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REPORT

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Preliminary experimental evaluations of occupant behavior during load shedding

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Executive Summary

Load shedding has become increasingly popular across the industrialized world in recent years. This is the practice of reducing some or all of a building's energy consumption for a period of time, usually during hours of peak energy demand, in order to reduce stress on the power grid and reduce the chances of total system collapse.

There is a large and growing body of literature on the effects and benefits of load shedding in regards to controlling energy demand and supply, but there is virtually no research done on the behavioral effects this practice may have on occupants of buildings undergoing the treatment.

This report describes the methods and results of an interrupted time series quasi-experiment used to try to capture these results. To do so, we employed a series of occupant surveys during both load shedding (of both HVAC and lighting systems, at several levels of intensity) and control (normal) conditions across nine multi-tenanted commercial buildings owned by a real estate investment trust in Greater Philadelphia and analyzed the results using a variety of statistical techniques, most notably linear regression models.

Our results suggest that there is no impact from these instances of load shedding on occupants in this set of buildings, or in some cases a slight *positive* effect, with the latter being counterintuitive when considering the program. This leads to two potential conclusions: either 1) the effect of the load shedding on occupants is slight enough that it goes unnoticed, or 2) that the buildings were operating inefficiently under normal conditions. In either case, there is the potential that *permanent* changes in operating practices may be a viable option. The results also suggest that organizational learning is taking place as the building owner gains experience with this technology.

1. Introduction

With growing populations and increased production throughout the world, the demand for electricity has never been higher than it is today. All hours of the day, and all days of each year, electricity is demanded all over the world. During times of highest, or peak, consumption, there are often instances of the demand for electricity outpacing the available supply. In the U.S., these peak periods generally occur around midday during the hot summer months, when air conditioners strain to shield occupants from ever increasing outdoor temperatures. As such, "emergency conditions [arise] due to generating power [deficiencies], and the consequent drop in power system frequency can lead to system collapse and a large scale loss of load" (Chuvychin et al., 1996). Essentially, this translates to rolling blackouts, or times when electricity transmission to certain areas is completely shut down.[1]

The process behind a blackout is that during areas of peak demand, "when there is a shortfall in the electricity supply, there can be a need to reduce demand very quickly to an acceptable level, or risk the entire electricity network becoming unstable and shutting down completely" (Citipower, 2013). This presents an obvious problem with which society must contend. Potential losses can arise in the functionality of local hospitals, as well as police and fire management, not to mention the economic impact of ending business operations during blackout periods.

The common practice at these times has been, as mentioned, to disconnect certain customers from the grid in order to reduce the risks of a cascading event, in which an entire network can overload and lead to a total shutdown. This is referred to as a rolling blackout. Another trend has recently been gaining popularity, which is that of partial load shedding during these periods. In essence, certain (or all, in some cases) large, commercial buildings in a specific area reduce their energy consumption during these periods by a certain percentage, in the hopes that all buildings combined will conserve enough to prevent blackouts. Rolling blackouts constitute a load shed of 100% to a building—but if enough were to comply, load shedding by factors of ten or fifteen percent might be enough, allowing for continued production during these periods.

There have been many articles and papers examining the efficacy of these load shedding procedures in controlling energy demand and supply. The purpose of this paper is to examine what effects these load shedding events may have on *the occupants* of buildings. The data used come from a quasi-experimental, interrupted time series evaluation of the occupants of nine commercial buildings which have experienced simulated load shedding events over a six week period. We use responses collected from multiple surveys on days with and without load shedding conditions to see how building tenants respond to the reduction in energy consumption.

The rest of this paper is organized as follows. Section 2 focuses on the theoretical framework behind load shedding and its effects on building occupants. Section 3 focuses on the research design of the evaluation, as well as the data used in the analysis. Section 4 highlights the analytic strategy used and results of the evaluation, and Section 5 will conclude.

[1] This report is based on a working paper by S. Malenchak. 2013. *Experimental evaluations of occupant load shedding behavior*, E.J. Bloustein School of Planning and Public Policy, Rutgers University, New Brunswick, NJ.

2. Theoretical Framework

Rolling blackouts are not a new or novel concept to most who live in even relatively industrialized countries. For years Pakistan has been facing severe supply shortages in electricity, resulting in almost daily blackouts throughout the country, lasting for as many as 12 hours of the day (Info Pakistan, 2011). Recently, unscheduled load shedding events have caused riots in Lahore, the capital of Punjab, where residents are experiencing periods of up to 18 hours without electricity (The Nation, 2013). India as well has been experiencing such effects, although perhaps not as severe. Still, load shedding is far from an occasional occurrence, with Indian power suppliers continuously failing to meet demand. (Narasimhan, 2013).

More advanced industrial countries are not immune to blackouts either. In 2011, Tokyo experienced rolling blackouts throughout the city, as power generation was not able to keep up with supply, sometimes falling as much as 25% below requested output (Weisenthal, 2011). Even in the U.S., brownouts and blackouts are, while not regular, still not unheard of during the summer months in the northeast. In 2003, the state of California experienced severe blackouts, although that is in larger part due to the alleged market tampering by energy suppliers (Johnson, 2004).

The practice of partial load shedding attempts to curtail occurrences such as these. The underlying idea behind partial load shedding is quite simple, as mentioned above: by reducing demand over many different customers at peak hours, the chances of a cascading total system failure reduce dramatically, as well as the chance of enforced 100% load sheds, or blackouts.

As mentioned in Section 1 above, there have been many studies evaluating the use of load shedding in commercial and residential buildings.[2] Capozza et al. look at demand side management in conjunction with load shedding in Italy after the occurrence of the 2003 blackouts, with a focus on persevering the security of the national electrical system (Capozza et al, 2005). Newsham and Bowker (2010) examine the effects of time-varying pricing and load control strategies of residential properties during peak summer demand. Chuvychin et al. (1996) look at potential alternative approaches to load shedding during peak conditions.

However, to our knowledge, there have been no formal evaluations on the effects of partial load shedding on the attitudes and performance of building occupants. This evaluation attempts to do just that. The goal of this evaluation is to examine whether building occupants respond to or are affected by partial load shedding practices, and if so, at what point do they notice or become affected.

[2] For additional readings see Koner et al. (2000), Bierman (2005), Smith and Norford (2003), and Akers et al. (2001).

3. Research Design and the Data

Research Design

The study population is a group of nine buildings owned by a forward leaning, large portfolio, commercial building developer and owner in the Greater Philadelphia region (referred to in this paper as 'the company,' 'the owners,' or some variation thereof). These commercial buildings have been retrofitted with equipment to support managed load shedding procedures, including lighting and mechanical system controls that allow building operators to shed 5%, 10%, or 15% of electricity demand remotely and on short notice.

The study seeks to answer multiple questions. The first has to do with advanced energy retrofits spread throughout the designated buildings. Over the past three years, there have been three different phases of retrofits, each hoping to learn from the previous phase. Essentially, the company hopes to establish best practices for incorporating energy retrofits in their buildings while still upholding customer satisfaction.[3]

The second question addresses the effects of partial load shedding on occupant behavior and satisfactions in the buildings. Based on an agreement with their local energy provider, the company agreed to participate in simulated load shedding events throughout peak periods during the summer of 2013; the sheds took place once a week for six weeks. The events consisted of reduction in energy consumption to the buildings' heating, ventilation, and air conditioning (HVAC) and lighting systems, of differing percentages.[4] Their goal was to see how this would affect their tenants.

This was to be accomplished in several ways, the first being field interviews and observations. During load shed events, the research team conducted intercept interviews among tenants, attempting to uncover any perceived differences noticed during the events. Also collected were observations on occupant behavior, such as the use of personal fans, lights, etc., as well as temperature and lighting measurements throughout the building. The last measure came in the form of tenant surveys, which are the focus of this paper.

This quasi-experiment took the form of an interrupted time series program evaluation. To evaluate the effects of load shedding, data were collected from occupants in each building using online surveys conducted both before the program took place (baseline surveys), as well as in the mornings and afternoons of both load-shed and separate control days, during which there were no changes to the building systems (daily surveys). The baseline survey consisted of a comprehensive questionnaire about the participant's background information as it pertains to this study, such as location in building, ratings on general building performance, age, etc. The daily surveys were shorter, and intended to only observe current behaviors and satisfactions.

[3] For instance, lighting sensors (that automatically turn on and off lighting in certain areas) were supposed to produce large amounts of energy savings while being of minor effect to tenant satisfaction. However, it was found after Phase 1 that many occupants were extremely upset over not only losing control over the lighting, but of many instances where lights were on that should not be, and vice versa. In addition, it was found that these sensors only saved marginal amounts of energy.

[4] The load sheds consisted of different 'shed levels' during the simulated events. Either or both of the HVAC and lighting systems would be reduced by 5, 10, or 15%, which correspond to shed levels 1, 2, or 3 respectively.

The baseline surveys were distributed before the shed events took place, and were left open for the duration of the experiment. The daily surveys were sent out only during the morning or afternoon period of the prescribed day, closing after a certain amount of time. For this program there were a total of twenty-four daily surveys administered- one in the morning and one in the afternoon for each load shed and control day, which each occurred once a week for the duration of the experiment (six weeks). During this time, six of these surveys were administered during load shedding events, which only took place during the afternoon, as that corresponds to actual peak consumption periods.

The largest concern pertaining to the validity of this experiment comes from the selection of participants. The owners of the buildings did not want to disturb or perturb their tenants by forcing them to participate in the survey, and so incentives were instead used to motivate occupants to participate. Cash prize raffles were instituted in order to draw attention and participation to the surveys, with one drawing based on participation in the baseline survey, and three based on participation in the daily surveys, with more chances to win based on the number of surveys completed.

This self-selection process poses a threat to both the internal and external validities of this experiment, in that the ratings and attitudes captured by the analysis may only reflect those experienced by people who share a common trait (such as self-selecting into surveys) which may not be shared by everyone. However, without full participation in the surveys or information on non-participating occupants[5], there is no way to deal with this threat other than to acknowledge that is exists.

In total, there were 81 baseline surveys completed and 554 daily surveys completed over the course of this experiment. Part B of this section will examine this sample and describe the key variables used in the analysis discussed in Section 4.

The Data

As mentioned above, there were 81 baseline and 554 daily surveys completed during the course of this program. The majority of the independent, or explanatory, variables used for this analysis came from the baseline survey, which were then matched to the participants of the daily surveys. Tables 1 and 2 shows the descriptive statistics for the categorical data used in this analysis:

[5] Additional information could have been used to run some sort of two stage regression (such as a Heckman Selection Model) to tease out this information.

Table 1

Building Number	Floor Location				Exposure Location				
	Floor 1	Floor 2	Floor 3	Total	Northeastern	Northwestern	Southeastern	Southwestern	Total
Building 1	11	15	14	40	13	10	12	5	40
Building 2	1	1	0	2	0	0	1	1	2
Building 3	1	0	0	1	0	0	1	0	1
Building 4	5	0	0	5	0	0	4	0	4
Building 5	1	0	0	1	0	0	0	0	0
Building 6	1	0	0	1	0	0	1	0	1
Building 7	6	9	4	19	0	5	5	4	14
Building 8	6	0	0	6	2	1	3	0	6
Building 9	0	6	0	6	4	2	0	0	6
Total	32	31	18	81	19	18	27	10	74

Table 2

Building Number	Type of Workspace				Building Phase			
	Office	Cubicle	Open	Total	1.00	2.00	3.00	Total
Building 1	12	25	0	37	40	0	0	40
Building 2	0	2	0	2	0	2	0	2
Building 3	1	0	0	1	0	0	1	1
Building 4	2	1	0	3	0	5	0	5
Building 5	0	1	0	1	0	1	0	1
Building 6	1	0	0	1	0	1	0	1
Building 7	10	6	3	19	0	0	19	19
Building 8	2	4	0	6	6	0	0	6
Building 9	1	5	0	6	0	0	6	6
Total	29	44	3	76	46	9	26	81

These cross tabulations show the total numbers of each categorical variable used for the analysis by building number. Building 1 here contributed to the majority of all responses in the surveys, with Building 7 contributing heavily as well. Three of these variables, floor location, exposure, and workspace type, were informed by the intercept interviews done in the buildings during these time periods. They were then analyzed using T-Tests and ANOVAs, and found to be of significant interest in explaining the variance of the dependent variables.

The fourth variable listed, building phase, was included based on the reported changes taking place throughout each of them—the thinking here is that later phases will show more satisfied occupants than earlier ones, which should demonstrate improved practices throughout the years by the building owners. Also of consideration are the relatively low number of responses across many of the buildings; pooling the responses into phases rather than buildings helps improve the quality of the analysis while losing relatively little in terms of the questions posed for this evaluation.

These variables were then matched to the daily surveys. Table 3 gives a breakdown of the total number of daily surveys completed by building, broken up by both what time of day the survey took place, and whether or not the survey took place during a load shedding event:

Table 3

Building Number	Time of Day			Survey Conditions		
	Morning	Afternoon	Total	Control	Load Shed	Total
Building 1	155	131	286	219	67	286
Building 2	13	7	20	15	5	20
Building 3	9	8	17	12	5	17
Building 4	29	22	51	40	11	51
Building 5	8	9	17	12	5	17
Building 6	8	8	16	11	5	16
Building 7	43	35	78	57	21	78
Building 8	21	15	36	27	9	36
Building 9	16	17	33	24	9	33
Total	302	252	554	417	137	554

Time of day here is included because load shedding events only took place during the afternoon periods. There is good representation of both morning and afternoon surveys, as well as a fairly large number of surveys during load shedding conditions. Tables 4 and 5 look at the same variables examined in Tables 1 and 2, only instead considering the daily surveys:

Table 4

Building Number	Floor Location				Exposure Location				
	Floor 1	Floor 2	Floor 3	Total	Northeastern	Northwestern	Southeastern	Southwestern	Total
Building 1	68	93	112	273	114	58	68	33	273
Building 2	14	6	0	20	0	0	14	6	20
Building 3	15	0	0	15	0	0	15	0	15
Building 4	51	0	0	51	0	0	28	0	28
Building 5	15	0	0	15	0	0	0	0	0
Building 6	16	0	0	16	0	0	16	0	16
Building 7	17	31	23	71	0	30	19	9	58
Building 8	33	0	0	33	16	0	17	0	33
Building 9	0	33	0	33	27	6	0	0	33
Total	229	163	135	527	157	94	177	48	476

Table 5

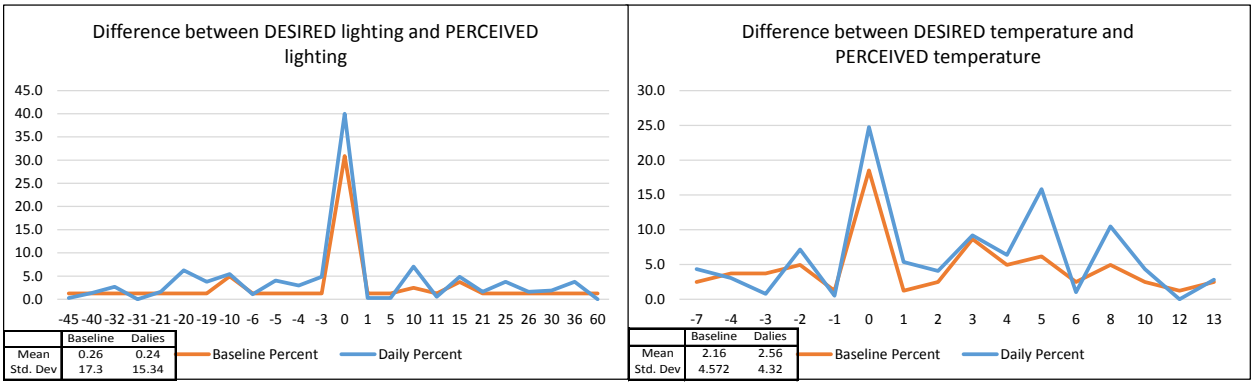
Building Number	Type of Workspace				Building Phase			
	Office	Cubicle	Open	Total	1.00	2.00	3.00	Total
Building 1	102	164	0	266	286	0	0	286
Building 2	0	20	0	20	0	20	0	20
Building 3	15	0	0	15	0	0	17	17
Building 4	13	4	0	17	0	51	0	51
Building 5	0	15	0	15	0	17	0	17
Building 6	16	0	0	16	0	16	0	16
Building 7	21	28	22	71	0	0	78	78
Building 8	16	17	0	33	36	0	0	36
Building 9	3	30	0	33	0	0	33	33
Total	186	278	22	486	322	104	128	554

The overall representation here for each variable is, for the most part, strong. The only issues occur when considering those in open workspaces and those in the southwestern exposure. However, the results of intercept interviews and observational data in the field suggest that these

variables may be strong indicators of satisfaction, and so they are included to help control for the effects of load shedding.

Figure 1 displays the two non-treatment continuous variables included in the model. These indicators were developed by subtracting the desired temperature and lighting levels reported on the baseline survey from the perceived level for each participant. The baseline survey included questions about these perceived and desired levels using slider bars, where the respondent would slide a bar to what they feel the temperature, for instance, is and what it should be.

Figure 1



Differencing these two values allows us capture some desired preferences of our participants: whether or not they feel the building is too hot or too bright on any given day. For instance, if the values of the two differences are negative, we know the respondent would like the building cooler and dimmer. We hypothesize that these desired preferences, and their deviations away from zero, will influence how a participant will respond to questions about the dependent variables.

Looking at the means and standard deviations in Figure 1, we can see that differences in lighting are clustered heavily around zero, suggesting that the majority of respondents are satisfied with current lighting levels, but the standard deviations imply that there are some outliers who are very uncomfortable. Looking at the temperature differences, while the majority responses center around zero, the mean is just over two, suggesting an overall preference for warmer conditions.

Table 6 describes the treatment variable for this analysis: load shedding. This table shows the percentage shed over each observed time period for both HVAC and lighting systems. Over the course of the experiment, HVAC sheds have been at either five or 10 percent, with lighting climbing as high as 15 percent. These shed percentages are treated as continuous variables in the regression analysis.

Table 6

Time Period	Load Shed Percentage	
	HVAC	Lighting
1	5	5
2	0	0
3	10	10
4	0	0
5	0	0
6	10	15
7	0	10
8	0	0
9	0	15
10	0	0
11	10	10
12	0	0

The dependent variables of interest for this analysis were questions tied to three different attributes: environmental satisfaction, health, and productivity/job satisfaction. For each scale, respondents were asked to slide a bar starting at zero between the range of negative fifty and fifty, with negative numbers representing lower satisfaction. The numbers were then converted for each into a scale from one to one hundred.

Columns three through six of Table 7 below show the questions asked and the descriptive statistics for each. Since all the data were transformed to be positive, a score of fifty represents neutral satisfaction, with those above showing positive satisfaction. For the most part, participants rated each condition generally positively with the exception of the ability to adjust the environment, which were either close to or below fifty with higher standard deviations.

The goal behind this evaluation is the see whether load shedding events affected building occupants in any of these conditions, and if so how much. Table 7 lists each attribute (column 1) and the scales we had originally developed to gauge each area (column 2). For two of the attributes (environmental satisfaction and health), our primary research (interviews, observations, etc.) had suggested that they each be broken down into separate groupings, and these five total scales would be best to measure each condition. The Cronbach Alpha score for each of our scales seem very strong (listed under each scale condition in the second column), but a factor analysis was performed to confirm these assumptions.

Table 7

Dependant Variables					
Attribute	**Scale (Cronbach's alpha shown in parentheses)**	**Slider Variables**	**Mean Score**	**Std. Dev.**	**N Size**
Environmental Satisfaction	Satisfaction with Environmental Conditions (α= 0.851)	Satisfaction with Air Quality	69.00	23.95	437
		Satisfaction with Temperature	59.09	29.72	462
		Satisfaction with Noise	67.57	27.89	462
		Satisfaction with Electric Lighting	69.59	25.34	434
	Satisfaction With Ability to Adjust Environment (α= 0.900)	Satisfaction with Ability to Adjust Lighting	40.98	29.55	426
		Satisfaction with Air Quality	37.63	30.50	448
		Satisfaction with Temperature	54.83	32.03	438
Health	Mental Health (α= 0.843)	How Would You Rate Your Mental Health?	79.21	21.22	523
		How Stressed Are You?	57.79	28.42	509
		Do You Feel Pleasant Today?	74.36	22.47	514
		How Would You Rate Your Ability To Concentrate?	80.23	20.65	519
	Physical Health (α= 0.812)	How Would You Rate Your Physical Health?	81.91	18.49	523
		How Alert Do You Feel?	77.79	21.09	522
		How Fatigued Do You Feel?	63.85	28.90	506
Job Satisfaction/Productivity	Job Satisfaction/Productivity (α= 0.836)	How Would You Rate The Quality of your Work?	81.22	17.03	514
		How Would You Rate Your Productivity?	79.19	18.53	515
		How Satisfied Are You With Your Job?	74.09	24.41	510

Table 8 shows the rotated factor loadings for all seventeen variables when performing a maximum likelihood factor analysis, stipulating five factors (loadings with scores lower than 0.4 were removed for clarity). Looking at these results, there seems to be a clear pattern between the three main attributes (environmental satisfaction, health, and job satisfaction), but factors four and five do not seem to be viable. To confirm this, a second analysis was run using the same specifications of the first, only stipulating three factors instead of five. Results are shown in Table 9.

Table 8

Scale	Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Satisfaction with Environmental Conditions	Air Quality	0.4279	**0.6221**			
	Temperature	0.4221	**0.4233**		0.504	
	Noise		**0.6296**			
	Light		**0.787**			
Satisfaction With Ability to Adjust Environment	Adjust Light		**0.6456**		0.5553	
	Adjust Air Quality		**0.4467**		0.8406	
	Adjust Temp		**0.7668**			
Mental Health	Mental Health	**0.6551**		0.5135		
	Stress	**0.6531**				
	Pleasantness	**0.635**				
	Concentrate	**0.4879**		0.6498		0.4478
Physical Health	Physical Health	**0.5722**				
	Alertness	**0.6003**		0.4188		
	Fatigue	**0.6899**				
Job Satisfaction/Productivity	Work Quality			**0.8282**		
	Productivity			**0.8509**		
	Job Satisfaction	0.4256		**0.5571**	0.4654	

Prob>chi2 = 0.0000

Table 9

Scale	Variable	Factor 1	Factor 2	Factor 3
Satisfaction with Environmental Conditions	Air Quality	**0.6465**		
	Temperature	**0.6531**		
	Noise	**0.4937**	0.4235	
	Light	**0.6395**		
Satisfaction With Ability to Adjust Environment	Adjust Light	**0.8622**		
	Adjust Air Quality	**0.8267**		
	Adjust Temp	**0.7707**		
Mental Health	Mental Health		**0.7765**	0.4625
	Stress		**0.5329**	
	Pleasantness		**0.614**	
	Concentrate		**0.6653**	0.5969
Physical Health	Physical Health		**0.6075**	
	Alertness		**0.7156**	
	Fatigue		**0.669**	
Job Satisfaction/Productivity	Work Quality			**0.8073**
	Productivity			**0.8516**
	Job Satisfaction			**0.5696**

Prob>chi2 = 0.0000

Clearly, based on these results, there should be three factors used for this analysis, and they are the original three that were questioned. The factor loadings from this analysis were then used to weight each variable by multiplying each variable score by the loading score, and then the variables for each attribute were averaged together to form the scales used as the dependent variables in the final regression analysis. Table 10 below gives the descriptive statistics for each scale, including the minimum and maximum scores, as they have been altered based on the weightings.

Table 10

Attribute (Cronbach's alpha shown in parentheses)	Min	Max	Mean	Std. Dev	N Size
Environmental Satisfaction (α= 0.910)	0	69.40	39.16	16.71	339
Health (α= 0.895)	0	65.44	49.06	11.94	473
Job Satisfaction/Productivity (α= 0.859)	0	74.28	58.54	12.82	503

4. Analytic Strategy and Results

After transforming the appropriate slider questions into the proper three scales listed above, the final analysis will consist of running a linear regression to analyze both the effects of load shedding as well as explore the possible determinants of satisfaction in the buildings. Fixed effect panel regression was considered for this analysis, but due to inconsistent participation by our "panel" of occupants (the average number of surveys completed per person was seven out of twenty four, and no person completed every survey), this was ruled out as a viable approach.
Equation (1) specifies the first model considered, including only variables for load shed and time, as well as interactions between each (time and interaction terms are just for control and not listed in the results):

$$y_i = \beta_0 + \beta_1 HVAC_i + \beta_2 Lighting_i + \beta_3 Time_i + \beta_4 (Time_i * HVAC_i) + \beta_5 (Time_i * Lighting_i) + \varepsilon_i \quad (1)$$

where y_i represents the three dependent scales discussed above, $HVAC_i$ is the amount of HVAC load shed taking place, $Lighting_i$ is the amount of lighting load shed taking place, $Time_i$ is the time period of the survey, and ε_i is all uncaptured error, assumed to be white noise. This model aims to see purely the effect of the load sheds without any other controls, to see which direction the treatment variables run in, which are assumed to be negative (results for each attribute shown in Table 11 below).

Equation (2) adds in certain elements of building location to see how they change the treatment variables:

$$y_i = \beta_0 + \tilde{T}_i\beta + \tilde{L}_i\beta + \widetilde{Time}_i\beta + \varepsilon_i \quad (2)$$

where $\tilde{T}_I$ represents the two treatment variables from (1) (HVAC and Lighting), $\tilde{L}_i$ are dummy location independent variables for floor, exposure, and type of workspace, and $\widetilde{Time}_i$ represents the time and interaction variables listed in (1). The remaining variables are unchanged from (1).

The results of these two models for each attribute are listed in Table 11 below. The most striking feature of these results are the coefficients for the HVAC load shed. For five of the six models the results are positive, and four of them are significantly so. This effect is counterintuitive, as we would expect decreased comfort and satisfaction from any load shedding activity. This becomes less strange when considering the results from Figure 1: it appears that a large majority of respondents desired warmer temperatures in the building, which cutting back on the air conditioning would provide- in essence, people prefer less air conditioning (in these buildings) in the summer!

Table 11

Regression Analysis of Treatment and Predictor Variables on Satisfaction and Health Scales						
	Environmental Satisfaction		Health		Job Satisfaction/Productivity	
Regressor	Equation (1)	Equation (2)	Equation (1)	Equation (2)	Equation (1)	Equation (2)
HVAC Load Shed	1.35	-0.12	1.96**	2.22**	2.07*	2.29*
	(1.454)	(1.153)	(0.985)	(0.987)	(1.123)	(1.231)
Lighting Load Shed	-1.01	0.36	-1.68*	-1.85**	-1.58	-1.78
	(1.391)	(1.065)	(0.929)	(0.928)	(1.061)	(1.163)
Floor 2		-3.10*		3.09*		1.33
		(1.806)		(1.809)		(1.988)
Floor 3		3.18		0.60		-1.44
		(2.016)		(1.531)		(1.793)
NW Exposure		5.61**		0.42		-2.99
		(2.844)		(2.000)		(2.268)
NE Exposure		3.72**		0.05		-1.41**
		(1.777)		(1.377)		(1.666)
SW Exposure		16.30***		9.97***		1.25**
		(5.677)		(2.269)		(2.902)
Office		13.20***		7.59***		6.68***
		(1.590)		(1.276)		(1.440)
Open space/other		-4.16		-3.97		-1.88
		(3.126)		(2.604)		(2.604)
Intercept	34.50***	27.68***	47.26***	41.45***	56.33***	53.74***
	(2.612)	(3.051)	(1.704)	(1.935)	(1.766)	(2.186)
N Size	339	300	473	409	503	435
F Statistic	1.71	13.12***	2.23*	9.93***	2.81**	5.98***
R-sq	0.018	0.246	0.023	0.195	0.026	0.121

All tests include a time variable and an interaction between time and the treatment variables. Robust standard errors are given in parentheses under coefficients. The individual coefficient is statistically significant at the *10%, **5%, or ***1% significance level using a two-tailed test.

Equation (3) adds in additional elements to the model, adding controls for what phase the building is in and whether or not it was morning:

$$y_i = \beta_0 + \tilde{T}_i\beta + \tilde{L}_i\beta + \tilde{x}_i\beta + \widetilde{Time}_i\beta + \varepsilon_i \quad (3)$$

where $\tilde{x}_i$ represents dummy variables for what phase building it is, and whether or not it was morning, with the other variables remaining unchanged from Equation (2). The results from this model can be seen in Table 12, as can the results from Equation (4), which adds in preference controls:

$$y_i = \beta_0 + \tilde{T}_i\beta + \tilde{L}_i\beta + \tilde{x}_i\beta + \tilde{P}_i\beta + \widetilde{Time}_i\beta + \varepsilon_i \quad (4)$$

where $\tilde{P}_i$ represents continuous variables for the temperature and lighting differences from Figure 1, and includes each other attribute not being regressed upon. The other variables remain unchanged from (3). Looking at the results of (3) and (4) in Table 12, several conclusions may be formed.

Table 12

Regression Analysis of Treatment and Predictor Variables on Satisfaction and Health Scales						
	Environmental Satisfaction		Health		Job Satisfaction/Productivity	
Regressor	Equation (3)	Equation (4)	Equation (3)	Equation (4)	Equation (3)	Equation (4)
HVAC Load Shed	0.13	-0.40	1.94**	0.66	2.07*	0.92
	(1.052)	(0.974)	(0.894)	(0.655)	(1.118)	(0.960)
Lighting Load Shed	0.06	0.37	-1.62*	-0.65	-1.63	-0.71
	(0.978)	(0.831)	(0.842)	(0.579)	(1.061)	(0.883)
Floor 2	-1.80	0.52	2.85	0.17	0.98	-3.31*
	(1.892)	(4.181)	(1.771)	(1.717)	(2.006)	(1.978)
Floor 3	6.54***	1.80	2.31	3.85*	0.47	-5.66*
	(1.906)	(4.275)	(1.408)	(2.225)	(1.843)	(2.884)
NW Exposure	7.25***	14.15***	-0.84	-8.59***	-4.30*	4.05
	(2.801)	(3.778)	(1.821)	(2.161)	(2.236)	(2.882)
NE Exposure	7.66***	6.16*	0.79	0.55	-0.48	-6.80***
	(1.946)	(3.561)	(1.455)	(2.026)	(1.746)	(2.096)
SW Exposure	21.13***	25.81***	11.85***	3.65	3.29	3.87
	(5.818)	(3.069)	(2.589)	(2.268)	(3.236)	(2.693)
Office	14.57***	5.76**	8.18***	4.30**	7.28***	-1.52
	(1.576)	(2.247)	(1.209)	(1.724)	(1.426)	(2.208)
Open space/other	-9.35**	-4.60	-5.43*	-1.26	-3.96	-2.70
	(3.893)	(4.559)	(2.923)	(2.835)	(3.001)	(4.212)
Phase 1	-8.87***	-0.75	-7.01***	-1.01	-8.20***	0.31
	(2.267)	(3.210)	(1.374)	(1.566)	(1.460)	(2.026)
Phase 2	5.52	13.94***	-3.97**	-5.96***	-4.28*	2.06
	(3.534)	(4.104)	(1.679)	(2.115)	(2.424)	(2.865)
Morning	1.95	-0.32	3.77***	1.60*	2.72**	-0.93
	(1.557)	(1.460)	(0.969)	(0.963)	(1.150)	(1.118)
Prefered Temp Difference		-0.06		-0.53***		0.54***
		(0.419)		(0.167)		(0.160)
Prefered Lighting Difference		0.13		-0.12		0.43***
		(0.283)		(0.083)		(0.091)
Environmental Satisfaction		(omitted)		0.17***		2.00
				(0.049)		(1.765)
Health		0.40***		(omitted)		-8.59***
		(0.116)				(0.343)
Job Satis/Product		0.05		0.55***		(omitted)
		(0.094)		(0.069)		
Intercept	28.44***	4.51	44.38***	8.51*	58.11***	88.41***
	(3.792)	(5.952)	(2.302)	(4.615)	(2.505)	(4.801)
N Size	300	177	409	177	435	177
F Statistic	15.23***	26.49***	10.42***	49.65***	7.71***	25.52***
R-sq	0.328	0.594	0.276	0.717	0.188	0.675

All tests include a time variable and an interaction between time and the treatment variables. Robust standard errors are given in parentheses under coefficients. The individual coefficient is statistically significant at the *10%, **5%, or ***1% significance level using a two-tailed test.

As in Table 11, the HVAC treatment coefficient is positive in all but one of the models, and significant in two of them. This strongly suggests that one of the problems across all the building phases is that they are consistently too cold relative to the occupants' preferences. The lighting load sheds coefficients are generally negative, but only significant at one point, suggesting that, while tenants may not have been enthusiastic about lower lighting, their satisfaction was not severely compromised.

As would be expected, people in offices are generally much happier than those in open spaces or cubicles. An interesting finding here is the large effect exposures seem to have on satisfaction. While this was expected based on primary research and earlier, simpler analyses, the cause behind this is unknown, especially for health related questions, and will require follow-up research.

Also interesting are the coefficients for the lighting and temperature differences—it would appear that it being too hot or too bright had little effect on environmental condition satisfaction, but were strong predictors of health and job satisfaction. Of interest as a side note is the effect of building phase on satisfactions. For almost all models, phase one buildings were generally more dissatisfied than phases two or three, which would suggest overall improvements in best practices over the years. However, phase two coefficients were sometimes positive, suggesting potential instances of backsliding between phases two and three.

Table 13 shows that a comparison of the difference in measurements of key attributes for Control Days minus Load Shed Days, afternoons only[6], yields insignificant differences for all variables. This supports a finding that occupants were not disturbed by the load shedding events.

Table 13

Control minus Load Shed Days, afternoons only					
Attribute	**Scale (Cronbach's alpha shown in parentheses)**	**Slider Variables**	**Mean Diff**	**p-value**	**Degrees of freedom**
Environmental Satisfaction (α= 0.910)	Satisfaction with Environmental Conditions (α= 0.851)	Satisfaction with Air Quality	2.02	0.56	199
		Satisfaction with Temperature	2.49	0.54	212
		Satisfaction with Noise	3.14	0.43	211
		Satisfaction with Electric Lighting	1.10	0.77	201
	Satisfaction With Ability to Adjust Environment (α= 0.900)	Satisfaction with Ability to Adjust Lighting	4.72	0.27	198
		Satisfaction with Air Quality	0.53	0.90	205
		Satisfaction with Temperature	2.20	0.64	202
Health (α= 0.895)	Mental Health (α= 0.843)	How Would You Rate Your Mental Health?	-1.41	0.64	237
		How Stressed Are You?	-2.52	0.52	233
		Do You Feel Pleasant Today?	1.90	0.55	231
		How Would You Rate Your Ability To Concentrate?	-1.26	0.67	235
	Physical Health (α= 0.812)	How Would You Rate Your Physical Health?	-3.00	0.25	238
		How Alert Do You Feel?	2.67	0.34	237
		How Fatigued Do You Feel?	-0.67	0.86	288
Job Satisfaction/Productivity (α= 0.859)	Job Satisfaction/Productivity (α= 0.836)	How Would You Rate The Quality of your Work?	-1.62	0.50	233
		How Would You Rate Your Productivity?	-1.67	0.52	235
		How Satisfied Are You With Your Job?	-3.26	0.31	232

5. Conclusions and Policy Implications

The goal of this evaluation was to test to the best extent possible the effects of load shedding on occupant environmental satisfaction, health, and job satisfaction/productivity. The results from the regression analyses point heavily toward there being either no impact from load shedding on occupants, or a positive effect, which is counterintuitive when considering the program.

[6] Occupants were shown to respond significantly higher across most questions during mornings as compared to afternoons, suggesting that including morning surveys may bias the results of the independent samples T-Tests. Also compared for robustness were scores of load shed mornings and control mornings (in which no load shed was ever taking place) to see if there were differences, with none found. In essence, this would mean that including the morning surveys (which would be counted as controls, as no load shedding would be taking place) would bias the results against load shedding conditions, when really people just enjoy mornings more across the board.

The conclusions gained from these seemingly contradictory results suggest that the buildings are perhaps not operating at their optimal levels, at least in terms of the HVAC systems. This implies that the effect of load shedding on occupants is minor, at least in the percentages used in this experiment. Going further, in terms of policy implications, these results suggest that it may be possible to shed certain amounts of loads permanently without loss of utility to building occupants. This implication is significant in terms of current energy policy, as it suggests that reductions in required electricity production may be possible on a fairly large scale, should these results prove robust.

For further research, we strongly recommend a larger, fully- rather than quasi-experimental, study into these questions, preferably with random assignment. The current research focusing solely on survey results is a first step toward answering the questions posed at the beginning of this paper. Future work could mine the field observations and interviews for additional insights.

6. References

Akers, J., Mead, D., Waldbauer, K., O'Niel, D,. Greenfield, L, and Fernandez, A. (2001). "Ensuring Sufficient Capacity Reserves in Today's Energy Markets: Should We? And How Do We?" Federal Energy Regulatory Commission. Available at: http://stoft.com/metaPage/lib/FERC-2001b-capacity-reserves-paper.pdf

Bierman, A. (2005). "Project 3.2, Energy Efficient Load-Shedding Lighting Technology: Final Report." California Energy Commission. Available at: www.archenergy.com/lrp/final-reports/LRP-FR-Attachments/A6-deliverable_3.2.10_Load-shed_FINAL-RPT.pdf

Capozza, A., D'Adamo, C., Mauri, G., and Pievatolo, A. (2005, June). "Load shedding and demand side management enhancements to improve the security of a national electrical system." In *Power Tech, 2005 IEEE Russia* (pp. 1-7). IEEE.

Chuvychin, V. N., Gurov, N. S., Venkata, S. S., and Brown, R. E. (1996). "An adaptive approach to load shedding and spinning reserve control during underfrequency conditions." *Power Systems, IEEE Transactions on*, 11(4), 1805-1810.

Citipower, (2013). "Load Shedding." CitiPower. Available at: www.powercor.com.au/Electricity_Networks/Power_Outages_Explained/Load_Shedding

Newsham, G. R., and Bowker, B. G. (2010). "The effect of utility time-varying pricing and load control strategies on residential summer peak electricity use: a review." *Energy Policy*, 38(7), 3289-3296.

Info Pakistan. (2011). "Electicity load shedding in Pakistan intensifies in summer 2011." *Info Pakistan*. Available at: www.infopakistan.pk/2011/04/electicity-load-shedding-in-pakistan-intensifies-in-summer-2011/

Johnson, L. (2004). "Enron Tapes Anger Lawmakers." *CBS News*. Available at: www.cbsnews.com/news/enron-tapes-anger-lawmakers/

Koner, P. K., Dutta, V., and Chopra, K. L. (2000). "A comparative life cycle energy cost analysis of photovoltaic and fuel generator for load shedding application." Solar energy materials and solar cells, 60(4), 309-322.The Nation. (2013). "Unscheduled loadshedding irks people in Punjab." *The Nation*. Available at: www.nation.com.pk/Politics/02-Oct-2011/Loadshedding-runs-riots-nationwide

Narasimhan, T. (2013) "Jaya blames Central PSUs for load shedding in TN." *Business Standard*. Available at: www.business-standard.com/article/current-affairs/tn-blames-central-generating-stations-for-power-cuts-in-state-113112600114_1.html

Smith, V.A., and Norford, L. (2003). "Final Report Compilation for Aggregated Load Shedding." California Energy Commission. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.194.8047&rep=rep1&type=pdf

Wiesenthal, J. (2011). "Nomura Examines The Economic Impact Of Rolling Blackouts In Japan." *Business Insider*. Available at: www.businessinsider.com/japan-rolling-blackouts-2011-3

7. Appendix 1: Organizational Learning

This Appendix outlines some trends that were observed in the data that lead to conclusions supporting a learning effect over the different phases of the buildings. Analysis of Variance (ANOVA) tests were used to compare the three dependent factors used above in the regression analysis (for environmental satisfaction, health, and job satisfaction/ productivity) by each building phase (as described in Section 3). Tests using each individual variable for each factor were done as well, with the most interesting environmental results being presented here.

Environmental Satisfaction

A one-way between subjects ANOVA was conducted to compare the effect of building phase level on satisfaction towards environmental conditions between phases one, two, and three (Tables 13 through 15). This resulted in a significant effect at the 5% level for the three conditions [F (2, 336) = 4.304, p = 0.014]. Results such as this suggest that the survey results for *at least* one condition (building phase) are statistically different than the others, but does not tell us which one(s), or in which direction the difference is.

As such, post hoc comparisons using the Tukey HSD test were run, which indicated that the mean score for environmental satisfaction in phase three (M = 43.12, SD = 12.95) was significantly greater than phase two (M = 34.15, SD = 19.20). However, phase one did not significantly differ from phases two and three (M = 39.65, SD = 16.47).

Table 13

Descriptives

Final factor analysis of env conditions

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Phase 1	229	39.6545	16.46551	1.08807	37.5105	41.7984	.00	69.40
Phase 2	61	34.1472	19.19608	2.45781	29.2309	39.0636	11.25	63.56
Phase 3	49	43.1171	12.94590	1.84941	39.3986	46.8355	15.82	69.19
Total	339	39.1640	16.70522	.90730	37.3793	40.9487	.00	69.40

Table 14

ANOVA

Final factor analysis of env conditions

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2356.049	2	1178.025	4.304	.014
Within Groups	91967.725	336	273.713		
Total	94323.775	338			

Table 15

Multiple Comparisons

Dependent Variable: Final factor analysis of env conditions

Tukey HSD

(I) What phase the building is	(J) What phase the building is	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Phase 1	Phase 2	5.50727	2.38377	.056	-.1045	11.1190
	Phase 3	-3.46256	2.60408	.380	-9.5930	2.6678
Phase 2	Phase 1	-5.50727	2.38377	.056	-11.1190	.1045
	Phase 3	-8.96983*	3.17381	.014	-16.4415	-1.4982
Phase 3	Phase 1	3.46256	2.60408	.380	-2.6678	9.5930
	Phase 2	8.96983*	3.17381	.014	1.4982	16.4415

*. The mean difference is significant at the 0.05 level.

As learning effects in regards to environmental satisfaction are especially important for this project, the individual variables of the Environmental Satisfaction factor were each also analyzed (Tables 16-18). Specifically, satisfactions with air quality, temperature, noise levels, and electric lighting were compared across each phase. The immediate results gained from each are as follows:

1) There *was not* a significant effect of differing building phases on satisfaction with air quality at the 5% level for the three phases [$F(2, 434) = 2.65$, $p = 0.072$]
2) There *was* a significant effect on satisfaction with temperature at the 5% level for the three phases [$F(2, 459) = 10.76$, $p = 0.000$]
3) There *was* a significant effect on satisfaction with noise levels at the 5% level for the three phases [$F(2, 459) = 13.51$, $p = 0.000$]
4) There *was* a significant effect on satisfaction with electric lighting at the 5% level for the three phases [$F(2, 431) = 4.49$, $p = 0.012$]

Based on these ANOVA F-statistics, post hoc comparisons are again needed for three of the four variables. Looking at temperature satisfaction first, the Tukey post estimation test revealed that the mean score for phase three ($M = 21.46$, $SD = 25.19$) was significantly greater than both those for phases one ($M = 5.54$, $SD = 29.35$) and two ($M = 7.24$, $SD = 32.25$). This suggests that improvements made between phases two and three were successful in increasing thermal comfort in the buildings, but any changes between phases one and two were negligible.

Comparing satisfaction with noise levels next, phase two was shown to score significantly *lower* ($M = 3.73$, $SD = 33.90$) than phases one ($M = 21.30$, $SD = 23.32$) and three ($M = 18.51$, $SD = 31.02$), with no significant difference between the first and last phases. This suggests that a design used during only phase two significantly decreased aural comfort in the buildings.

Lastly, electric lighting was revealed to score significantly higher in phase three ($M = 26.91$, $SD = 20.71$) than in phase one ($M = 17.37$, $SD = 25.93$), with phase two not being significantly different from either ($M = 19.67$, $SD = 26.43$).

Table 16

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
How SATISFIED are you with the overall AIR QUALITY in your workspace?	Phase 1	263	17.2471	22.92961	1.41390	14.4631	20.0312	-50.00	50.00
	Phase 2	82	19.1220	26.64323	2.94225	13.2678	24.9761	-42.00	50.00
	Phase 3	92	23.9022	23.88022	2.48969	18.9567	28.8476	-50.00	50.00
	Total	437	19.0000	23.95351	1.14585	16.7479	21.2521	-50.00	50.00
How SATISFIED are you with the TEMPERATURE in your workspace?	Phase 1	285	5.5439	29.35364	1.73876	2.1214	8.9664	-50.00	50.00
	Phase 2	83	7.2410	32.25152	3.54006	.1986	14.2833	-45.00	50.00
	Phase 3	94	21.4574	25.18989	2.59814	16.2981	26.6168	-41.00	50.00
	Total	462	9.0866	29.72231	1.38281	6.3692	11.8040	-50.00	50.00
How SATISFIED are you with the NOISE level in your workspace?	Phase 1	284	21.2993	23.31862	1.38371	18.5756	24.0230	-50.00	50.00
	Phase 2	83	3.7349	33.89945	3.72095	-3.6672	11.1371	-50.00	50.00
	Phase 3	95	18.5158	31.01814	3.18239	12.1971	24.8345	-44.00	50.00
	Total	462	17.5714	27.88562	1.29736	15.0220	20.1209	-50.00	50.00
How SATISFIED are you with the ELECTRIC LIGHTING in your workspace?	Phase 1	270	17.3704	25.92991	1.57804	14.2635	20.4773	-50.00	50.00
	Phase 2	83	19.6747	26.42851	2.90091	13.9039	25.4455	-50.00	50.00
	Phase 3	81	26.9136	20.70821	2.30091	22.3346	31.4925	-20.00	50.00
	Total	434	19.5922	25.34386	1.21654	17.2011	21.9832	-50.00	50.00

Table 17

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
How SATISFIED are you with the overall AIR QUALITY in your workspace?	Between Groups	3020.165	2	1510.082	2.652	.072
	Within Groups	247143.835	434	569.456		
	Total	250164.000	436			
How SATISFIED are you with the TEMPERATURE in your workspace?	Between Groups	18245.325	2	9122.662	10.764	.000
	Within Groups	389009.212	459	847.515		
	Total	407254.537	461			
How SATISFIED are you with the NOISE level in your workspace?	Between Groups	19921.688	2	9960.844	13.505	.000
	Within Groups	338555.455	459	737.594		
	Total	358477.143	461			
How SATISFIED are you with the ELECTRIC LIGHTING in your workspace?	Between Groups	5675.238	2	2837.619	4.489	.012
	Within Groups	272445.575	431	632.124		
	Total	278120.813	433			

Table 18

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) What phase the building is	(J) What phase the building is	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
How SATISFIED are you with the overall AIR QUALITY in your workspace?	Phase 1	Phase 2	-1.87480	3.01825	.809	-8.9731	5.2235
		Phase 3	-6.65503	2.89050	.057	-13.4528	.1428
	Phase 2	Phase 1	1.87480	3.01825	.809	-5.2235	8.9731
		Phase 3	-4.78022	3.62413	.385	-13.3034	3.7429
	Phase 3	Phase 1	6.65503	2.89050	.057	-.1428	13.4528
		Phase 2	4.78022	3.62413	.385	-3.7429	13.3034
How SATISFIED are you with the TEMPERATURE in your workspace?	Phase 1	Phase 2	-1.69710	3.63108	.887	-10.2350	6.8408
		Phase 3	-15.91359*	3.46264	.000	-24.0554	-7.7718
	Phase 2	Phase 1	1.69710	3.63108	.887	-6.8408	10.2350
		Phase 3	-14.21648*	4.38488	.004	-24.5268	-3.9061
	Phase 3	Phase 1	15.91359*	3.46264	.000	7.7718	24.0554
		Phase 2	14.21648*	4.38488	.004	3.9061	24.5268
How SATISFIED are you with the NOISE level in your workspace?	Phase 1	Phase 2	17.56436*	3.38878	.000	9.5962	25.5325
		Phase 3	2.78351	3.21890	.663	-4.7852	10.3522
	Phase 2	Phase 1	-17.56436*	3.38878	.000	-25.5325	-9.5962
		Phase 3	-14.78085*	4.08054	.001	-24.3756	-5.1861
	Phase 3	Phase 1	-2.78351	3.21890	.663	-10.3522	4.7852
		Phase 2	14.78085*	4.08054	.001	5.1861	24.3756
How SATISFIED are you with the ELECTRIC LIGHTING in your workspace?	Phase 1	Phase 2	-2.30433	3.15550	.746	-9.7255	5.1169
		Phase 3	-9.54321*	3.18515	.008	-17.0342	-2.0522
	Phase 2	Phase 1	2.30433	3.15550	.746	-5.1169	9.7255
		Phase 3	-7.23888	3.92683	.157	-16.4741	1.9964
	Phase 3	Phase 1	9.54321*	3.18515	.008	2.0522	17.0342
		Phase 2	7.23888	3.92683	.157	-1.9964	16.4741

*. The mean difference is significant at the 0.05 level.

Also computed in the Environmental Satisfaction factor were three other variables gauging satisfaction with the ability to adjust the environment. Once again, results from each of these questions were analyzed based on phase number (Tables 19 and 20). The results gained from each are as follows:

1) There *was not* a significant effect on satisfaction with the ability to change indoor air quality at the 5% level for the three phases [$F(2, 423) = 1.366$, $p = 0.256$]
2) There *was not* a significant effect on satisfaction with the ability to change temperature at the 5% level for the three phases [$F(2, 445) = 1.638$, $p = 0.196$]
3) There *was not* a significant effect on satisfaction with the ability to adjust lighting at the 5% level for the three phases [$F(2, 435) = 1.490$, $p = 0.226$]

Here, we can see that none of these conditions showed improvement or detriment across time, as scores for all three phases are statistically the same across each variable. We can conclude therefore that overall satisfaction with the ability to change the environment has not changed over time, and has remained at the same (negative) level, suggesting that new improvements need to be made.

Table 19

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
How satisfied are you with your ABILITY TO CHANGE the INDOOR AIR QUALITY in your workspace	Phase 1	276	-7.9710	30.15160	1.81491	-11.5439	-4.3981	-50.00	50.00
	Phase 2	71	-14.3099	34.36302	4.07814	-22.4435	-6.1763	-50.00	50.00
	Phase 3	79	-7.9494	21.51380	2.42049	-12.7682	-3.1305	-50.00	50.00
	Total	426	-9.0235	29.55146	1.43177	-11.8377	-6.2092	-50.00	50.00
How satisfied are you with your ABILITY TO CHANGE the TEMPERATURE in your workspace?	Phase 1	291	-12.9828	31.54236	1.84905	-16.6221	-9.3436	-50.00	50.00
	Phase 2	71	-15.8310	34.56463	4.10207	-24.0123	-7.6497	-50.00	46.00
	Phase 3	86	-7.4535	21.88185	2.35958	-12.1450	-2.7620	-50.00	50.00
	Total	448	-12.3728	30.50268	1.44112	-15.2050	-9.5406	-50.00	50.00
How satisfied are you with your ABILITY TO ADJUST the LIGHTING in your workspace?	Phase 1	274	5.6642	31.88861	1.92646	1.8716	9.4568	-50.00	50.00
	Phase 2	85	7.2353	38.68851	4.19636	-1.1096	15.5802	-50.00	50.00
	Phase 3	79	-.6456	23.17383	2.60726	-5.8362	4.5451	-50.00	50.00
	Total	438	4.8311	32.02829	1.53037	1.8232	7.8389	-50.00	50.00

Table 20

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
How satisfied are you with your ABILITY TO CHANGE the INDOOR AIR QUALITY in your workspace	Between Groups	2381.017	2	1190.508	1.366	.256
	Within Groups	368766.749	423	871.789		
	Total	371147.765	425			
How satisfied are you with your ABILITY TO CHANGE the TEMPERATURE in your workspace?	Between Groups	3038.548	2	1519.274	1.638	.196
	Within Groups	412856.200	445	927.767		
	Total	415894.748	447			
How satisfied are you with your ABILITY TO ADJUST the LIGHTING in your workspace?	Between Groups	3051.018	2	1525.509	1.490	.226
	Within Groups	445228.480	435	1023.514		
	Total	448279.498	437			

Health

Also analyzed was the Health factor used in Section 4 across each phase. A one-way ANOVA was conducted to compare the effect of building phase level on health related responses between phases one, two, and three (Tables 21 through 23). This resulted in a significant effect at the 5% level for the three conditions [F (2, 470) = 11.27, p = 0.000]. Results such as this suggest that the survey results for *at least* one building phase are statistically different than the others, but does not tell us which one(s), or in which direction the difference is.

As such, post hoc comparisons using the Tukey HSD test were once again run, which suggested that the mean score for health related questions in phase three (M = 53.41, SD = 10.69) was significantly greater than both phases one (M = 48.55, SD = 10.94) and two (M = 45.64, SD = 14.68). Phases one and two were not significantly different from each other.

Table 21

Descriptives

Final factor analysis of health responses

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Phase 1	280	48.5539	10.94093	.65385	47.2668	49.8410	.00	65.44
Phase 2	90	45.6394	14.68040	1.54745	42.5646	48.7141	12.01	65.06
Phase 3	103	53.4184	10.68707	1.05303	51.3297	55.5070	19.69	65.44
Total	473	49.0586	11.94170	.54908	47.9797	50.1376	.00	65.44

Table 22

ANOVA

Final factor analysis of health responses

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3081.293	2	1540.646	11.274	.000
Within Groups	64227.945	470	136.655		
Total	67309.238	472			

Table 23

Multiple Comparisons

Dependent Variable: Final factor analysis of health responses

Tukey HSD

(I) What phase the building is	(J) What phase the building is	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Phase 1	Phase 2	2.91450	1.41649	.100	-.4159	6.2449
	Phase 3	-4.86447*	1.34715	.001	-8.0318	-1.6971
Phase 2	Phase 1	-2.91450	1.41649	.100	-6.2449	.4159
	Phase 3	-7.77898*	1.68675	.000	-11.7448	-3.8131
Phase 3	Phase 1	4.86447*	1.34715	.001	1.6971	8.0318
	Phase 2	7.77898*	1.68675	.000	3.8131	11.7448

*. The mean difference is significant at the 0.05 level.

Job Satisfaction and Productivity

The final ANOVA examined the Job Satisfaction and Productivity factor, again across each phase (Tables 24-26). Once again, this resulted in a significant difference at the 5% level in at least one of the three phases [F (2, 500) = 10.09, p = 0.000].

Tukey post estimation results showed that the main (and only) difference came between phases one (M = 56.63, SD = 12.77) and three (M = 62.81, SD = 10.71), with three being rated significantly higher than one, once again suggesting learned improvement over time. Phase two (M = 59.36, SD = 14.01) was not significantly different from either phase one or three.

Table 24

Descriptives

Final factor analysis of productivity responses

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Phase 1	294	56.6297	12.77159	.74485	55.1638	58.0957	.00	74.28
Phase 2	96	59.3591	14.00651	1.42953	56.5211	62.1970	8.85	74.28
Phase 3	113	62.8100	10.70503	1.00704	60.8146	64.8053	28.54	74.28
Total	503	58.5390	12.81667	.57147	57.4163	59.6618	.00	74.28

Table 25

ANOVA

Final factor analysis of productivity responses

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3197.539	2	1598.769	10.085	.000
Within Groups	79264.508	500	158.529		
Total	82462.047	502			

Table 26

Multiple Comparisons

Dependent Variable: Final factor analysis of productivity responses

Tukey HSD

(I) What phase the building is	(J) What phase the building is	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Phase 1	Phase 2	-2.72935	1.48005	.156	-6.2085	.7498
	Phase 3	-6.18024*	1.39360	.000	-9.4562	-2.9043
Phase 2	Phase 1	2.72935	1.48005	.156	-.7498	6.2085
	Phase 3	-3.45089	1.74764	.120	-7.5591	.6573
Phase 3	Phase 1	6.18024*	1.39360	.000	2.9043	9.4562
	Phase 2	3.45089	1.74764	.120	-.6573	7.5591

*. The mean difference is significant at the 0.05 level.

The next step in this research would be to try to isolate the specific changes made between phases that caused these positive and negative effects across time for each factor.

8. Appendix 2: Baseline Survey Instrument

Green Buildings Baseline Survey Summer 2013 - V2

Q1.1 Building Occupant Initial Survey.
Thank you for agreeing to participate in this US DOE Energy Efficient Buildings Hub survey. The survey takes approximately 10-15 minutes to complete. Please DO NOT USE THE BACK BUTTON, as it will take you to the beginning of the survey without saving your responses.

Q1.2 Background information about your work

Q1.3 How many years have you worked for this organization?
- ❍ Less than 1 year (1)
- ❍ 1 to 3 years (2)
- ❍ 3 to 10 years (3)
- ❍ 10 to 20 years (4)
- ❍ More than 20 years (5)

Q1.4 How would you describe the work you do?
- ❍ Executive / Managerial (1)
- ❍ Professional / Technical (2)
- ❍ Clerical / Support (3)
- ❍ Other (please specify) (4) _____

Q2.1 Background Information (Workspace)

Q2.3 How long have you worked in this building?
- ❍ Less than 3 months (1)
- ❍ 3 to 6 months (2)
- ❍ 6 to 12 months (3)
- ❍ 1 to 3 years (4)
- ❍ 3 to 10 years (5)
- ❍ 10 to 20 years (6)
- ❍ more than 20 years (7)

Q2.4 Where is your workspace located?
- ❍ Floor 1 (1)
- ❍ Floor 2 (2)
- ❍ Floor 3 (3)
- ❍ Other (4) _____
- ❍ My building is one story (5)

Q2.5 We would like to know which side of the building your workspace is in. For example, is your workspace located nearest the northwest, southwest, northeast, or southeast wall of the building? Please refer to the site map below.

- ❍ Northeastern exposure (toward open field) (1)
- ❍ Northwestern exposure (toward Best Western) (2)
- ❍ Southeastern exposure (toward PA Turnpike) (3)
- ❍ Southwestern exposure (toward URS Warehouse area) (4)
- ❍ Other (Please specify) (5) _____
- ❍ Don't know (6)

Q2.6 How long have you occupied your present workspace (e.g., enclosed office, cubicle, or other space that you consider to be your primary work location)?

- ❍ Less than 3 months (1)
- ❍ 3 to 6 months (2)
- ❍ 6 to 12 months (3)
- ❍ 1 to 3 years (4)
- ❍ 3 to 10 years (5)
- ❍ 10 to 20 years (6)
- ❍ More than 20 years (7)

Q2.7 Which of the following best describes your workspace?

- ❍ Enclosed office, private (1)
- ❍ Enclosed office, shared with other people (2)
- ❍ Shared cubicle with high partitions (about five or more feet high) (3)
- ❍ Private cubicle with high partitions (about five or more feet high) (4)
- ❍ Shared cubicle with low partitions (lower than five feet high) (5)
- ❍ Private cubicle with low partitions (lower than five feet high) (6)
- ❍ Workspace in an open office with no partitions (just desks) (7)
- ❍ Other (please specify) (8) _____

Q2.8 Do any of your partitions or walls contain transparent panels?

- ❍ Yes (1)
- ❍ No (2)

Q3.1 Qualities of the Indoor Environment Air Quality

Q3.2 How satisfied are you with the following attributes related to environmental quality of your workspace?

	Very Dissatisfied (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Satisfied (7)
Air quality (1)	❍	❍	❍	❍	❍	❍	❍
Air freshness (2)	❍	❍	❍	❍	❍	❍	❍
Air movement (3)	❍	❍	❍	❍	❍	❍	❍
Humidity (too much or too little) (4)	❍	❍	❍	❍	❍	❍	❍

Q3.3 How frequently do you experience the following environmental conditions at your workspace?

	Daily (1)	1-3 Days/Week (2)	1-3 Days/Month (3)	Not in the last month (4)	Never (5)
Air drafts (1)	❍	❍	❍	❍	❍
Stuffiness (2)	❍	❍	❍	❍	❍
Too humid (3)	❍	❍	❍	❍	❍
Too dry (4)	❍	❍	❍	❍	❍
Unpleasant odors (5)	❍	❍	❍	❍	❍
Air quality varies (6)	❍	❍	❍	❍	❍

Q3.5 Comments on air quality:

Q3.6 To improve the air quality in your workspace, how often do you...

	Don't have this feature (85)	Can't be adjusted (86)	More than 2 times a day (91)	1-2 times / day (90)	1-3 times / week (89)	1-3 times / month (88)	Not in the last month (87)	Never (92)
Use an air purifier (1)	❍	❍	❍	❍	❍	❍	❍	❍
Open or close doors (2)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust vents (3)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust windows (4)	❍	❍	❍	❍	❍	❍	❍	❍
Turn on fan (5)	❍	❍	❍	❍	❍	❍	❍	❍
Use non-toxic cleaners (6)	❍	❍	❍	❍	❍	❍	❍	❍
Use air freshener (7)	❍	❍	❍	❍	❍	❍	❍	❍
Notify management (my supervisor, main office or facilities dept.) (9)	❍	❍	❍	❍	❍	❍	❍	❍
Other (please specify) (10)	❍	❍	❍	❍	❍	❍	❍	❍
Use a humidifier or dehumidifier (11)	❍	❍	❍	❍	❍	❍	❍	❍

Q3.9 How satisfied are you with your ability to improve the INDOOR AIR QUALITY in your workspace?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Very Dissatisfied:Very Satisfied (1)	❍	❍	❍	❍	❍	❍	❍

Q4.1 Temperature

Q4.2 How satisfied are you with the following attributes related to environmental quality of your workspace?

	Very Dissatisfied (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Satisfied (7)
Current temperature (26)	❍	❍	❍	❍	❍	❍	❍
Heating (27)	❍	❍	❍	❍	❍	❍	❍
Cooling (28)	❍	❍	❍	❍	❍	❍	❍

Q4.3 How frequently do you experience the following environmental conditions in your workspace?

	Daily (1)	1-3 Days/week (2)	1-3 Days/month (3)	Not in the last month (4)	Infrequently / Almost never (5)	Never (6)
Temperature too hot in heating season (1)	❍	❍	❍	❍	❍	❍
Temperature too cold in heating season (2)	❍	❍	❍	❍	❍	❍
Temperature too hot in cooling season (3)	❍	❍	❍	❍	❍	❍
Temperature too cold in cooling season (4)	❍	❍	❍	❍	❍	❍
Temperature varies from day to day (5)	❍	❍	❍	❍	❍	❍

Q4.4 Do you ever feel too hot or cold to be able to focus on your work?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Definitely:Not at all (1)	❍	❍	❍	❍	❍	❍	❍

Q4.6 Comments on temperature in cooling season:

Q4.7 Comments on temperature in heating season:

Q4.8 We would like to know more about your desired temperature during the CURRENT SEASON. On the thermometer scale please use the top arrow to indicate the temperature you typically have at midday (noon). Use the bottom arrow to indicate the temperature you would like to have, at the same time of day.
_____ Typical temperature at mid-day (in Fahrenheit): (1)
_____ Desired temperature at mid-day (in Fahrenheit): (2)

Q4.9 Which of the statements below best describes your situation? (check only 1)
- ❍ I have control of a thermostat that adjusts temperature for my workspace only. (1)
- ❍ I share control of a thermostat that adjusts temperature for my workspace as well as that of others. (2)
- ❍ The thermostat that adjusts temperature in my workspace is controlled by my supervisor. (3)
- ❍ The thermostat that adjusts temperature in my workspace is controlled by the building manager. (4)
- ❍ There is no thermostat that adjusts temperature in my workspace. (5)
- ❍ Other (6) _____

Q4.10 If the temperature in your workspace is too hot or too cold, what do you usually do? (Check all that apply)

	Don't have this feature (64)	Can't be adjusted (65)	More than 2 times a day (70)	1-2 times/ day (69)	1-3 times/ week (68)	1-3 times/ month (67)	Not in the last month (66)	Never (71)
Adjust thermostat (1)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust air vent (2)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust portable fan (3)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust room air conditioner unit (4)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust ceiling fan (5)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust portable heater (6)	❍	❍	❍	❍	❍	❍	❍	❍
Open or close windows (7)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust window blinds or shades (8)	❍	❍	❍	❍	❍	❍	❍	❍
Open or close door (9)	❍	❍	❍	❍	❍	❍	❍	❍
Dress in layers/adjust clothing (10)	❍	❍	❍	❍	❍	❍	❍	❍
Notify management (my supervisor, main office or facilities dept.) (11)	❍	❍	❍	❍	❍	❍	❍	❍

Other (please specify) (12)	❍	❍	❍	❍	❍	❍	❍	❍

Q4.12 How much do you Agree or Disagree with the following statement?

	Very Strongly Disagree (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Strongly Agree (7)	N/A (-999)
It is easy to figure out how the heating, cooling and ventilation systems work here in order to adjust them. (1)	❍	❍	❍	❍	❍	❍	❍	❍

Q4.13 How satisfied are you with your ability to improve the TEMPERATURE in your workspace?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Very Dissatisfied:Very Satisfied (1)	❍	❍	❍	❍	❍	❍	❍

Q5.1 Lighting

Q5.2 We would like to know more about your desired amount of lighting. On the scale below, where 100 is the maximum possible light available in a workspace (all lights on full, shades open on a bright day) and 0 is complete darkness, please use the top arrow to indicate the amount of light you typically have at midday (noon) and the bottom arrow to indicate how much light you would like to have, at the same time of day.

_____ Amount of light you have at midday: (1)
_____ Amount of light you want at midday: (2)

Q6.1 Does natural light from the sun or sky provide general lighting in your workspace?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not sure (4)

If No Is Selected, Then Skip To End of Block

Q6.2 Indicate your agreement with the following statements about daylight in your workspace:

	Very Strongly Disagree (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Strongly Agree (7)	NA (8)
The blinds or other shading devices are effective in blocking out unwanted light from the sun and/or sky. (1)	❍	❍	❍	❍	❍	❍	❍	❍
I am bothered that I lose daylight when I adjust shades/blinds to block out the heat from the windows (3)	❍	❍	❍	❍	❍	❍	❍	❍
Overall, I am satisfied with the daylighting in my workspace (5)	❍	❍	❍	❍	❍	❍	❍	❍

Q6.3 How often do you experience the following conditions in your workspace?

	Daily (1)	1-3 Days / Week (2)	1-3 Days / Month (3)	Not in the last month (4)	Infrequently / Almost never (5)	NA (6)
Daylight too bright, glare (1)	❍	❍	❍	❍	❍	❍
Daylight too dim, gloomy (2)	❍	❍	❍	❍	❍	❍

Q6.4 How satisfied are you with...

	Very Dissatisfied (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Satisfied (7)	NA (8)
Daylighting (1)	❍	❍	❍	❍	❍	❍	❍	❍
Ability to adjust daylighting (2)	❍	❍	❍	❍	❍	❍	❍	❍

Q7.1 How often do you experience the following conditions in your workspace?

	Daily (1)	1-3 Days / Week (2)	1-3 Days / Month (3)	Not in the last month (4)	Infrequently / Almost never (5)	NA (6)
Electric light too bright, glare (1)	❍	❍	❍	❍	❍	❍
Electric light too dim (2)	❍	❍	❍	❍	❍	❍

Q7.2 How satisfied are you with...

	Very Dissatisfied (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Satisfied (7)	NA (8)
Electric lighting (1)	❍	❍	❍	❍	❍	❍	❍	❍
Ability to adjust electric lighting (2)	❍	❍	❍	❍	❍	❍	❍	❍

Q7.3 To adjust the lighting in your workspace, how often do you.....

	Don't have this feature (1)	Can't be adjusted (7)	More than 2 times/ day (2)	1-2 times/ day (3)	1-3 times/ week (4)	1-3 times/ month (5)	Not in the last month (6)	Never (8)
Adjust window blinds or shades (1)	❍	❍	❍	❍	❍	❍	❍	❍
Turn my overhead lighting on or off with a switch (2)	❍	❍	❍	❍	❍	❍	❍	❍
Adjust the level of my overhead lighting with a dimmer (3)	❍	❍	❍	❍	❍	❍	❍	❍
Turn on/off a task light (4)	❍	❍	❍	❍	❍	❍	❍	❍
Notify management (my supervisor, main office or facilities dept.) (6)	❍	❍	❍	❍	❍	❍	❍	❍
Other (please specify) (7)	❍	❍	❍	❍	❍	❍	❍	❍

Q7.5 Where is the dimmer located in your suite?

- ❍ On a wall within my workspace (2)
- ❍ On a wall outside my workspace (3)
- ❍ On my computer screen (4)
- ❍ On a computer screen that is in my office suite but not on my computer (5)
- ❍ I don't know (6)
- ❍ Other _____ (7)

Q7.6 In whose office is the dimmer control located (facility manager's office, supervisor's office, etc.)?

Q7.7 Does the dimmer control the overhead light in your workspace only?

- ❍ Yes (1)
- ❍ No, it also controls overhead light in other occupants' workspaces (2)
- ❍ I don't know (3)

Q7.8 How much do you Agree or Disagree with the following statements?

	Very Strongly Disagree (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Strongly Agree (7)	N/A (-999)
It is easy to figure out how the lighting systems work here in order to adjust them. (1)	❍	❍	❍	❍	❍	❍	❍	❍
It is easy to adjust window & shade systems. (2)	❍	❍	❍	❍	❍	❍	❍	❍
It is easy to find ways to override or adjust the light sensors if needed. (3)	❍	❍	❍	❍	❍	❍	❍	❍

Q7.9 Do you ever feel lighting is too bright or too dim to comfortably perform your work?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Definitely:Not at all (1)	❍	❍	❍	❍	❍	❍	❍

Q7.10 Please explain above response

Q8.1 Visual and Acoustic Privacy

Q8.2 From where you sit in your workspace, how satisfied are you with

	Very Dissatisfied (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Satisfied (7)
Access to a view of outside (1)	❍	❍	❍	❍	❍	❍	❍
Visual privacy (what people can see or what you can see from you workspace) (2)	❍	❍	❍	❍	❍	❍	❍
Acoustic privacy (what people can hear or what you can hear from your workspace) (3)	❍	❍	❍	❍	❍	❍	❍
Noise level (4)	❍	❍	❍	❍	❍	❍	❍

Q8.4 If noise affects your workspace, is the noise from (check all that apply):

- ❑ Conversations in adjacent workspaces (1)
- ❑ Conversations in the circulation / lobby areas (2)
- ❑ Background mechanical noise (3)
- ❑ Your communications (4)
- ❑ Other, please specify (5) _____
- ❑ Not relevant (6)

Q9.1 Overall Workspace Ratings

Q9.2 The following is asking how important these are to you, not how satisfied you are with them.

	Not All Important (1)	(2)	(3)	(4)	(5)	(6)	Very Important (7)
Noise levels (1)	❍	❍	❍	❍	❍	❍	❍
Temperature (2)	❍	❍	❍	❍	❍	❍	❍
Privacy (3)	❍	❍	❍	❍	❍	❍	❍
Air quality/Ventilation (4)	❍	❍	❍	❍	❍	❍	❍
Size of Work Space (5)	❍	❍	❍	❍	❍	❍	❍
View to the outside (6)	❍	❍	❍	❍	❍	❍	❍
Lighting (7)	❍	❍	❍	❍	❍	❍	❍
Daylight in my workspace (8)	❍	❍	❍	❍	❍	❍	❍
Ability to adjust my workspace to fit my needs (9)	❍	❍	❍	❍	❍	❍	❍
Comfort of furnishings (10)	❍	❍	❍	❍	❍	❍	❍

Q9.3 Taking all things into consideration, how satisfied are you with your workspace environment?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Very Dissatisfied :Very Satisfied (1)	❍	❍	❍	❍	❍	❍	❍

Q9.4 How well does your building perform in extreme weather conditions?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Not well at all:Very well (1)	❍	❍	❍	❍	❍	❍	❍

Q9.5 If you have any additional comments on how workspace and building features affect your work, please type in the text box below.

Q10.1 Health and Well-Being

The next several questions ask about your health, both in and outside of your workplace. Please answer to the best of your ability and skip any questions you do not wish to answer. Your responses are completely confidential and any identifying information is kept private, and may help guide improvements to the workplace.

Q10.2 General Health Please respond to each item by marking one box per row.

	Poor (1)	Fair (2)	Good (3)	Very Good (4)	Excellent (5)
In general, would you say your health is: (1)	❍	❍	❍	❍	❍
In general, would you say your quality of life is: (2)	❍	❍	❍	❍	❍
In general, how would you rate your physical health? (3)	❍	❍	❍	❍	❍
In general, how would you rate your mental health, including your mood and your ability to think? (4)	❍	❍	❍	❍	❍

Q10.3 How frequently have you experienced the following health problems in your workspace during the work day?

	Daily (1)	1-3 Times/week (2)	1-3 Days/month (3)	Not in the last month (4)	Infrequently/Almost never (5)	Never (6)
Fatigue (1)	❍	❍	❍	❍	❍	❍
Feeling of stress or irritability (2)	❍	❍	❍	❍	❍	❍
Inability to concentrate (3)	❍	❍	❍	❍	❍	❍
Lack of alertness, sleepiness (4)	❍	❍	❍	❍	❍	❍
Feeling unpleasant and out of sorts (5)	❍	❍	❍	❍	❍	❍
Headaches (6)	❍	❍	❍	❍	❍	❍
Eyes discomfort (7)	❍	❍	❍	❍	❍	❍
Symptoms of respiratory or allergy conditions (8)	❍	❍	❍	❍	❍	❍
Dry, itchy skin (9)	❍	❍	❍	❍	❍	❍
Muscular aches or pains (10)	❍	❍	❍	❍	❍	❍

Q11.1 Work Performance and Satisfaction

Q11.6 Do the following factors affect your motivation and ability to get the job done?

	Not at all (1)	Somewhat (2)	Definitely (3)	Very Definitely (4)
Salary (1)	❍	❍	❍	❍
Fringe benefits (2)	❍	❍	❍	❍
Management style (3)	❍	❍	❍	❍
Environmental quality of my workspace, generally (4)	❍	❍	❍	❍

Q11.7 Generally, how satisfied are you with your JOB?
_____ (1)

Q11.8 How would you rate the general QUALITY of your work?
_____ (1)

Q12.1 Please indicate how much you agree or disagree with the following statements.

	Very Strongly Disagree (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	Very Strongly Agree (7)	N/A (-999)
I feel it is very important for this building to save energy. (1)	❍	❍	❍	❍	❍	❍	❍	❍
Most people who are important to me think that I should save energy whenever possible (2)	❍	❍	❍	❍	❍	❍	❍	❍
Protecting the environment is an important goal in our society. (3)	❍	❍	❍	❍	❍	❍	❍	❍

Q12.2 People weigh many factors when choosing how to do things that use water and energy in their workplaces. Please rate each of the following items in response to the question: How important is it for you to avoid:

	Not Important (1)	Slightly Important (2)	Somewhat Important (3)	Very Important (4)	Supreme Importance (5)
Personal discomfort? (1)	❍	❍	❍	❍	❍
Effort and hassle? (2)	❍	❍	❍	❍	❍
Extra cost and expense? (3)	❍	❍	❍	❍	❍
Environmental impacts? (4)	❍	❍	❍	❍	❍

Q13.1 Background Information (Personal)
The following questions are about you. The answers to these questions will help us to further understand your experience in your workspace. Your responses to these and all questions will be held completely confidential. If you are uncomfortable about answering any of these questions please feel free to refrain from answering.

Q13.2 What is your sex?
- ❍ Female (1)
- ❍ Male (2)

Q13.3 What is your age?
- ❍ Under 20 (1)
- ❍ 20 to 29 (2)
- ❍ 30 to 39 (3)
- ❍ 40 to 49 (4)
- ❍ 50 to 59 (5)
- ❍ 60 to 69 (6)
- ❍ 70 and over (7)

Q13.4 What is the highest level of formal education you have completed?
- ❍ Completed grade school or less (1)
- ❍ Some high school (2)
- ❍ Completed high school or received GED (3)
- ❍ Some college (4)
- ❍ Completed college (5)
- ❍ Graduate or professional degree (6)
- ❍ Other_____ (-999)

Q13.5 Final major field of study in college (e.g., history, accounting, medicine)?
- ❍ Major: (1) _____
- ❍ N/A (-999)

Q13.6 Which of these categories represents your race/ethnic background? (Mark all that apply to you)
- ❑ White (1)
- ❑ Black or African American (2)
- ❑ American Indian or Alaska Native (3)
- ❑ Asian (4)
- ❑ Hispanic, Latino (5)
- ❑ Other (please specify) (6) _____

Q14.1 End of Survey.
If you are satisfied with your responses to the survey please click on the "Submit" button below. Please note that you will not be able to return to the survey once you click on "Submit". We really appreciate the time and effort you spent in answering this questionnaire. Thank you!!

9. Appendix 3: Daily Survey Instrument

GB 2013 Afternoon Daily

Q1 This is the "End of Work Day" survey: You will receive this daily afternoon survey approximately 2-3 times per week. Each daily takes approximately 2-3 minutes to complete. Each response you provide will be entered into the pool for the random drawings once the entire study is completed. This survey is part of the second component of the 2-part survey protocol in which you have already agreed to participate. Please take a few minutes now or before leaving to complete this survey. Thank you for your continued participation in this study!

PLEASE CHOOSE THE ANSWER THAT BEST REFLECTS YOUR RESPONSE CONSIDERING YOUR TIME AT WORK THIS AFTERNOON.
Please complete this survey sometime before you leave work.

Q2 How many hours did you spend in YOUR WORKSPACE this afternoon (Please round to nearest hour)?
- ❑ 0 (8)
- ❑ 1 (2)
- ❑ 2 (3)
- ❑ 3 (4)
- ❑ 4 (5)
- ❑ 5 (6)
- ❑ 6+ (7)

Q3 How PLEASANT do you FEEL this afternoon?
_____ (1)

Q4 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q5 How ALERT do you FEEL this afternoon?
_____ (1)

Q6 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q7 How would you rate your PHYSICAL health this afternoon?
_____ (1)

Q8 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q9 How would you rate your MENTAL health, including your mood and your ability to think, this afternoon?
_____ (1)

Q10 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q11 How would you rate your ability to CONCENTRATE this afternoon?
_____ (1)

Q12 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q13 How STRESSED are you this afternoon?
_____ (1)

Q14 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q15 How FATIGUED are you this afternoon?
_____ (1)

Q16 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q17 How would you rate the QUALITY of your work this afternoon?
_____ (1)

Q18 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q19 How would you rate your PRODUCTIVITY this afternoon?
_____ (1)

Q20 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q21 How satisfied are you with your JOB this afternoon?
_____ (1)

Q22 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q23 How does the AIR QUALITY in your workspace today COMPARE to:
_____ Earlier today (1)
_____ The day before (2)

Q25 How SATISFIED are you with the overall AIR QUALITY in your workspace this afternoon?
_____ (1)

Q26 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q27 Which of the following conditions are you experiencing in your workspace?
- ❑ Air Drafts (1)
- ❑ Stuffiness (2)
- ❑ Too humid (3)
- ❑ Too Dry (4)
- ❑ Unpleasant odors (5)
- ❑ Air quality varies (6)

Q28 How satisfied are you with the TEMPERATURE in your workspace this afternoon?
_____ (1)

Q29 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q30 What changes did you make to improve the AIR QUALITY in your workspace this afternoon?
- ❑ Opened windows (1)
- ❑ Used freshner (2)
- ❑ Contacted facilities (3)
- ❑ Other (4) _____
- ❑ No changes made (5)

Q31 How satisfied are you with your ABILITY TO CHANGE the INDOOR AIR QUALITY in your workspace this afternoon?
_____ (1)

Q32 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q33 How does the TEMPERATURE in your workspace today COMPARE to:
_____ Earlier today (1)
_____ The day before (2)

Q34 How satisfied are you with the TEMPERATURE in your workspace this afternoon?
_____ (1)

Q35 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q36 Do you feel TOO HOT OR TOO COLD to be able to FOCUS on your work?
- ❍ Definitely (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ 6 (6)
- ❍ Not at all (7)

Q37 What kinds of CHANGES did you make to the TEMPERATURE in your workspace this afternoon?
- ❑ Opened windows (1)
- ❑ Adjusted local controls for vents, fans, thermostats (2)
- ❑ Contacted facilities (3)
- ❑ Other (4) _____
- ❑ No changes (5)

Q38 How SATISFIED are you withyour ABILITY to CHANGE the TEMPERATURE in your workspace this afternoon?
_____ (1)

Q39 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q40 How SATISFIED are you with the NOISE level in your workspace this afternoon?
_____ (1)

Q41 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q42 How does the LEVEL OF LIGHT in your workspace today COMPARE TO:
_____ Earlier today (1)
_____ The day before (2)

Q43 How satisfied are you with the ELECTRIC LIGHTING in your workspace this afternoon?
_____ (1)

Q44 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q45 Does the LIGHTING allow you to see well at your desk, in order to read, write, and use the computer?
- ❍ Not at all (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)
- ❍ Definately (6)

Q46 How did you adjust the LIGHTING in your workspace this afternoon? (choice, select all that apply)
- ❑ Used switch/dimmer for all overhead lights (1)
- ❑ Used switch/dimmer for some overhead lights (2)
- ❑ Adjusted task light (3)
- ❑ Adjusted the window shades or blinds (4)
- ❑ No adjustments made (5)
- ❑ Other (6) _____

Q47 How satisfied are you with your ability to adjust the LIGHTING in your workspace this afternoon?
_____ (1)

Q48 Do you want to leave this question without moving the slider? If No, please use the lower back button to go back and answer the question. If Yes, please select from the following:
- ❍ I want to skip this question (1)
- ❍ My answer choice is "0" (2)

Q49 How much does the WEATHER OUTSIDE today affect your indoor work environment?
_____ 1 (1)