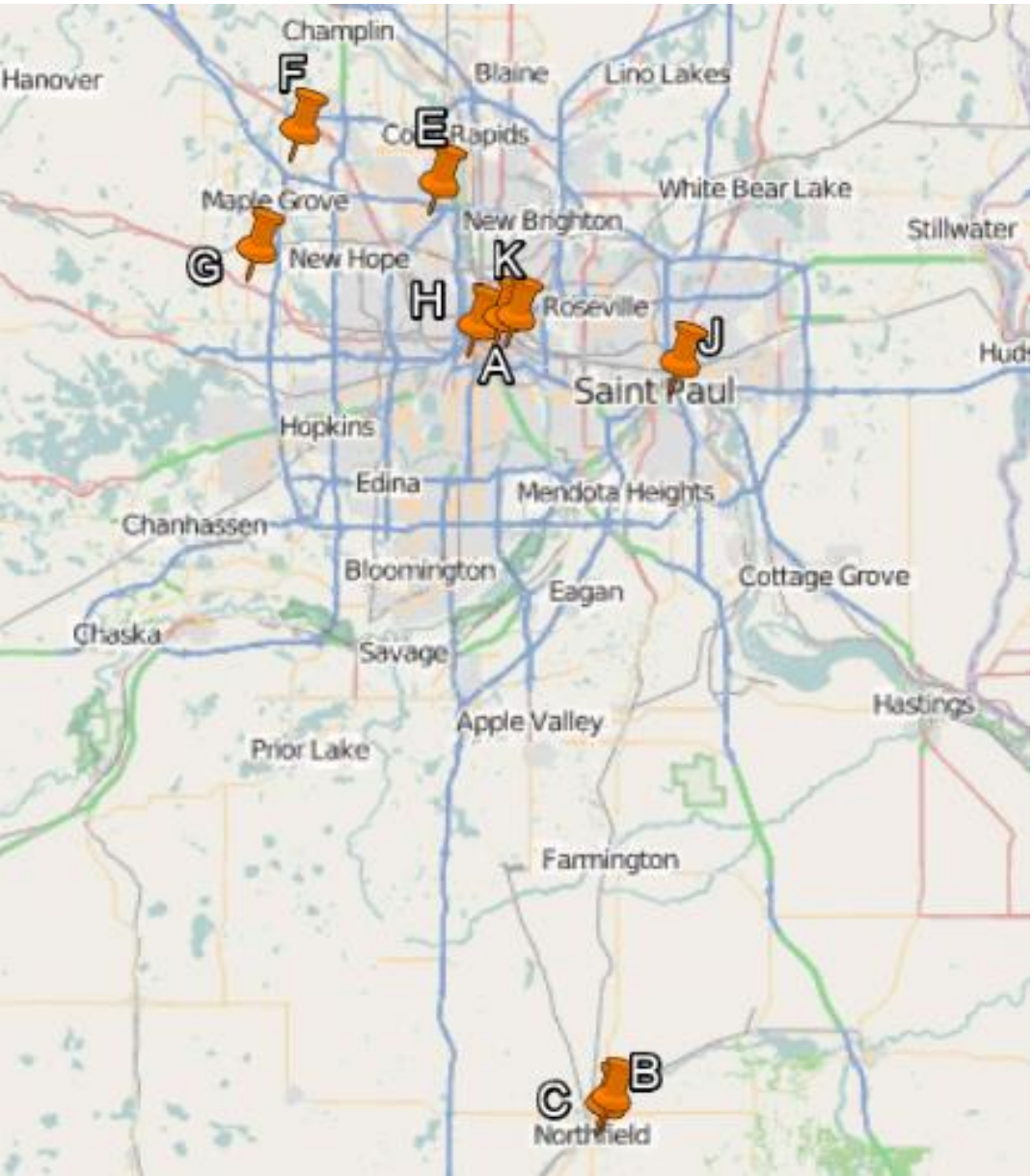


N = 18

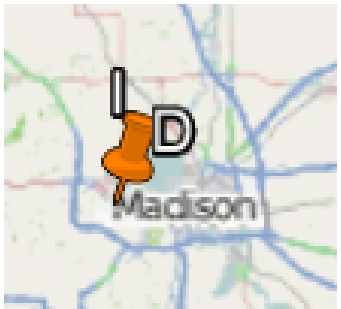
Space characterization



Monitored sample

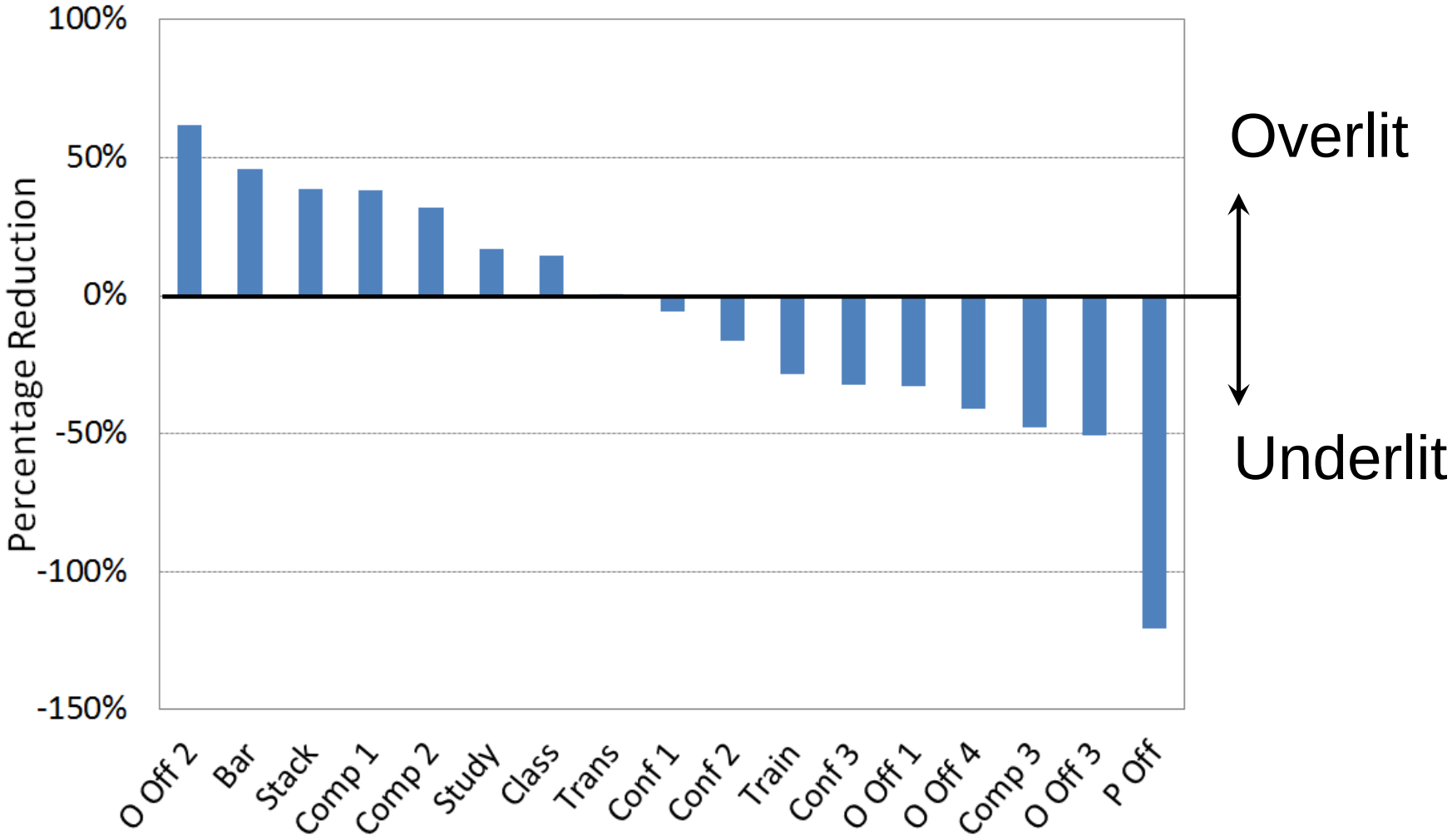


Monitored 17 total spaces in 10 buildings

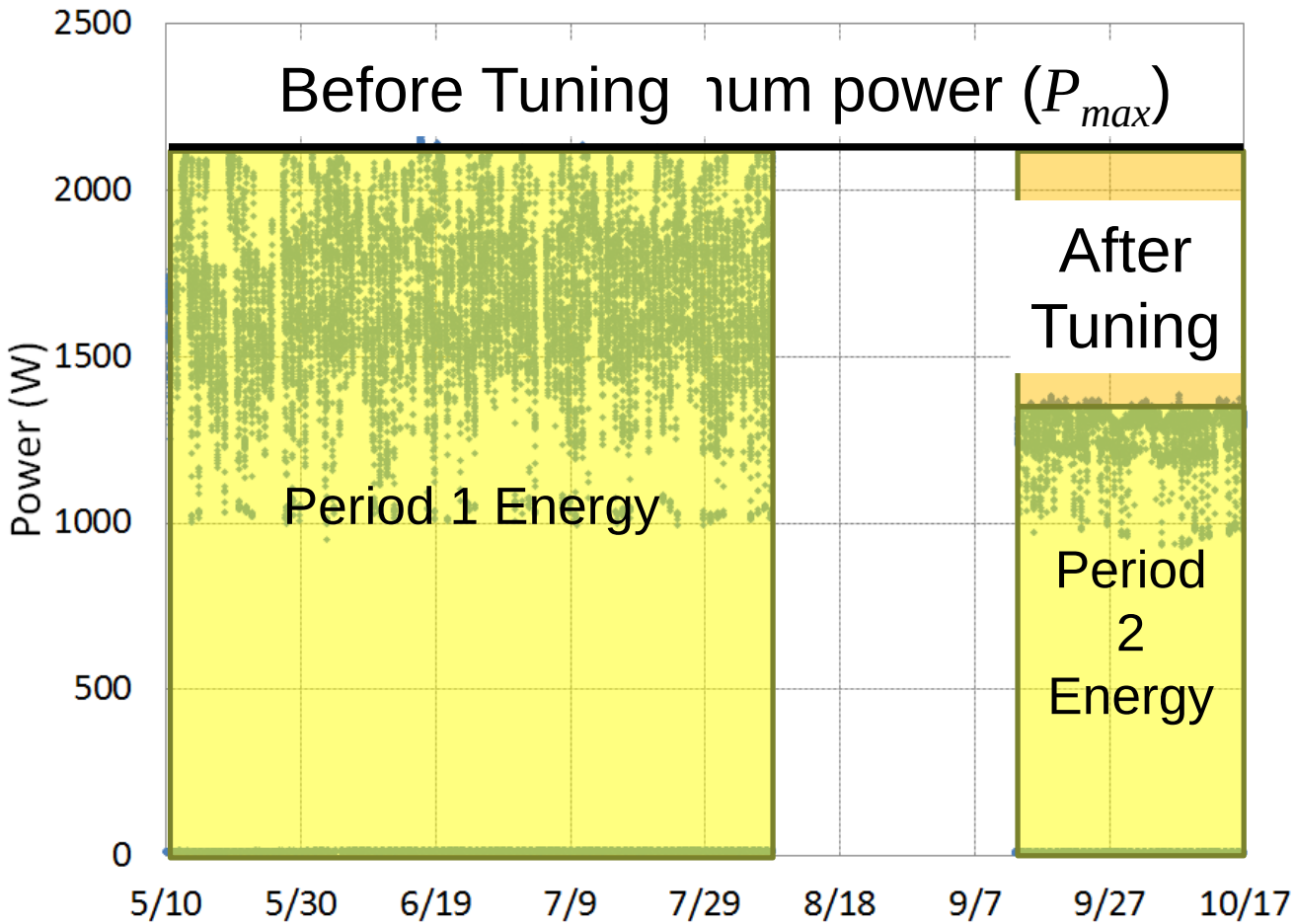


Monitored sample

On average, overlit spaces needed their light levels reduced by 36%.

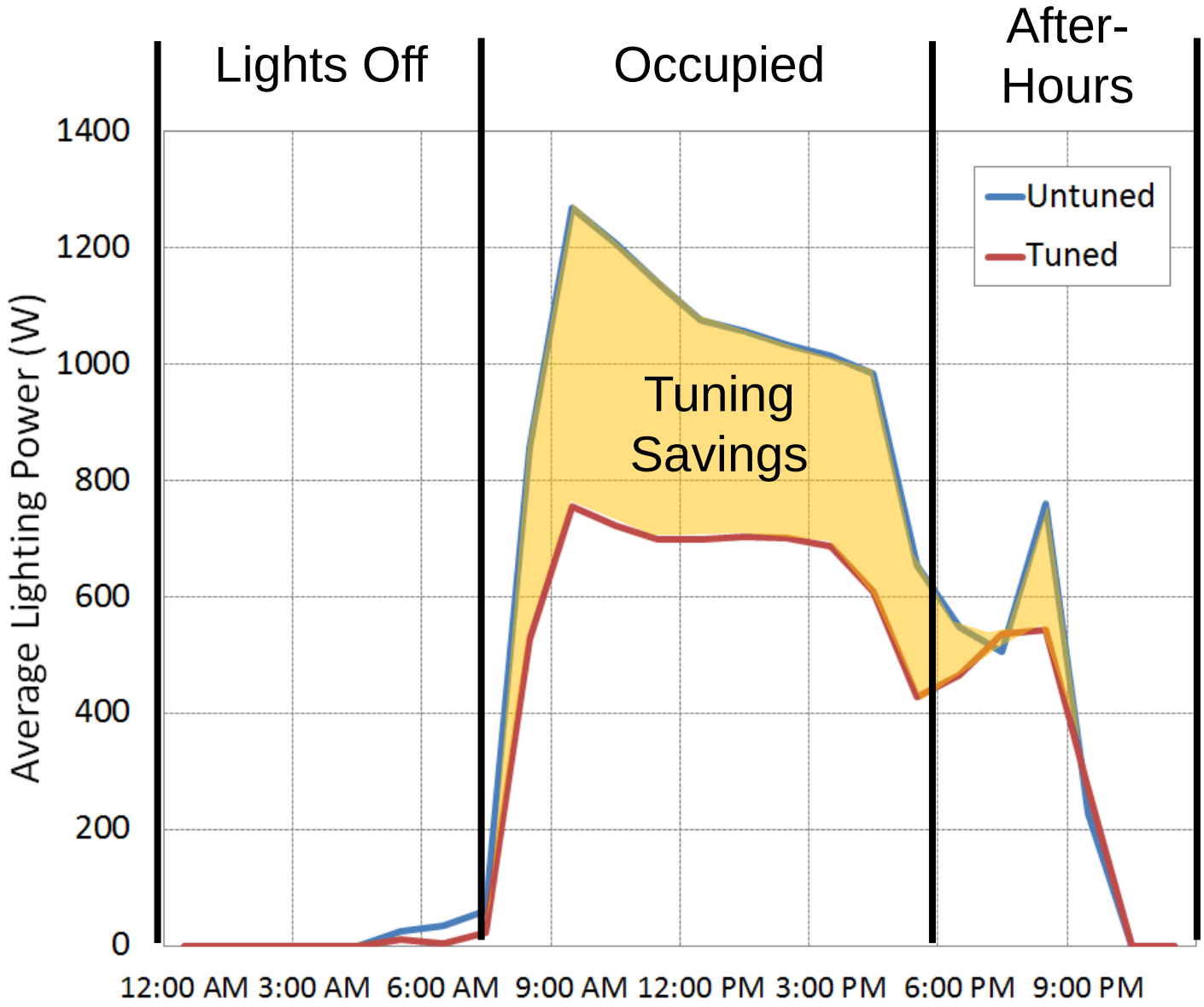


Monitored data



$$\text{Measured Lighting Energy} = V \cdot PF \cdot \sum_{i=1}^{n_{measurements}} I_i \cdot \left(\frac{1\ \text{hr}}{12\ \text{samples}}\right)$$

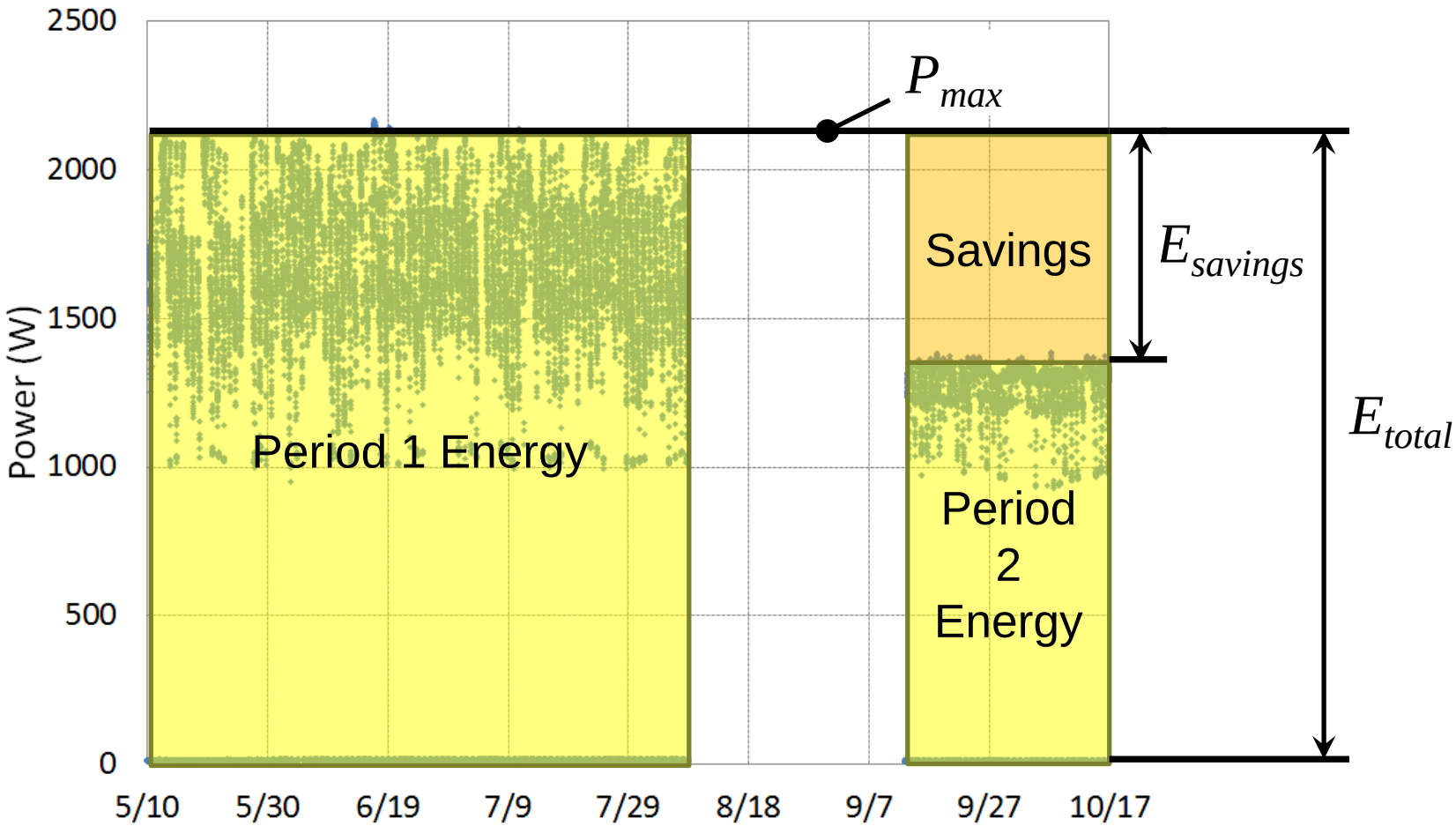
Monitored data



Savings metrics

$$Percent\ Savings = \frac{E_{savings}}{E_{total}}$$

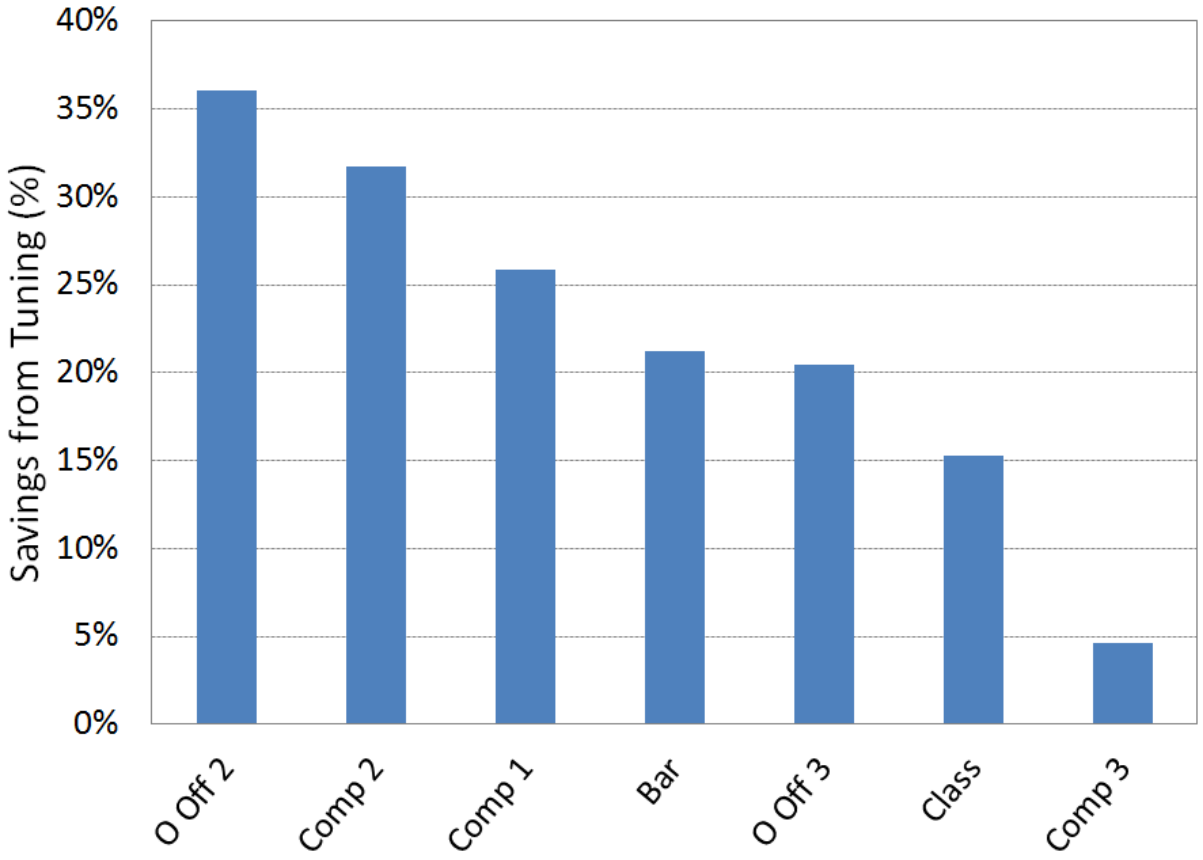
$$kWh_kWSavings = \frac{E_{savings}}{P_{max}}$$



Study results

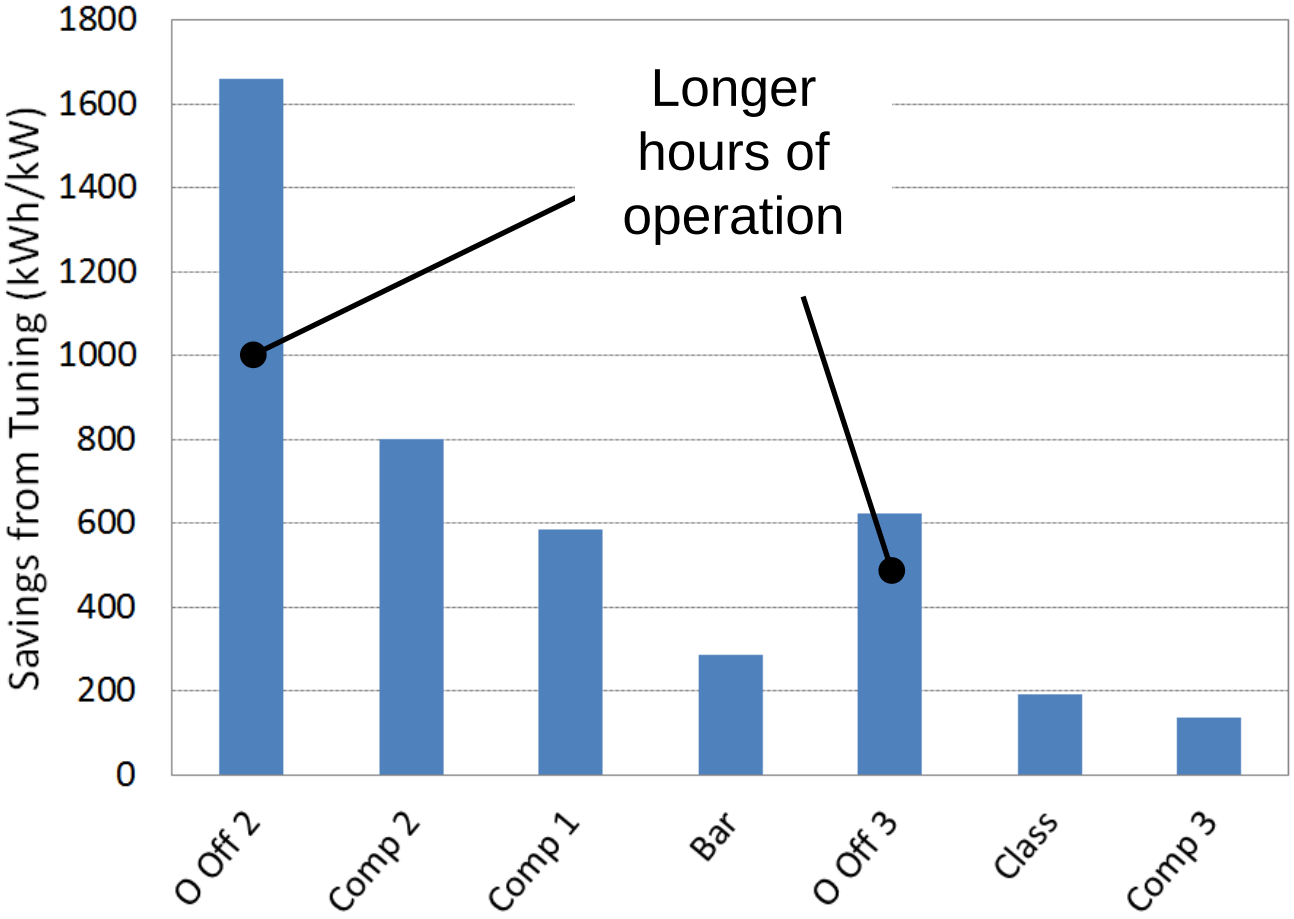
Measured energy savings—percentage

Average savings was **22% of dimmable lighting energy**, or 0.6 kWh/ft^2.



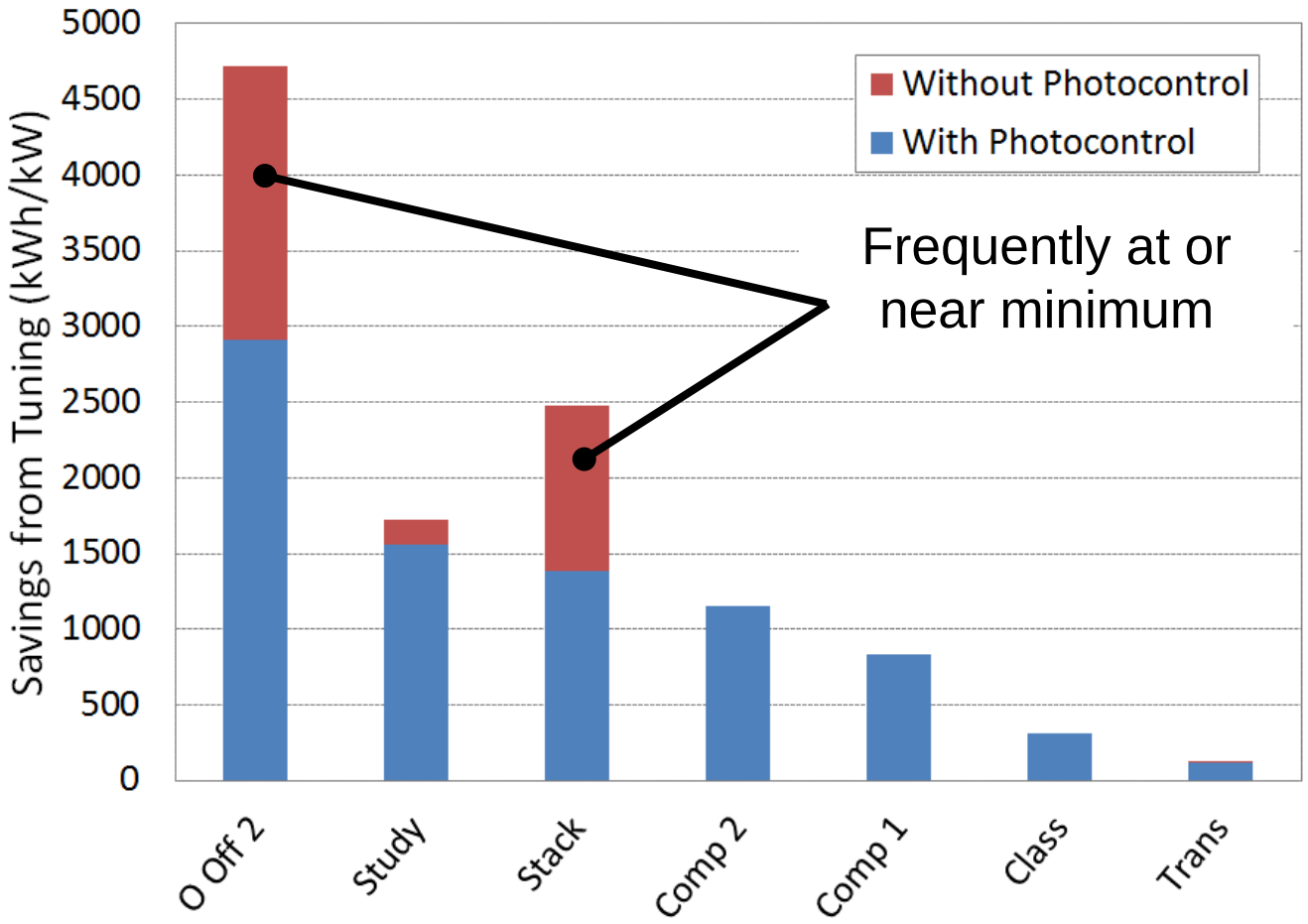
Measured energy savings—kWh per kW

Average savings was **613 kWh per kW** of dimmable power.



Interactivity with photocontrol

On average, photocontrol reduced task tuning savings by **440 kWh/kW or 27%**.



Economics

Cost of time only

- Tuning 50% of a 25,000 square foot office

  Preparation = 2-4 hours

  Measurement = 2-4 hours

  Controls adjustment = 2 hours

- $0.03 to $0.06/ft^2
- Simple payback: 0.5 to1.1 years

Economics are less favorable when the incremental cost of purchasing the dimming equipment is included.

NOTE: Full life cycle cost analysis included in final report

Program considerations

Minnesota impact

TASK TUNING PROGRAM IMPACT

Assuming

- 1% existing buildings, 50% new construction
- Education, office, public assembly, warehouse

5,023 megawatt-hours annually

- Equivalent to 528 typical Minnesota households annual electric consumption

4,823 tons of carbon dioxide annually

- Equivalent of taking 1,020 passenger vehicles off the road for a year

$487,000 of annual cost savings for MN businesses

Areas of greatest potential

Systems that

- Have not been commissioned or commissioned by the owner
- Were designed by a contractor
- Are in an office, education or public assembly building
- Also have photocontrol

LED??

Dennis Schroeder, NREL

Occupant comfort

We recommend that task tuning be conducted while incorporating occupant feedback in order to maintain high levels of occupant comfort:

- May decrease initial savings
- Increases savings persistence

NOTE

Our fact sheet contains additional program considerations

Conclusions

Final thoughts

Large (and growing) potential for energy savings from task tuning

Process is straightforward

Barriers

- Understanding controls
- Maintaining high levels of occupant comfort

Additional resources

The Lighting Handbook

DiLaura, 2011, Published by the Illuminating Engineering Society

Illuminating Engineering Society: Fundamentals of Lighting

iesmsp.org

Lighting Controls Association: Education Express

aboutlightingcontrols.org/Education_Express.welcome.php

Thank you

Thanks again to the Minnesota Conservation Applied Research and Development (CARD) Grant Program

MINNESOTA DEPARTMENT OF COMMERCE
DIVISION OF ENERGY RESOURCES

And our partners on this project

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For more information

Report and fact sheet coming soon

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Learn about our work

seventhwave.org/buildings