

University of Pittsburgh

MCSI Energy Model Analysis

Final Report

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1. Overview

The main goal of this final report is to run multiple simulations with different settings to compare energy usage values. It will also be good to compare the energy usage values to the original values obtained by Justin DeBlois and Ziad Ewias from the model they constructed (before a lot of the material and internal specifications had been updated). All of the simulations are done in Energy Plus version 6.0.0.023 and the simulation parameters are developed in DesignBuilder version 2.4.2.016 and 2.4.2.026. The results are analyzed in Excel and the results are presented in this report.

2. Tasks

- Analyze the total energy usage and lighting energy usage for one week in the summer
- Analyze the total energy usage and lighting energy usage for one week in the winter
- Analyze the total energy usage and lighting energy usage for one week in the summer with a reduced lighting “on” schedule and compare to the baseline with the original lighting “on” schedule
- Analyze the total energy usage and lighting energy usage for one week in the winter with a reduced lighting “on” schedule and compare to the baseline with the original lighting “on” schedule

3. Analysis

Set-Up

The biggest time consumer of this part of the project was allowing the energy simulations to run. A one week simulation took approximately 10 hours, a one month simulation approximately 21 hours, and a one year simulation greater than 72 hours.

Energy Plus settings that were changed in DesignBuilder:

Option	Selection
Shading	Full Exterior
Wall Heat Transfer Method	Finite Difference Method
Maximum Number of Shading Overlaps	10000
Shadowing interval (days)	62 (only for full year simulation)

Table 1. Changes made from the standard Energy Plus settings in DesignBuilder

The benchmark source used in this report is a survey of commercial buildings done by the US Department of Energy in 2003. The Office category was used because while the MCSI is an educational facility, it consists mainly of offices rather than classrooms. (Energy Information Administration, Commercial Buildings Energy consumption Survey (CBECS), U.S. Dept. of Energy, 2003)

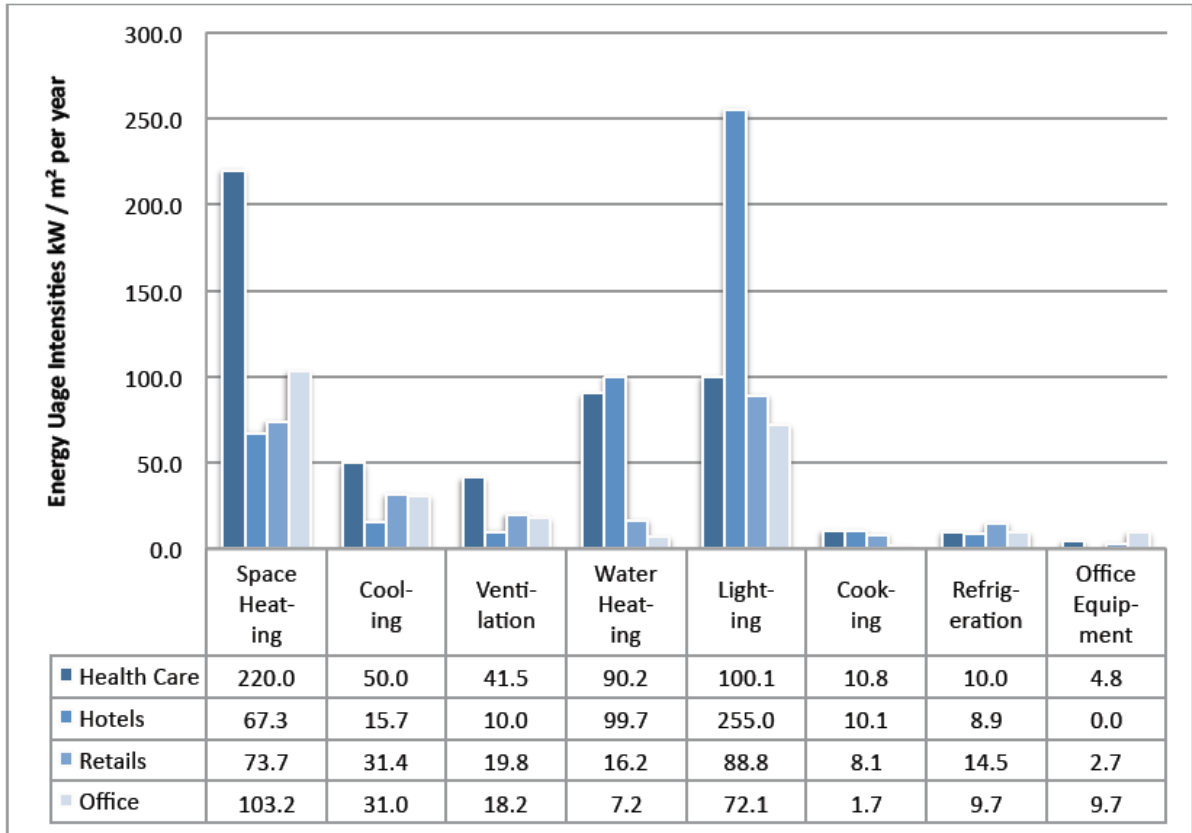


Figure 3.1 and Table 3.1: Energy usage intensities (EUI) of different building types

Figure 1. Benchmark model courtesy of Justin DeBlois and Ziad Eqias.

The benchmark values for Office Lighting will be compared to the values obtained from different simulations in DesignBuilder of the MCSI building.

First, here is what the lighting schedules look like for the weekdays and weekends that were used to test the effects of different amounts of lighting used in the simulations.

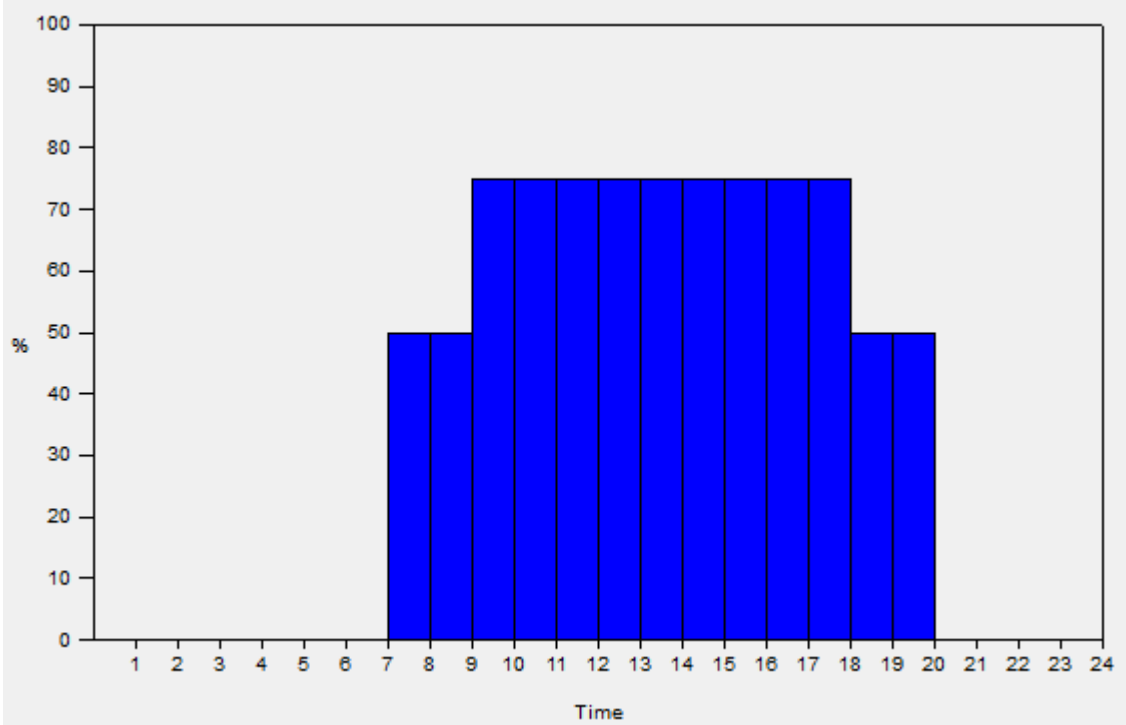


Figure 2. Weekday lighting schedule, original

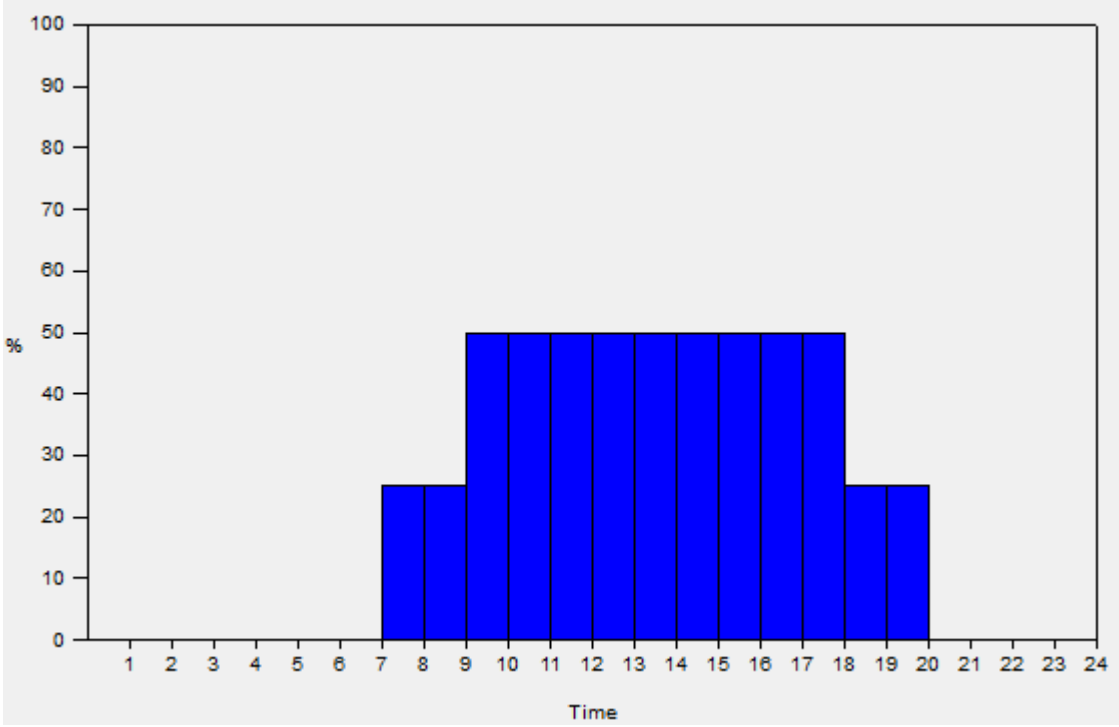


Figure 3. Weekday lighting schedule, reduced

As you can see from figures 2 & 3, the lighting was reduced by 25% each hour of the typical workday. This would be equivalent to using the lights 3.25 less hours a day.

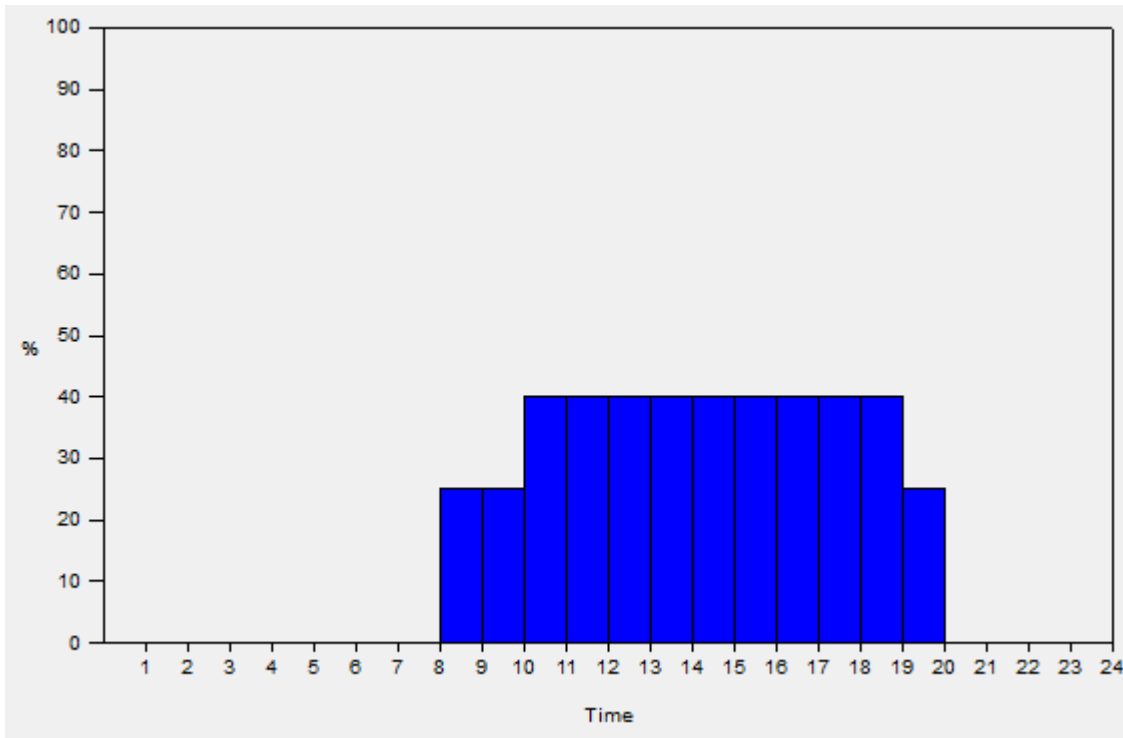


Figure 4. Weekend lighting schedule, original

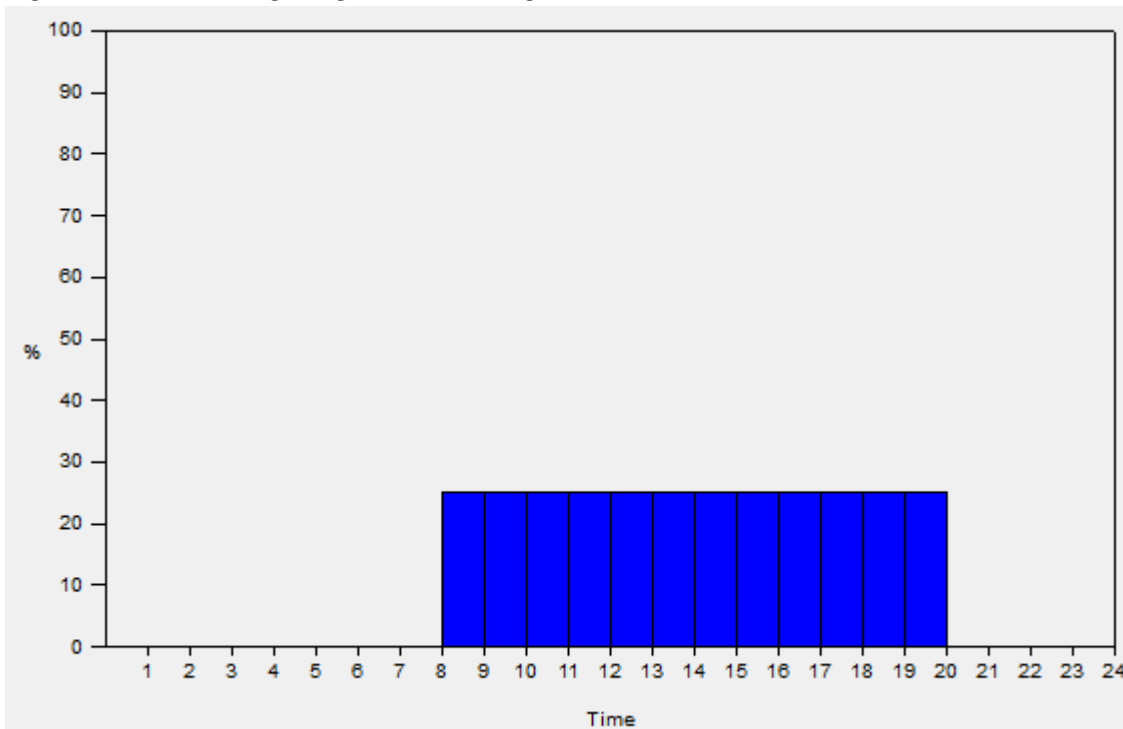


Figure 5. Weekend lighting schedule, reduced

As you can see from figures 4 & 5, the lighting was reduced by 15% for the hours from 10am to 7pm. This would be equivalent to using the lights 1.35 less hours a day. This is less of a change than what was done to the weekday schedules, but it should be safe to assume that the building is used much less during the weekends.

Results

Below are the graphs of the results from four EnergyPlus simulations. The electricity lines are the sum of the fuel consumed for electricity and gas and the lighting line is the fuel consumed just for lighting.

Here is what the total electrical energy consumption looks like for the MCSI building in the summer with the original lighting schedule.

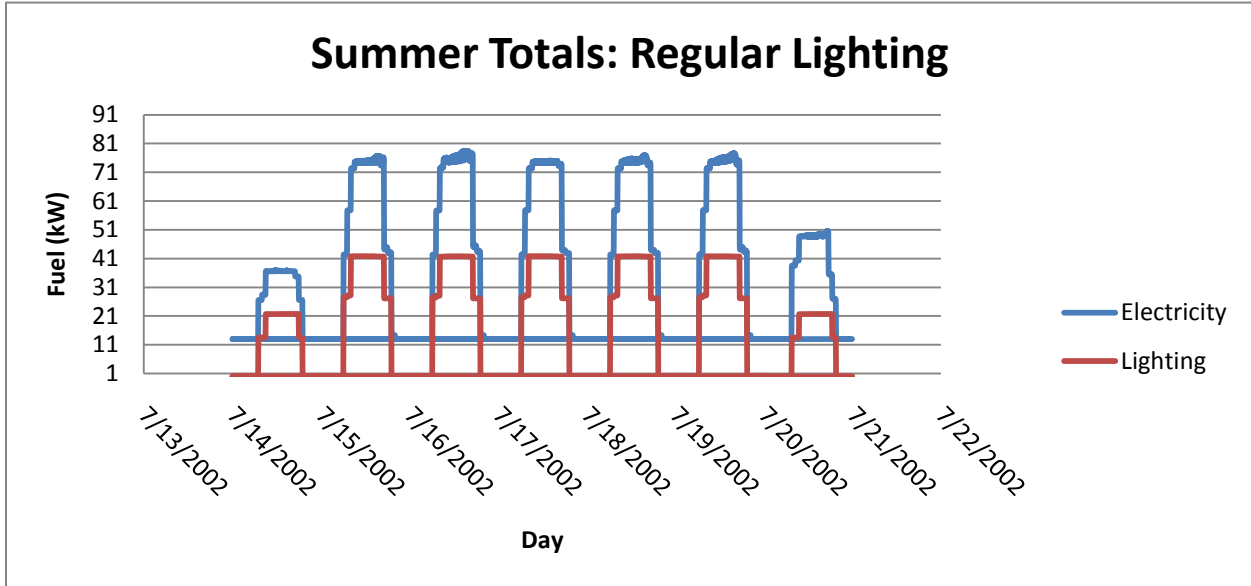


Figure 6. Graph of fuel consumption/day; regular lighting schedule; one week in the summer

Here is what the total electrical energy consumption looks like for the MCSI building in the summer with a reduced lighting schedule.

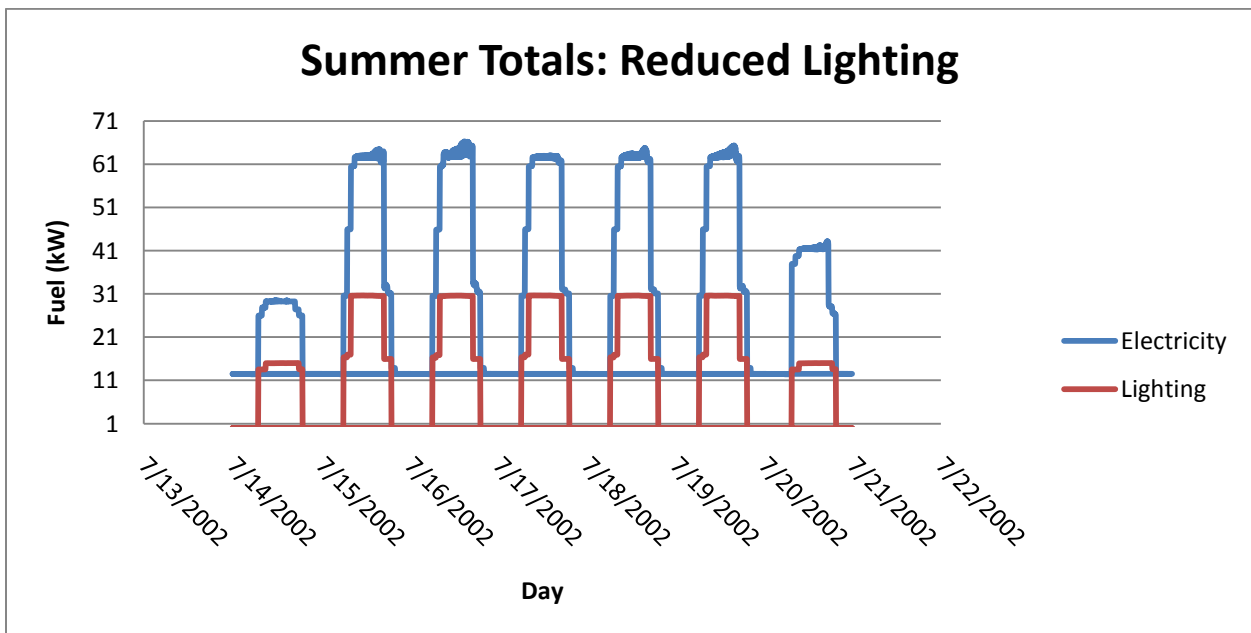


Figure 7. Graph of fuel consumption/day; reduced lighting schedule; one week in the summer

Here is what the total electrical energy consumption looks like for the MCSI building in the winter with the original lighting schedule.

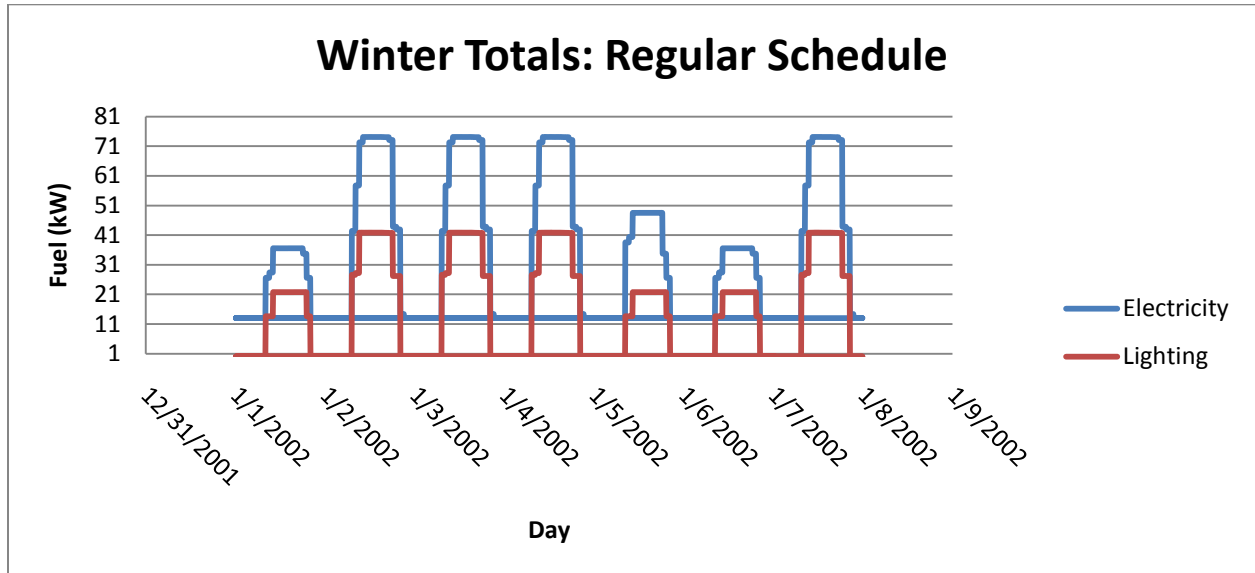


Figure 8. Graph of fuel consumption/day; regular lighting schedule; one week in the winter

Here is what the total electrical energy consumption looks like for the MCSI building in the summer with a reduced lighting schedule.

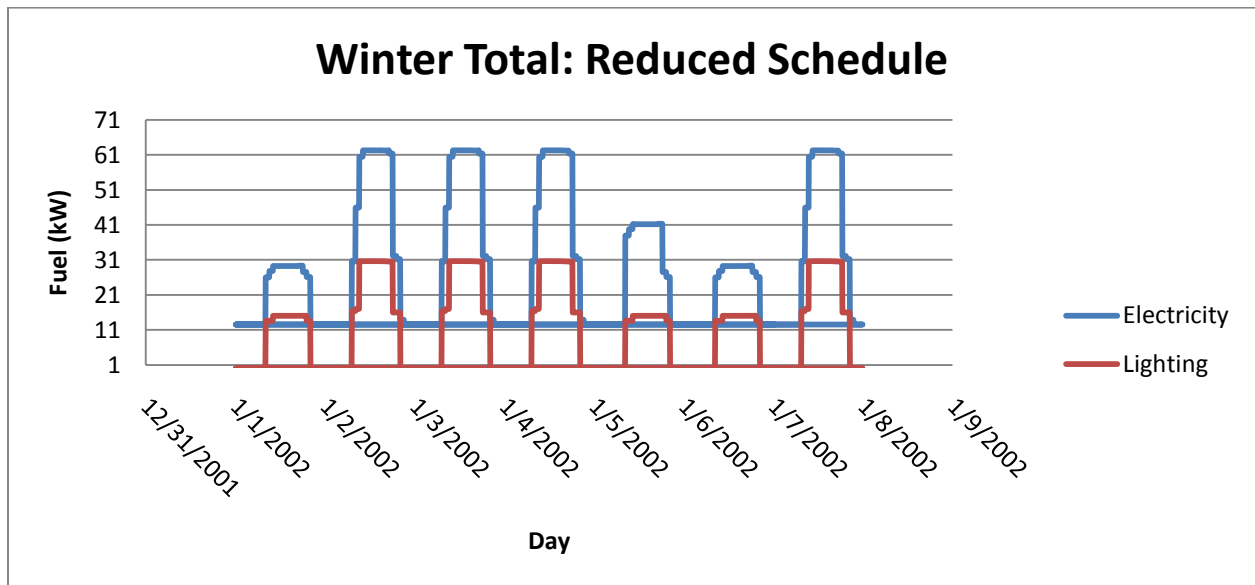


Figure 9. Graph of fuel consumption/day; reduced lighting schedule; one week in the winter

Tabulated summary of energy usage totals:

<u>Time</u>	<u>Lighting Schedule</u>	<u>Electricity (kWh)</u>	<u>Lighting (kWh)</u>	<u>Peak Electricity (kWh)</u>	<u>Peak Lighting (kWh)</u>	<u>% of Electricity Consumed by Lighting</u>
Summer	Regular	6281.38	2902.39	6.53	3.49	46.21%
Summer	Reduced	5327.41	2051.76	5.52	2.55	38.51%
Winter	Regular	5794.75	2655.07	6.18	3.49	45.82%
Winter	Reduced	4941.85	1889.72	5.20	2.55	38.24%

Table 2. Results from simulations; energy totals

<u>Time</u>	<u>Lighting Schedule</u>	<u>Difference in Electricity (kWh)</u>	<u>% Electrical Energy Saved</u>	<u>Difference in Lighting (kWh)</u>	<u>% Lighting Energy Saved</u>	<u>Cost Savings (\$/week)</u>
Summer	Regular	953.97	15.19%	850.62	29.31%	\$79.36
Summer	Reduced					
Winter	Regular	852.89	14.72%	765.34	28.83%	\$71.41
Winter	Reduced					

Table 3. Results from simulations; savings by reducing lighting

As you can see from tables 2 & 3, there are significant reductions in the amount of energy used for lighting by reducing the time the lights are on by only a small amount. When putting it into dollar terms we get savings that would average around \$75/week over the whole year, totaling to around \$3900 saving over the whole year. The dollar amounts were calculated using a rate of \$0.0933/kWh from Duquesne Light. The amounts do not reflect costs from the peak values.

4. Summary

This model can still be updated significantly to match the actual variables such as plug load, occupancy schedules, and lighting schedules. Once the electricity sensors are installed a more accurate estimation of plug load for each area can be determined. As for the occupancy, this will be very time consuming to determine because it mainly depends on class schedules and work schedules, which differ day by day. Lighting schedules are also somewhat difficult to determine because they depend on the occupancy and the sensors installed in different areas.

Seen in the results, reducing the time the lights are on can lead to a fairly significant cost savings for the year. It was calculated that by reducing the amount of time the lights are on by around 3 hours a day could lead to a savings of around \$3900 over the whole year.

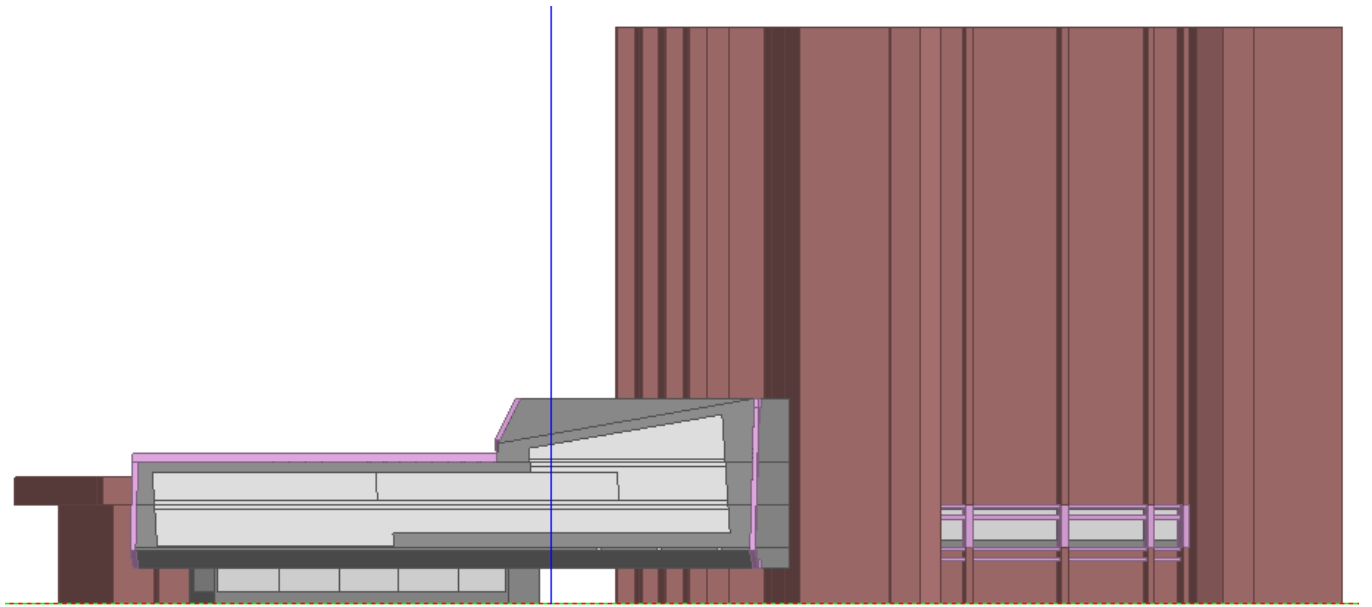


Figure 10. The DesignBuilder model used for all the simulations