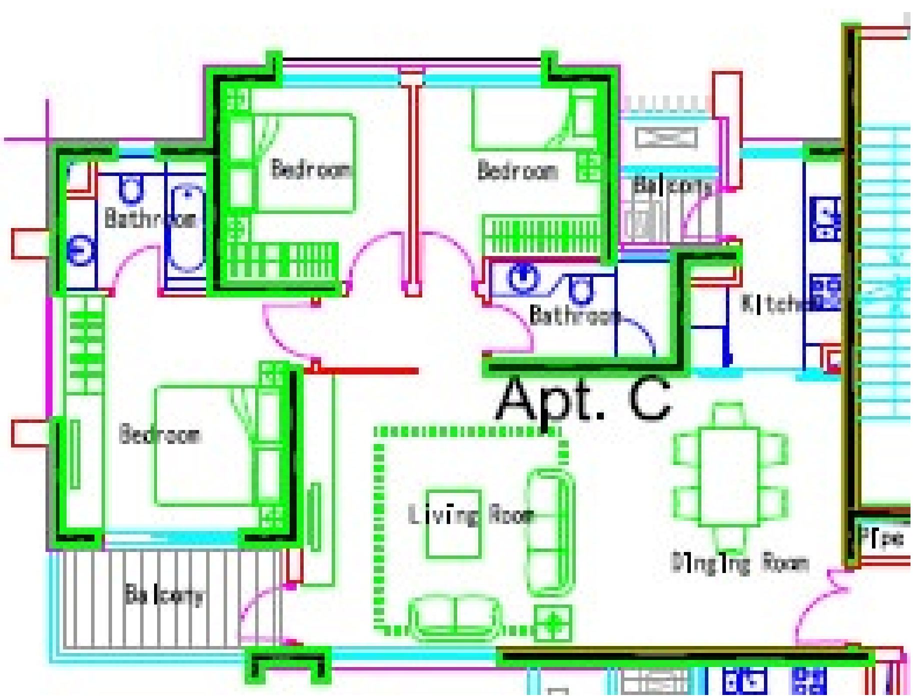
Ryan Ralston & Sam Rashid
Enviro II - Lighting
Interim Report

Building Description

The building is a single story apartment space. The living room and dining room face South, the Kitchen, two bedrooms and a bathroom face North, and the last bedroom faces West. The center of the apartment contains a small hall way and a bathroom for the two North facing bedrooms. The North facing bathroom connects to the West facing bedroom and the kitchen connects to the dining room. The dining room and the living room are all one space, but the window is located on the living room side of the space.

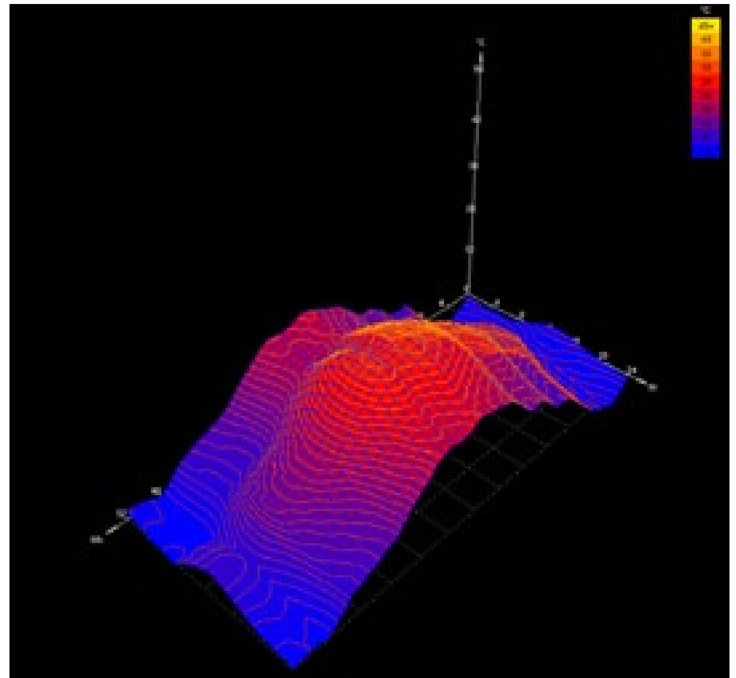
The intent for the spaces is pretty much self-explanatory. The living is designed as the primary living space while the bedrooms function as the secondary living spaces. The master bedroom is the West facing bedroom, because it is given it's own bathroom. Meals aren't eaten in the kitchen, or at least they are not supposed to be. The kitchen is very small and suggests that the meals are eaten in the dining room or even in the living room. The TV in the living room is on the West wall which implies everyone in the space will probably be facing West or Northwest if they want to watch their shows. The same condition occurs in the master bedroom. The counters in the kitchen are located on the East and West walls which means if you are preparing a meal you will either be facing East or West.

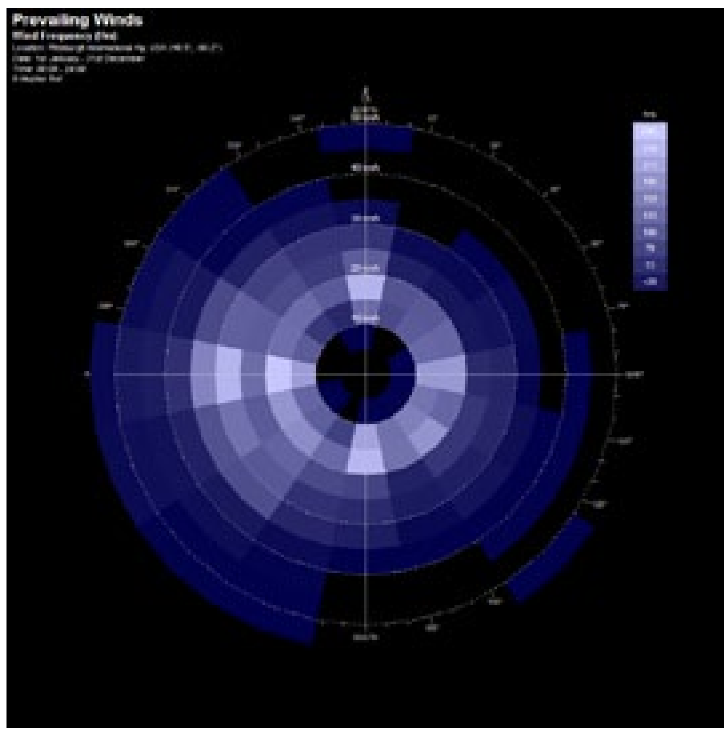
Materials play a huge roll in the design of this building. The building is concrete, but it is probably not exposed. It probably has at least a coat of paint on it. Glare is going to be a big issue. Even though the kitchen faces North, you may still find problems with glare. You don't want to find yourself blinded while you are chopping up vegetables for a tossed salad. The most light is going to come through the living room window. One will expect to see glare on the TV screen in the morning. A lot of light is needed in this space. It is the primary living space, so you can expect to see people reading or preforming other activities that need atiquite lighting. The light is also needed to help keep the space warm. The materials must be chosen carefully so that the room is well lit, but there is not so much glare that you can't inhabit the space. The lighting has to be even. The same thing applies to the bedrooms.

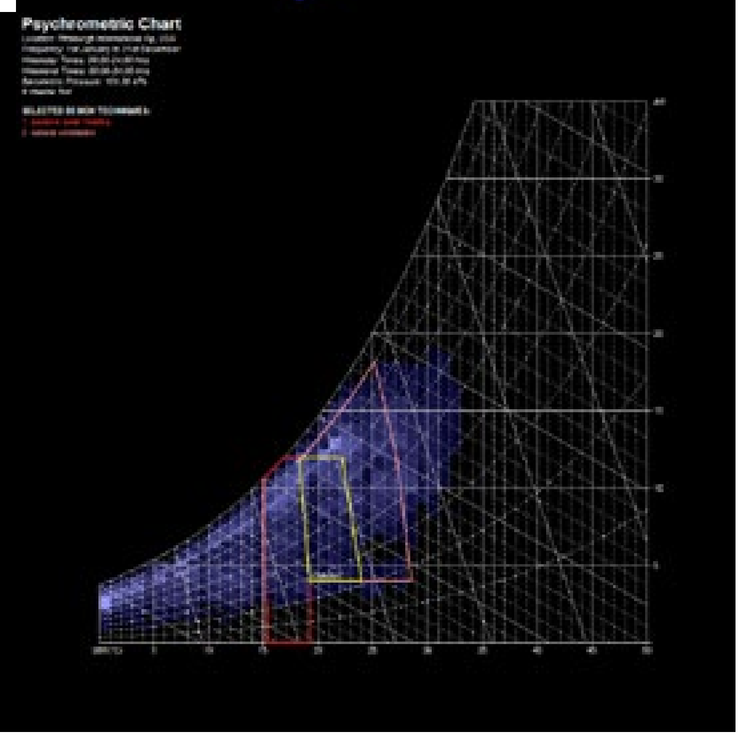


Enviroment Description

Our building is located in Pittsburgh, PA. Pittsburgh is located in a fairly moderate climate zone. Most of the year is comfortable, however about three months of the year are spent in very cold weather. It frequently hits freezing and sometimes reaches as low as -10 F. The winds come from the West, and sometimes you get winds comming from the Northwest. Pittsburgh is often overcast and doesn't recieve much sun, so when you are designing a building you have to make sure you try to capture as much sun as you can. Solar radiation capture can be utilized to help with high heating loads durting the coldest of the winter months. Natural ventilation will help deal with the peaks in temperature for the summer.







Model Description

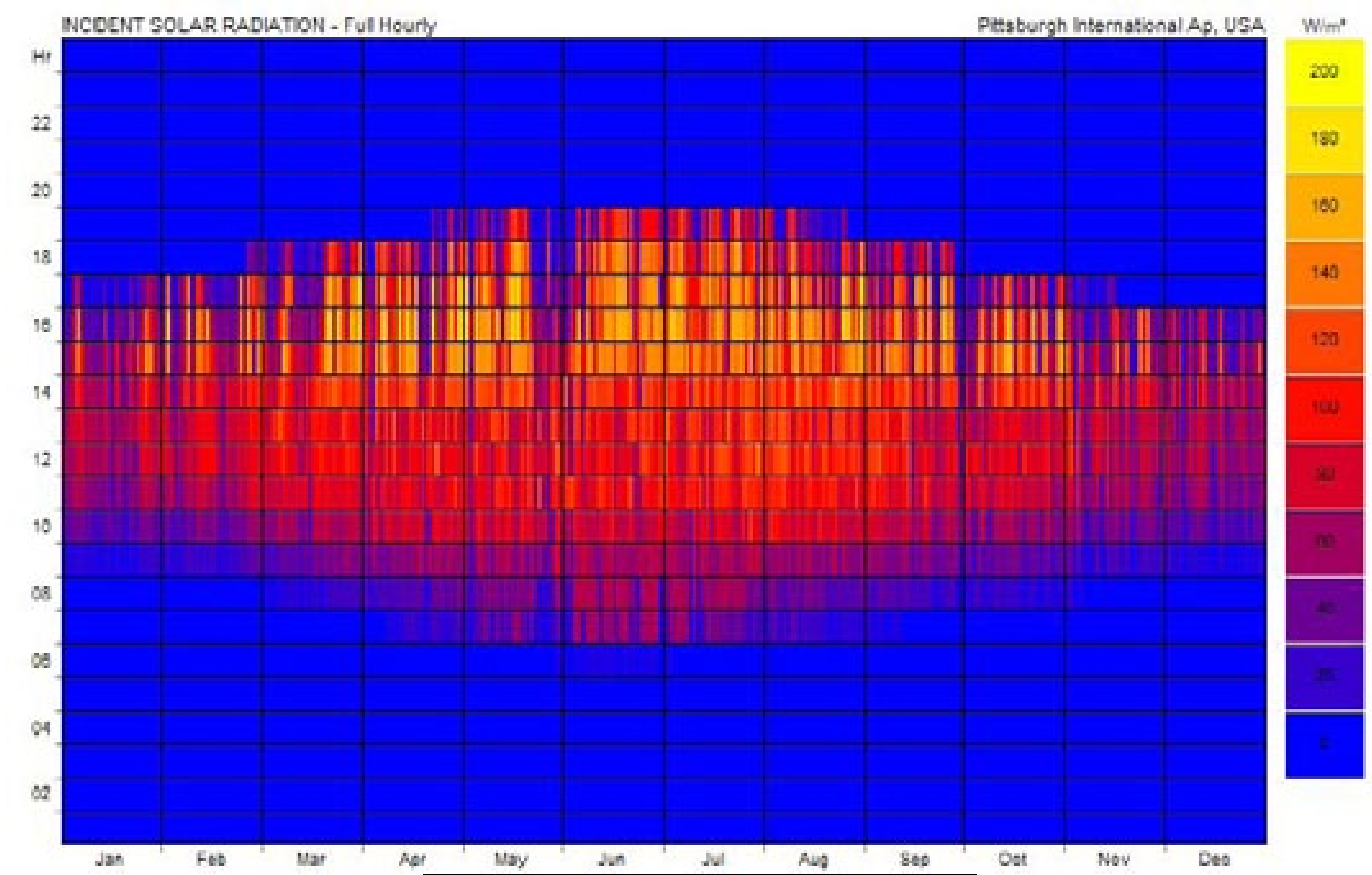
The model wasn't very dificult to make. The model was made in Rhino with propper wall thicknesses. The walls were extruded and windows were made. The ground is represented as one plane, and the cieling is made out of several planes so that the material of the cieling can be changed depending on the room. The file was saved as a STL file and then imported into Ecotect. This broke up the planes into triangles, so to solve this problem you select modify and then merge coincident triangles. You then group each room into it's own zone.

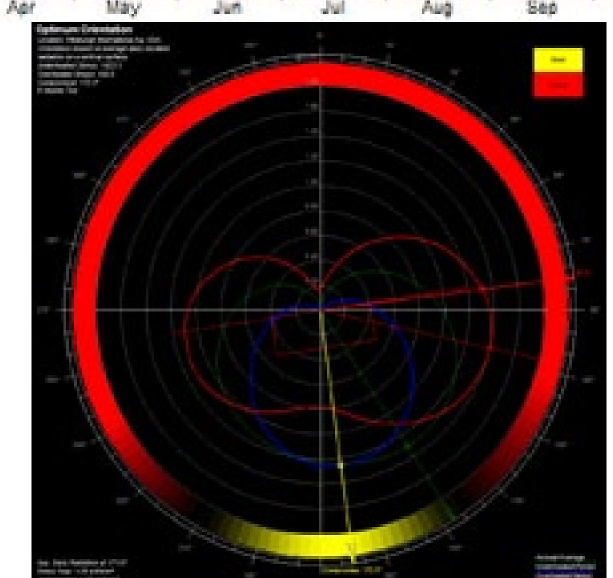
Important settings for the model are things such as the materials, climate data, and analysis parameters. We got the climate data from the internet and imported to the model from WeatherTool. The materials were set to match as closely as possible the reflectance, absorbtion, etc. of the materials in the actual building. The start of the analysis required our parameters to be setup to clearly examine the issue of study.

Lighting Analysis

The solar radiation chart below shows the amounts of radiation on the exterior of the building art various times of the day throughout the year. The chart makes it clear that the summer months see an increase in the period of the day that has sun exposure as well as a sizable increase in intensity. The increase through the day can be attributed to the building's layout with mostly Western facing walls catching radiation after noon. The orientation chart helps clarify the best positioning for our site by understanding where the sun is located at the overheated and underheated periods of the year.

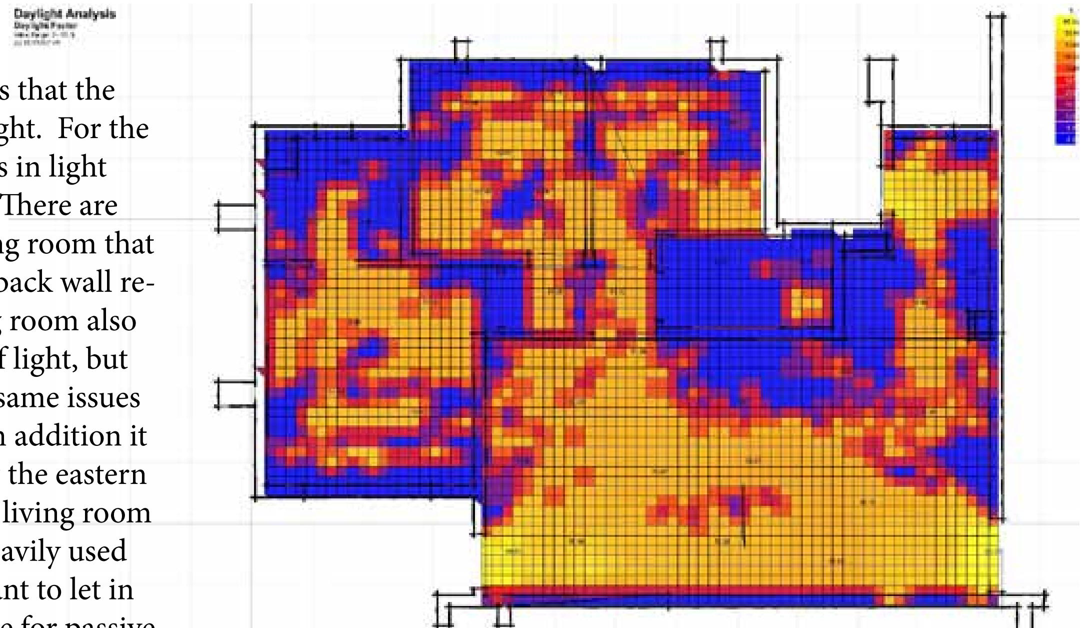
It is crucial in the lighting design to understand the amounts and quality of natural light that will be entering spaces from windows. During the daytime hours, rooms with large windows will be getting a majority of their lighting from daylight. This also poses problems when we consider the unpredictable nature of daylight and also the dynamic shifting of angles that can create glare and unevenly lit surfaces.





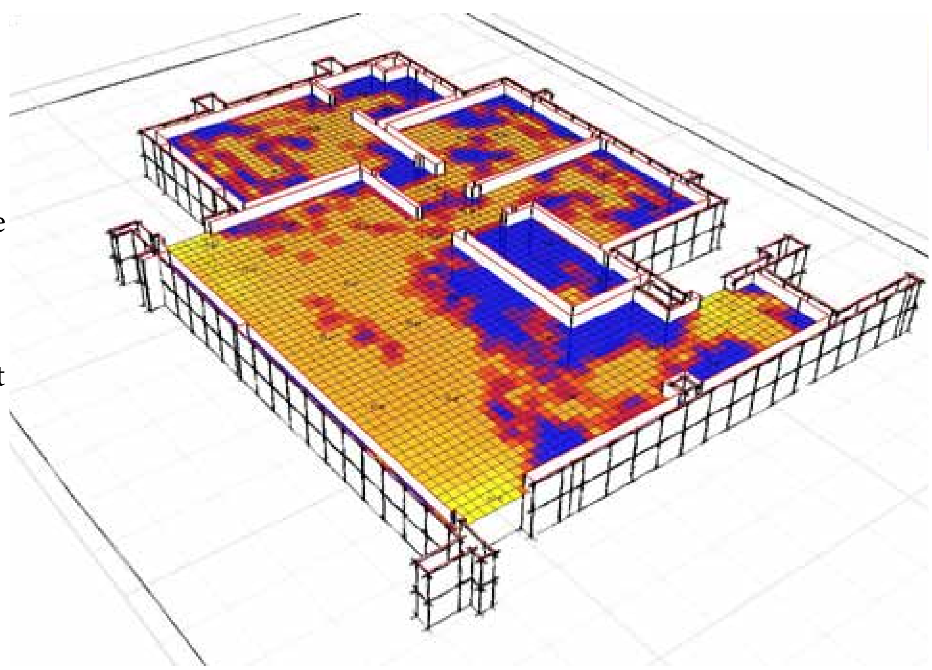
Daylight Factor

The Daylight analysis shows that the Living area gets the most light. For the most part the living room is in light for about 50% of the time. There are some dark spots in the living room that recieve no light at all. The back wall recieves no light. The Dining room also recieves a decent amount of light, but it suffers from some of the same issues that the living room has. In addition it does not recirve light along the eastern wall. If we assume that the living room and the dining room are heavily used spaces, It would be important to let in as much sunlight as possible for passive heating reasons.



Daylight Factor Over the Corse of a Day

One of the major problems with this layout is that the Kitchen recieves no light. The kitchen is a space that is all about preforming tasks. The living room and dining room also are, however the tasks are more recreational. The kitchen is designed with a specific function. It is a place to prepare and store food. It needs light so you can see what you are doing.



The bedrooms don't recieve too much light. Which should be fine if you don't spend most of your time there.

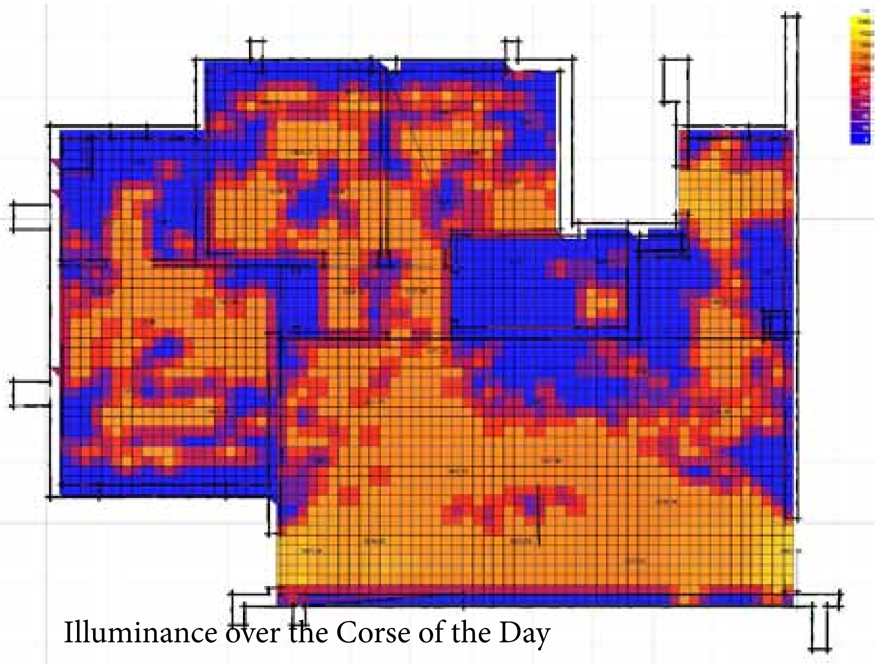
The bathrooms recieve almost no light, but they need very little lighting, and it may make more sense to put a light fixture in the bathroom instead of tackleing the challenge of how to put a window in a space that doesn't want one.

Illuminance Grid

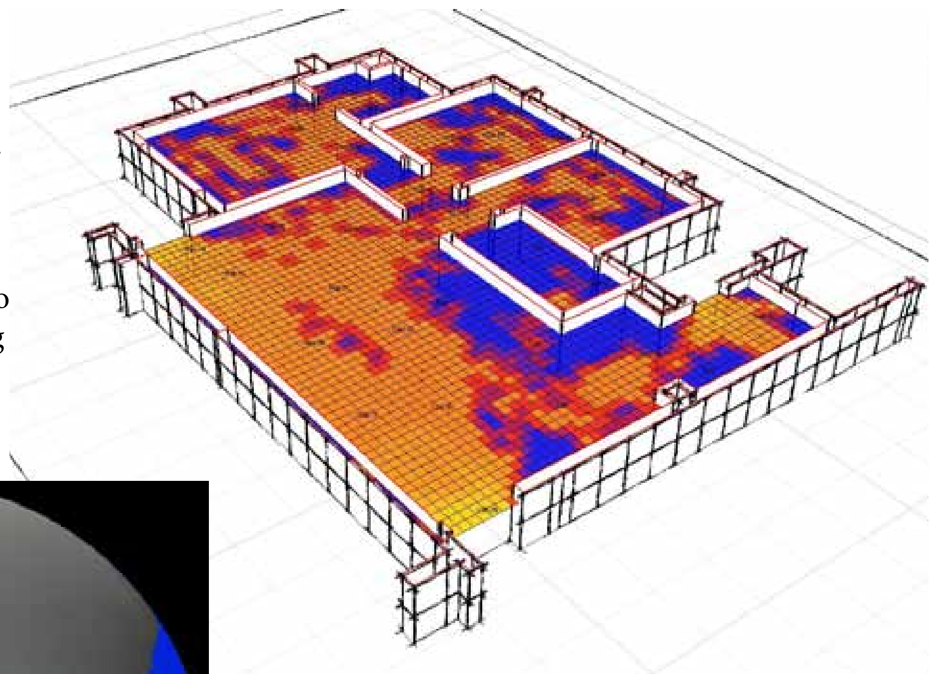
As you can see in the Illuminance diagram above, the amount of light entering the room is often above 3000 lux. This is way more light than is needed to preform tasks. 1500 lux would be sufficient. The owner of this house may want to put some shades in. Some of the illuminance levels in the bedrooms are also high, but don't receive those levels consistently over the whole day.

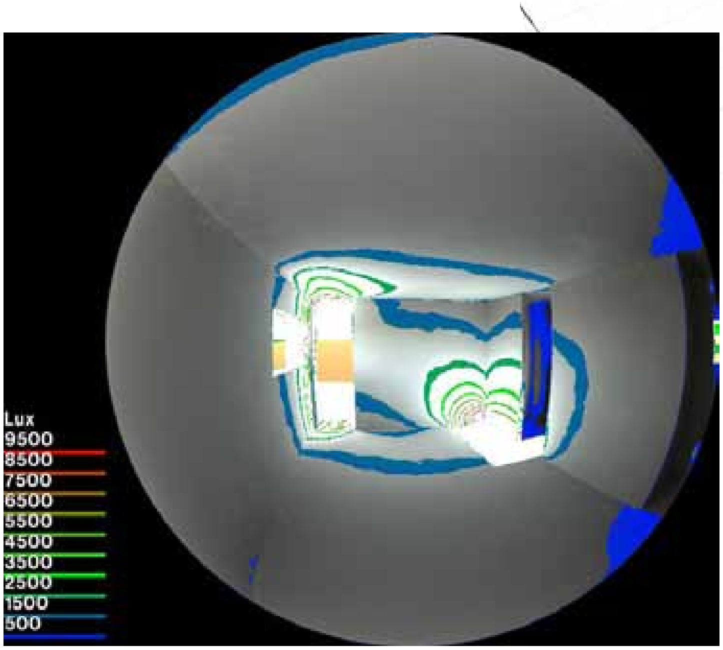
The kitchen needs more light. It receives some light infiltration the door way, but the levels are not high enough to preform tasks. Installing a light would definitely be needed in this space.

The bathrooms also don't receive that much light but they don't need that much light. You only really need enough light to see where you are going. We would recommend putting in lights that will give the space an illuminance of at least 80 lux. You may even want to consider putting in adjustable lighting so that you have more lighting for morning and evening activities.



Illuminance over the Corse of the Day



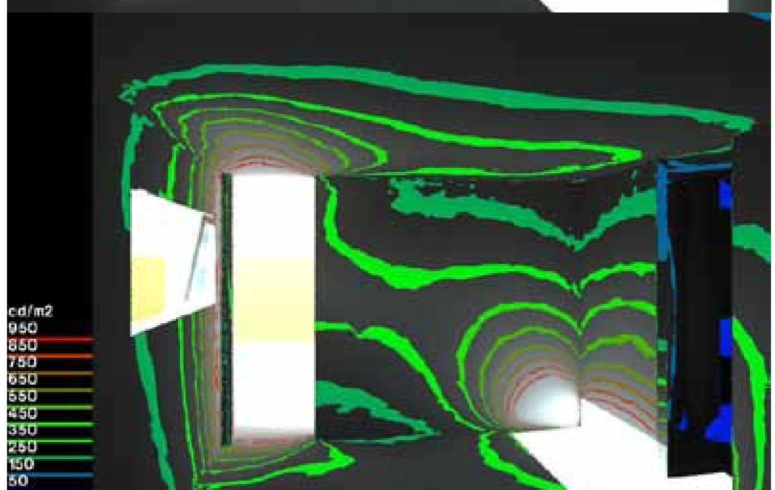


The fish eye to the left demonstrates the high levels of light comming in through the window. The Intens light is isolated but the analysis above shows that the intense light does make it across the room.

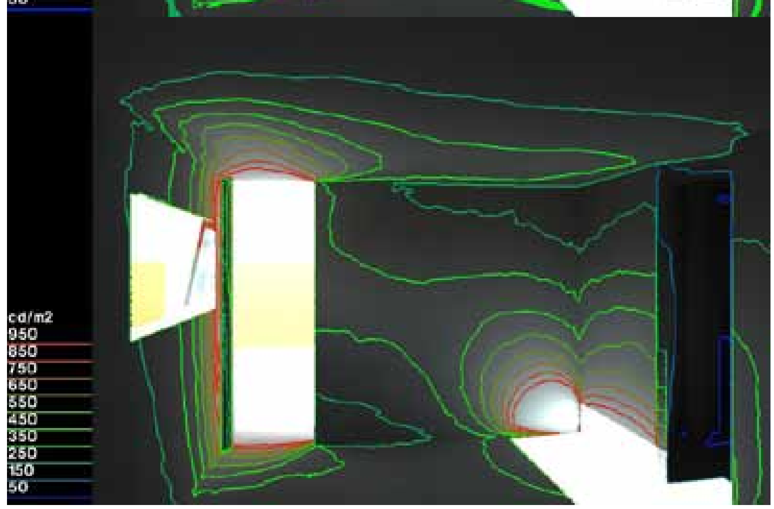
Luminance Analysis

For the luminance analysis we decided to focus on the living room. Based on the layout of the building we concluded that the most time would be spent in the living room.

The top image clearly shows the high level of contrast produced by the cast light from the window. This is probably pretty distracting when you are trying to watch TV. In the original plan of the house, the TV was supposed to be placed against this wall. I would not recommend that for two reasons. The first is that the high level of contrast produced by the light will be distracting while one is trying to watch TV. The second reason would be glare. One solution would be to switch the dining room and the living room.



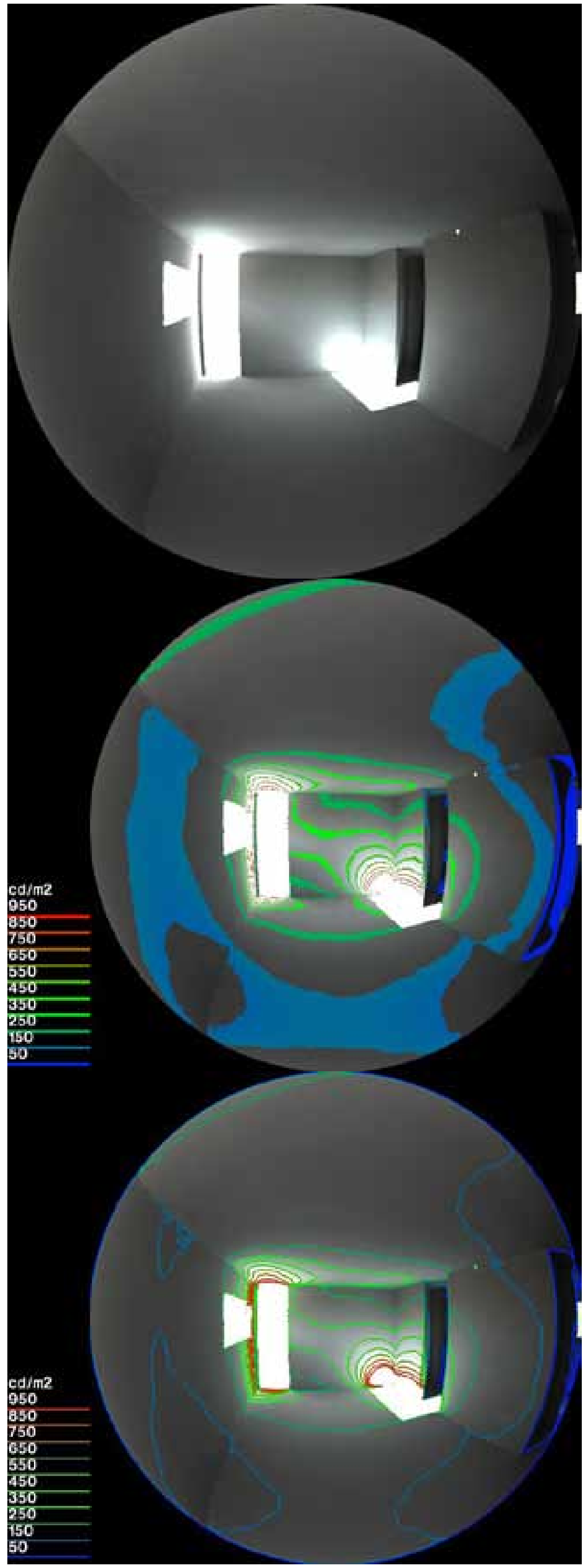
Another issue with the space which is better seen in the contoured diagrams is the actual numerical value associated with the contrast as well as where that differential is occurring. The luminance of the floor as you leave the hallway is above 950 cd/m2, while the luminance in the hallway is below 50 lux. So you stumble around the hallway until you turn the corner and blind yourself. A solution may be to put a filter over the window to cut back on the light coming through the window. This in turn will cut back on the amount of light reflecting off the floor.



Luminance Analysis Fish

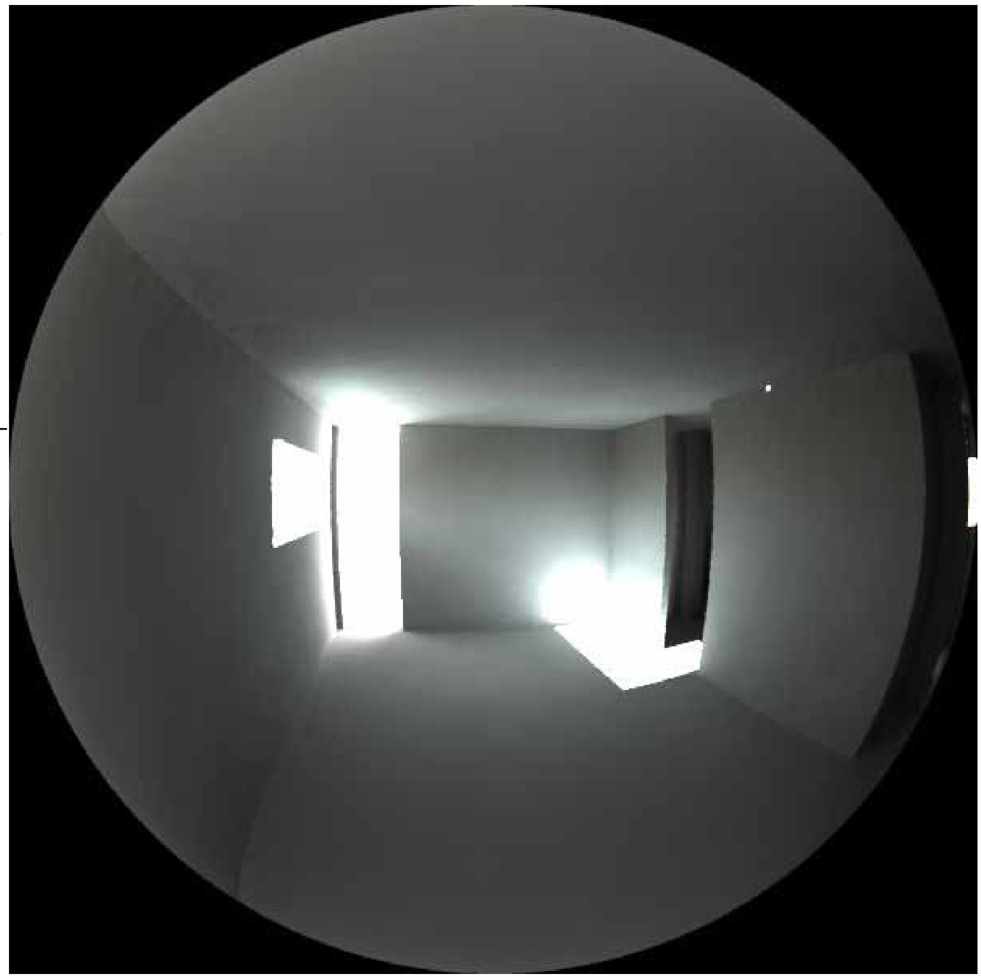
This is in line with the illuminance analysis which demonstrated that the living room on average received way too much light for the activities being preformed in the space.

The fisheyes on the right begin to demonstrate a different condition. The transition from the kitchen to the dining room is only showing a difference of 100 cd/m2, but the spaces themselves aren't that bright. The maximum luminance of either of the two spaces is rarely over 150 cd/m2. The luminance levels in the kitchen hover around 50cd/m2. A solution would be to place a small light in the pass through between the kitchen and the dining room. This will increase the luminance and illuminance in both rooms. As shown on the grid analysis, the dining room does get a decent amount of light on average, so one may want to consider shifting this light back towards the kitchen so more light is emitted into the kitchen.



Glare Analysis

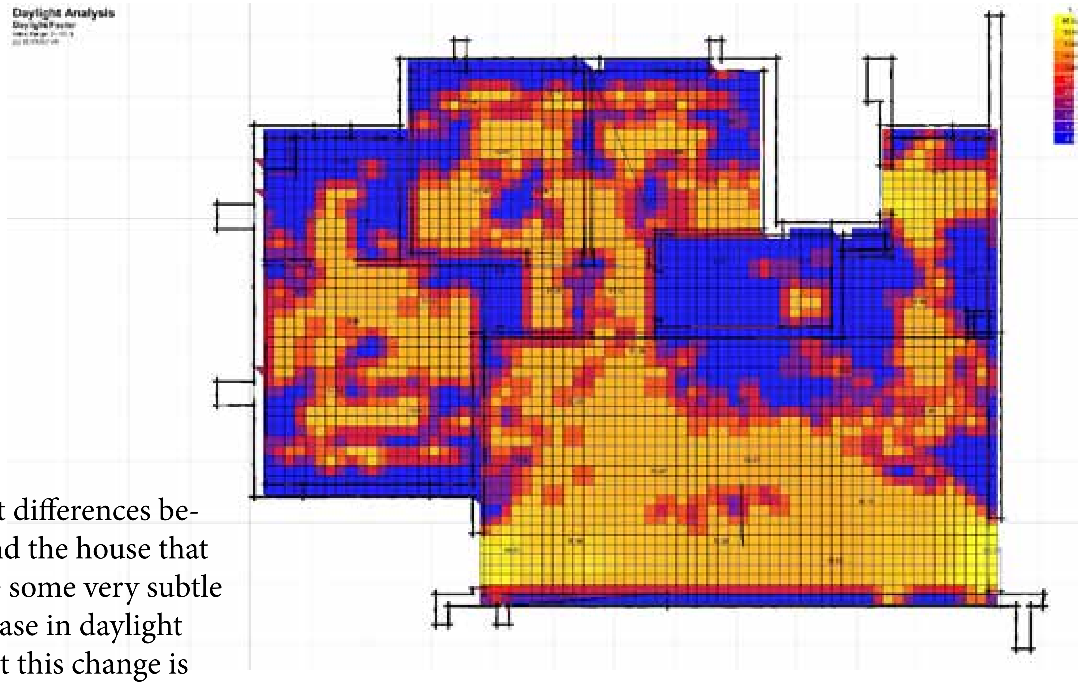
The UGR for the space was 23.300426. This is due to the intensity of the light cast through the door and window in the living space and the concentration of the light in the space. Needless to say the VCP wasn't that great either. The VCP rating was 24. 257347. This means that only about 24% of people inhabiting this space would actually find this space comfortable. A solution to this problem would be to paint the walls in matte paint and reduce the amount of light let through the door. Both of these should reduce the contrast between light and dark thus increasing the VCP and reducing the UGR.



90° Rotation Analysis

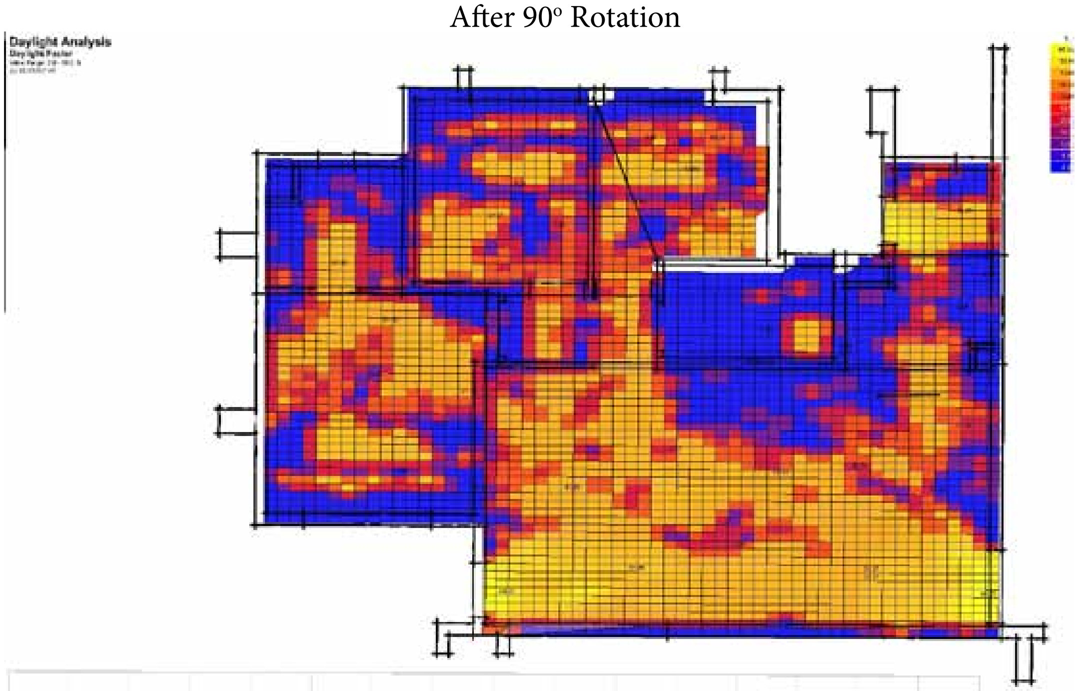
Daylight Factor

Before 90° Rotation



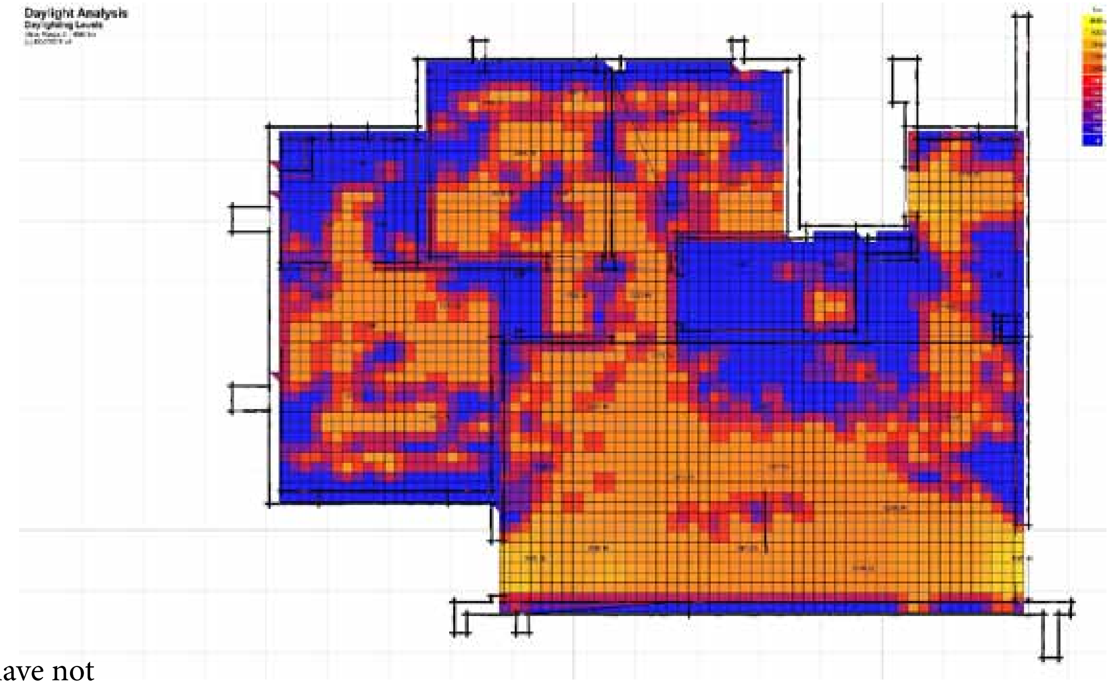
There are no real significant differences between the original house and the house that has been rotated. There are some very subtle differences such as an increase in daylight factor in the bathrooms, but this change is very slight and therefore any design changes that we would make in response to this diagram would be the same as our response to the original diagram which is discussed above.

After 90° Rotation



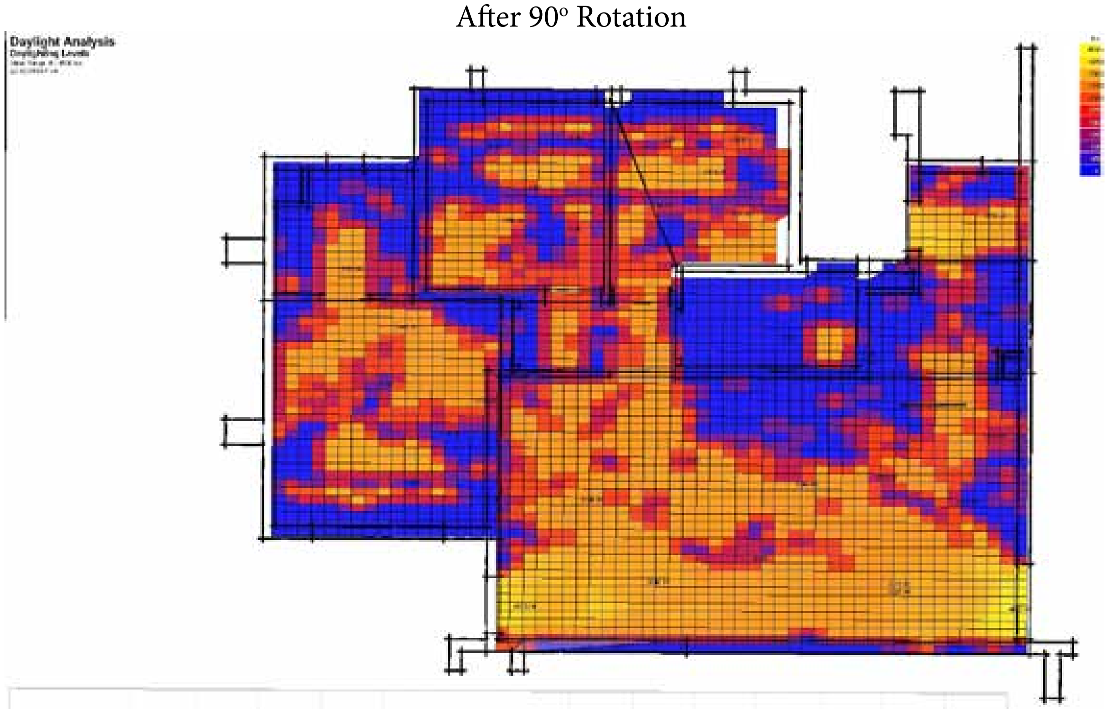
Illuminance

Before 90° Rotation



The illuminance values have not changed much either. Any design recommendation would be identical to the recommendation of the original building.

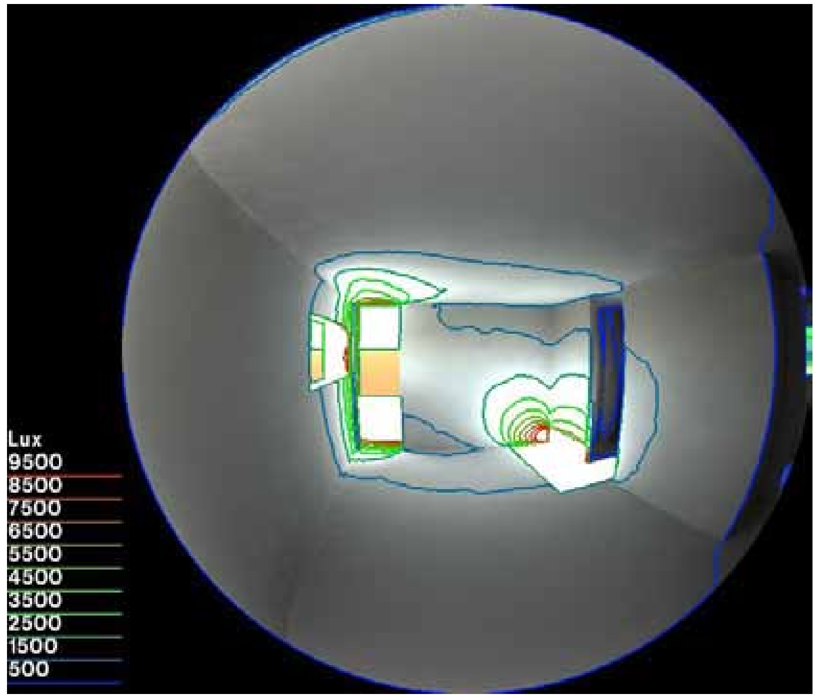
After 90° Rotation



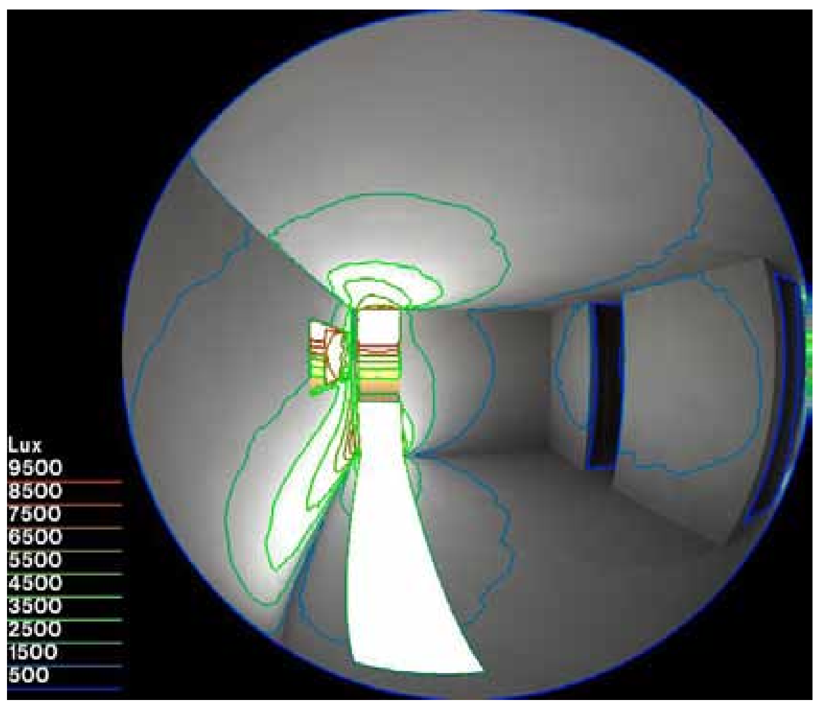
Illuminance

A distinct difference appears when one looks at the illuminance levels at a particular date and time, and in a particular space. As you can see, the light now washes down the wall that has the window. As a result, the light is more evenly distributed. The illuminance in the living room now fluctuates between about 2000 lux and about 500 lux. The entries into the space are still not very well lit, however the difference in illuminance between the two rooms is not as significant. Unfortunately there is still a line of light produced by the door that has a very high illuminance reading. One suggestion would be to invest in a non glass door, but this would significantly change the positive lighting conditions in the space as well.

Before 90º Rotation



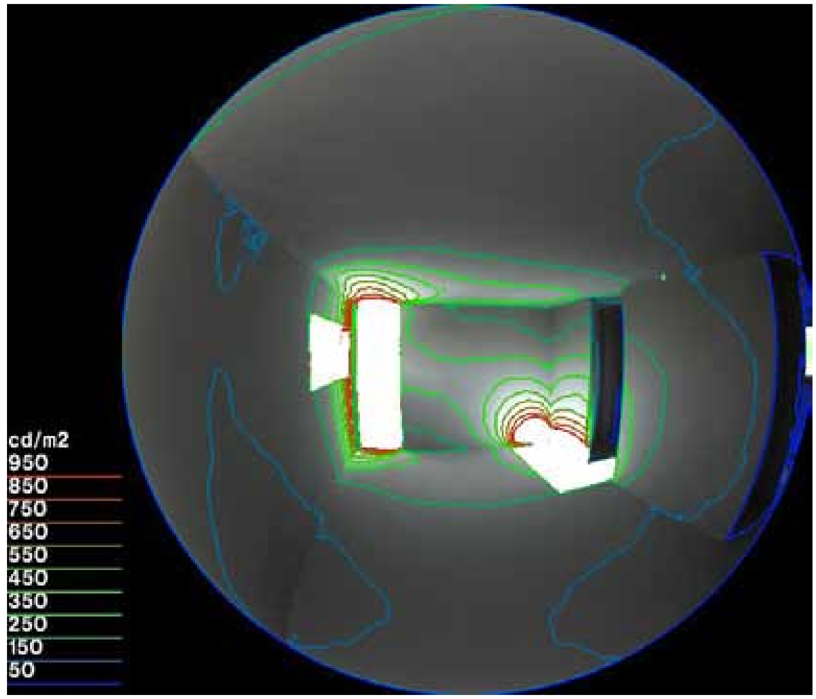
After 90º Rotation



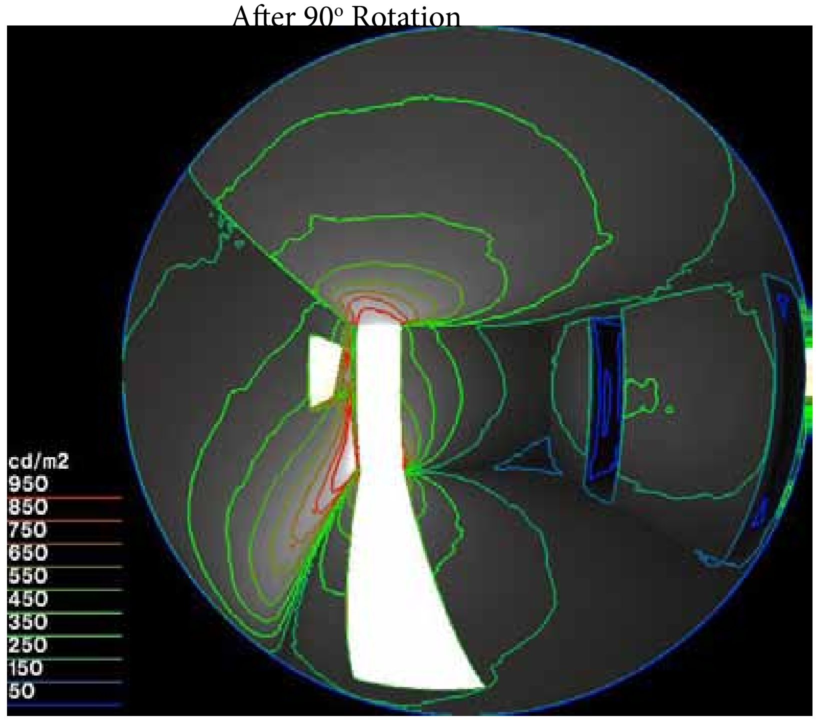
Luminance

The luminance in the first model of this apartment had a high intensity of luminance in the right corner, due in large part to the window allowing direct sun rays to fall on the white wall. Lower levels of luminance are present in the rest of the room ranging from 350-150 cd/m2. After the rotation of the model by 90 degrees the model shows improvement in an even distribution of luminance values. Extremely high levels stretch across the room by the direct light rays cast on the floor from the full height door. The reflections from this evenly light the remaining space with moderate luminance levels that are much higher than the first model. Luminance levels throughout the room in the second model range from 550-250 cd/m2. However the larger area of ultra high intensity should still be considered in overall visual comfort as seen by the later glare study.

Before 90º Rotation



After 90º Rotation



Glare

The UGR in the space once the building was rotated is 24.972767. This is probably because the door is letting in much more light than when it was at it's previous orientation and the window was casting light perpendicular to the occupant's light of sight. The VCP was 26.492099 which is an increase of about 2%. This can be attributed to a more even light distribution throughout the room. Although the overall room has a better light distribution and created a better VCP, the UGR has still increased due to the larger amount of intense direct light coming through the doorway directly across the room. This light is also parallel with the occupants line of sight, increasing its perceived intensity.