

# Triple Bottom Line Benefits of Investing in Lighting and Daylighting Retrofits

## ACEEE National Symposium on Market Transformation

Baltimore MD  
March 21-22, 2016



**Vivian Loftness**, FAIA

University Professor

Paul Mellon Chair in Architecture

**Rohini Srivastava**

PhD Candidate

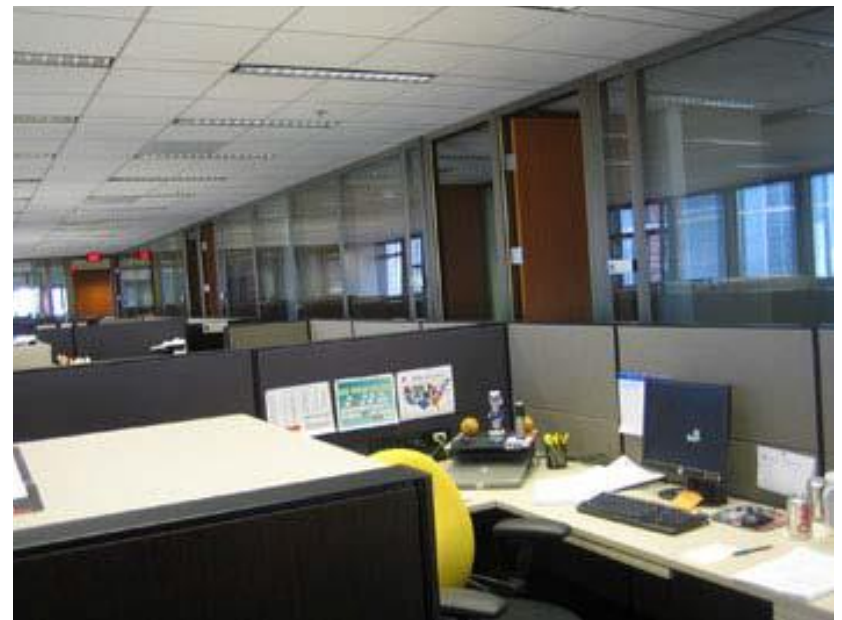
### Six Energy Efficient Lighting Retrofits

Recommendations for Triple Bottom Line Savings

	Light Energy Saved
<b>1 Install occupancy/vacancy sensors for closed spaces.</b> Savings: Economic ROI = 52% Environmental ROI = 68%	13%
<b>2 Install daylight harvesting for perimeter lights.</b> Savings: Economic ROI = 21% Environmental ROI = 28% Equity = 354%	30%
<b>3 Lower task-Ambient light levels and add task lights.</b> Savings: Economic ROI = 32% Environmental ROI = 41% Equity = 142%	40%
<b>4 Use blinds effectively for daylight, shade and glare control as well as for heat exchange control at night.</b> Savings: Economic ROI = 5% Environmental ROI = 7% Equity = 94%	32%
<b>5 Install individually addressable high performance fixtures with automation system.</b> Savings: Economic ROI = 15% Environmental ROI = 19% Equity = 260%	65%
<b>6 Install "vertically integrated" LED light fixtures (lamp, ballast, and fixture) plus add-ons for dimming and IP controlling.</b> Savings: Economic ROI = 18% Environmental ROI = 22% Equity = 289%	85%

Center for Building Performance & Diagnostics Carnegie Mellon University

the status quo?



## Triple Bottom Line calculations

---

The United Nations ICLEI Triple Bottom Line standard for full cost accounting quantifies three levels of benefits of investing in lighting upgrades.

<b>Economic/ profit</b>	<b>Environmental/ planet</b>	<b>Equity/ people</b>
Energy savings	Carbon benefits (related to electricity)	Task performance
Facilities Management?	Water (related to electricity)	Health
	SO <sub>x</sub> / NO <sub>x</sub> Outdoor Air Quality benefits	Satisfaction

In our EEBHub research, the NPV calculations are successive, based on a 15 year time frame, 10% discount rate, and average costs for lighting upgrades in existing medium sized office buildings.

---

**Would an understanding of Triple  
Bottom Line cost benefits  
of building investments...**

**Affect your decision to invest?**

**You will need to take out your phone for this activity**

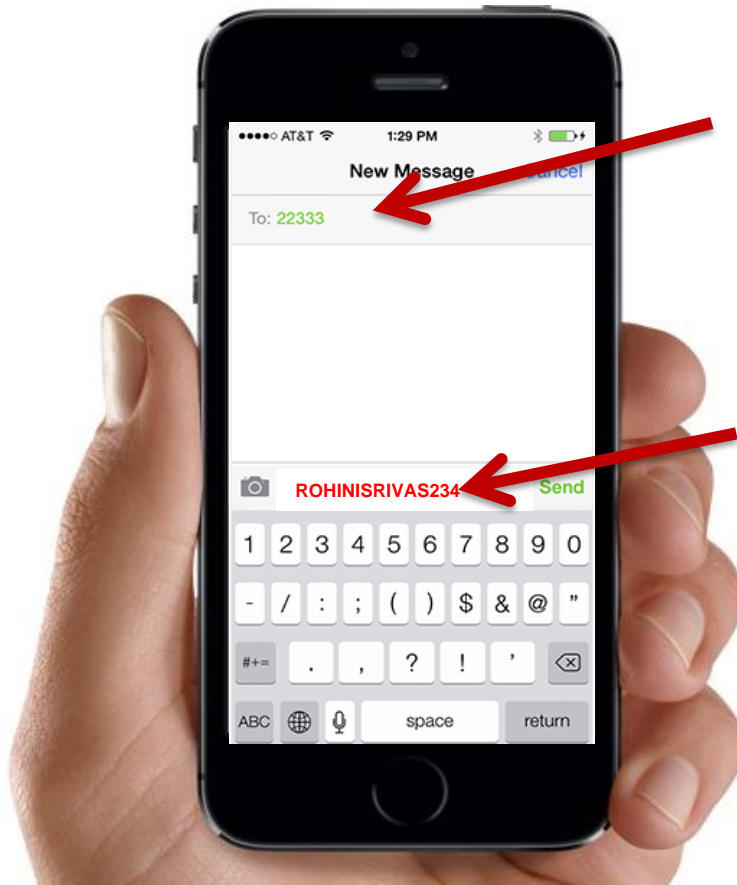
---

**Go to your mobile phone's text message (SMS) feature**



## Compose a new message by following the instructions below

---



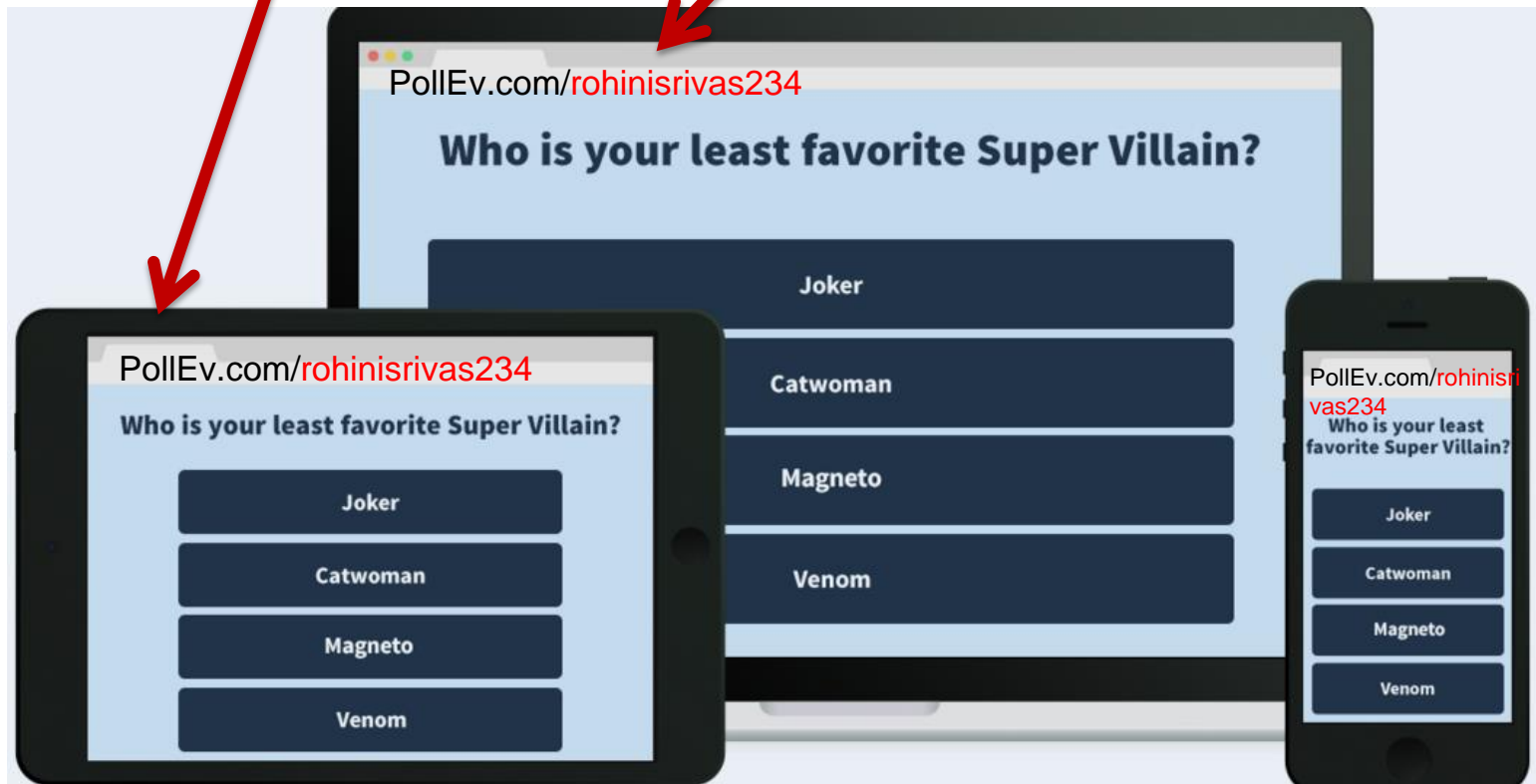
Type '22333' here to join the session

Text ROHINISRIVAS234

## If you prefer using a computer or a web browser

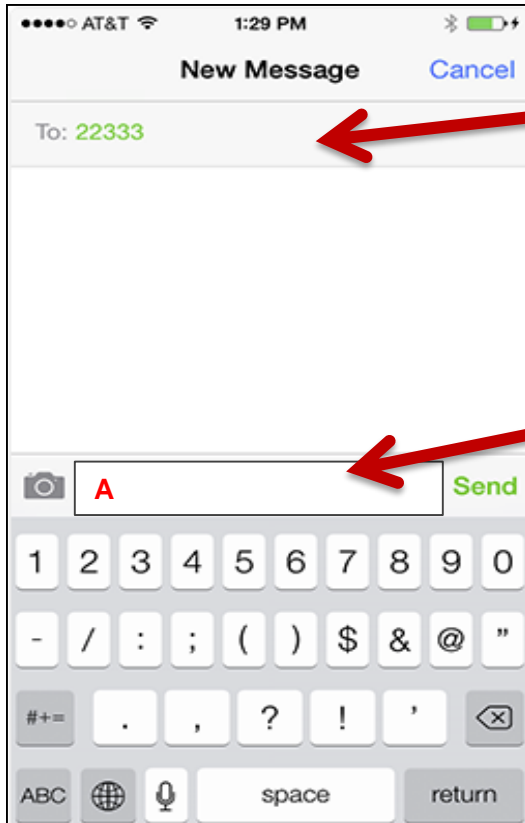
---

Type **PollEv.com/rohinisrivas234** into the browser



Once you are in the session, then simply type in your answer

---



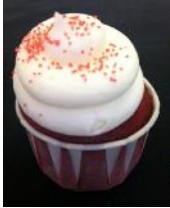
Stay in the same text window '22333',

Text A, B, C, D or E based on your choice



## Which is your favorite cup cake flavor?

---



**A. Red Velvet**



**B. Rich Vanilla**



**C. Dark Chocolate**



**D. Carrot Cake**



# Your poll will show here

1



Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)



## You are contemplating investing in some energy retrofit

Would you Invest in Lowering Ambient & Adding Task Lights?



### Costs to Reduce Ambient Lighting and Add Task Lights

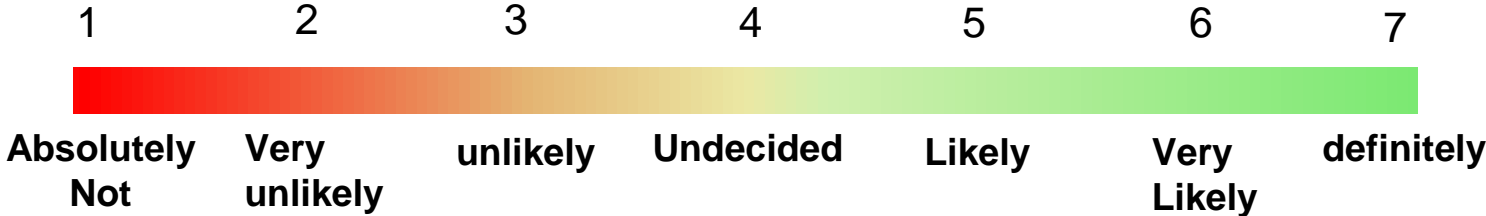
	Per sq ft	Per employee
Cost for reducing ambient light levels	\$0.16	\$32
Cost for LED desk lamp	\$0.82	\$164
<b>First cost for the investment</b>	<b>\$0.98</b>	<b>\$196</b>
<b>Initial Investment costs for a 100,000 sq ft building</b>	<b>\$98,000</b>	



<b>First cost</b> for the investment	<b>(\$0.98)</b> /sq ft	<b>(\$196)</b> /employee
--------------------------------------	---------------------------	-----------------------------

Given the costs of lowering the ambient light levels and adding a task light for each workstation,

**how likely are you to promote this retrofit?**





# Your poll will show here

1



Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)





In a 1999 study of an office building in Frankfurt, Knissel (IWU) identified an **88% reduction in primary energy consumption**, from 82 kWh/m<sup>2</sup> to 10 kWh m<sup>2</sup>, as a result of **effective daylighting, split task and ambient lighting, high performance parabolic louver fixtures and daylight dimming controls.**



## Lower Ambient & add Task - Financial capital



### Costs to Reduce Ambient Lighting and Add Task Lights

	Per sq ft	Per employee
Cost for reducing ambient light levels	\$0.16	\$32
Cost for LED desk lamp	\$0.82	\$164
<b>First cost for the investment</b>	<b>(\$0.98)</b>	<b>(\$196)</b>

### Financial Capital savings

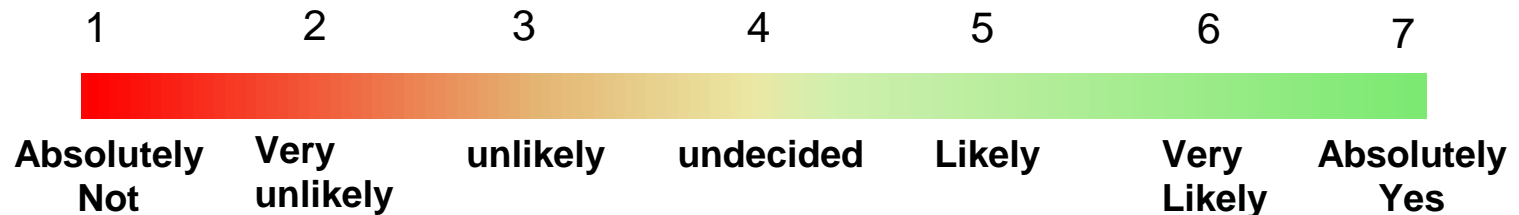
	Per sq ft	Per employee
<b>Energy savings (40%)<sup>1</sup></b>	\$0.27	\$54
<b>O &amp; M Savings<sup>2</sup></b>	\$0.05	\$10
Annual 1 <sup>st</sup> bottom line savings	+\$0.32	+\$64
<b>Cumulative ROI (Financial)</b>		<b>32%</b>
<b>Payback Period</b>		<b>3 years</b>
<b>15 year Net Present Value</b>		<b>\$244,000</b>



<b>First cost</b> for the investment	<b>(\$0.98)</b>	<b>(\$196)</b>
Annual 1 <sup>st</sup> Bottom line <b>savings</b>	<b>+\$0.32</b>	<b>+\$64</b>

Given the energy and maintenance savings from lowering ambient light levels and adding task lights for each workstation,

**how likely are you to promote this retrofit?**







# Your poll will show here

1



Install the app from  
[pollev.com/app](https://pollev.com/app)

2

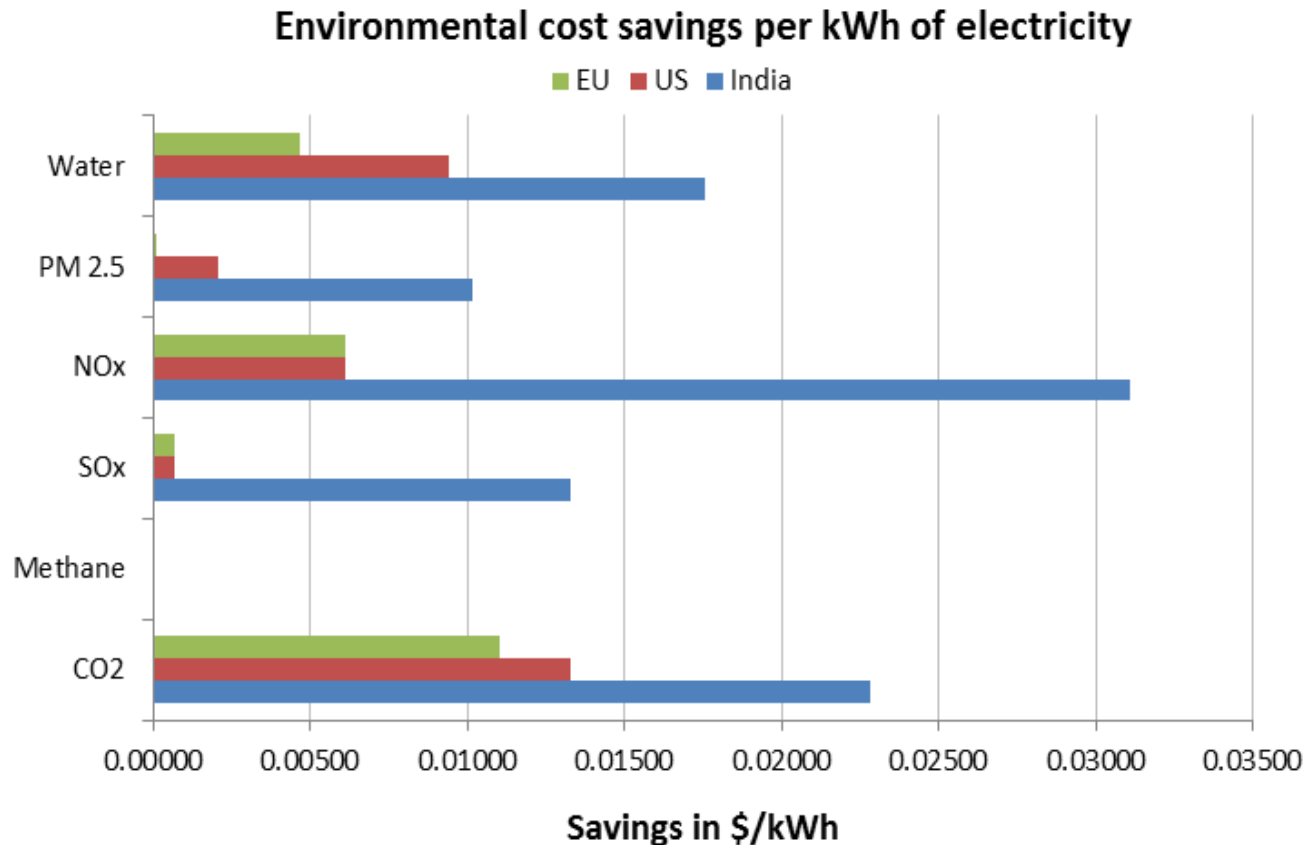
Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
*or*

[Open poll in your web browser](#)



**For every kWh saved you would be saving your company's CO2, SOx, NOx, PM2.5 and water use , which you could claim under your CSR strategy**



Energy Information Agency (EIA), 2003; M.Deru and P.Torcellini. (2007); October, R. (2010).; Central Electricity Authority. (2015).; Brander et al. (2011); Mittal, M. L. (2010); Eurostat. (2015); Covenant of Mayors. (2015).; IEA. (2012). EPA eGrid (2015) Leonardo Academy Inc., "Emission Factors and Energy Prices for the Cleaner and Greener<sup>SM</sup> Environmental Program", January 2003. *Emission impact value data for CO2, SOx, NOx and particulates from various sources (Included as an appenix in annual report are used to derive the baseline impact values*

# Lower Ambient & add Task 2nd Bottom Line – Natural capital savings



## Costs to Reduce Ambient Lighting and Add Task Lights

	Per sq ft	Per employee
Cost for reducing ambient light levels	\$0.16	\$32
Cost for LED desk lamp	\$0.82	\$164
<b>Initial Investment costs for 100,000 sq ft</b>		<b>\$98,000</b>

## 2 Financial + Natural Capital savings

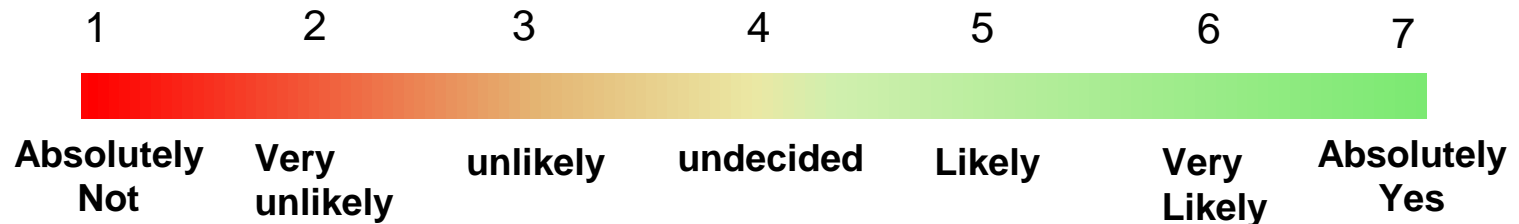
	Per sq ft	Per employee
Environmental benefits from energy savings of:	2.71 kWh	542 kWh
<b>Air pollution emissions (SO<sub>x</sub>, NO<sub>x</sub>, PM)<sup>3</sup></b>	<b>\$0.04</b>	<b>\$9</b>
<b>CO<sub>2</sub> reductions<sup>3</sup></b>	<b>\$0.03</b>	<b>\$5</b>
<b>Water savings<sup>4,5,6</sup></b>	<b>\$0.01</b>	<b>\$2</b>
<b>Annual 2<sup>nd</sup> bottom line savings</b>	<b>+\$0.08</b>	<b>+\$16</b>
<b>Cumulative ROI (Financial + Natural)</b>		<b>41%</b>
<b>Payback Period</b>		<b>2 years</b>
<b>15 year Net Present Value</b>		<b>\$305,860</b>



<b>First cost</b> for the investment	<b>(\$0.98)</b>	<b>(\$196)</b>
Annual 1 <sup>st</sup> Bottom line <b>savings</b>	<b>+\$0.32</b>	<b>+\$64</b>
Annual 2 <sup>nd</sup> Bottom line <b>savings</b>	<b>+\$0.08</b>	<b>+\$16</b>

Given the energy, maintenance and the environmental savings (CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, PM<sub>2.5</sub> etc) from lowering ambient light levels and adding task lights for each workstation,

**how likely are you to promote this retrofit?**





# Your poll will show here

1



Install the app from  
[pollev.com/app](https://pollev.com/app)

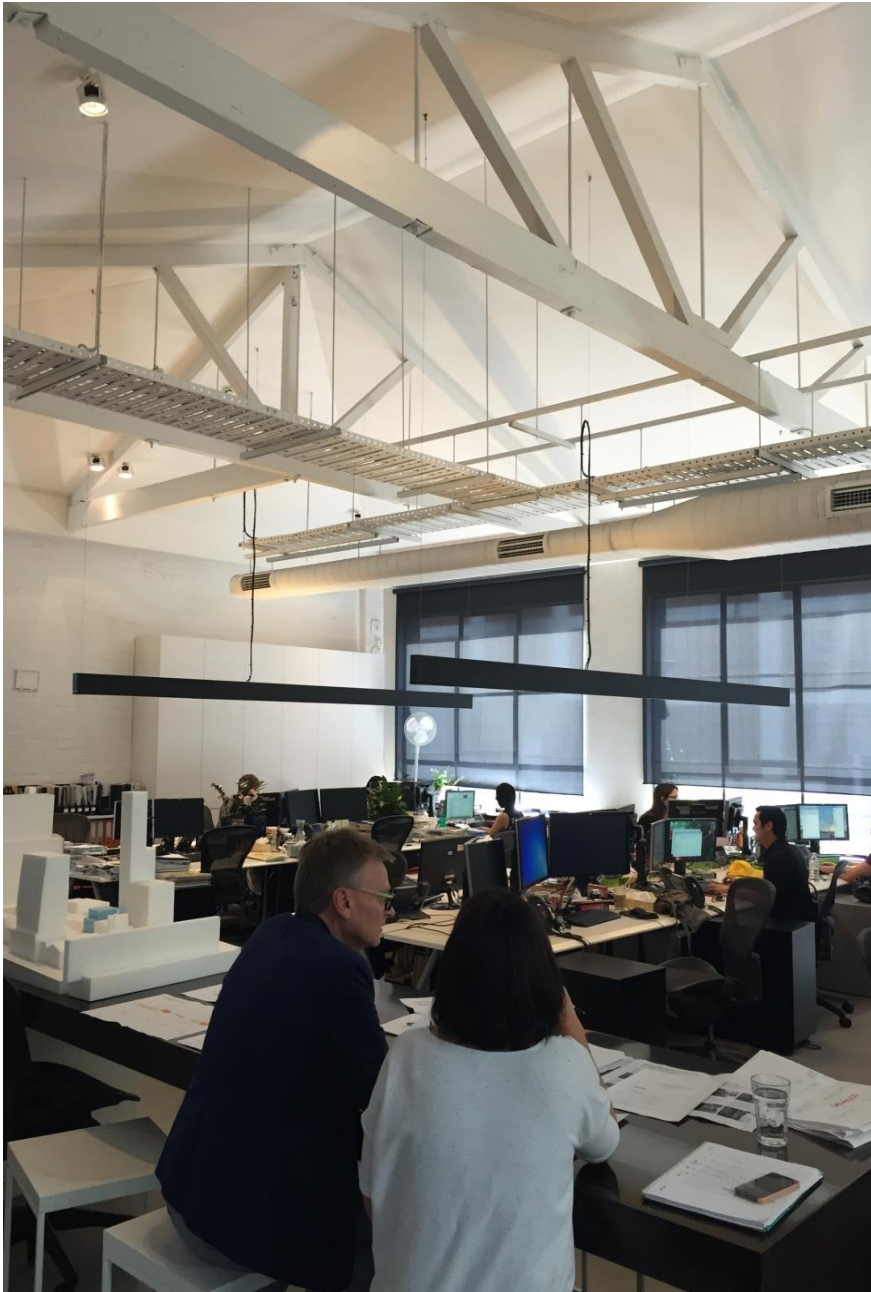
2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)





In a 1998 multiple building study in Germany, Çakir and Çakir identify a **19% reduction in headaches for workers with separate task and ambient lighting**, as compared to workers with ceiling-only combined task and ambient lighting.

First cost increase:	\$314 /employee
Annual health savings:	\$14 /employee
Annual productivity savings:	\$87 /employee
<b>ROI:</b>	<b>32%</b>



# Lower Ambient & add Task 3rd Bottom Line – Human Capital savings

## Costs to Reduce Ambient Lighting and Add Task Lights

	Per sq ft	Per employee
Cost for reducing ambient light levels	\$0.16	\$32
Cost for LED desk lamp	\$0.82	\$164
Initial Investment costs for 100,000 sq ft		\$98,000

## 3 Financial + Natural + Human capital savings of Reducing Ambient and Adding Task

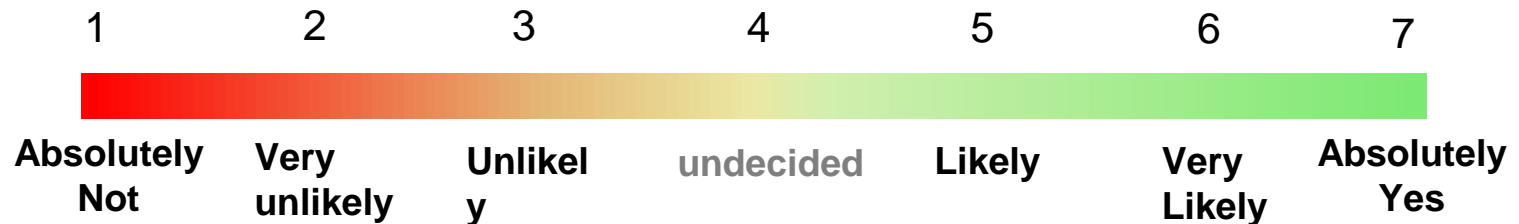
	Per sq ft	Per employee
Absenteeism reduction (1%) <sup>7</sup>	\$0.03	\$6
Productivity increase (11%) <sup>8</sup>	\$0.90	\$180
Health benefits (19%) <sup>9</sup>	\$0.07	\$14
Annual 3 <sup>rd</sup> bottom line savings	\$1.00	\$200
Cumulative ROI (Economic + Environment+ Equity)		142%
Payback Period		8 months
15 year Net Present Value (10% discount rate)		\$1,058,550



<b>First cost</b> for the investment	Per employee	<b>(\$196)</b>
Annual Financial capital <b>savings</b>	<b>+\$64</b>	<b>(\$132)</b>
Annual Natural capital <b>savings</b>	<b>+\$16</b>	<b>(\$116)</b>
Annual Human capital <b>savings</b>	<b>+\$200</b>	<b>+\$84</b>

Given the energy, maintenance, environmental savings (CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, PM<sub>2.5</sub> etc) **and** human health, productivity benefits from lower ambient light levels and addition of task light for each workstation,

### how likely are you to promote this retrofit?







# Your poll will show here

1



Install the app from  
[pollev.com/app](https://pollev.com/app)

2

Make sure you are in  
Slide Show mode

Still not working? Get help at [pollev.com/app/help](https://pollev.com/app/help)  
or

[Open poll in your web browser](#)





## **The Intelligent Workplace**

**Carnegie Mellon University  
A Living Laboratory for Building Environmental Research**