JÖNKÖPING UNIVERSITY

School of Engineering

Analyses, Simulation and Assessment Systems
TASR22

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1. Introduction

1.1 Purpose:

This report investigates the use of digital tools in Building Information Models (BIM) and tries to understand through this tool how the construction industry benefits or add value from BIM. It discusses how various simulations and analyses influence a certification system like Miljöbyggnad in the three categories: materials, energy, health and well-being.

The purpose is to demonstrate how these analyses can be used in building design with the aim of achieving very particular goals, like maximizing daylight and energy efficiency. For instance, it provides insight on how you can modify the placement and design of windows to suffice daylight needs.

This is a project for the course "Analyses, Simulations and Assessment Systems" at Jönköping University. It analyses the use of digital analysis tools to achieve models closer to reality and aligned with project goals.

1.2 Background:

These is the report was done during course "Analyses, Simulations and Assessment Systems" at Jönköping University. The research examines the ways in which digital aids and analysis kept within BIM can create models that are more aligned to project goals. This information is then utilized to assess and score the building under various certification categories including, but not limited to materials, energy, health and well-being.

The idea is to design a building that fulfils certain criteria in an accurate and more realistic manner.

The analyses are as follows:

- Solibri Software for Collision Investigation
- Building G daylight &lighting evaluation through Velux software.
- Energy analysis
- Cost calculations
- Life Cycle Assessment (LCA)

Assessing the BIM model from materials, energy and health & well-being perspectives following Miljöbyggnad requirements.

2. 3D Modelling of the Building in Revit:

To get started, I chose Building G from the drawings available in Canvas. It has been almost 2 weeks to use Revit software for modelling in the G building.

Materials were measured and taken from the original drawings to ensure accuracy of this part. The assembly began from the ground to up, using a very methodical approach to minimize error and gain avoid structural interference. It helped us to visualize the building and run different types of analysis once we completed the model.

Below is the model set with ground for Building G, which represents its primary architectural features; Completed Model: Building G.

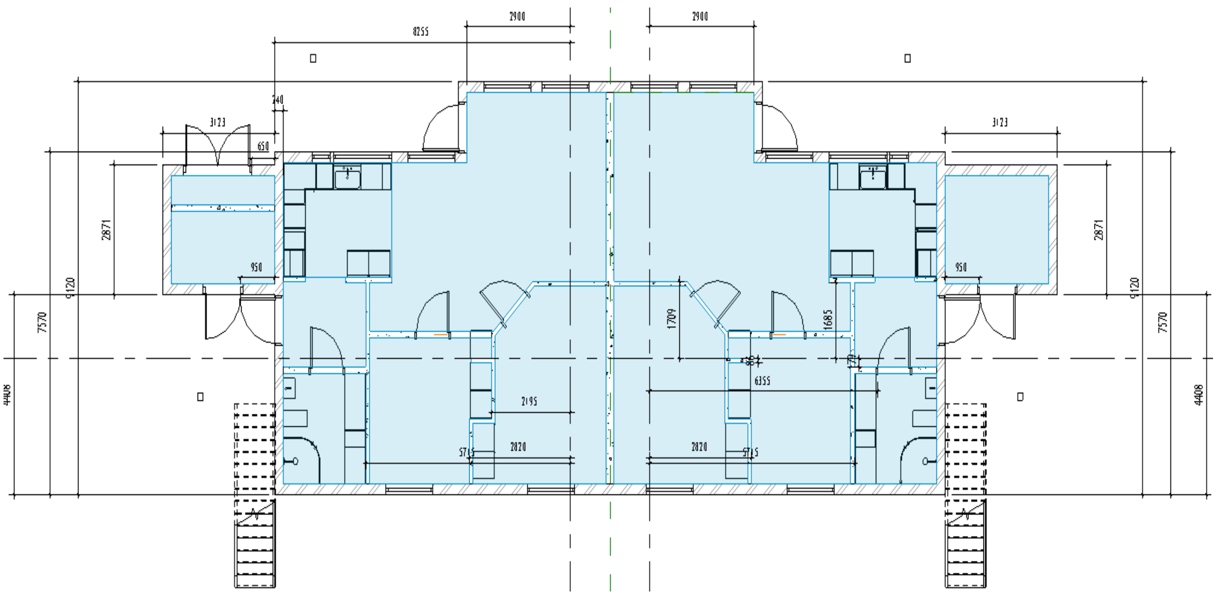

Figure 1.First Floor Plan of Building G

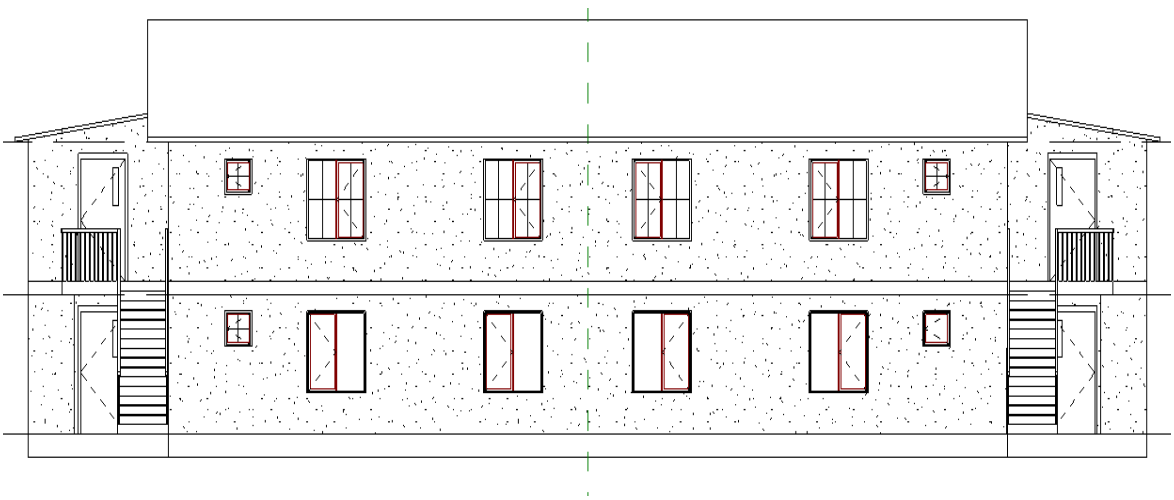

Figure 2.The South Section of Building G

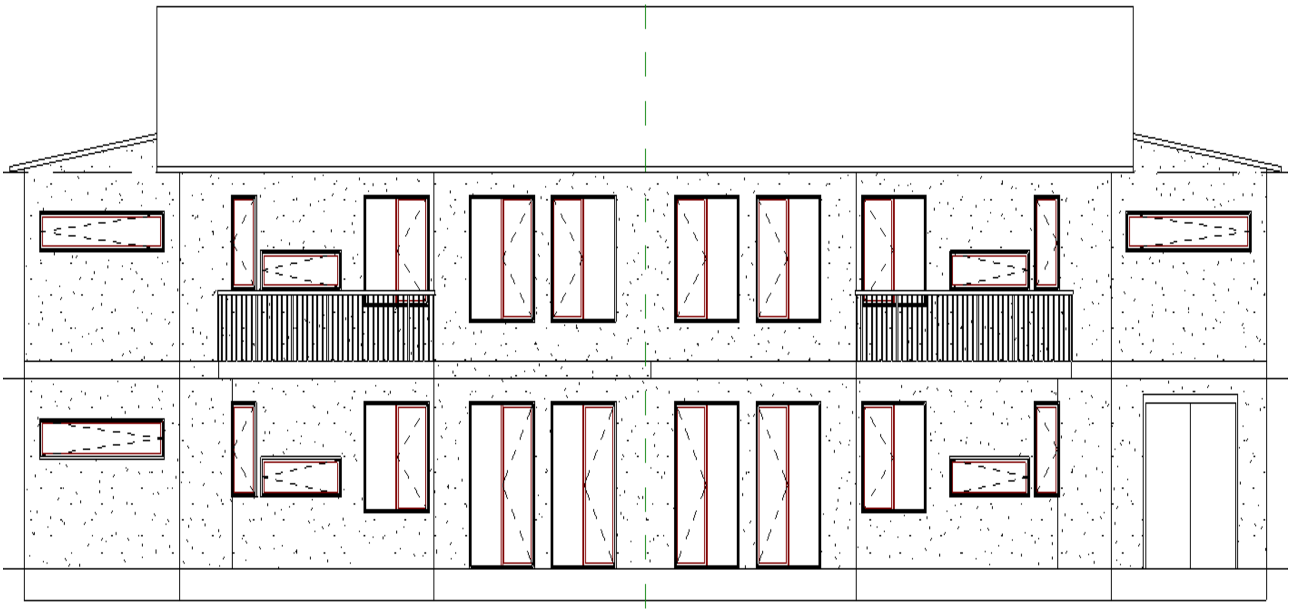

Figure 3.The North Section of Building G

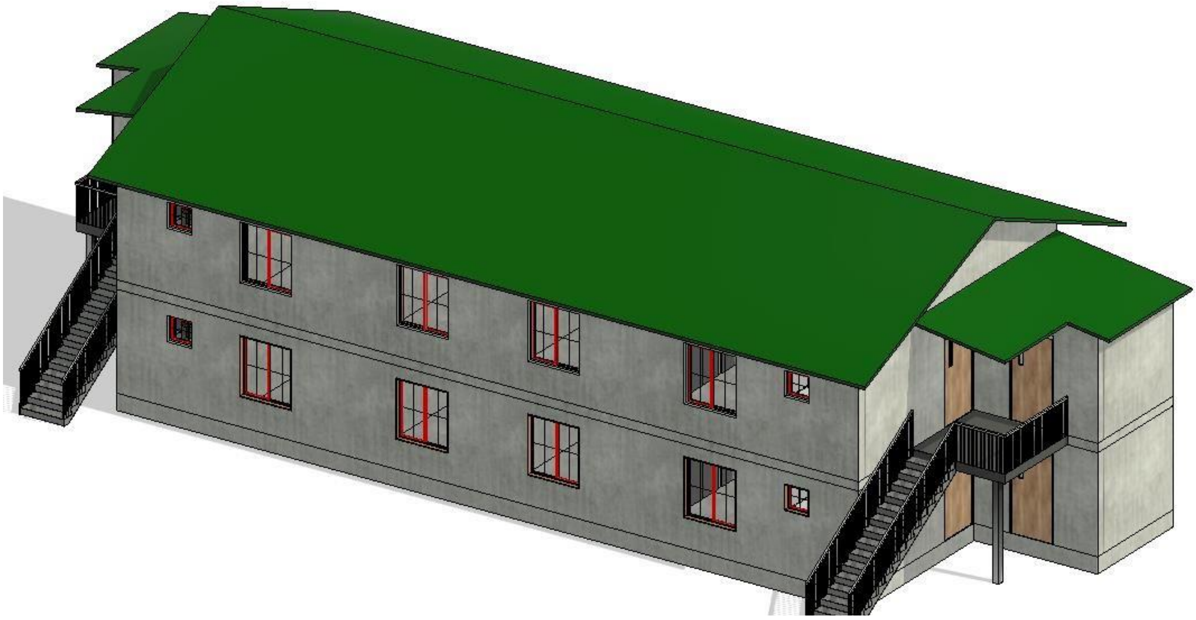

Figure 4.3D Modelling of Building G

3. Collision Check (Solibri):

After finishing the Revit models for G, a collision analysis was done by using the Solibri software. Nordic BIM Group (2023) states that Solibri is software for checking the quality of BIM models. By examining digital models, it helps in identifying possible issues or conflicts in building projects.

After the Revit models were exported to the IFC format. Since many BIM applications accept IFC, this makes it simple to import the models into Solibri. We chose the type of study, concentrating on architectural and BIM components, after the models were imported.

The models' errors and collisions were then highlighted by Solibri, demonstrating the extent of the problems and our progress towards creating an error-free model. We used to make presentations in Solibri to pinpoint the precise regions of the model that required fixing in order to have a deeper understanding of the issues. We were able to go back into Revit and fix the errors thanks to this information.

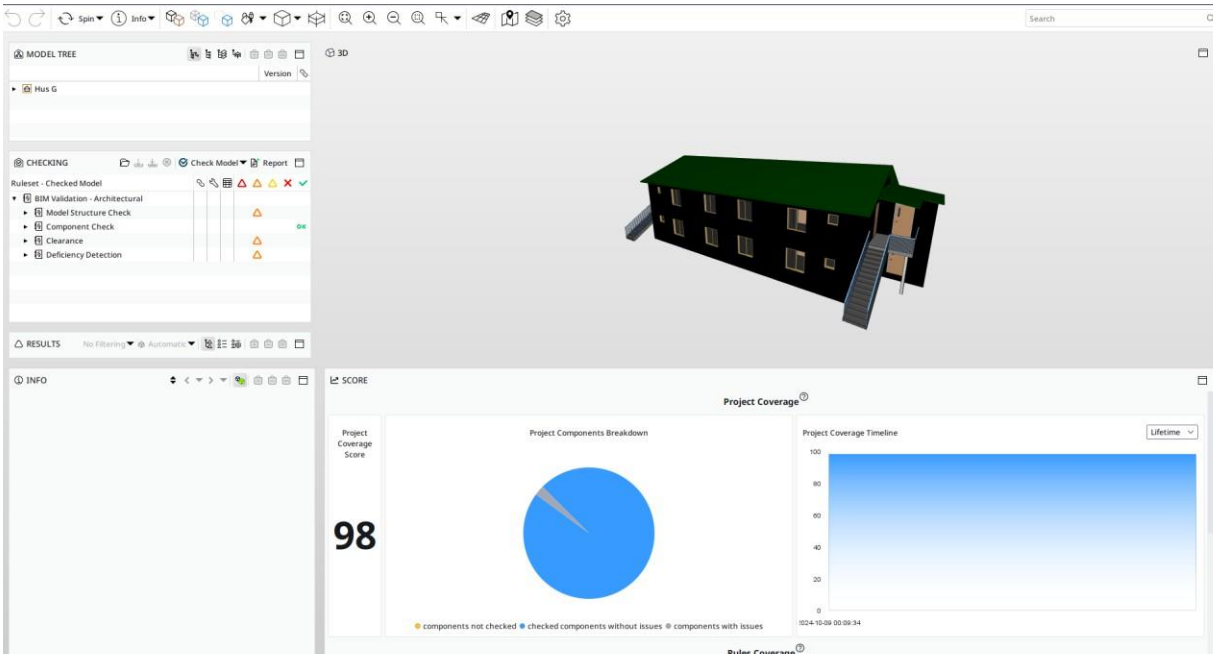

Figure 5. The Score and Collision of Building G in Solibri without furniture

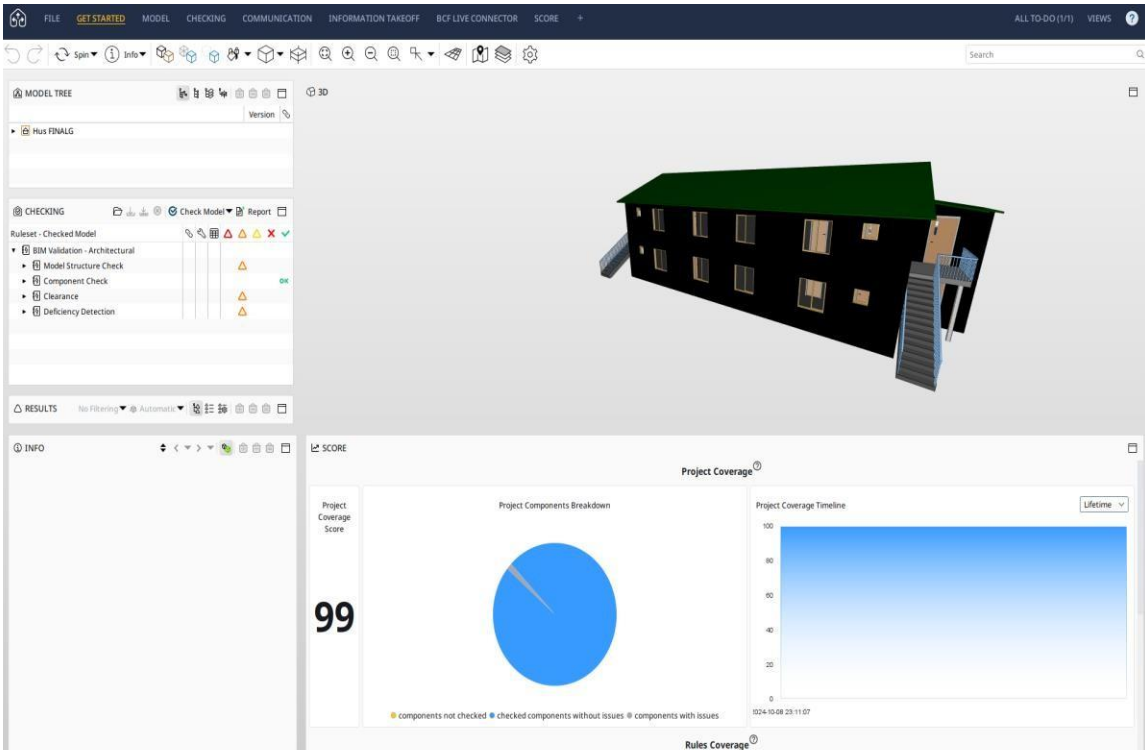

Figure 6.The Result of Solibri Check of Building G with furniture.

Some of the worst issues were collisions of walls with slabs in level 2. To solve this problem, the wall offset value was given in the Revit model. Another problem was that some windows are too close to each other. To solve this problem, some window types needed to change, and also making some fixed windows.

Some of the minor errors were no component of beam and some default materials. We can neglect those.

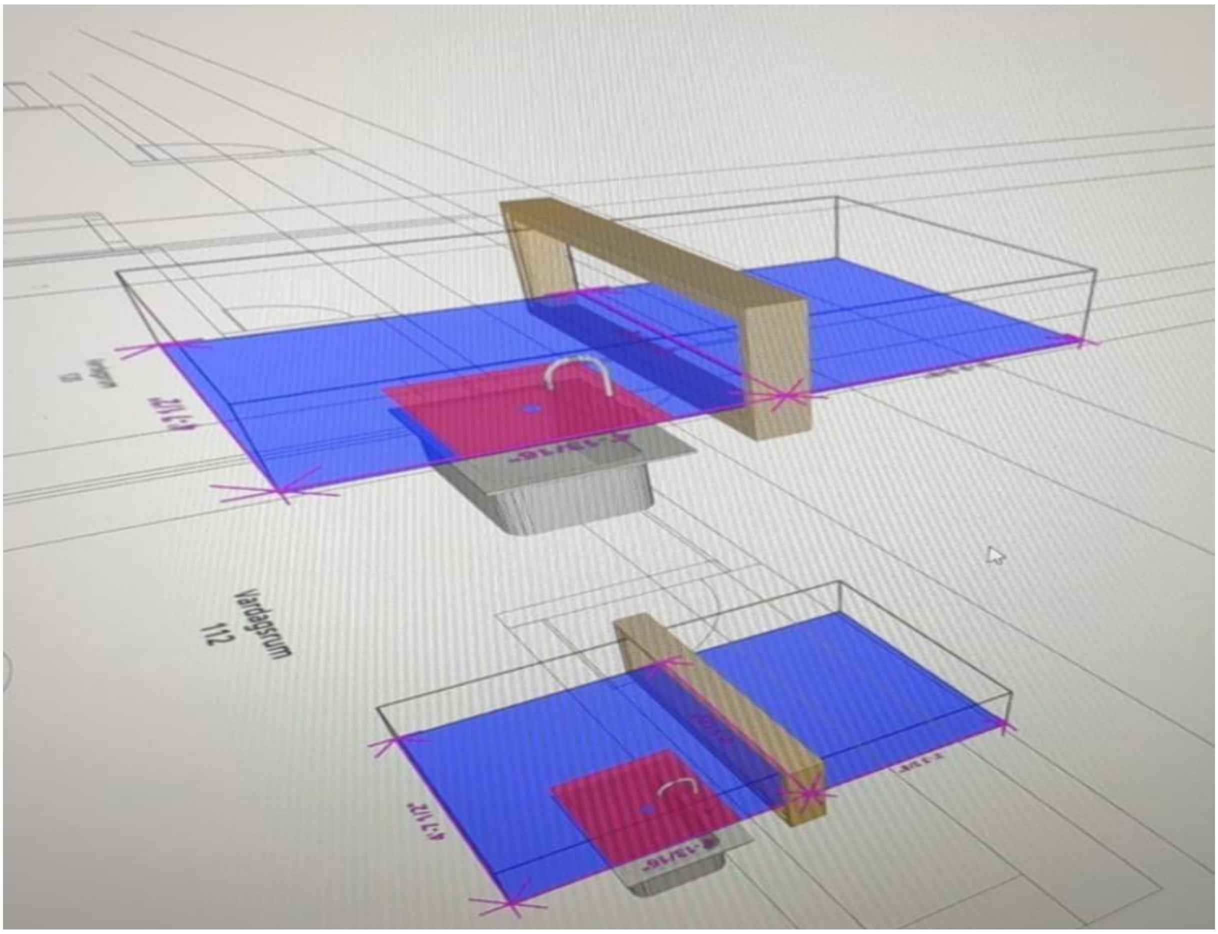

Figure 7. Highlights issues related with windows.

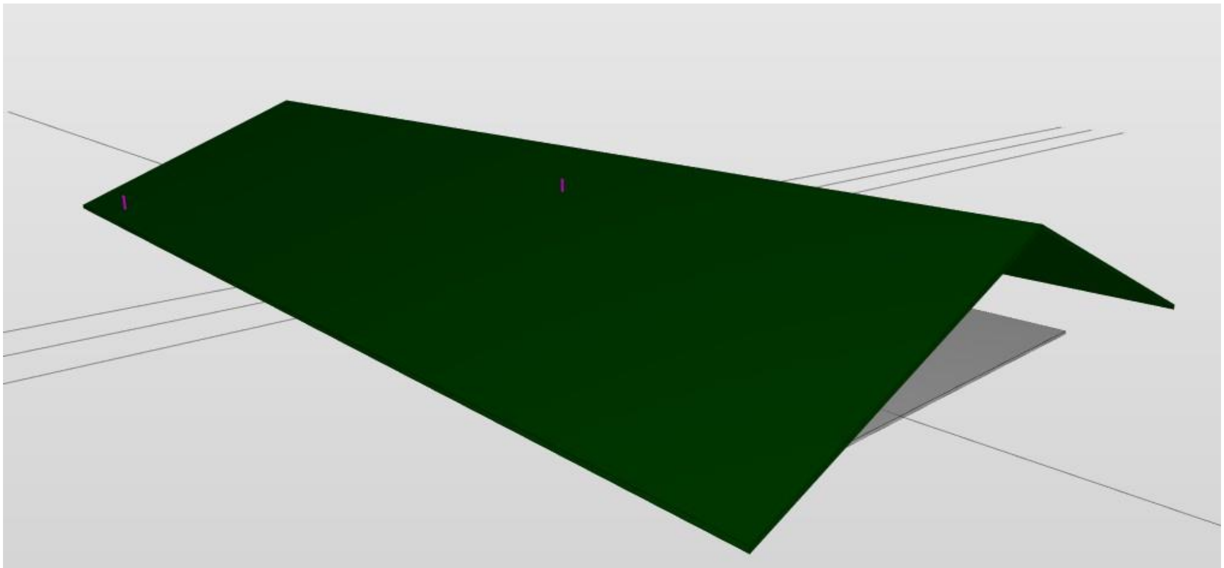

Figure 8. Some Minor Error in Solibri

4. Road Construction (Novapoint):

In this software, we have learned how to draw a road using two software programs, AutoCAD and Novapoint. First step is to create the road design in AutoCAD, which is then exported to Nova Point. Both the softwires share their information together.

We must import all data about the route and its surroundings before we start drawing the road in Nova Point. Some of the data are about soil layers, existing roads, elevation contours, and materials required for the new road. A better alignment is to be gathered of the road and its surroundings by processing this data in both AutoCAD and Nova Point.

I had never used Novapoint before, and I found it difficult because there are a lot of steps to follow. To perform it properly, a great deal of learning of software is needed. But Nova Point is cutting edge software that has the power to transform the building sector. It helps in visualizing current structures and the locations of upcoming ones, helping workers in avoiding errors and collisions.

In addition to mapping out the route, Nova Point offers a range of evaluations that can help you save time and money. The Quantity Complete Report determines how much material is required for the project. Improved resource management and project planning are made possible by these studies.

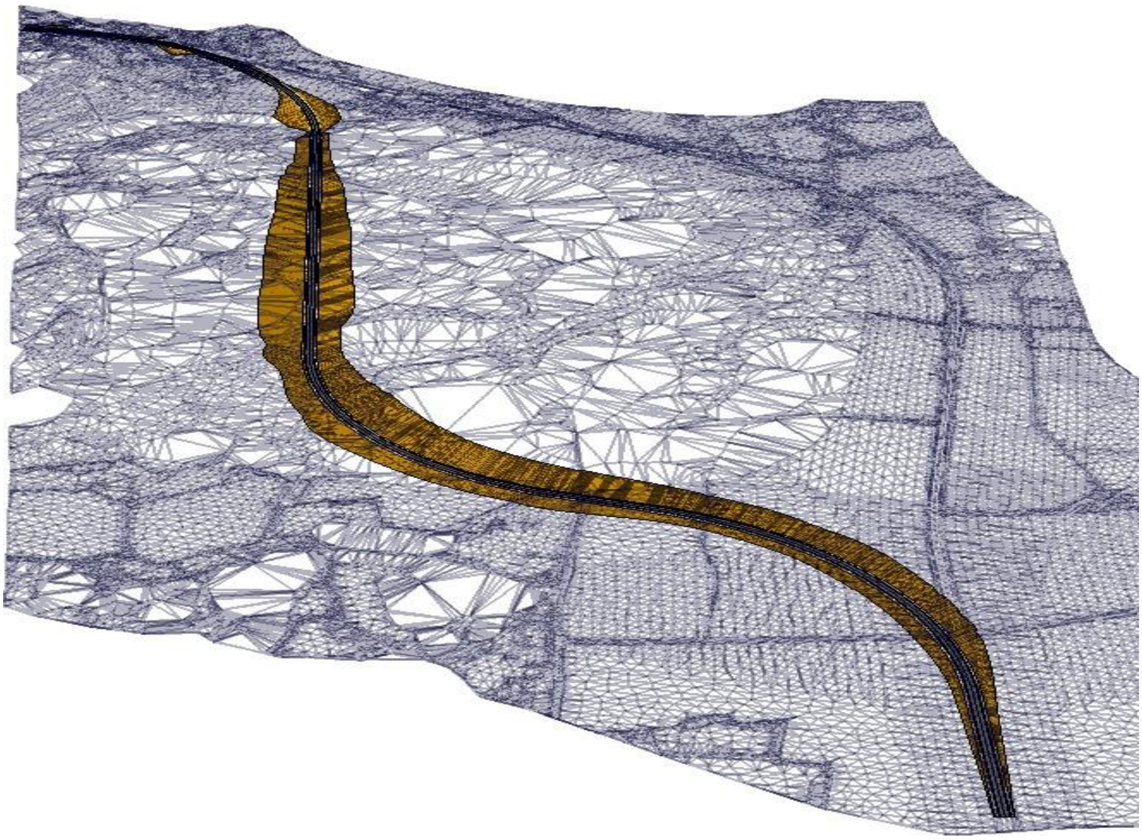

Figure 9.3D drawing of Road in Novapoint

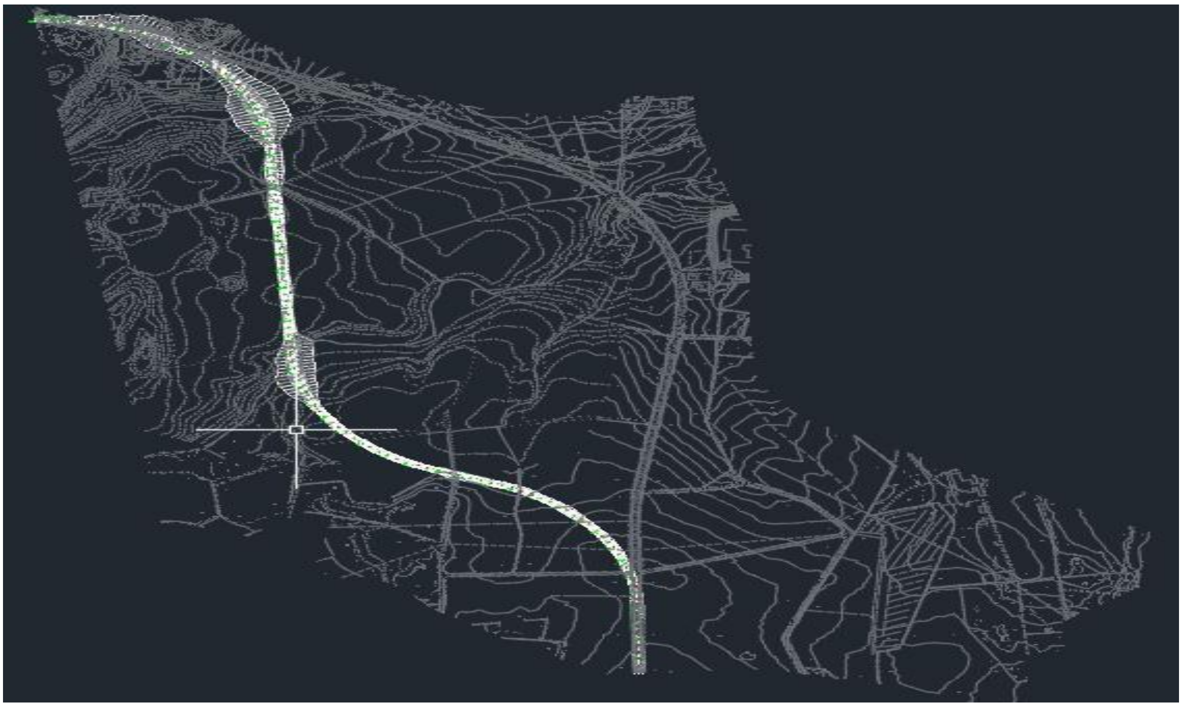

Figure 10.The plan of the Road

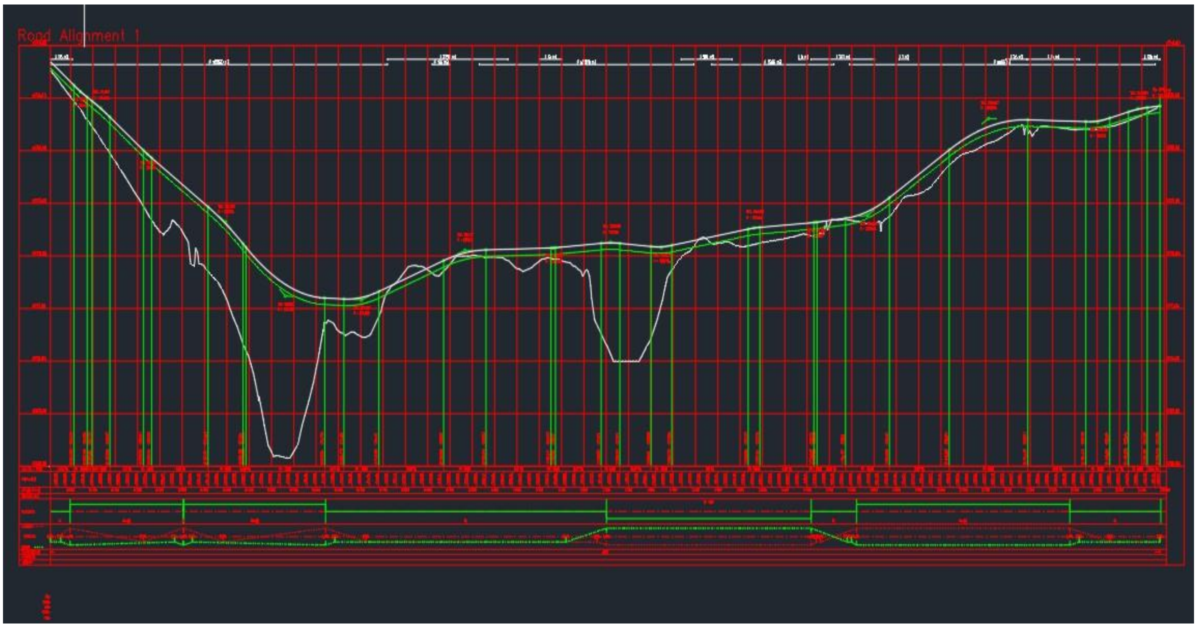

Figure 11.The Road Profile

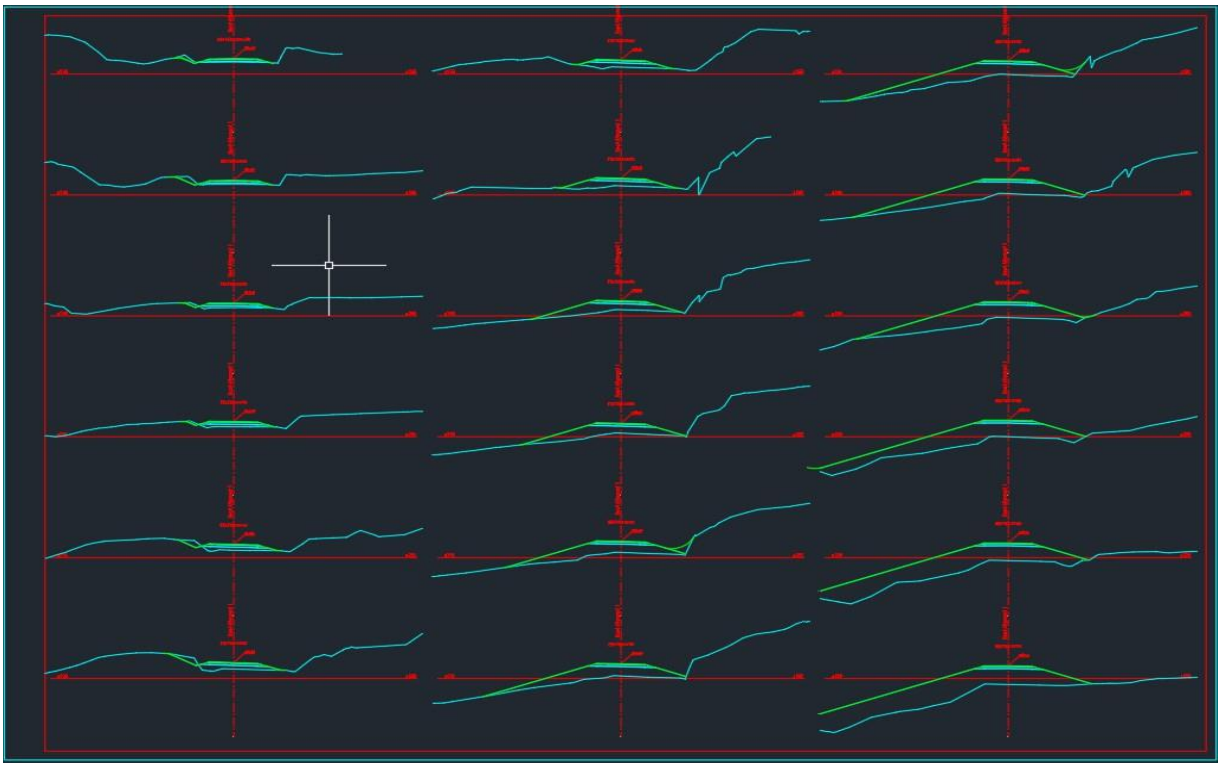

Figure 12.Cross section of the Road Profile

5. Daylight Visualizer, Lighting analysis (Velux):

The exercise is about how various things perform a room's daylighting. We analyzed a various number of tests to understand this, different number of parameters and analyzing those effects on the amount of daylight in the rooms.

These tests' values are displayed in Appendices. In this process, we learned more knowledge about to determine a room's amount of daylight, including the Window-Wall Ratio, the different sill height of window, the G value (the amount of heat that travels through the window), and the reflectance of the ceiling, walls, and floor.

We discovered that doing daylight assessments at the first stage of the building design process is difficult. We might determine the building's certification daylight category rank by following how various window designs affect the amount of daylight in rooms.

It is essential to determine to plan the size, kind, placement, and overall shape of windows early on in the building process and the primary source of daylight in a building. Early analysis reduces the need for later modifications to the building's façade or materials, such as colors. It also provides us with a decent indication of the building's behavior regarding daylight access.

5.1 Exercise one

5.1.1 Part One

In the first section of the test, which is displayed in Appendices 17-22, we examined the relationship between the daylighting in the rooms and the Window-Wall-Ratio (WWR). To observe how the WWR values affect the daylight factor, we altered them to 30%, 60%, and 80%.

We observed a significant rise in the average daylight factor when comparing the findings for WWR values of 30%, 60%, and 80%. For example, the average daylight factor increased by 164.705%, from 1.7 to 4.5, when the WWR climbed from 30% to 60%. This demonstrates how adding a 30% larger window may significantly increase the amount of daylight in the space. Similarly, the daylight factor increased from 4.5 to 6.1 (a 35% increase with only 20% more window area) when the WWR climbed from 60% to 80%.

You can refer to Appendices to gain a better understanding of how these various WWR values impact the amount of daylight in the space. These display images as they would appear to the human eye.

5.1.2 Part two

This section examines the effects of varying the window size (2 m wide by 1 m high) and sill height on the outcomes of the assessments of brightness and daylight. The results are displayed in Appendices 23-28. This test aims to determine the effects of three distinct sill heights: 0.1, 0.9, and 1.5 meters on brightness and daylight.

The daylight factor average, which displays the daylight analysis for a 0.1 m sill height, is 0.3%. There is a significant improvement when we compare this to the findings for a sill height of 0.9 meters; the average daylight factor rises to 1.6%, a 433% increase. Additionally, for 0.1 meters sill height, the location with the highest daylight access increases from 4.9% to 18.5% at 0.9 meters.

Nevertheless, we don't observe any additional improvement in the average daylight factor in Appendix, where the sill height is 1.5 meters. Rather, it declines somewhat to 1.4%.

These findings demonstrate the significance of the sill height in daylight analysis. Raising the sill height from 0.1 m to 0.9 m significantly enhances daylight access; however, the benefits are not as considerable when the height is increased to 1.5 m.

5.1.3 Part three

We altered the floor, wall, and ceiling's reflectance characteristics in this section of the study. Appendices 29 -36 describe how various reflectance value impact the daylight analysis. These findings demonstrate that the largest daylight factor is achieved by increasing the reflectance of the floor, walls, and ceiling combined.

Increasing the walls' reflectivity, on the other hand, had the greatest influence on improving the amount of daylight in the space and had the greatest impact on daylight access.

5.1.4 Part four

We wanted to find out how altering the windows' LT (Light Transmittance) values affected the amount of daylight in a space. Three levels of LT were examined, as shown in Appendices 37-42: 40%, 60%, and 80%.

The findings shows that more light can enter the room when the LT level is raised. For instance, a window with 40% LT lets in 1.3% of the light, a window with 60% LT lets in 2.0%, and an 80% LT window lets in the maximum amount of light, 2.8%.

5.1.5 Part five

This part describes a daylight analysis on the Building G BIM model, with an emphasis on the first floor. The findings are displayed in Appendix 43 -46. It was identified that the building's average daylight factor was 1.8% ,1.5% in both the floors. The daylight factor was highest in the parts closest to the windows, which are indicated in red. In direct proportion to your distance from the windows is the daylight factor.

Shading is necessary to create a comfortable environment in places with high sunshine, especially during sunny times of the year to control temperature and light. The darkest regions, indicated in dark blue on Appendix Building G's southern section, had the lowest daylight factor. To guarantee that these spaces are well-lit, more artificial lighting is required. During the darker months, such as winter, artificial lighting may be required even in the brightest regions.

See Appendix for a more accurate illustration of how daylight functions in the space. Appendix has the luminance analysis results.

5.2 Exercise two

In Exercise two we perform spatial lighting analysis of first floor of Building G which is in (appendix 47-50). Here we can understand the summary of Lighting Analysis of the first floor of Building G, we can understand how the building gets the sunlight inside the building and where is the dark area so that artificial light is required, and it also helps to understand the position and parameters of the windows and building. We can also understand how much sunlight we can utilize in the building so that in that part artificial light is not required so we can save the cost.

6. Energy Analysis (IDA ICE):

IDA ICE is a software where we can do dynamic simulation analysis for the building performance by giving focus on energy efficiency and indoor climate. For this simulation we need to make a IFC export from Revit and then imported into IDA ICE and then all the required parameters for simulation were filled in. Subsequently the simulation can be carried out and after that we get the result.

At first from House G got an average U-Value 0.4303W/(m2k) and the total primary energy was 131.3KWh/m2. To make the energy efficiency of the building a set of changes were made.

Decreasing the U-Value can be profitable as it helps to make more resistance to heat loss and there are many ways to achieve that such as having thicker exterior walls with thicker layers of insulations and increase the amount of insulation in the roof. So, the improvement to the walls, roofs and windows could decrease the U-Value for better thermal performance.

The window-to-envelop ratio is 11.1% and envelop area per volume is 0.6179 m2/m3 show a good balance between daylight and energy efficiency reducing thermal exchange through window. Additionally with 15% thermal dissatisfaction, the building provides a good thermal comfort especially in cold climate.

With all the modification the simulation carried out again and that makes enhancement in energy efficiency, with an average U-Value 0.3563 W/(m2k) and the total primary energy is 120.3KWh/m2. So, it is 8.4% more efficient which is given in the figure below.

SIMULATION TECHNOLOGY GROUP

Delivered Energy Report

Project		Building	
		Model floor area	296.2 m2
Customer		Model volume	766.9 m3
Created by	Debashruti Dawn	Model ground area	157.2 m2
Location	Kalmar	Model envelope area	473.8 m2
Climate file	Kalmar-1968	Window/Envelope	11.1 %
Case	Hus nGr6	Average U-value	0.4303 W/(m2 K)
Simulated	2024-09-19 16:10:13	Envelope area per Volume	0.6179 m2/m3

Building Comfort Reference

Percentage of hours when operative temperature is above 27°C in worst zone	35 %
Percentage of hours when operative temperature is above 27°C in average zone	22 %
Percentage of total occupant hours with thermal dissatisfaction	15 %

Overall Energy Performance (ISO 52000-1, Chapter 9.6)

	Total		Total primary energy		Non-renewable primary energy		CO2 Emission	
	kWh	kWh/m²	kWh	kWh/m²	kWh	kWh/m²	kg	kg/m²
Purchased by facility (el)	7572.3	25.6	18930.7	63.9	17416.3	58.8	3180.4	10.7
Total Electricity	7572.3	25.6	18930.7	63.9	17416.3	58.8	3180.4	10.7
Purchased by facility (fuel)	6603.8	22.3	7264.2	24.5	7264.2	24.5	1452.8	4.9
Total Fuel	6603.8	22.3	7264.2	24.5	7264.2	24.5	1452.8	4.9
Purchased by facility (dh)	9775.3	33.0	12707.8	42.9	12707.8	42.9	2541.6	8.6
Total Heat	9775.3	33.0	12707.8	42.9	12707.8	42.9	2541.6	8.6
Overall energy performance			38902.8 (2)	131.3	37388.3 (3)	126.2	7174.8	24.2
RER*			0.039	0.0				
RER on-site**			0.0	0.0				

Figure 13.Result of IDA ICE report, amount of electricity requirement for the house G

EQUA SIMULATION TECHNOLOGY GROUP

Delivered Energy Report

Project		Building	
		Model floor area	296.2 m2
Customer		Model volume	766.9 m3
Created by	Debashruti Dawn	Model ground area	161.7 m2
Location	Kalmar	Model envelope area	478.3 m2
Climate file	Kalmar-1968	Window/Envelope	11.0 %
Case	Hus nGr7	Average U-value	0.3563 W/(m2 K)
Simulated	2024-10-13 15:30:58	Envelope area per Volume	0.6238 m2/m3

Building Comfort Reference

Percentage of hours when operative temperature is above 27°C in worst zone	47 %
Percentage of hours when operative temperature is above 27°C in average zone	29 %
Percentage of total occupant hours with thermal dissatisfaction	18 %

Overall Energy Performance (ISO 52000-1, Chapter 9.6)

	Total		Total primary energy		Non-renewable primary energy		CO2 Emission	
	kWh	kWh/m^2	kWh	kWh/m^2	kWh	kWh/m^2	kg	kg/m^2
Purchased by facility (el)	7572.0	25.6	18930.1	63.9	17415.7	58.8	3180.3	10.7
Total Electricity	7572.0	25.6	18930.1	63.9	17415.7	58.8	3180.3	10.7
Purchased by facility (fuel)	6603.8	22.3	7264.2	24.5	7264.2	24.5	1452.8	4.9
Total Fuel	6603.8	22.3	7264.2	24.5	7264.2	24.5	1452.8	4.9
Purchased by facility (dh)	7257.0	24.5	9434.1	31.9	9434.1	31.9	1886.8	6.4
Total Heat	7257.0	24.5	9434.1	31.9	9434.1	31.9	1886.8	6.4
Overall energy performance			35628.3 (2)	120.3	34113.9 (3)	115.2	6519.9	22.0
RER*			0.043	0.0				
RER on-site**			0.0	0.0				

Figure 14. Results of IDA ICE report, amount of electricity requirement for the house G after modification

7. Life Cycle Assessment (Anavitor):

Using Anavitor software, we performed a life cycle assessment (LCA) on Building G in this section. Following the instructions in our course materials, we first exported the BIM model from Revit as an IFC file.

After uploading the IFC file to Anavitor, we matched that all construction components had been accurately transferred and in the appropriate quantities. Next, we compared the quantity of the materials chosen in Anavitor with the 2D drawings, using "recipes" that corresponded to the building's components.

The environmental impact of the building was shown by the LCA analysis. Building G's total carbon emissions were 93583 kg, or 247.835 kg of CO2 per square meter, as shown in Figure 15. This lies between 200 and 250 kg CO2 per square meter, which is standard for concrete buildings. In some other objects, like columns, might not have been included completely, which could have an impact on the accuracy.

The clients can understand how much the building is sustainable with the use of the Life Cycle Assessment analysis. It also provides us with the opportunity to think about more environmentally friendly options to reduce the carbon impact of the structure. To obtain green construction certifications like Miljöbyggnad, which concentrate on sustainability.

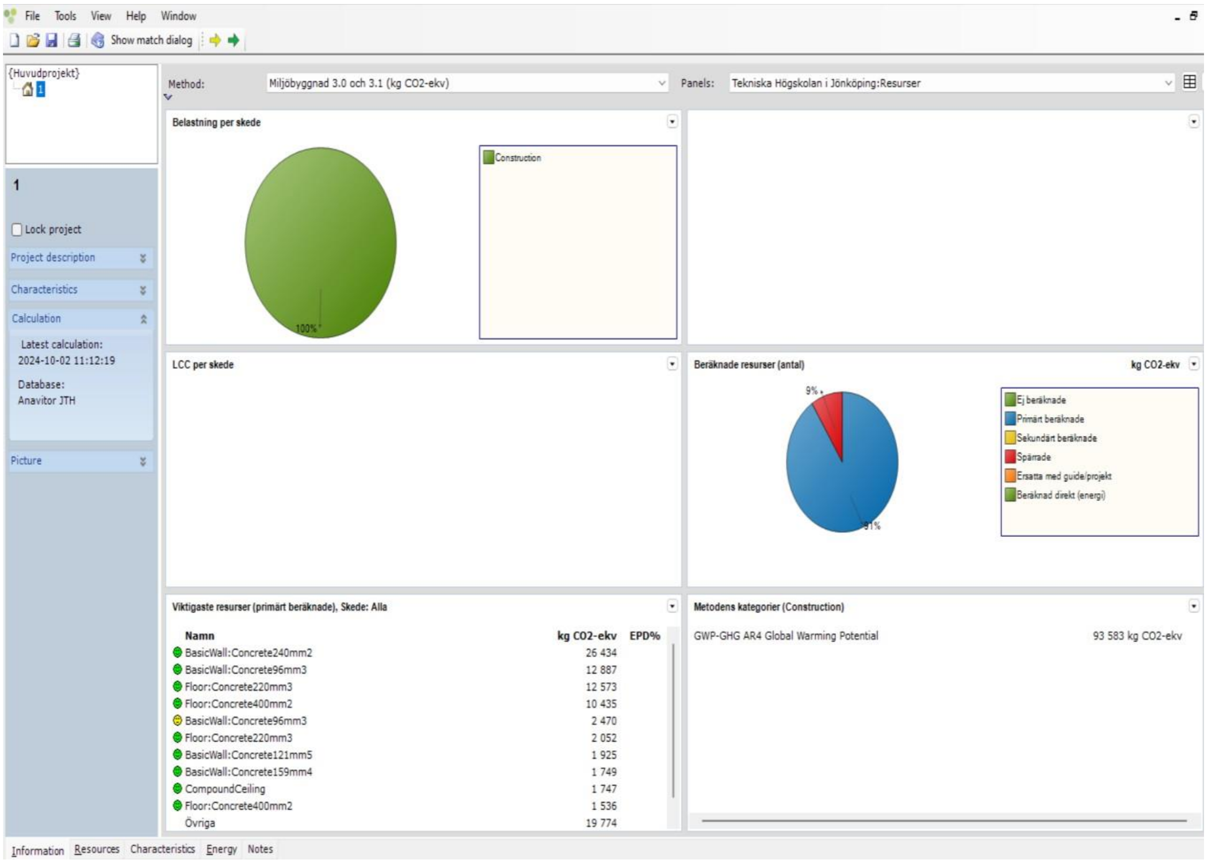

Figure 15. Result of Life Cycle Assessment (LCA)Analysis using Anavitor Software for Building G

8. Cost Estimation (Bidcon):

The first step in utilising Bidcon was to import an IFC file into the software. The file was tidyed up by eliminating unnecessary details before moving on. Then, by using the project's designs as a guide, precise materials, amount, and specifications were chosen for important building elements, including windows, walls, and roofs. The software provides the amount and cost of the materials.

In this exercise we learn how difficult it is to have an accurate and thorough BIM model. Time was saved and increased dependability in the cost and quantity computations by providing accurate information about materials and quantities.

In Hus G, Bidcon's cost estimate is 2323733 SEK for the project's overall cost (Figure16). The reason is that the BIM model did not contain all required parts, which led to an underestimation of the cost and reduced computation accuracy. For instance, the report credibility was impacted by the omission of the edge reinforcement estimation.

Other than this, Bidcon helps in the building sector, particularly in the initial phases of a project. In order to increase project efficiency and cut waste, it helps provide cost estimates and material requirements. Achieving a Miljöbyggnad certification can also be more likely with efficient use of Bidcon.

Nettokalkyl BDT innehåll

Project Code	Project Description	Project Location	Customer	Administrator	Checked
Project1	BuildingG				
Selection				Date: 2024-10-10	Page: 17

BD	Name	Total Quantity	Unit	Material Cost/Unit	Material Total Cost	Time (h)/Unit	Time Total (h)	SC Cost/Unit	SC Total Cost	Net Cost/Unit	Net Cost/Total
	Virke, 15x69 mm, furu, planhyvlat	*67,7*	*m*	*42,40*	*2 871*					*42,40*	*2 871*
	Fästmaterial	*18,5*	*st*	*1,00*	*18*					*1,00*	*18*
	Träarbetare	*7,8*	*tim*			*1,000*	*7,8*			*450,00*	*3 521*
78	*Foderlist av furu 12x56 fabriksbeh*	*62,6*	*m*	*31,76*	*1 987*	*0,069*	*4,3*	*0,00*	*0*	*62,96*	*3 939*
	Foderlist, 12x56 mm, furu, fabriksbehandlad	*68,8*	*m*	*28,69*	*1 975*					*28,69*	*1 975*
	Fästmaterial	*12,5*	*st*	*1,00*	*13*					*1,00*	*13*
	Träarbetare	*4,3*	*tim*			*1,000*	*4,3*			*450,00*	*1 952*
55	*Drevningsremsa 22x100 mm, glasull*	*64,1*	*m*	*6,44*	*412*	*0,058*	*3,7*	*0,00*	*0*	*32,43*	*2 078*
	Drevningsremsa 22x100 mm, glasull	*67,9*	*m*	*6,07*	*412*					*6,07*	*412*
	Träarbetare	*3,7*	*tim*			*1,000*	*3,7*			*450,00*	*1 666*
Summary: Fönster / dörrar / partier / portar					**1 094 387**		**229,8**		**26 609**		**1 224 390**
Summary Total :					**1 868 031**		**838,1**		**78 550**		**2 323 733**

Figure 16.Result of cost estimation for Building G utilizing the Bidcon software.

9. Certification System:

For Hus G Miljöbyggnad system is chosen. It shows the environmental performance of the building. It has four aspects and 15 indicators. This system has been chosen because it is for the Swedish market and mainly for building and authority regulation and construction practice. This system can be used for both new and old buildings. It also has three different ratings: gold, Silver and bronze.

9.1 What aspect of your building can you analyses with this certification?

The four aspects that can be analyzed are heat power demand, energy, climate impact, and thermal climate (Figure 17). Some of the other aspects can also be analyzed.

2. ÖVERSIKT AV MILJÖBYGGNAD

Områden, aspekter, indikatorer och kriterier

	Aspekt	Indikatorer	EU-taxonomi kriterium och sammanfattning
Energi och klimat	Effektbehov	1. Värmeeffektbehov	**A1-7.1-SC 1** Testning eller tillförlitlig process för lufttäthet.
		2. Solvärmelast	
	Energi	3. Energianvändning	**A2-7.1-DNSH 1** Energianvändningen överstiger ej BBR-krav. Energideklaration. **A1-7.1-SC 1** Energianvändningen är minst 10 procent lägre än BBR-krav. Energideklaration.
	Klimat-påverkan	4. Klimatpåverkan	**A1-7.1-SC 1** Full LCA för byggnaden.
Inomhusmiljö	Fukt	5. Fukt	
	Ljud	6. Ljud	
	Termiskt klimat	7. Termiskt klimat vinter	
		8. Termiskt klimat sommar	
	Utfasning av farliga ämnen	9. Utfasning av farliga ämnen	**A1-7.1-DNSH 5** Förebyggande och bekämpning av föroreningar.
Utomhusmiljö	Klimatrisker	10. Klimatrisker	**A1-7.1-DNSH 2** Klimatrisk- och sårbarhetsanalys. **A2-7.1-SC 2** Anpassningslösningar.
	Ekosystem-tjänster	11. Ekosystemtjänster	**A1-7.1-DNSH 6** Hänsyn till ekosystem och biologisk mångfald.
Cirkularitet	Cirkulärt byggande	12. Flexibilitet och demonterbarhet	**A1-7.1-DNSH 4** Byggnadskonstruktionen uppfyller krav gällande flexibilitet och demonterbarhet.
		13. Cirkulära materialflöden	
		14. Avfallshantering	**A1-7.1-DNSH 4** Bygg- och rivningsavfall uppfyller krav gällande avfallshantering.
	Byggmaterial	15. Loggbok med byggvaror	

Figure 17. Aspects, Indicators and EU taxonomy of Miljöbyggnad

9.2 How would your building perform according to the certification system?

Conducted analysis that could be used to get building performances useful for the chosen certification by using the different software's and the analyses conducted in the project, numerous indicators can be calculated. In Anavitor, an LCA can be created that can be used for indicator (4) climate impact. The software VELUX Daylight Visualizer and its analysis can be used for indicator (2) solar heat load while through the add-on module on IDA ICE, the indicators (1) heat power demand, (2) solar heat load, (3) energy usage, (7) thermal climate winter, and (8) thermal climate summer can be calculated (EQUA, n.d.).

The remainder of indicators cannot be graded through the conducted analyses and software's used in the project. With external services of experts in the fields and other software's, indicators of for instance sound and moist can analyzed and graded as well. The combined performance of the building and its environmental characteristics determines the total rating of the property.

9.3 How would your building perform according to the certification system?

The performance of Building G in the Miljöbyggnad certification system cannot be fully determined based on the information gathered from the analyses and software used. However, an example is shown in Figure 17, where the building's heat power demand (Indicator 1) was calculated. In this case, the building achieved a gold grade, which is a high-performance rating, based on values from Revit and IDA ICE software. Through the cost estimation performed in Bidcon and the Life Cycle Assessment (LCA) done in Anavitor, it's possible to identify and replace expensive or environmentally harmful materials with more eco-friendly and cost-effective alternatives. To improve the building's overall performance and achieve a higher grade in the certification, several upgrades can be made:

Conducted analysis that could be used to get building performances useful for the chosen certification by using the different software's and the analyses conducted in the project, numerous indicators can be calculated. In Anavitor, an LCA can be created that can be used for indicator (4) climate impact. The software VELUX Daylight Visualizer and its analysis can be used for indicator (2) solar heat load while through the add-on module on IDA ICE, the indicators (1) heat power demand, (2) solar heat load, (3) energy usage, (7) thermal climate winter, and (8) thermal climate summer can be calculated (EQUA, n.d.).

The remainder of indicators cannot be graded through the conducted analyses and software's used in the project. With external services of experts in the fields and other software's, indicators of for instance sound and moist can analyzed and graded as well. The combined performance of the building and its environmental characteristics determines the total rating of the property.

Install windows with lower U-values: This will improve insulation and reduce heat loss. Add solar panels on the roof: This will help generate renewable energy and lower energy consumption. Use environmentally friendly materials: Choosing sustainable materials reduces the building's environmental impact. Increase insulation in the walls: Better insulation will reduce heat loss, keeping the building more energy-efficient. Lower indoor temperatures: This can save energy by reducing the need for heating. By making these improvements, the building can perform better and achieve a higher level of certification in Miljöbyggnad.

Byggnad	Hus G
Eventuell kommentar	

Beräknat värmeeffektbehov W/m², A_{temp}	5.7	GULD

Areor och klimat	
A_{temp}, m²	318
Andel bostäder av A_{temp} i %	100%
Andel lokaler av A_{temp} i %	0%
F_{geo}, se flik	1
Omslutningsarea, obs A_{om}, m²	997
Inomhustemperatur, °C	20
Klimatort	Jönköping
Tidskonstant, dygn	1
DVUT, °C	-13.6
Värmeeffektbehov /m²A_{temp}	17.9

Gränser för den aktuella byggnaden. Beror på andel bostäder och lokaler och aktuell F_{geo}		
BRONS	SILVER	GULD
25.0	20.0	15.0

Transmissionsförluster		
Byggnadsdel	**Delarea** m²	**U-värde** W/K,m²
Fönster, typ 1	61.6	0.083
Fönster, typ 2	0	0
Fönster, typ 3	0	0
Yttervägg, typ 1	493.2	0.083
Yttervägg, typ 2	0	0
Yttervägg, typ 3	0	0
Tak, typ 1	246.1	0.086
Tak, typ 2	0	0
Tak, typ 3	0	0
Grundkontruktion, typ 1	167.4	0.11
Grundkontruktion, typ 2	0	0
Källarväggar typ 1	0	0
Källarväggar typ 2	0	0
Källargolv, typ 1	0	0
Källargolv, typ 2	0	0
Ytterdörr, typ 1	16.48	0.03
Ytterdörr, typ 2	12	0.03
Byggnadsdel mot t ex garage	0	0
	0	0

Ventilationsförluster för FTX	
FTX aggregat typ 1	
Luftflöde, l/s	143
Temperaturverkningsgrad	75%
FTX aggregat typ 2	
Luftflöde, l/s	0
Temperaturverkningsgrad	0%
FTX aggregat 4	
Luftflöde, l/s	0
Temperaturverkningsgrad	0%

Ventilationsförluster om F el FVP finns	
Frånluftsflöde, l/s	0
Frånluftens temperaturfall FVP	0
VP:s kompressoreffekt i W	0

Luftläckage genom klimatskärmen	
Lufttäthet, l/s,m²A_{om} vid 50 Pa	0
Luftläckageflöde, l/s	0.0

Köldbryggor		
Om köldbryggor anges i %:		30.0%
Om köldbryggor specificeras:	**Längd, m**	**psi, W/m,K**
Bjälklagskanter	67.5	0
Sockel	0	0.02
Tak-yttervägg	82.8	0.08
Fönstersmygar	169.2	0.05
	0	0
	0	0

Ändra scahblonvärdet ovan till 0 %
Ändra scahblonvärdet ovan till 0 %

U_{medel} för kontroll, W/m² A_{om}/K	0.128

Figure 18. Results of the indicator For House G

9.4 What are the pros and cons of the chosen certification?

Every Certification System has advantages and disadvantages.

The Pros are:

1. Certification system can convince investor with the benefits of sustainability.
2. It promotes sustainable with good indoor environment, energy and material choice.
3. The energy efficiency promoted and encourage energy efficient technologies.
4. It’s also less expensive than other certification system.
5. A combined grade of all indicators is required to obtain a complete certification where all the indicators are equally ranked.

The Cons are:

1. The certification system is costly to meet all the requirements.
2. The system is only specific in Sweden.
3. The process is time consuming, make it a large challenge for short project.
4. It is less known than LEED and BREEAM.
5. It does not have many indicators as LEED and BREEAM.

10. Reference List

[1] Sweden Green Building Council, *Miljöbyggnad 4.0 Manual*, Dec. 2022. [Online]. Available: https://www.sgbc.se/app/uploads/2022/12/Manual_MB_4.0_1.pdf

11. Appendix

11.1 Daylight Factor and luminous factor of 30,60,80 percent Window

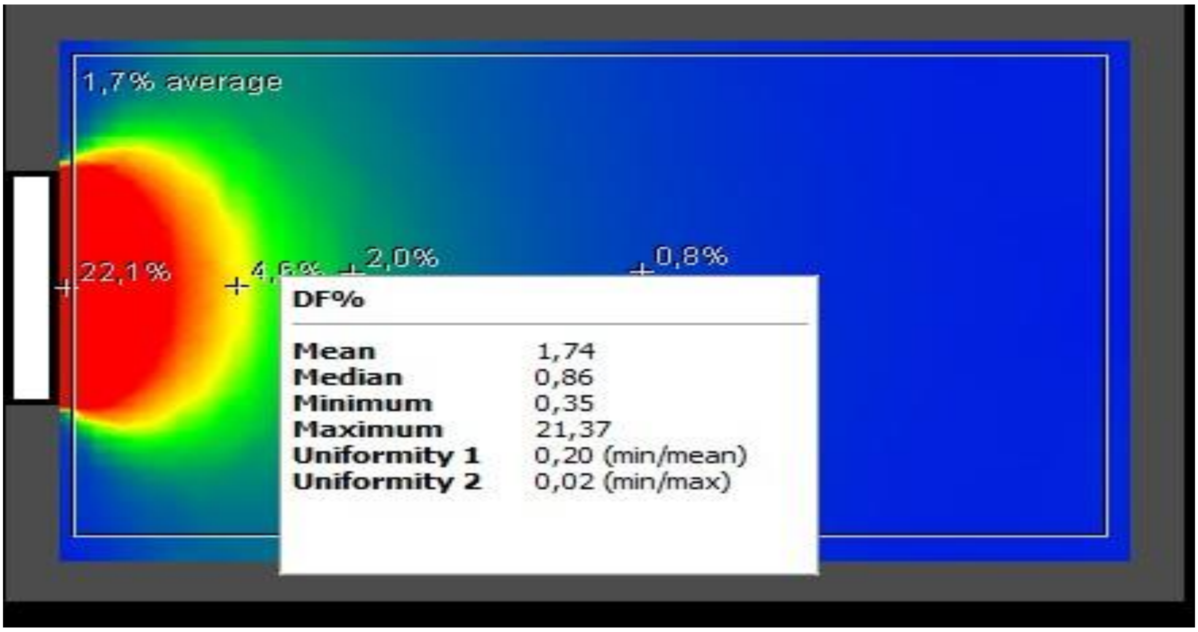

Figure 19.The daylight factor of 30 percent window.

Here we can see the daylight factor of 30 percent window. As the red area has 22.1%which get the most daylight and as it goes inside the light slowly decreases as the yellow part is 4.6% and green part is 2.0% and blue part is 0.8%.

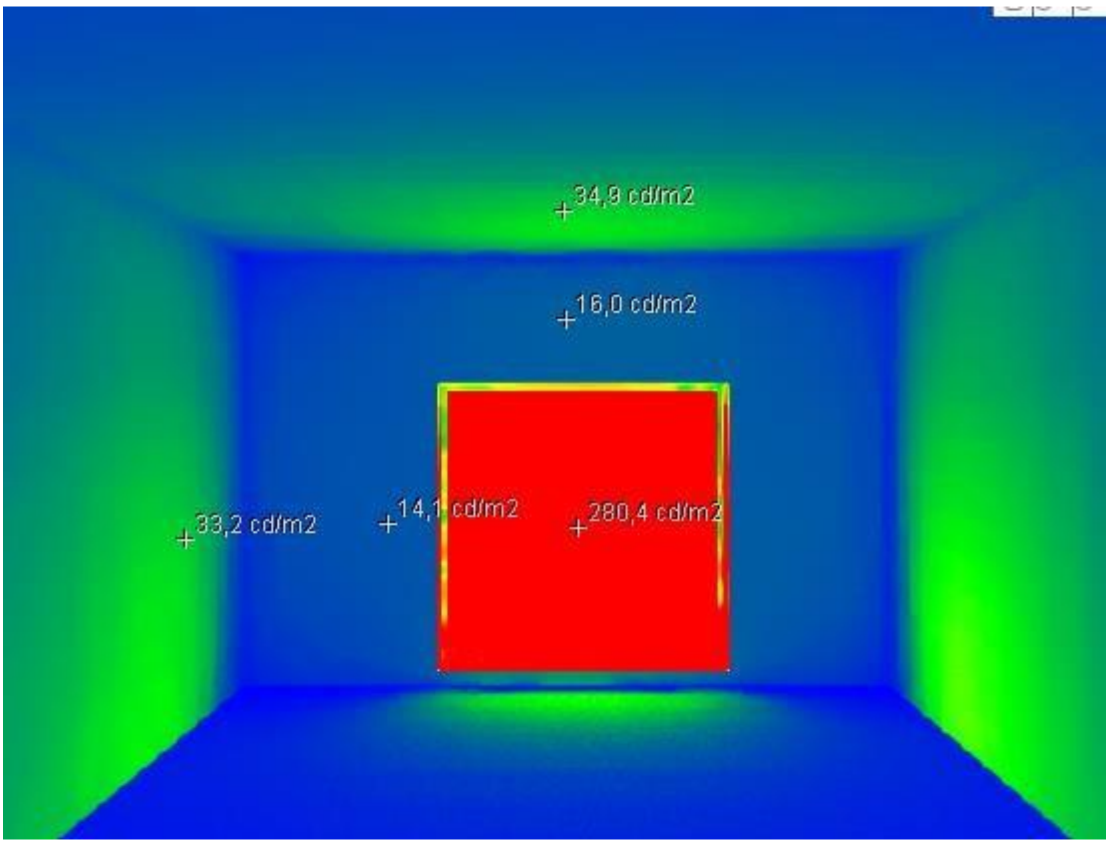

Figure 20. The luminous factor of 30 percent window.

Here we can see the luminous factor of 30 % window, we can understand that the red area has maximum light which is 280.4cd/m2 and the wall in which the window is located has less luminous value which are 14.1 and 16.0 cd/m2 which is in blue color. We can also find light in both side wall as we can see 33.2 cd/m2 the green area and to the top and bottom green area i.e.34.9cd/m2.Through the color we can understand the part of area which will get more light.

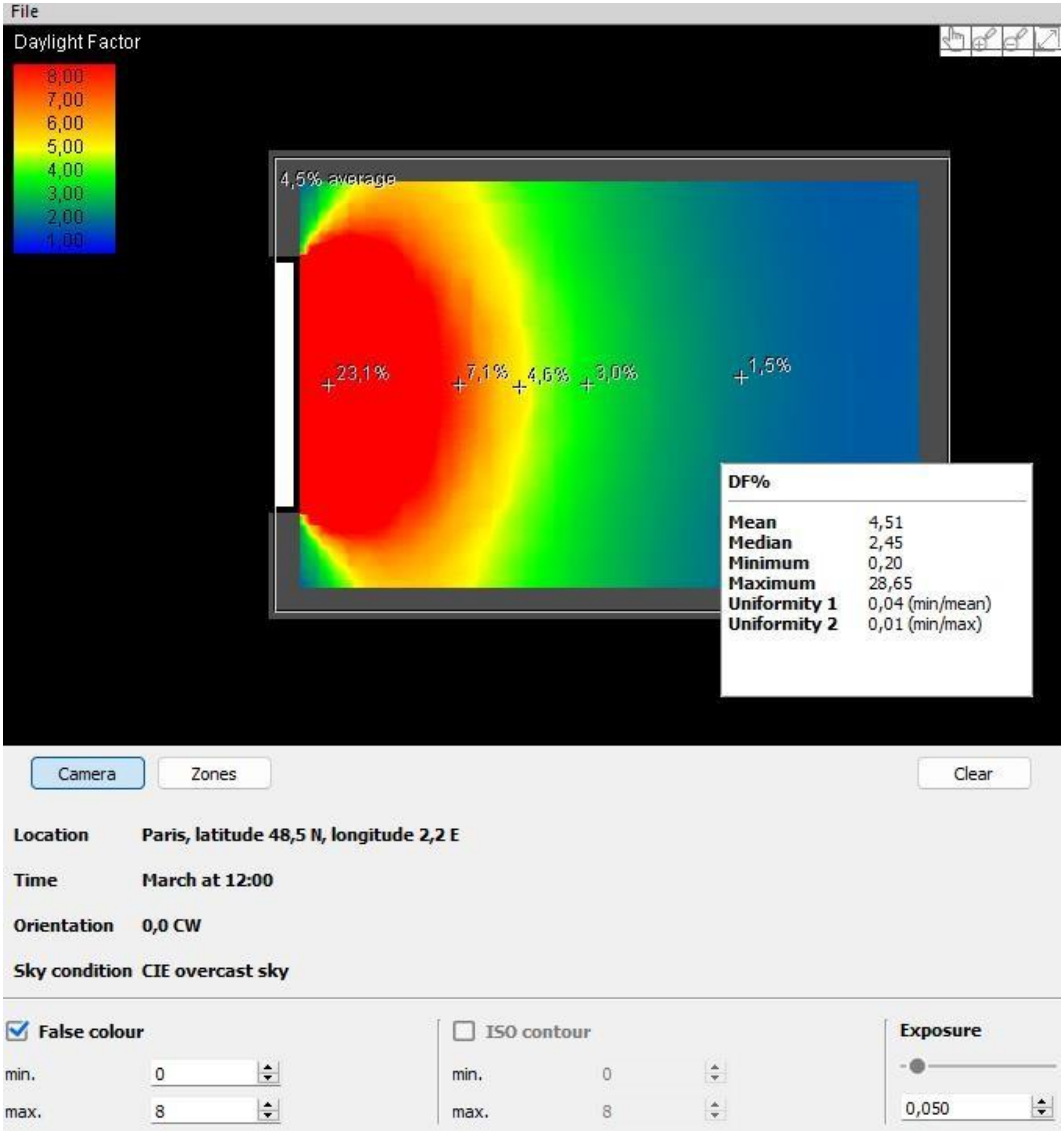

Figure 21.The daylight factor of 60% window.

Here we can see the daylight factor of 60 percent window. As the red area has 23.1%which get the most daylight and as it goes inside the light slowly decreases as the yellow part is 4.6% and green part is 3.0% and blue part is 1.5%.

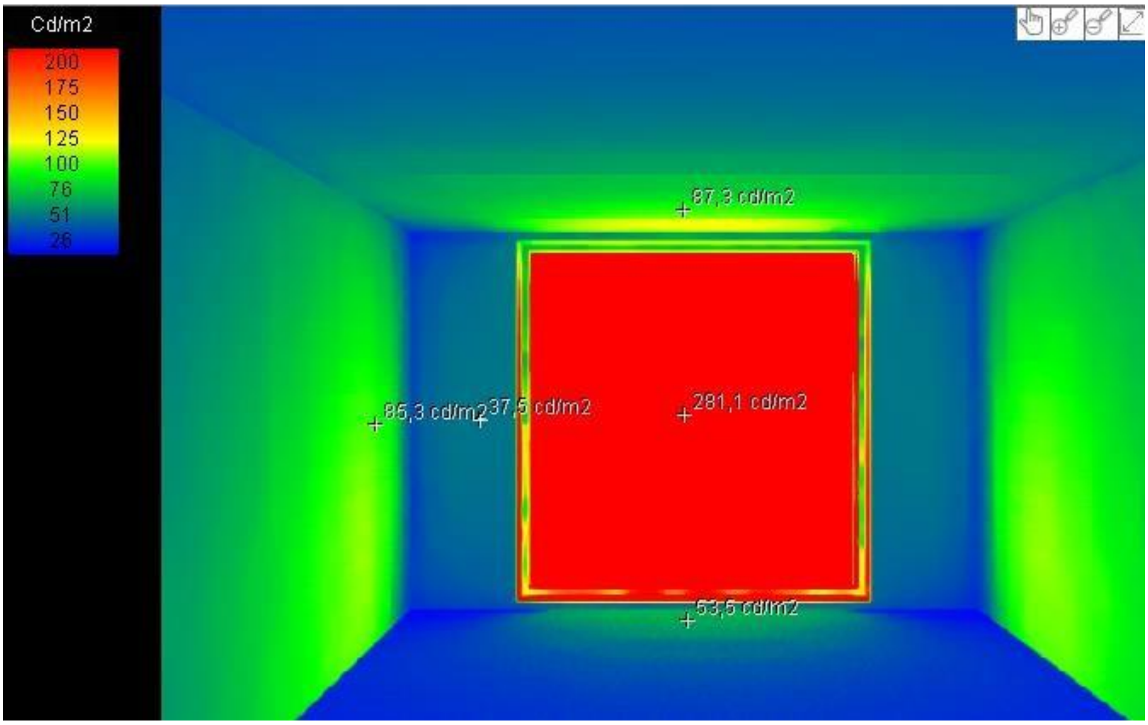

Figure 22. The luminous value of 60% window

Here we can see the luminous factor of 60 % window, we can understand that the red area has maximum light which is 281.1cd/m2 and the wall in which the window is located has less luminous value which are 37.5 cd/m2 which is in blue color. We can also find light in both side wall as we can see 85.3 cd/m2 the green area and also to the top and bottom green area i.e.87.3 and 53.5cd/m2.Through the color we can understand the part of area which will get more light.

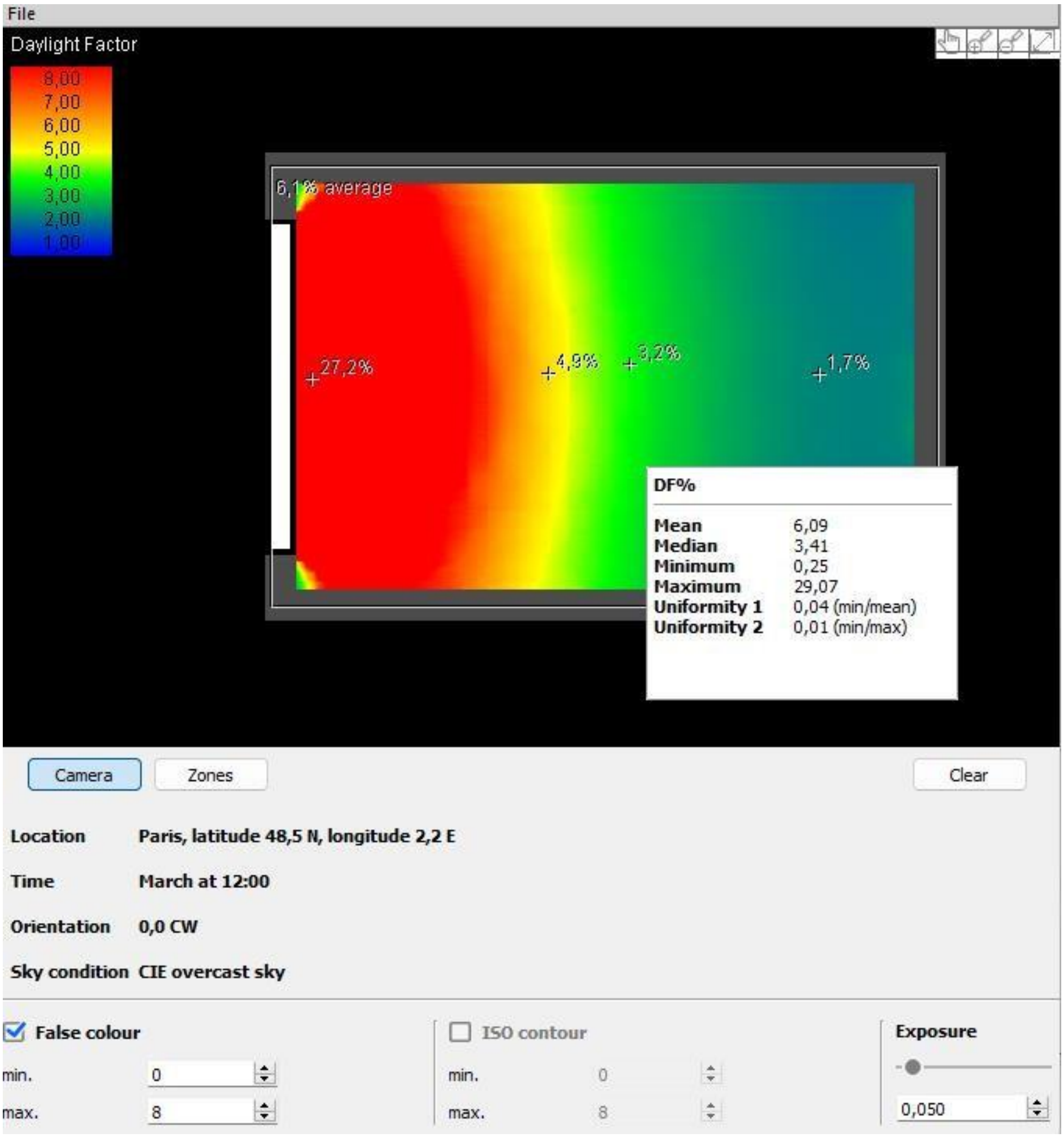

Figure 23. The daylight factor of 80% window

Here we can see the daylight factor of 80 percent window. As the red area has 27.2%which get the most daylight and as it goes inside the light slowly decreases as the yellow part is 4.9% and green part is 3.2% and blue part is 1.7%.

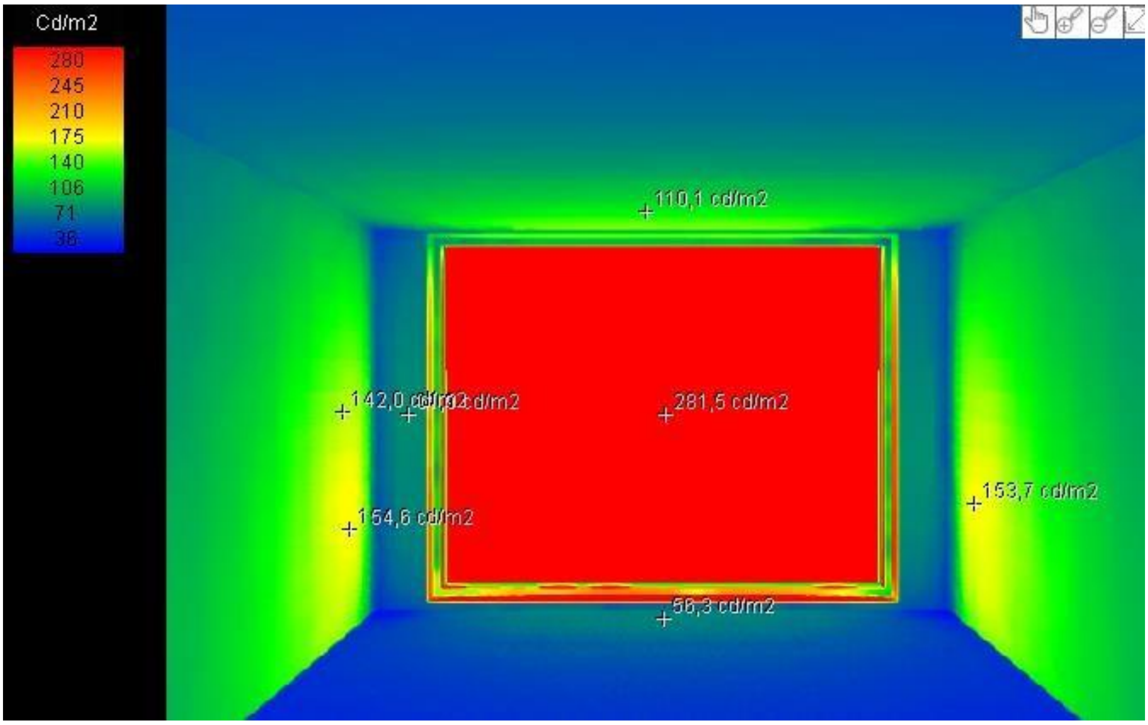

Figure 24.The luminous value of 80% window

Here we can see the luminous factor of 80 % window, we can understand that the red area has maximum light which is 281.5cd/m2 and the wall in which the window is located has less luminous value which are 31.2 cd/m2 which is in blue color. We can also find light in both side wall as we can see 154.6 and 153.7 cd/m2 the green area and to the top green area i.e.110.1/m2.Through the color we can understand the part of area which will get more light. We can also understand as the size of the window increase the lighting value also increased.

11.2 Daylight factor and Luminous value of window of sill height 0.1m,0.9m and 1.5m

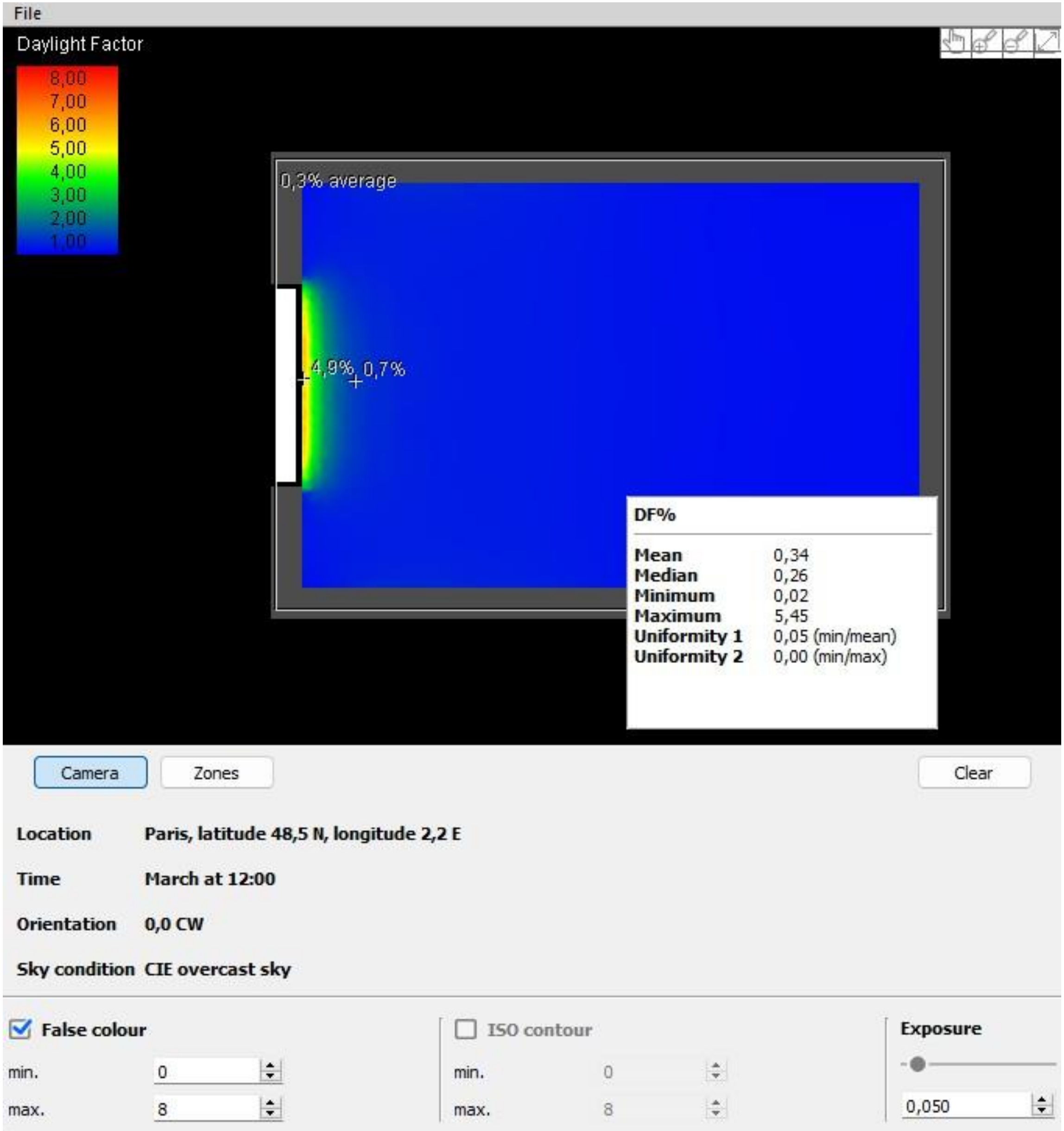

Figure 25. The daylight factor of sill height 0.1m

Here we can see the daylight factor of window's sill height 0.1m. As the sill height is very low the yellow area has 4.9%which get the most daylight and as it goes inside the light slowly decreases as the blue part is 0.7%.

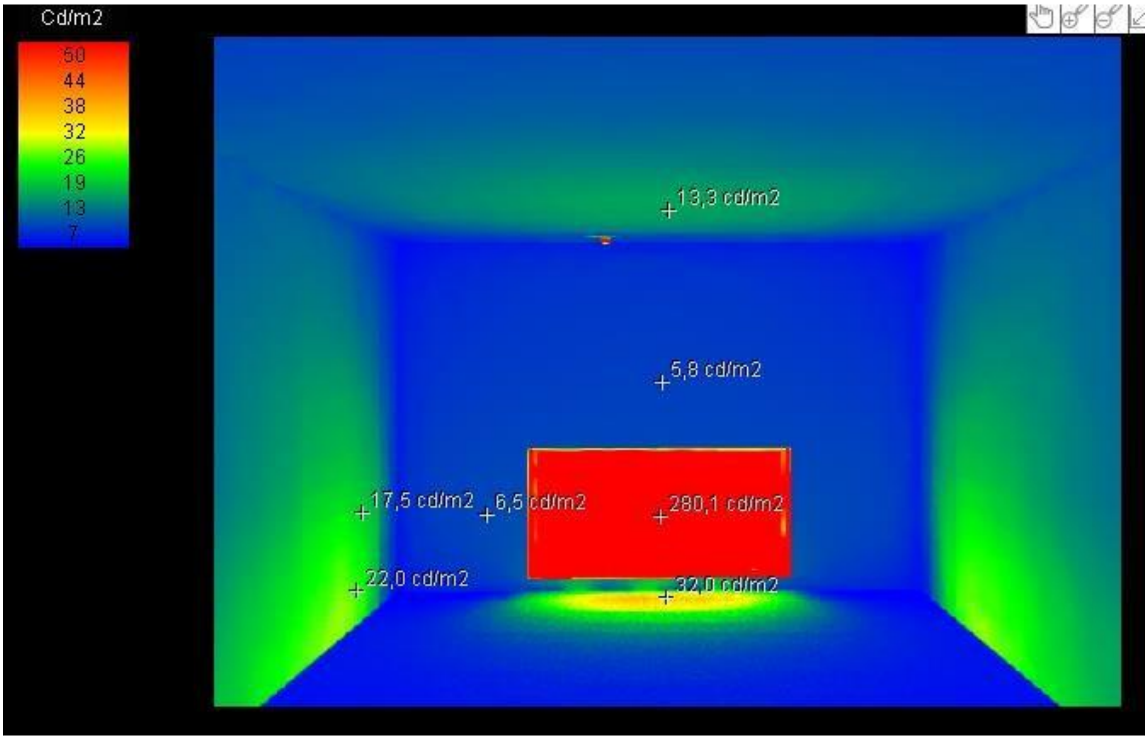

Figure 26. The luminous value of window's sill height 0.9m

Here we can see the luminous factor of window's sill height 0.1m, we can understand that as the sill height is very low the red area has maximum light which is 280.1cd/m2 and the wall in which the window is located has less luminous value which are 6.5 and 5.8cd/m2 which is in blue color. We can also find light in both side lower part of the wall as we can see 22.0 and 17.5 cd/m2 the green area. As the window located down the bottom surface we will get more light at floor which is 32,0cd/m2 and the roof will get less light which is 13.3cd/m2.Through the color we can understand the part of area which will get more light.

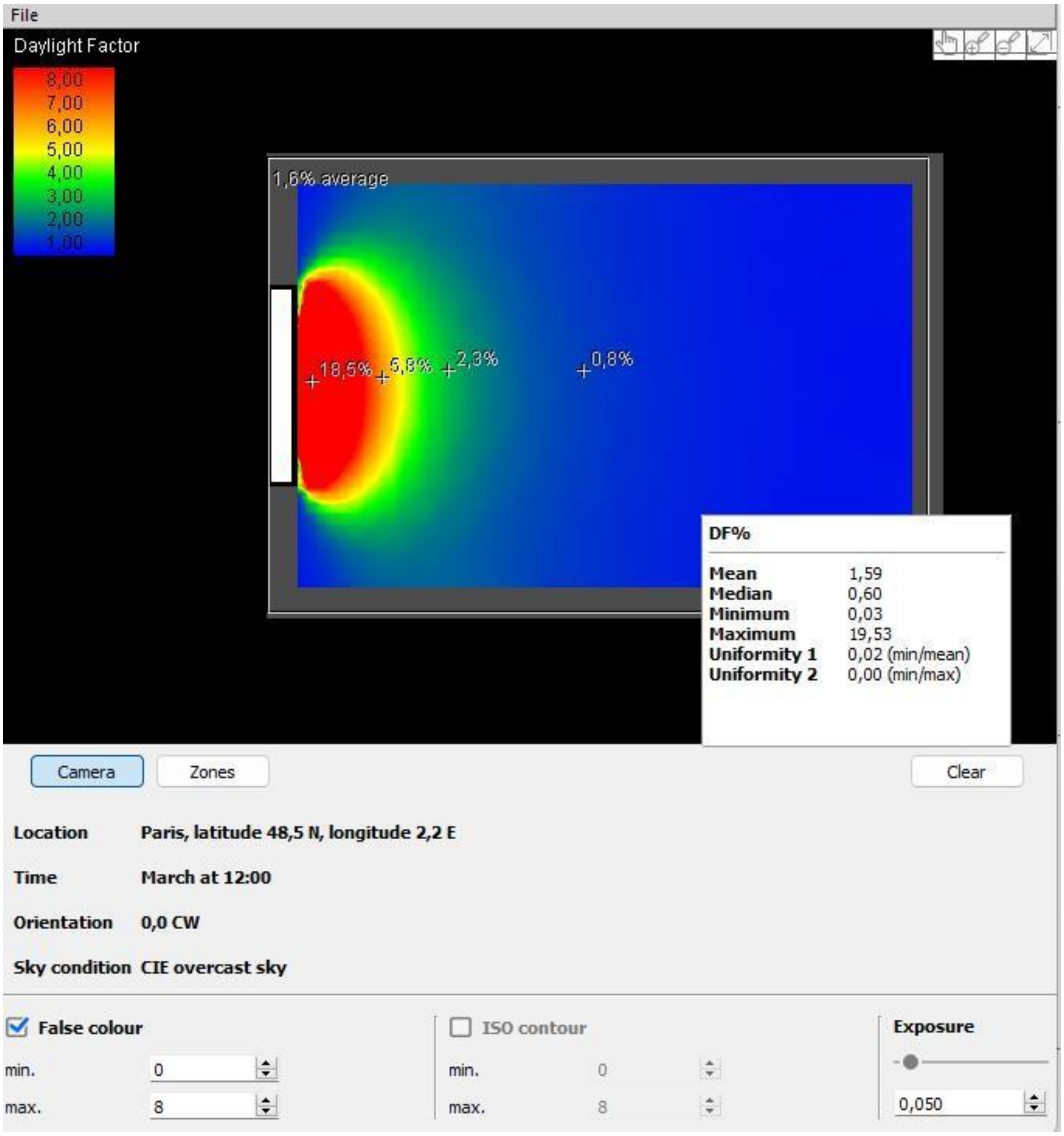

Figure 27. The daylight factor of window's sill height of 0.9m

Here we can see the daylight factor of window’s sill height 0.9m. As the sill height is on 0.9m the red area has 18.9%which get the most daylight and as it goes inside the light slowly decreases as the yellow part is 5.8% and the green part is 2.3% and the blue part is 0.8%.

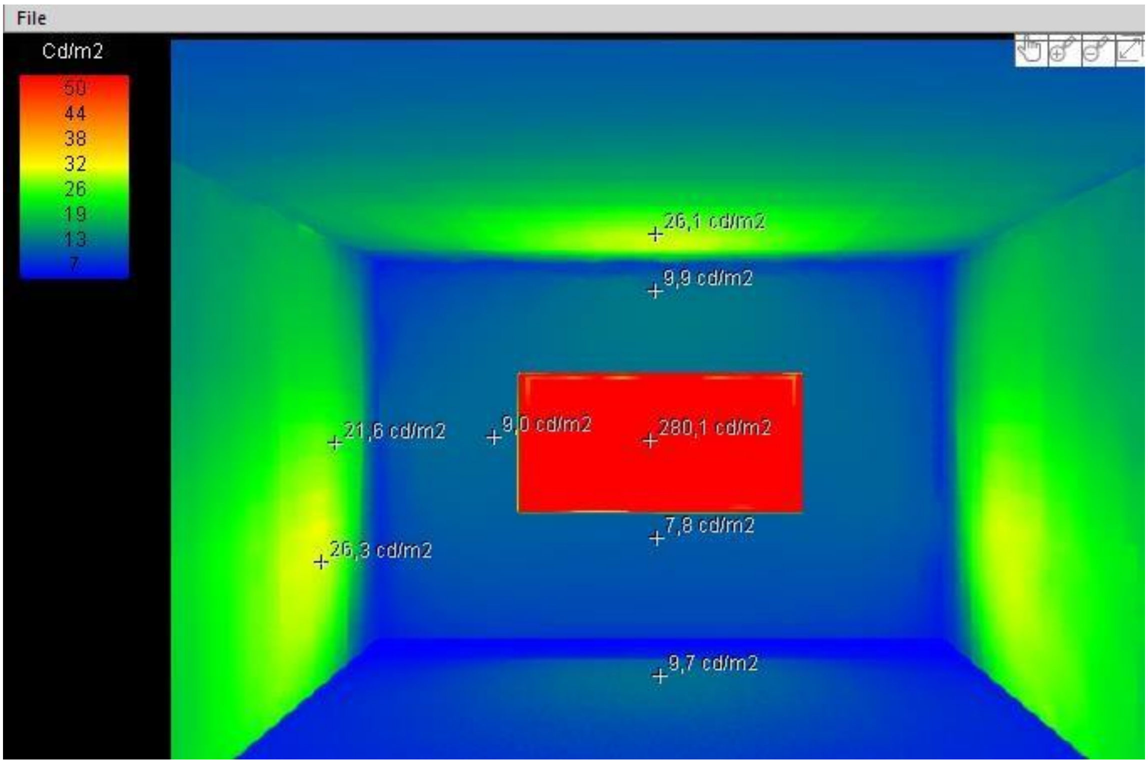

Figure 28.The luminous value of window of sill height of 0.9m

Here we can see the luminous factor of window's sill height 0.9m, we can understand that as the sill height is on 0.9 m, so the red area has maximum light which is 280.1cd/m2 and the wall in which the window is located has less luminous value which are 9.0 and 9.9cd/m2 which is in blue color. We can also find light in both side wall as we can see 26.3 and 21.6 cd/m2 the green area and as the window located the center of the wall it will get more light at roof which is 26.1cd/m2 and the floor will get less light which is 9.7cd/m2.Through the color we can understand the part of area which will get more light.

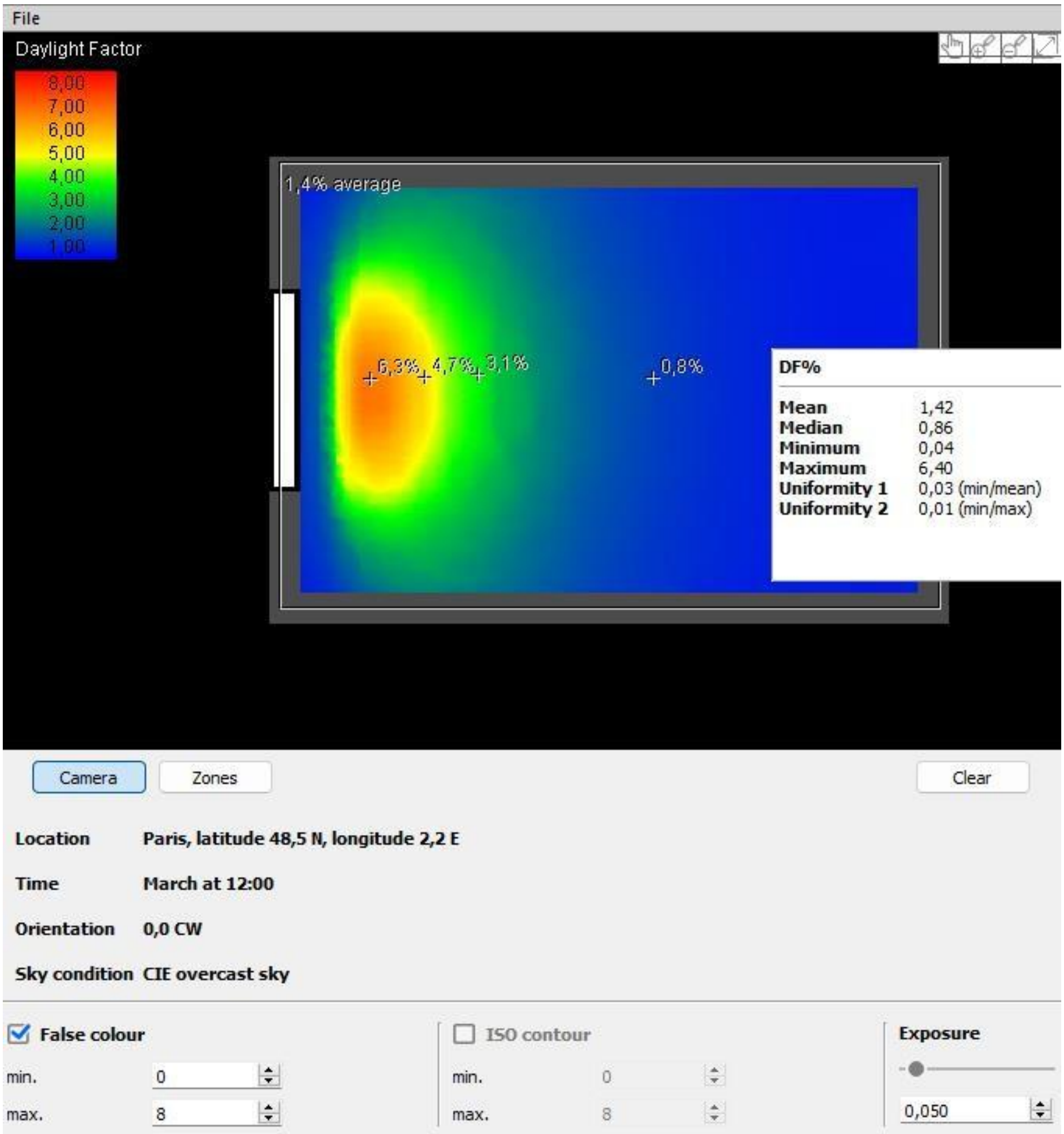

Figure 29. The daylight factor of window of sill height of 1.5m

Here we can see the daylight factor of window's sill height 1.5m. As the sill height is on 1.5m the orange area has 6.3%which get the most daylight and as it goes inside the light slowly decreases as the yellow part is 4.7% and the green part is 3.1% and the blue part is 0.8%.

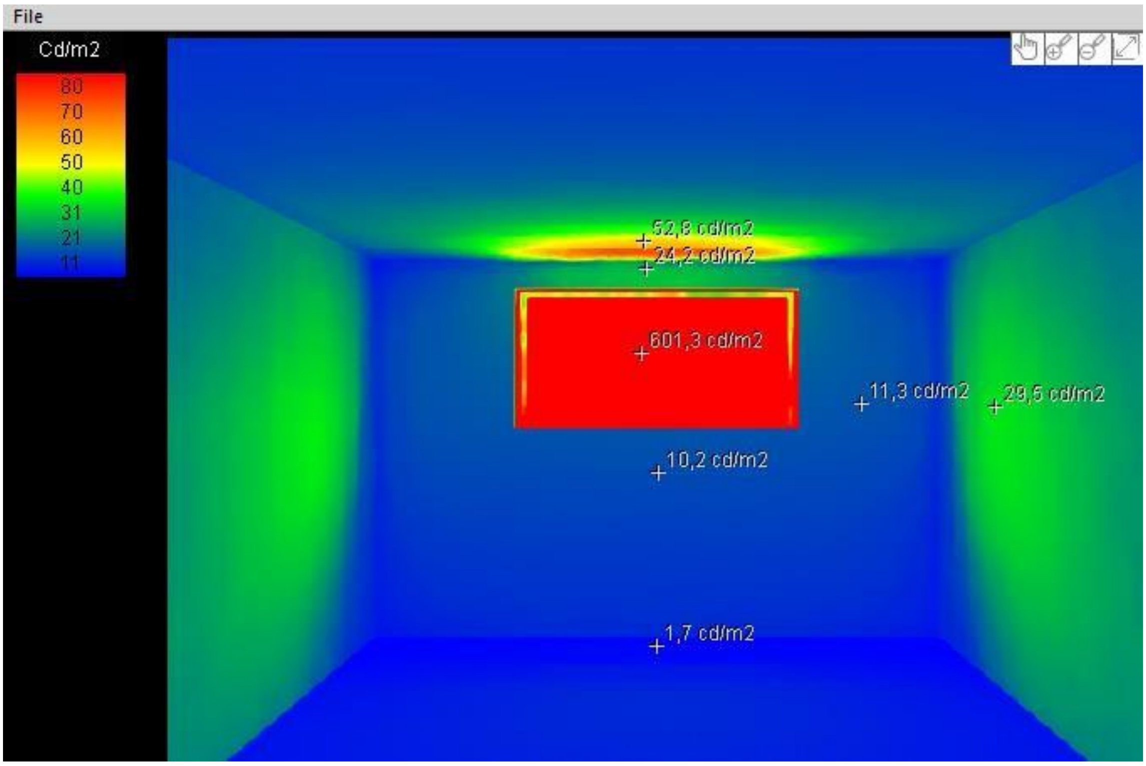

Figure 30. The luminous value of window whose sill height is 1.5m

Here we can see the luminous factor of window's sill height 1.5m, we can understand that as the sill height is on 1.5 m at the top, so the red area has maximum light which is 601.3cd/m2 and the wall in which the window is located has less luminous value which are 10.2 and 11.3cd/m2 which is in blue color. We can also find light in both side wall as we can see 29.5 the green area and as the window located up from the center of the wall it will get more light at roof which is 52.3/m2 and the floor will get less light. Through the color we can understand the part of area which will get more light.

11.3 Daylight factor and luminous factor of different reflectance value of floor, wall, and Roof

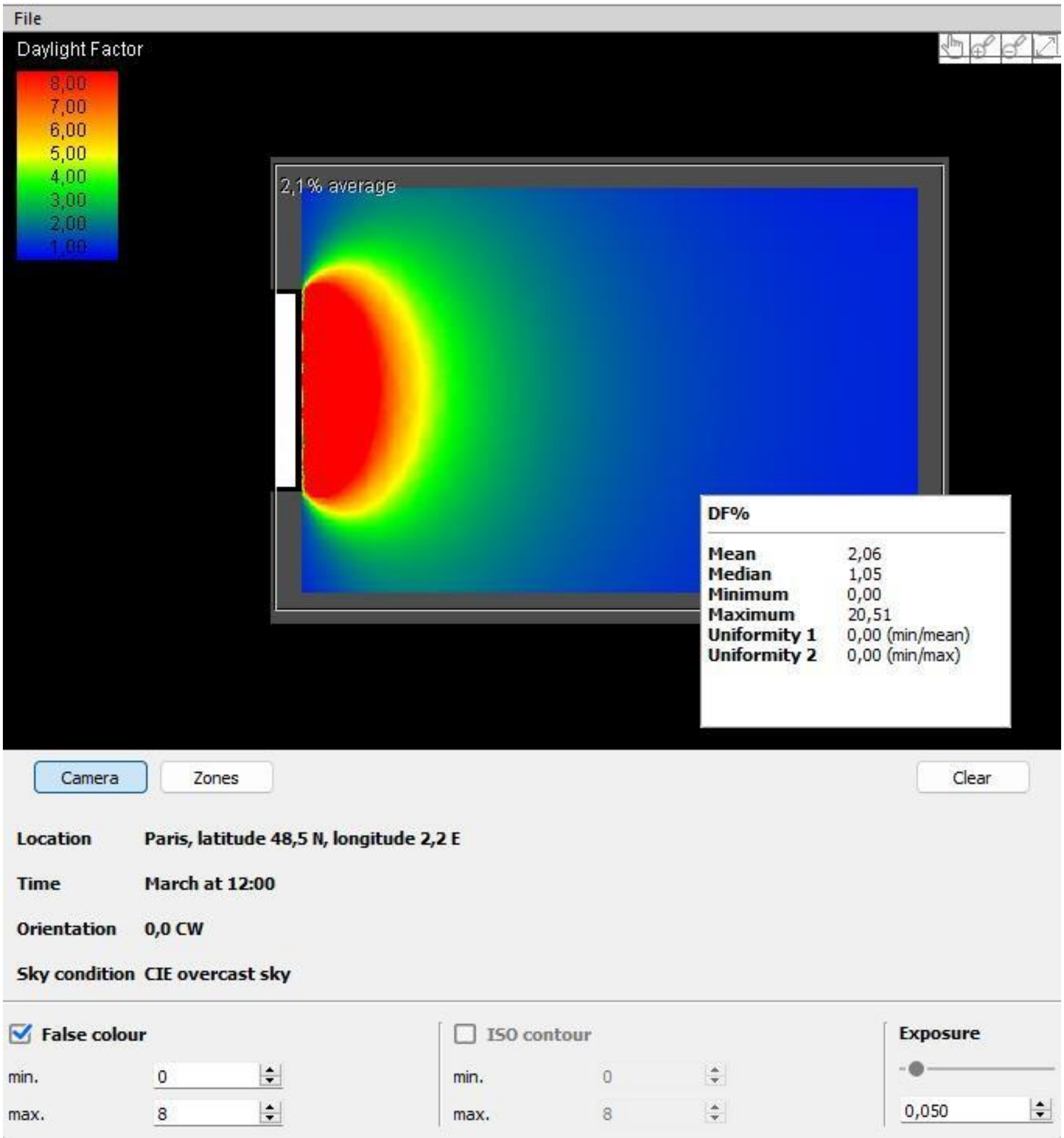

Figure 31. The daylight factor with floor 20% wall 50% and Ceiling 85%

Here we can see the daylight factor of window with reflectance of floor 20% wall 50% and Ceiling 85%. The red area gets the most daylight and as it goes inside the light slowly decreases.

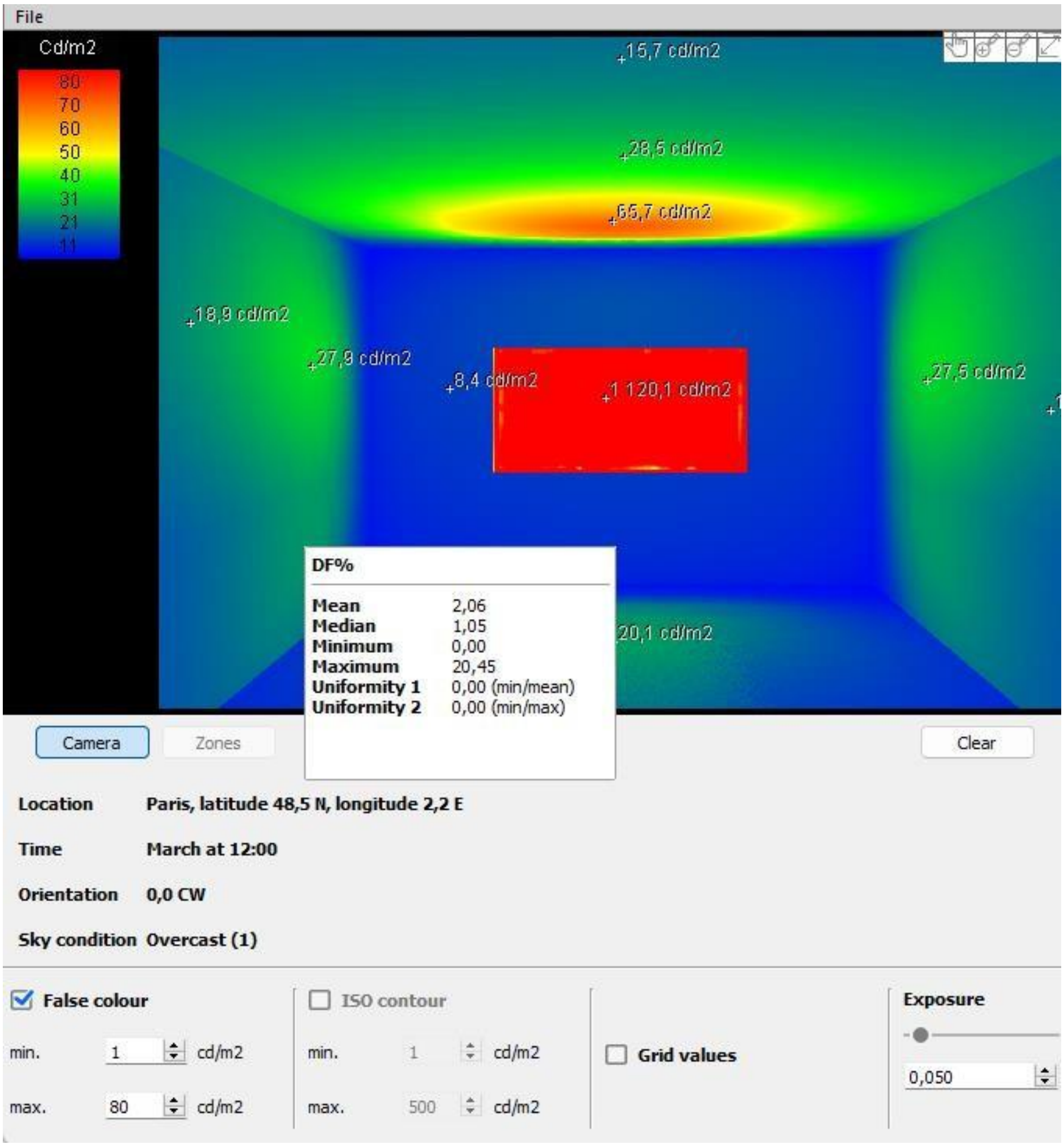

Figure 32. The Luminous value with floor 20% wall 50% and ceiling 85%

Here we can see the luminous factor with reflectance 20% floor,50% wall and 85% ceiling, we can understand that the red area has maximum light which is 1120.1cd/m2 and the wall in which the window is located has less luminous value which is 8.4cd/m2 which is in blue color. We can also find light in both side wall, as the wall is 50% reflector as we can see 27.9 the green area and as the window located at the center of the wall it will get more light at roof as the ceiling reflector value is more (85%) which is 65.7/m2 and the floor will get less as the reflector value is less. Through the color we can understand the part of area which will get more light.

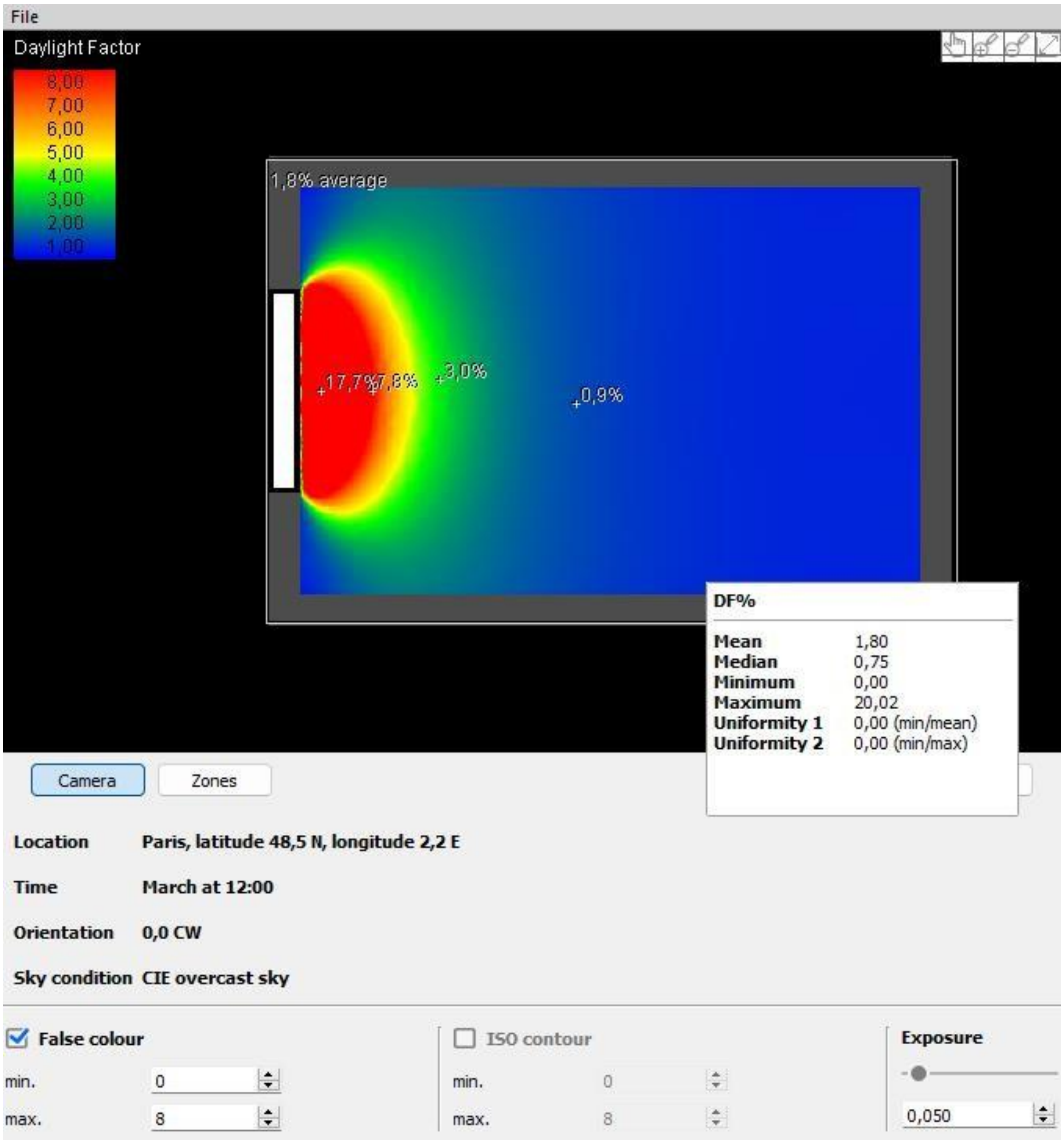

Figure 33.The reflectance values are 20 % floor,85%wall and 20% ceiling.

Here we can see the daylight factor of window with reflector of floor 20% wall 85% and Ceiling 20%. The red area gets the most daylight i.e. 17.7 and as it goes inside the light slowly decreases i.e. 0.9 in blue part.

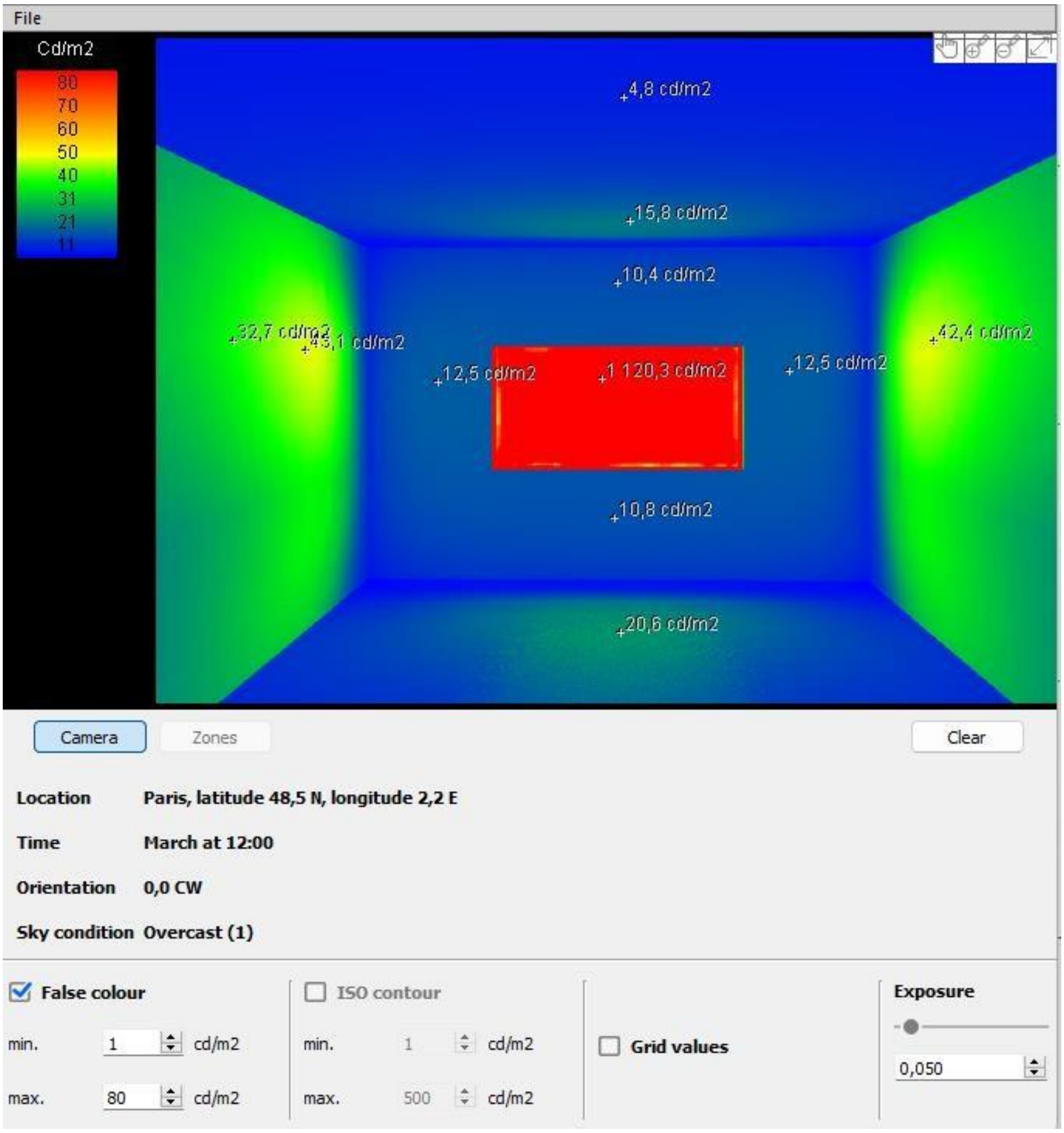

Figure 34. The reflectance value of floor 20%, wall 85%, ceiling 20%

Here we can see the luminous factor with reflector 20% floor,85% wall and 20% ceiling, we can understand that the red area has maximum light which is 1120.3cd/m2 and the wall in which the window is located has less luminous value which is 12.5 and 10.4cd/m2 which is in blue color. We can also find light in both side wall i.e., 45.1(green area) where it is 85% reflector so it will get more lighting and as the window located at the center of the wall it will get less light at roof and floor, as the reflector is 20% which is 20.6 and 15.8. Through the color we can understand the part of area which will get more light.

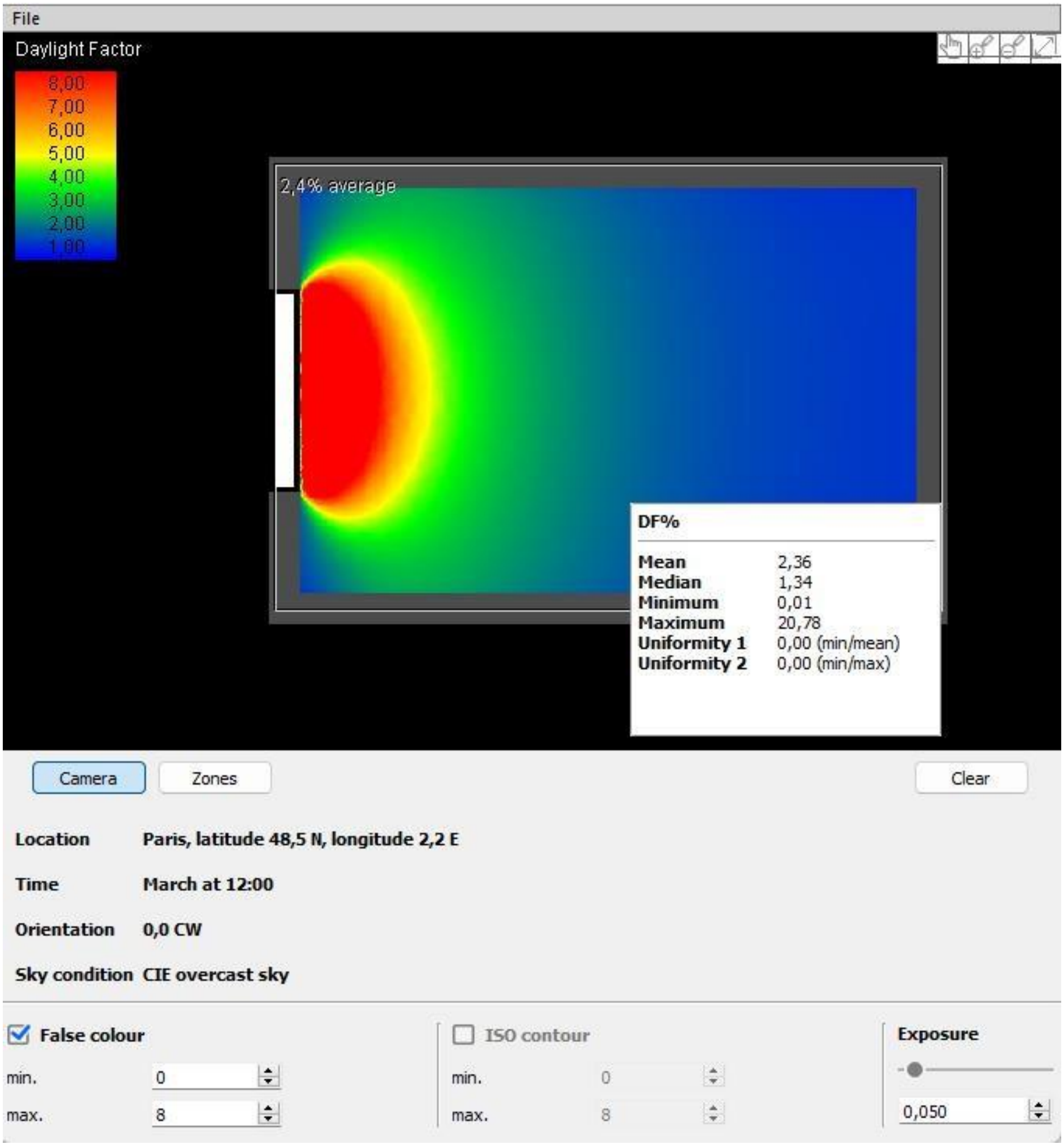

Figure 35. The daylight factor where the reflectance of floor is 20%, wall 85%, ceiling 85%

Here we can see the daylight factor of window with reflector of floor 20% wall 85% and Ceiling 85%. The red area gets the most daylight and as it goes inside the light slowly decreases.

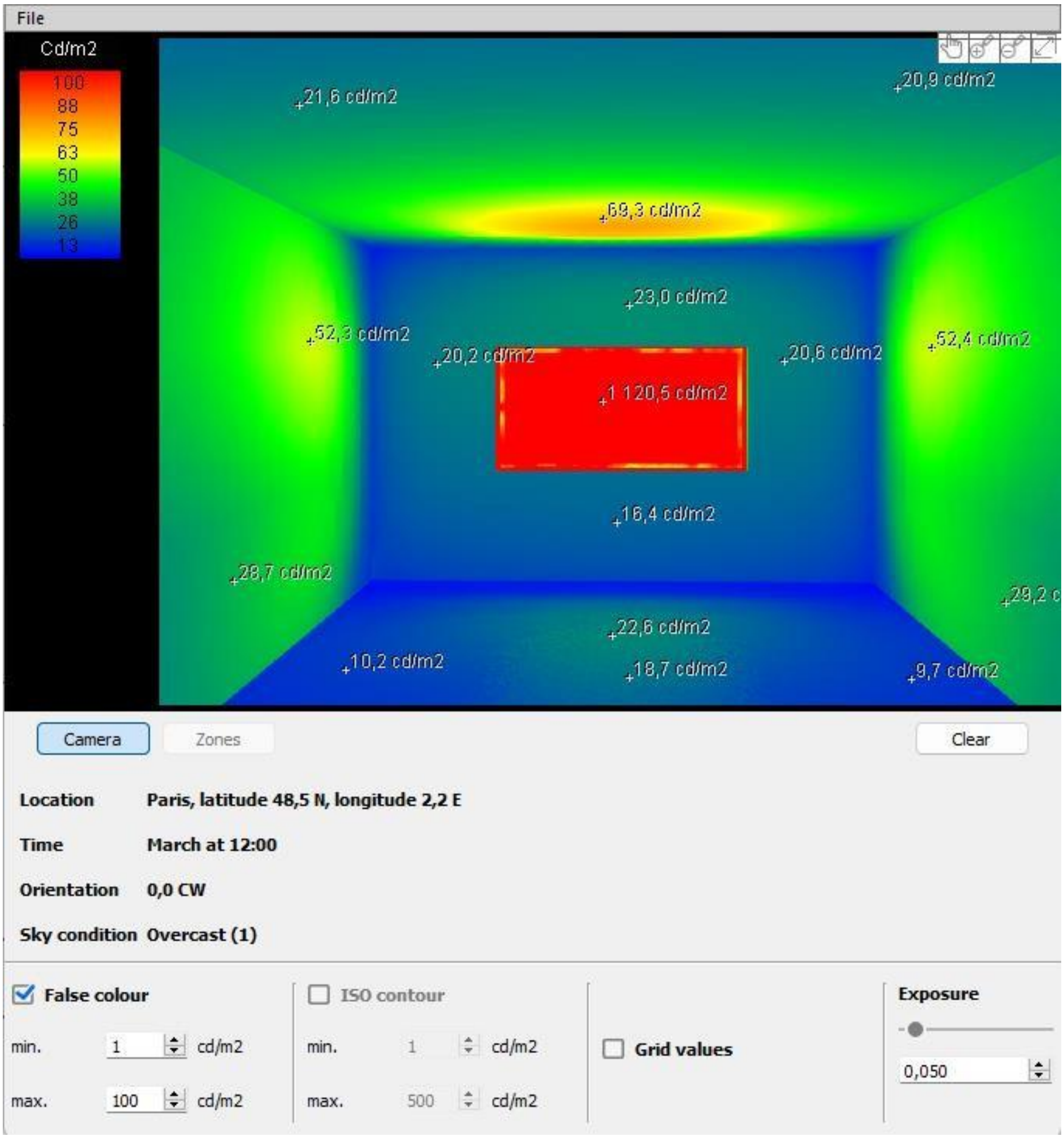

Figure 36.This luminous value where the reflector of floor is 20%, wall is 85% and Ceiling is 85%

Here we can see the luminous factor with reflector 20% floor,85% wall and 85% ceiling, we can understand that the red area has maximum light which is 1120.5cd/m2 and the wall in which the window is located has less luminous value which is 20.6 and 23.0cd/m2 which is in blue color. We can also find light in both side wall as the wall i.e., 52.4(green area) where it is 85% reflector and floor will get less light as the reflector is 20% which is 22.6 and it will be more value in roof as the roof reflector value is 85% i.e69.3cd/m2.Through the color we can understand the part of area which will get more light.

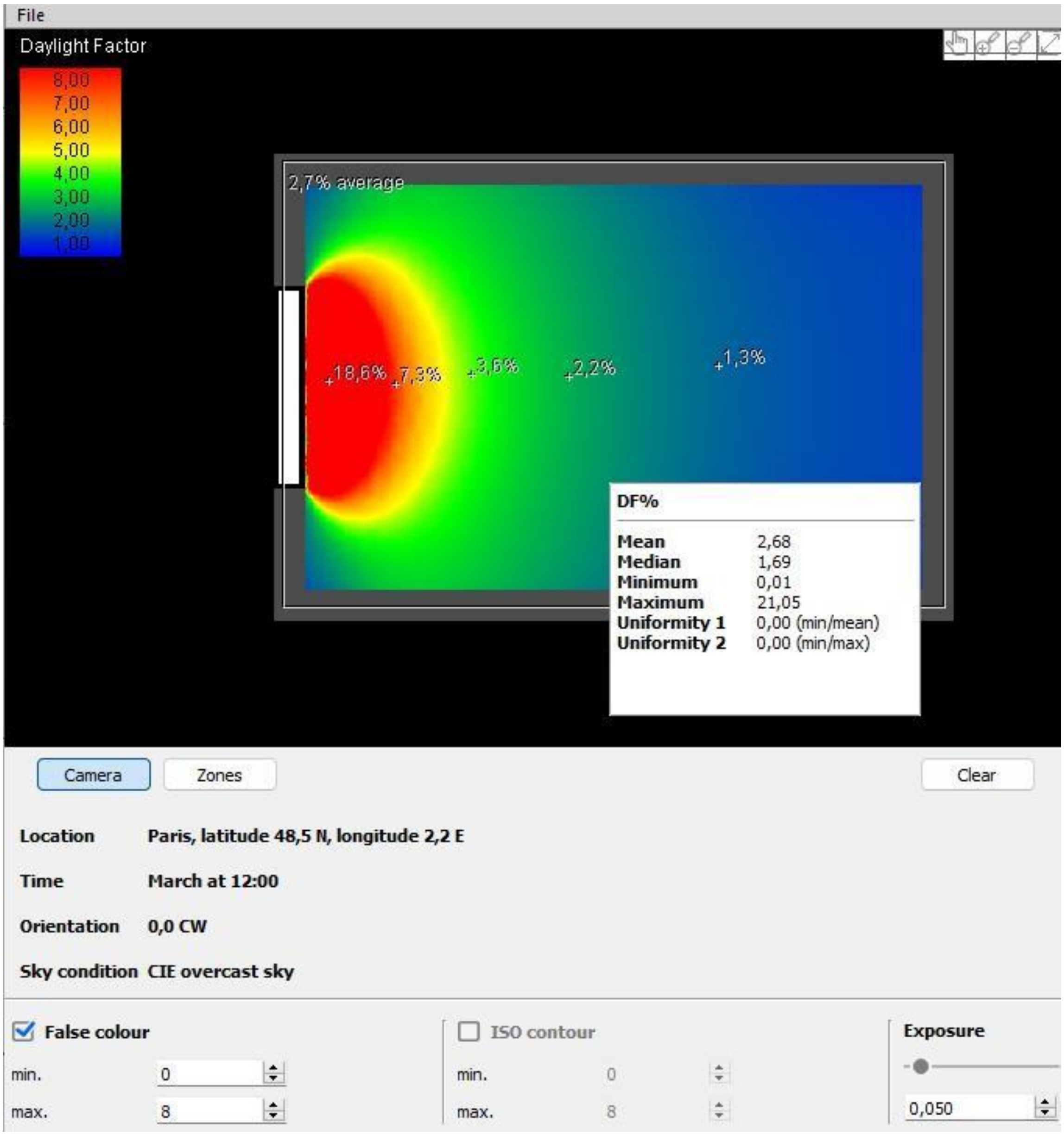

Figure 37. The daylight factor where the reflectance value of wall floor and ceiling is 90%

Here we can see the daylight factor of window with reflector of floor 90% wall 90% and Ceiling 90%. The red area gets the most daylight and as it goes inside the light slowly decreases.

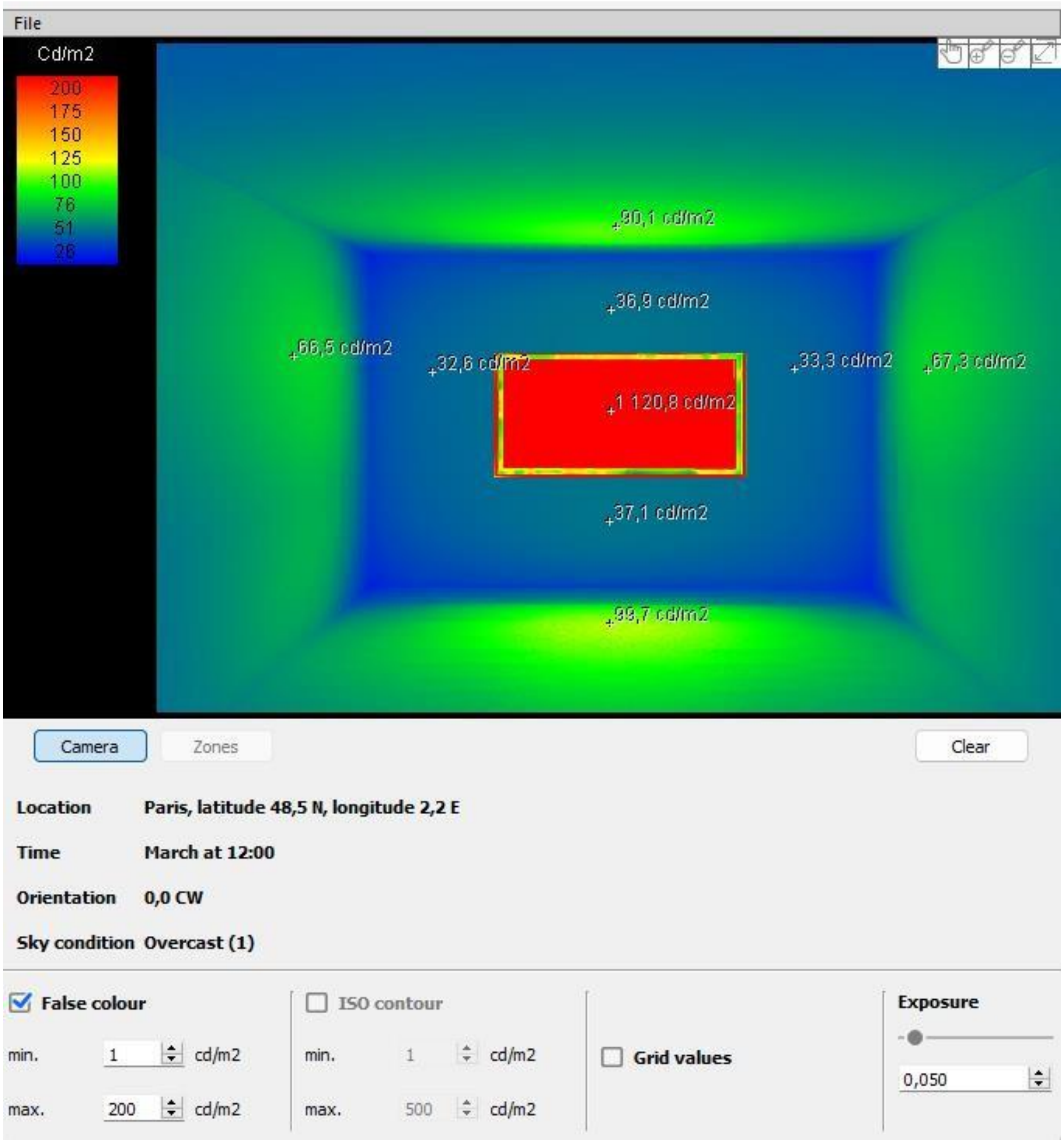

Figure 38. The luminous value where the wall, floor and ceiling is 90%

Here we can see the luminous factor with reflector 90% floor,90% wall and 90% ceiling, we can understand that the red area has maximum light which is 1120.8cd/m2 and the wall in which the window is located has less luminous value which is 37.10cd/m2 which is in blue color. We can also find light in both side wall i.e., 67.3(green area) where it is 90% reflector, and it will get also get equal light at floor and roof as the reflector is 90% which is 99.7. Through the color we can understand the part of area which will get more light.

11.4 Daylight Factor with different transmittance 40%,60%,80%

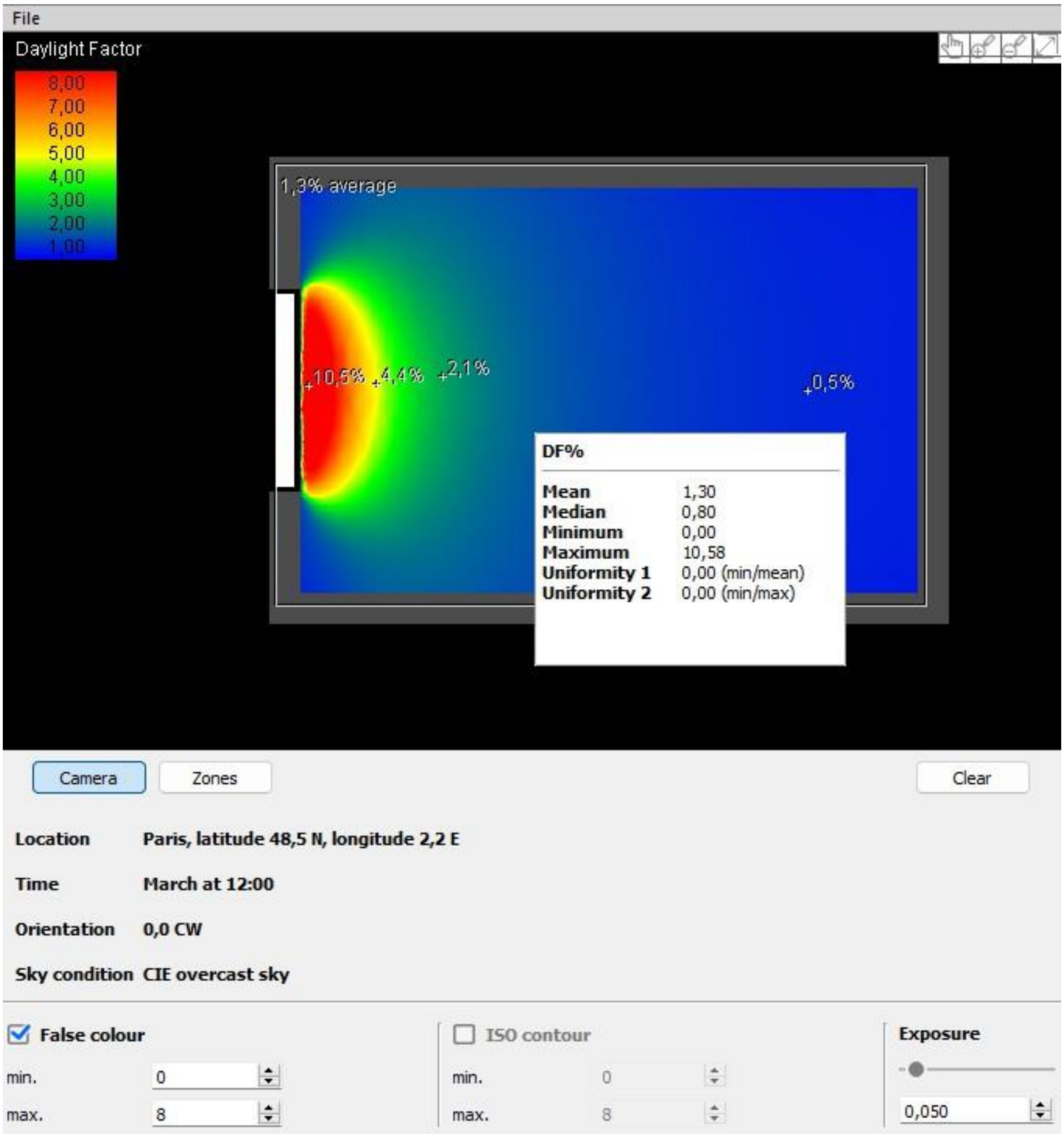

Figure 39.The daylight factor where LT 40

Here we can see the daylight factor of window with transmittance of 40% The red area gets the most daylight i.e., 10.5 and as it goes inside the light slowly decreases.

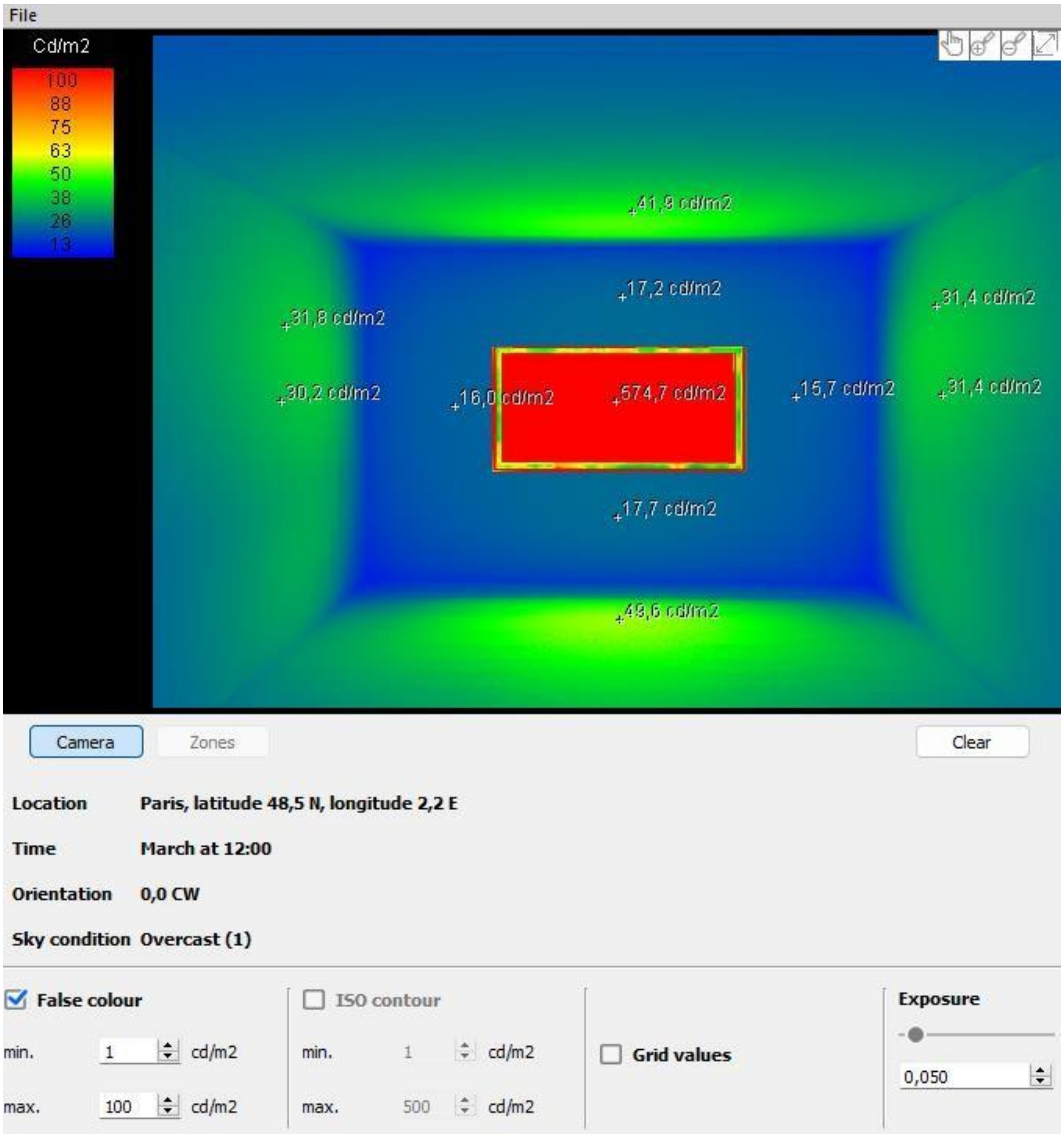

Figure 40. The luminous value where the transmittance value is 40%

Here we can see the luminous factor with transmittance 40%, we can understand that the red area has maximum light which is 574.7cd/m2 and the wall in which the window is located has less luminous value which is 17.2/m2 which is in blue color. We can also find light in both side wall as the wall i.e., 31.8(green area) and it will get also get light at floor and roof which is 49.6. Through the color we can understand the part of area which will get more light.

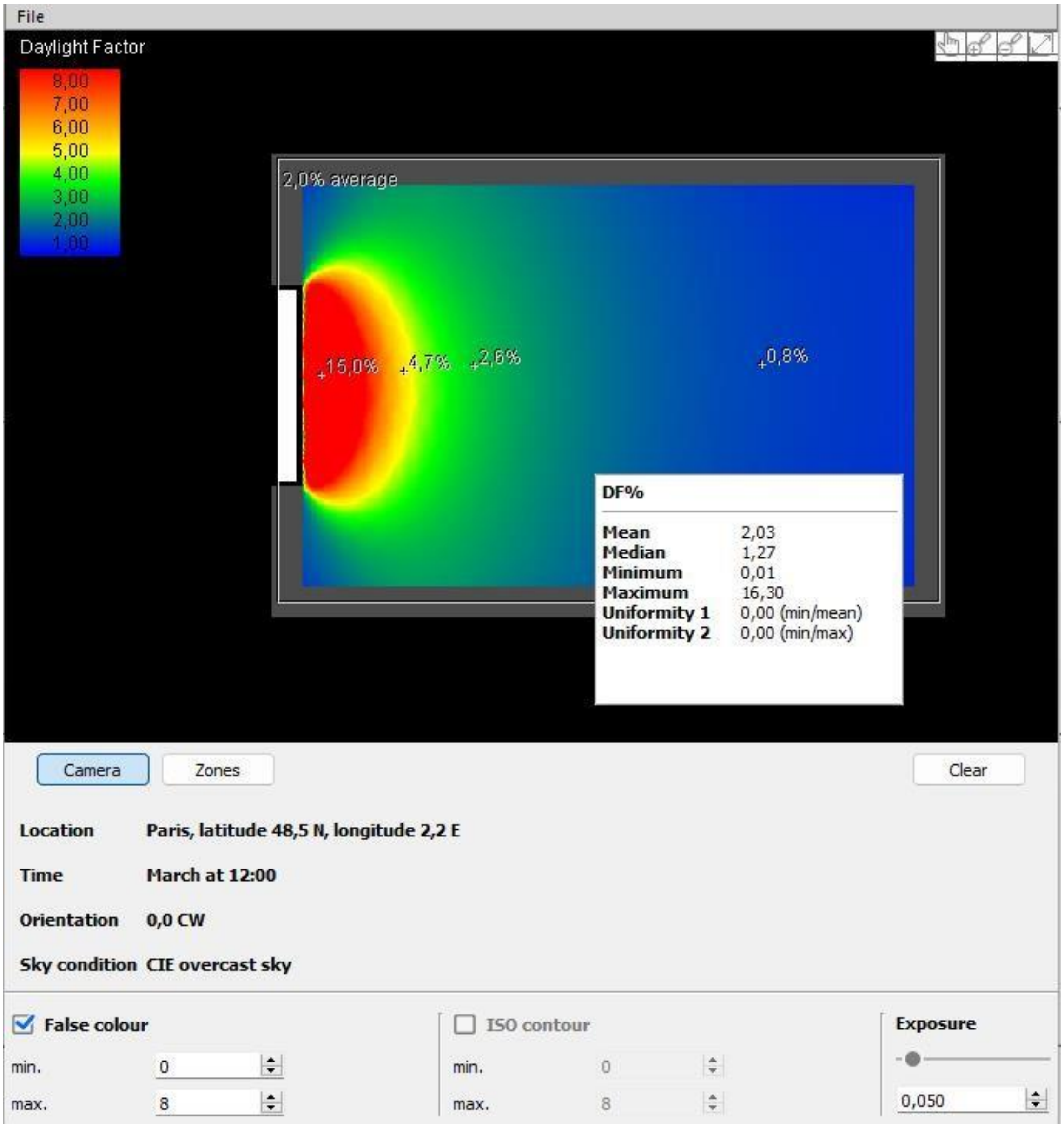

Figure 41. The daylight factor where the transmittance is 60 percent.

Here we can see the daylight factor of window with transmittance of 60% The red area get the most daylight i.e. 15.0%and as it goes inside the light slowly decreases4.7 %in the yellow part,2.6 %the green part and 0.8 %in the blue.

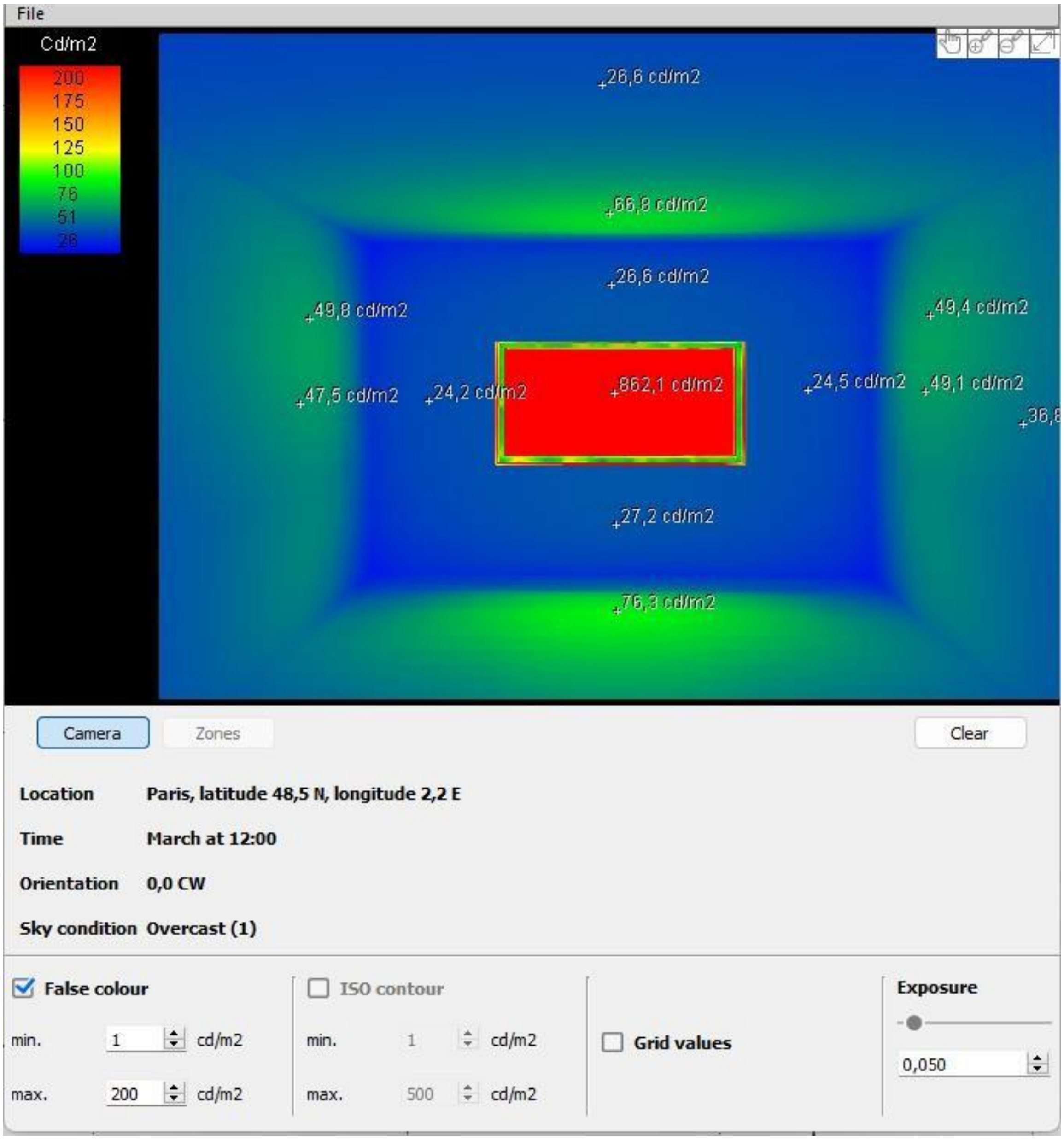

Figure 42. The luminous value where the transmittance is 60%

Here we can see the luminous factor with transmittance 60%, we can understand that the red area has maximum light which is 862.1/m2 and the wall in which the window is located has less luminous value which is 24.5 which is in blue color. We can also find light in both side wall i.e. 49.4(green area) and it will get also get light at floor and roof which are 76.3 and 68.8 respectively as the transmittance value is 60%. Through the color we can understand the part of area which will get more light.

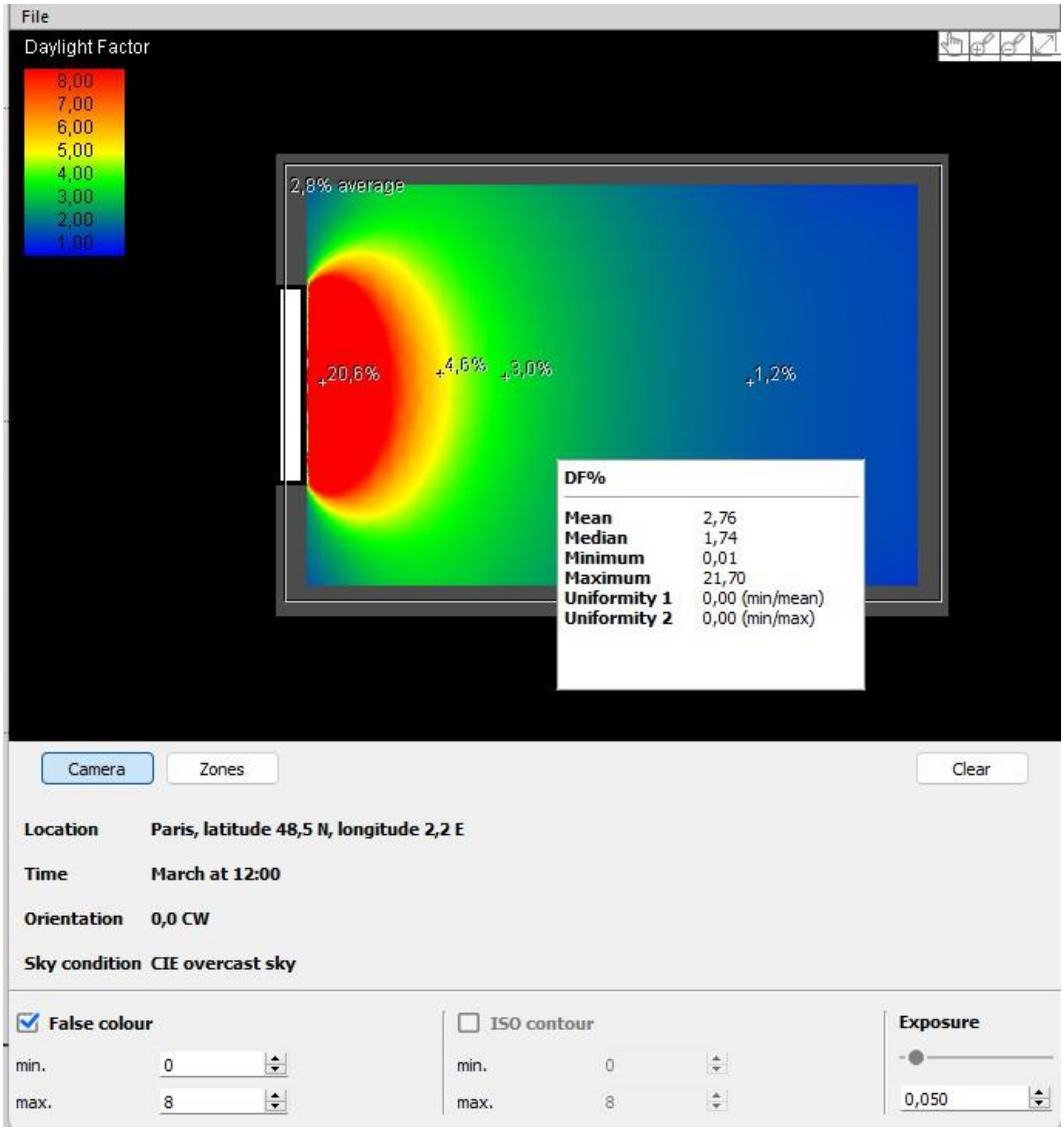

Figure 43.The daylight factor where the transmittance is 80%

Here we can see the daylight factor of window with transmittance of 80% The red area gets the most daylight i.e. 20.8%and as it goes inside the light slowly decreases4.6 %in the yellow part,3.0 %the green part and 1.2 %in the blue.

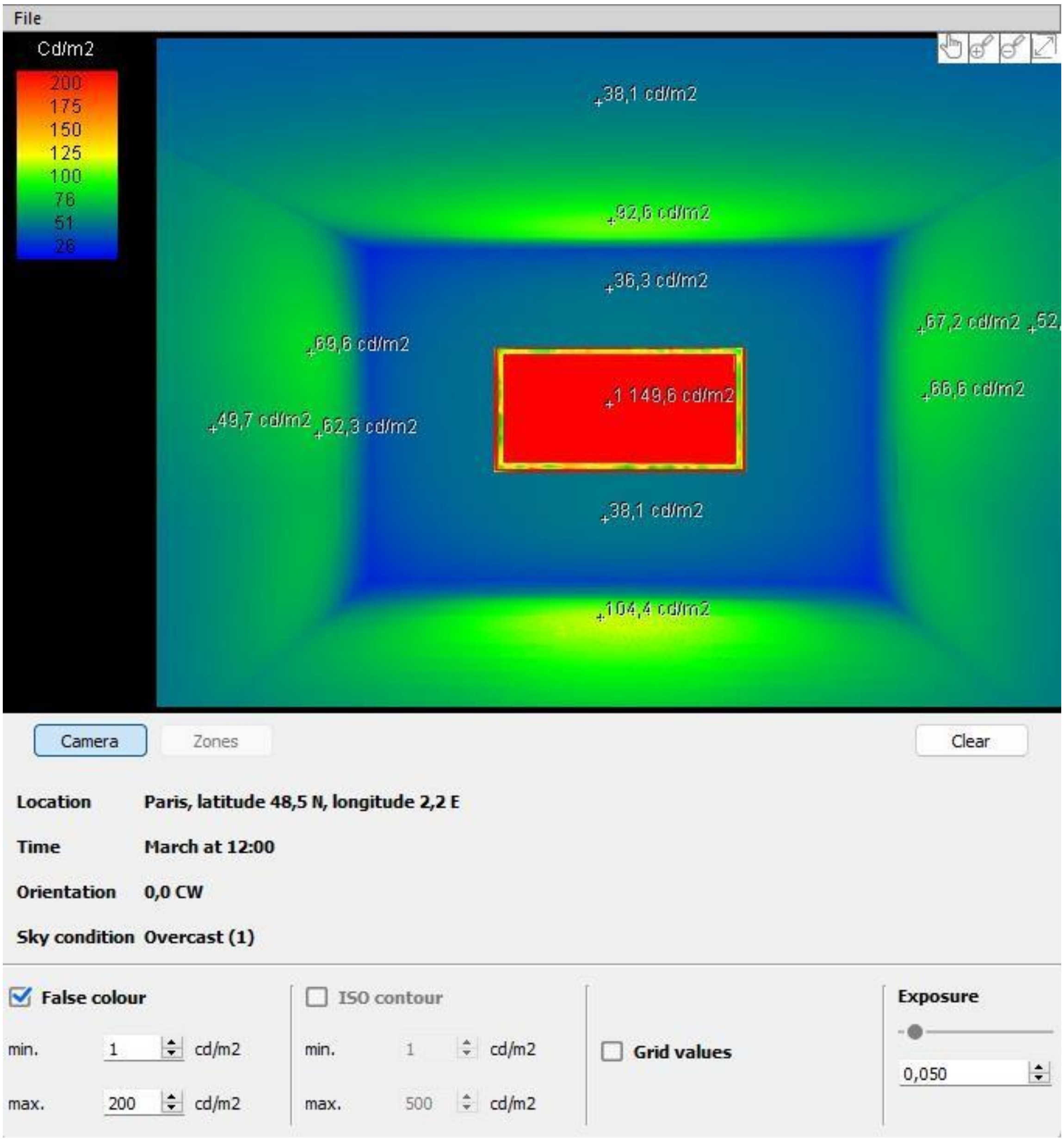

Figure 44.The luminous factor where the transmittance is 80%)

Here we can see the luminous factor with transmittance 80%, we can understand that the red area has maximum light which is 1149.6/m2 and the wall in which the window is located has less luminous value which is 38.1 which is in blue color. We can also find light in both side wall i.e. 62.3(green area) and it will get also get light at floor and roof which are 104.4 and 92.6 respectively as the transmittance value is 80%.Through the color we can understand the part of area which will get more light.

11.5 Daylight and Luminous factor of first and second floor of the Building G

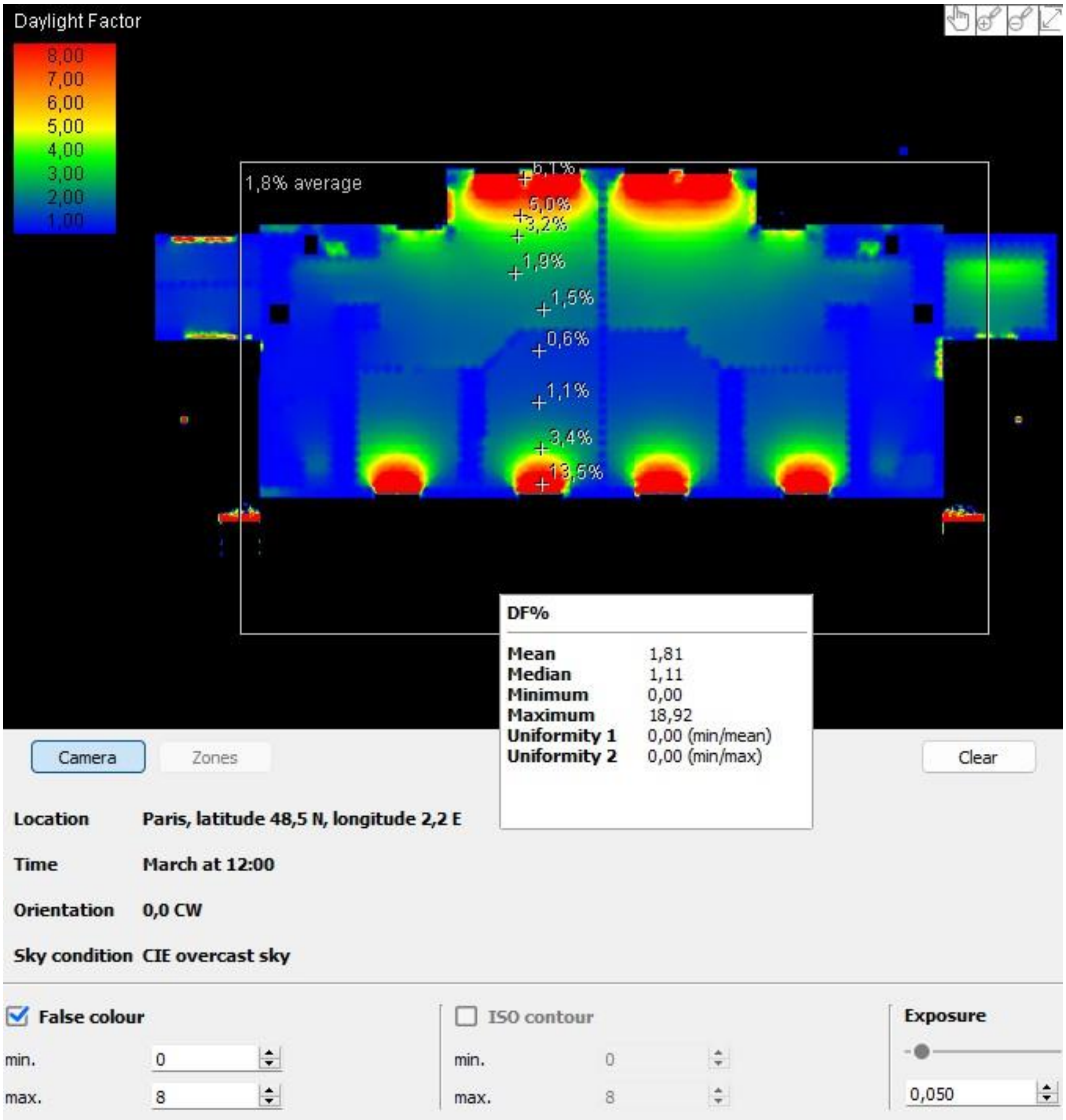

Figure 45. The daylight factor in First floor of Building G

Here we can see the daylight factor of window of first floor of the Building G. The red area gets the most daylight as we can see in picture and as it goes inside the light slowly decreases. From the color difference we can understand the part of building which will get more daylight, and which is less so that we can decide the parameter of window and location of the building.

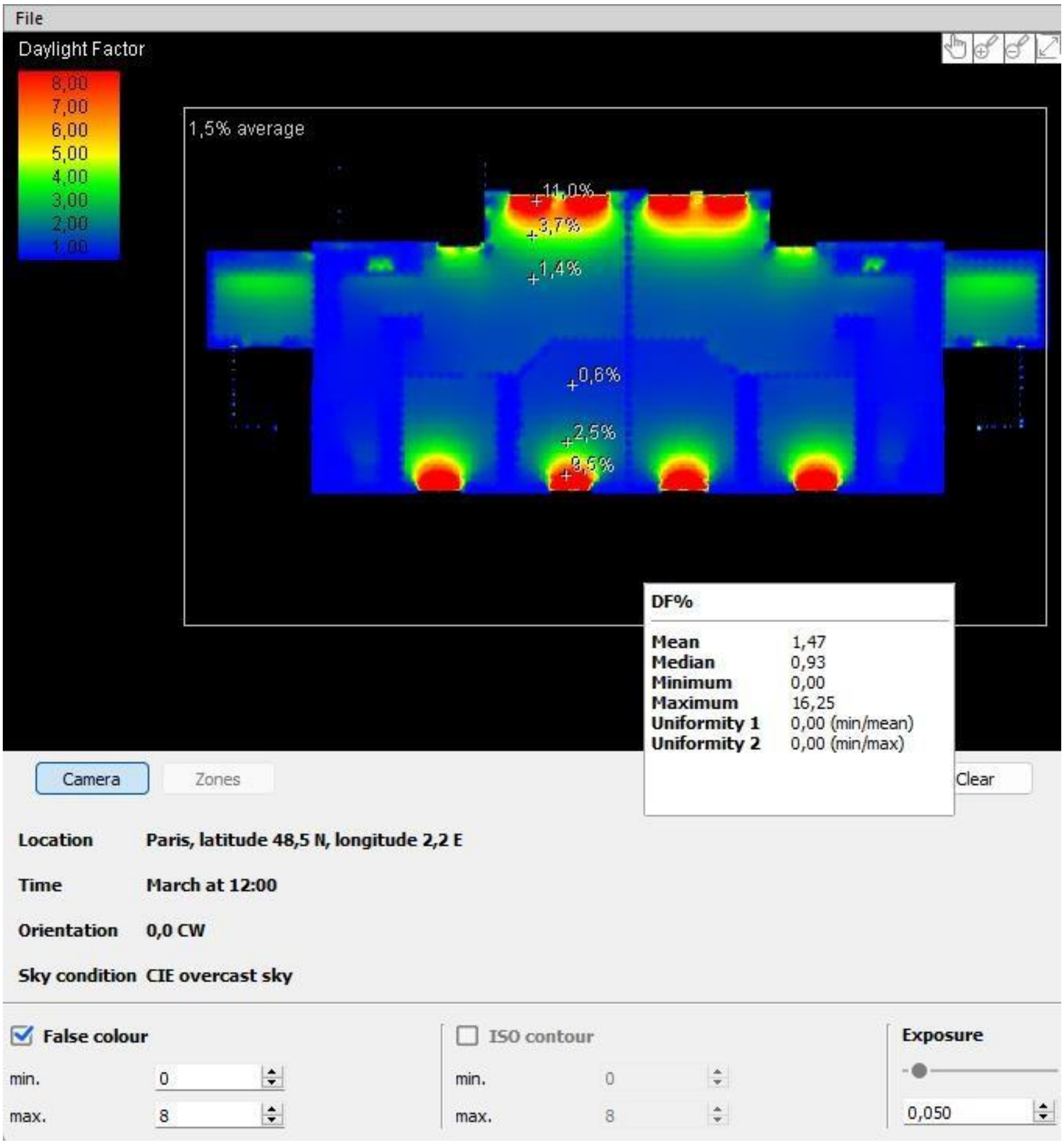

Figure 46.The daylight factor in Second floor of the building G

Here we can see the daylight factor of window of second floor of the Building G. The red area gets the most daylight as we can see in picture and as it goes inside the light slowly decreases. From the color difference we can understand the part of building which will get more daylight, and which is less so that we can decide the parameter of window and location of the building.

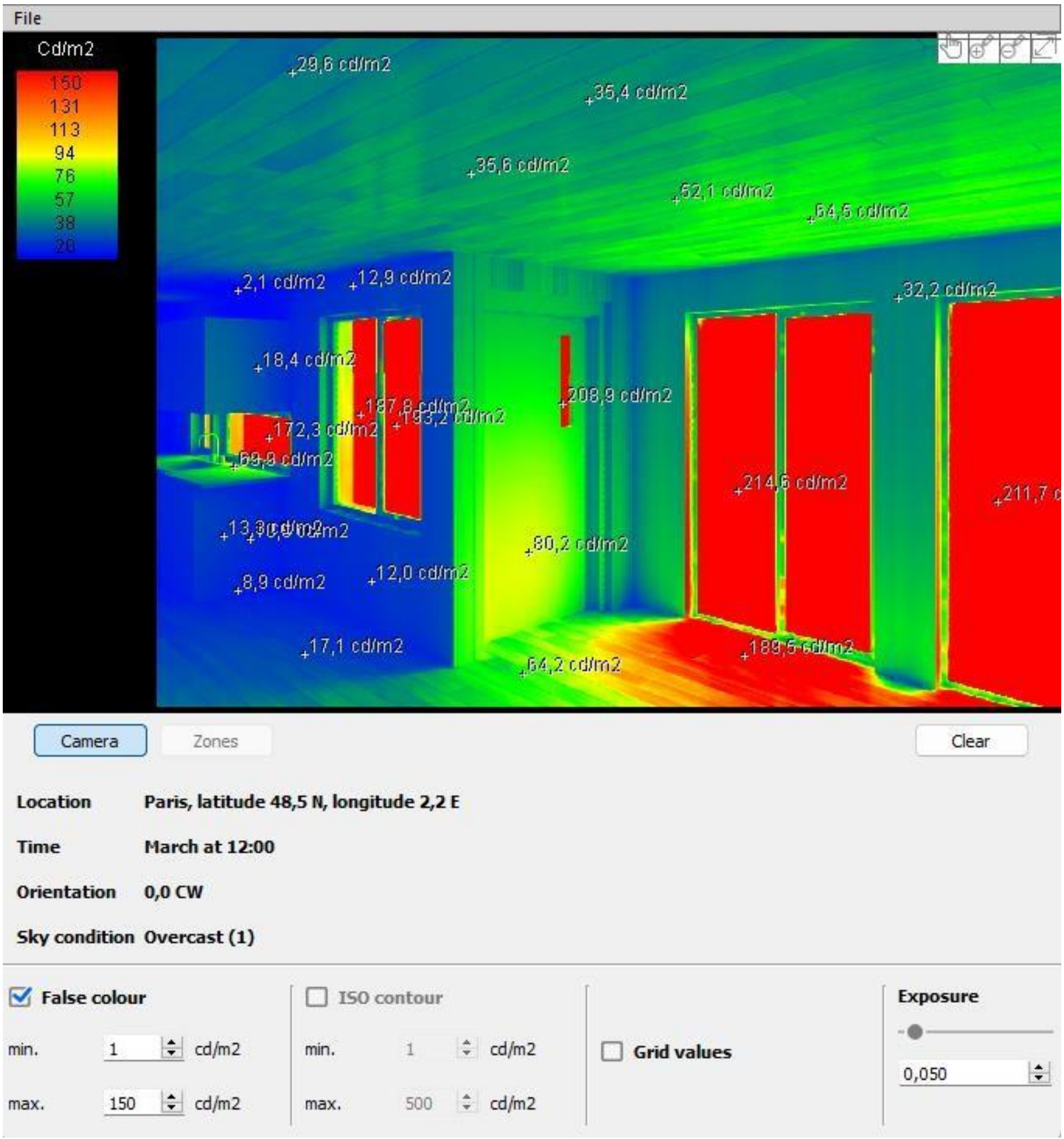

Figure 47.The luminous value of first floor of the building.

Here we can see the luminous factor of the first floor of Building G, we can understand that the red area has maximum light which and the wall in which the window is located has less luminous value which is in blue color. We can understand as the light goes inside it slowly decreases. From the color difference we can understand the part of building which will get more daylight, and which is less so that we can decide the parameter of window and location of the building.

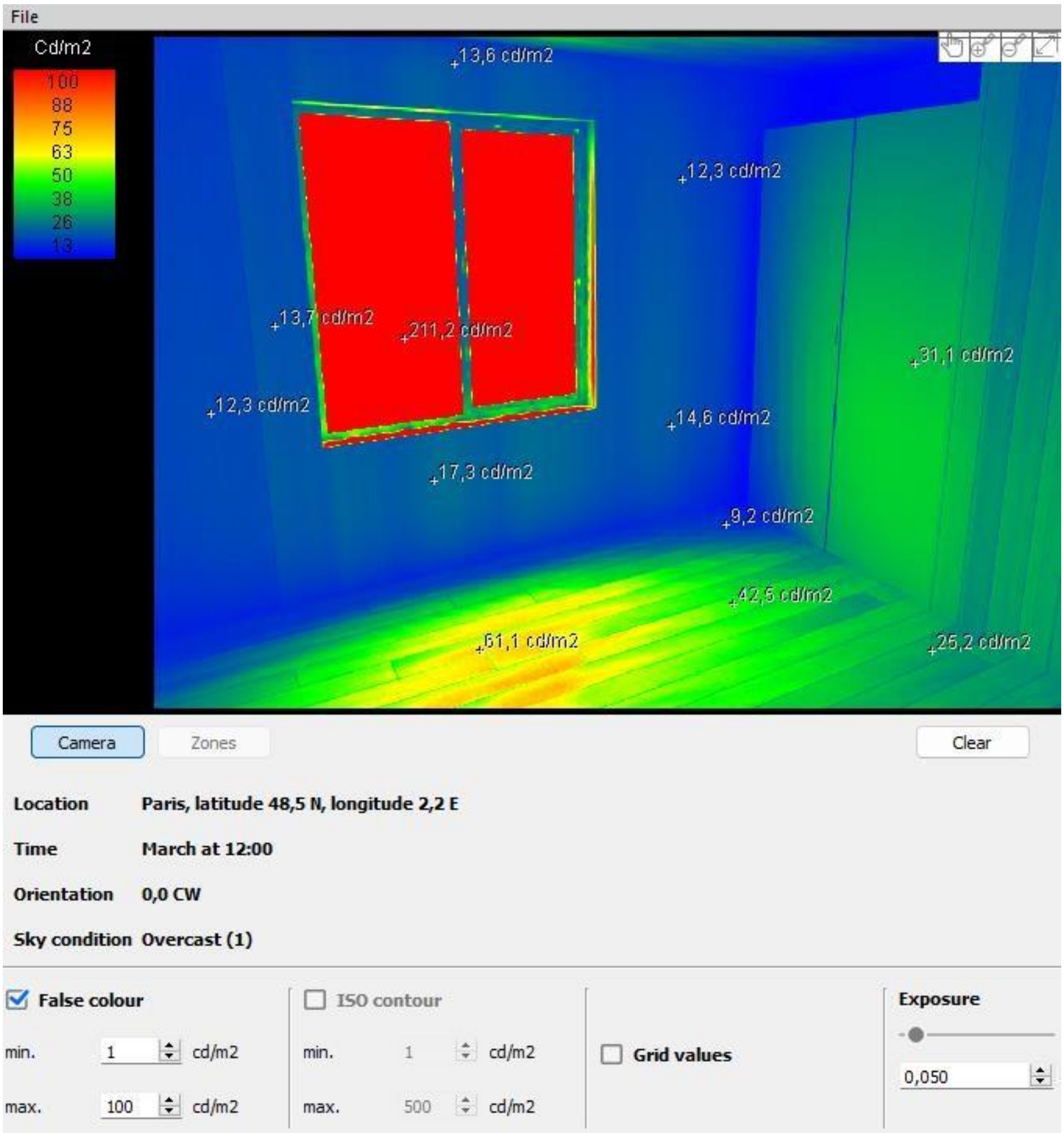

Figure 48.The Luminous value of second floor of Building G

Here we can see the luminous factor of the second floor of Building G, we can understand that the red area has maximum light which and the wall in which the window is located has less luminous value which is in blue color. We can understand as the light goes inside it slowly decreases. From the color difference we can understand the part of building which will get more daylight, and which is less so that we can decide the parameter of window and location of the building.

11.6 Lighting analysis of First floor of the building

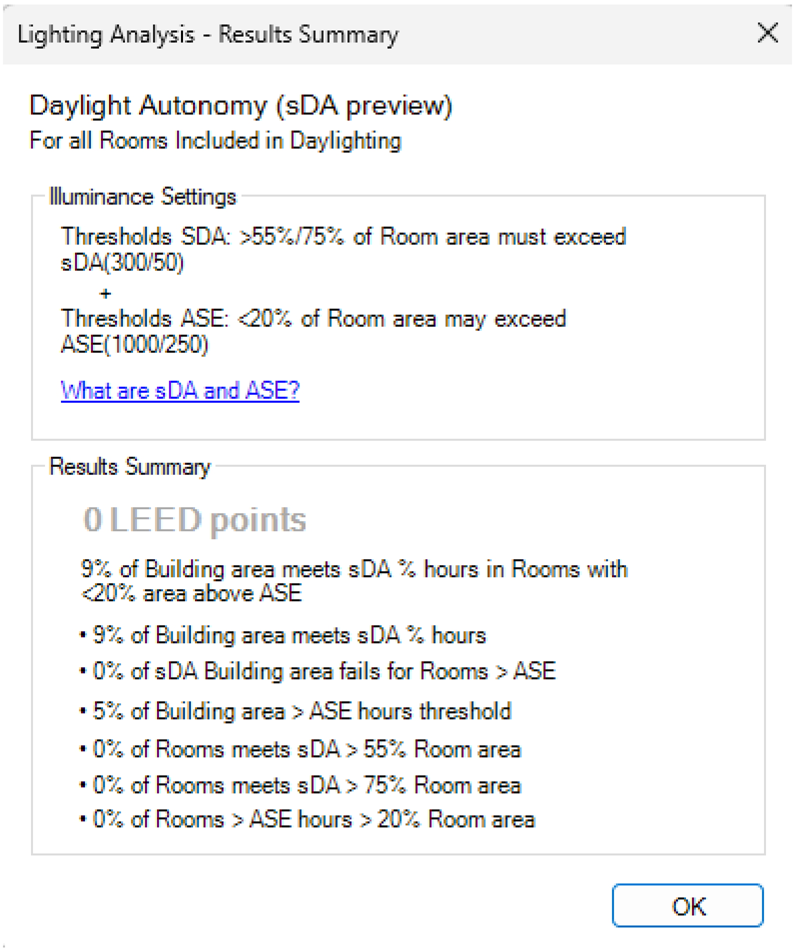

Figure 49. The summary of Lighting Analysis of the first floor of the Building G

Here we can see the summary of Lightning Analysis of the first floor of Building G, we can understand how the building get the sunlight inside the building and where is the dark area so that artificial light is required and it also helps to understand the position and parameters of the windows and building. We can also understand how much sunlight we can utilize in the building so that in that part artificial light is not required so we can save the cost.

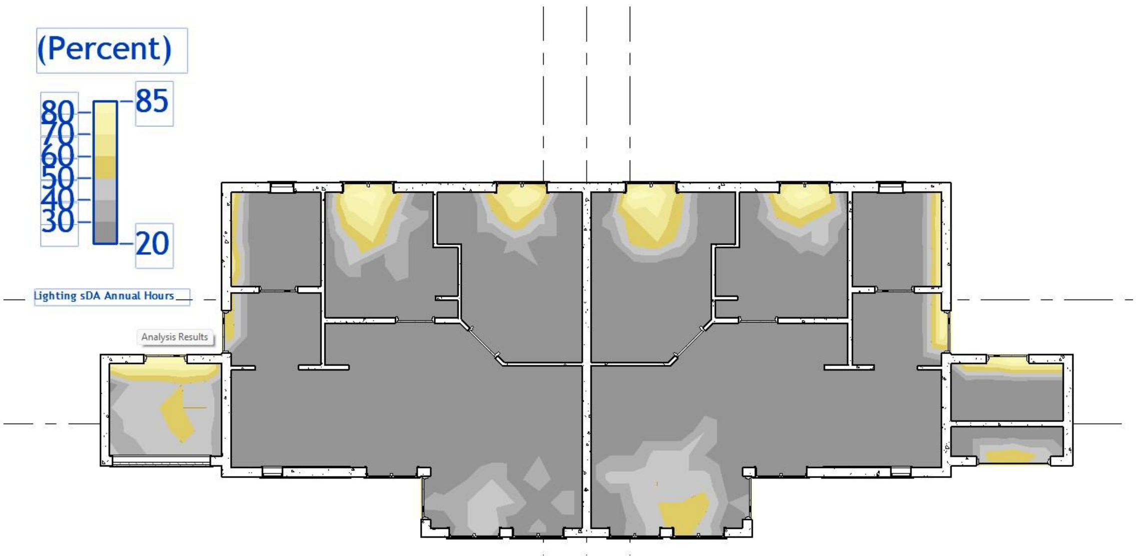

Figure 50.The spatial lighting effect in First floor of the Building G

<_InsightLighting Room Schedule>

sDA_floor 1st: Daylight Autonomy (sDA Preview) Results Summary: Jönköping, Sverige - 159407

Building scores 0 LEED points with 9% Building area passing thresholds

At least 55% must exceed sDA300/50 in Rooms with ASE1000/250 < 20% of Room area

A	B	C	D	E	F	G	H	I	J	K
				Include In	sDA 300/50		ASE 1000/250		sDA/ASE	
Level	Name	Number	Area	Daylighting	%	Points	%	Pass	%	Points
L1	Sovrum	100	14 m²	☑	20	none	15	Yes	20	none
L1	Sovrum	101	10 m²	☑	15	none	18	Yes	15	none
L1	Badrum	102	6 m²	☑	8	none	0	Yes	8	none
L1	Sovrum	103	14 m²	☑	10	none	12	Yes	10	none
L1	Sovrum	104	10 m²	☑	19	none	19	Yes	19	none
L1	Badrum	105	6 m²	☑	0	none	0	Yes	0	none
L1	Förråd	106	7 m²	☑	30	none	0	Yes	30	none
L1	Förråd	107	4 m²	☑	0	none	0	Yes	0	none
L1	Förråd	108	2 m²	☑	30	none	0	Yes	30	none
L1	Kök	109	6 m²	☑	0	none	0	Yes	0	none
L1	Hall	110	4 m²	☑	0	none	0	Yes	0	none
L1	Vadagsrum	111	28 m²	☑	6	none	0	Yes	6	none
L1	Vadagsrum	112	28 m²	☑	1	none	0	Yes	1	none
L1	kök	113	6 m²	☑	0	none	0	Yes	0	none
L1	Hall	114	4 m²	☑	0	none	0	Yes	0	none

Figure 51. SDA, ASE of different rooms.

Here we can see the summary of Lightning Analysis of the first floor of Building G, we can understand how the building gets the sunlight inside the building and where is the dark area so that artificial light is required, and it also helps to understand the position and parameters of the windows and building. We can also understand how much sunlight we can utilize in the building so that in that part artificial light is not required so we can save the cost. We can also understand how much sustainable the building is.