J. Appl. Environ. Biol. Sci., 5(12S)472-488, 2015

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Optimizing the Lighting Production through Photovoltaic and Fluorescent Lamps in Iran Residential Applications by Calculux Software

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Received: July24, 2015
Accepted: September 31, 2015

ABSTRACT

The one of main human's challenges is energy challenge. The way of exit of it, is going toward sustainable architecture. PV cells are one of the solutions that we have. One of important things in using pv cells is optimizing the using it's products. This research is reaching to calculating and modeling of optimizing of light producing of residential units in Iran by PV cells. This research's achievements are: calcuting the require lighting a common residential unit in Iran and how much it wants electricity and PV cells.
KEYWORDS: Solar energy, PV cells, Residential's Lighting, Sustainable architecture

1. INTRODUCTION

Moving to sustainable architecture is inevitable because of increasing the population, the consumerism and the problems in common energies caused by waste pollution. Since the underground sources of energy are consuming with a tremendous speed and nothing will be left in the near future, it is an obligation of the current generation to refer to the long-lasting energy sources. Nowadays people are focusing on the solar energy again after the events such as oil crisis, Chernobyl event and the greenhouse phenomenon[1].

The origin and persistence of human life is based on solar energy. Most of the basic activities and life-giving on earth such as photosynthesis and the water cycle will be done by solar energy. From the beginning of human history, man has recognized that proper using of solar energy would be suitable. However, only during the last 40 years the solar energy has been controlled by specialized tools and has been used as an alternative energy source. The main reasons for this choice is that this energy is free and do not damage the environment. These two reasons are the main factors of the sustainable architecture[7].

In the present age the solar energy can be used in many cases such as:

Photo biological systems; changes in the life and life of plants and animals caused by sunlight like the process of animal manure decomposition and the use of their gas.

Photochemical system; chemical changes due to the sunlight such as hydrogen supply installations.

Heating and cooling systems; heaters, heating and cooling installations, desalination devices, greenhouses, driers and solar cookers.

Photovoltaic systems; converting the solar energy into the electrical energy such as solar cells[1].

In Iran at least 5.5 kilowatt hours of solar energy radiate from the sun on every square meter of the earth surface and we have 300 sunny days in 90% of the country. The area of Iran is approximately 1600000 square kilometers. This means that the area of Iran is about $1.6 * 10^{12}$ square meters. The solar daily radiation in Iran is $1.6 * 5.5 * 10^{12}$ kWh. The total amount of solar radiation equals to 9000000000 megawatt hours. If we absorb the solar energy from 1% of Iran area and the efficiency of the receiving energy system is only 10%, we can receive 9000000 megawatts hour energy from the sun daily[2].

2. MATERIALS AND METHODS

2.1.The application of solar energy in order to produce the residential lighting

The solar lighting systems are divided into two main categories: The interior lighting including houses, workshops and ….

The external lighting including street and parks lights, advertising panel lighting and ….

The solar lighting system components include:

1-Solar Panels
2-Controller charge
3-Battery
4- Electronic ballast

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5-Energy-saving fluorescent lamps

Photovoltaic systems can be generally divided into 3 main sections:

Solar Panels: this section actually is a solar energy converters which converts the solar energy into no mechanical interface electrical energy. The Photovoltaic panels which are exposed to the sunlight actually are photovoltaic cells. It should be noticed that the current and output voltage in these panels are DC.

Producing the optimal power or control unit: this section actually controls the system specifications and injects or controls the productive power into the load or battery.

The consumer or the electric charge:

According to the photovoltaic panels DC output the consumer can be two types of DC or AC. It can also be provided the needs of different consumers with the different powers through different arrangements of photovoltaic panels. For this reason the photovoltaic systems have the most commercial markets in the field of renewable energy applications. Of course the Photovoltaic consumers can be classified in the different power ranges. Although the price of photovoltaic electricity is now more than other resources, in terms of removing the transmission and distribution expenses it can be predicted that in 2020 its price will be equal to the price of the peak electricity and in 2040 will be equal to the price of the basic electricity price[2].

2.2.The importance of lighting for users:

One of the important vital nutrients for producing the hormones is the sun natural light spectrum which plays an important role in essential ecological processes. Our body needs to daylight just like the weather and it can be considered as an important nutrient. None of the artificial light sources can properly reconstruct the full spectrum of sunlight. The artificial light such as ordinary light bulbs and fluorescent contain only a narrow part of the spectrum of the sun. The appropriate lighting has considerable visual and biological effects. The results of research on the biological effects of lighting show that the rules of designing and installing the lighting equipment differ from the traditional rules in certain degrees[3].

2.3.Introducing Lumen method and Calculux software:

This method is the former method of American lighting engineer society and has been changed over the past years. However, this method has been considered for designing the interior lighting.

The method of designing: obtaining the index space

For direct light, semi-direct light and also equal distribution:

$$K_r = \frac{LW}{H\,(L+W)} \quad (1)$$

For indirect light and semi-indirect light:

$$K_r = 1.5\,\frac{LW}{H\,(L+W)} \quad (2)$$

Now having K_r and reflection ceiling, the walls and the floor coefficient depending on the selected lights the interest coefficient and the maintenance coefficient and the maximum distance between two average luxury lamps is calculated through the following equation[4]:

$$E_{av} = \frac{\Phi}{A}\,(CU)\,(MF)$$

The intelligent software; calculux indoor software, is the product of Philips Company which in addition to simplicity is consistent with international standards such as Iranian national standard lighting. It is even capable to suggest the best and most optimal installation height, the distance of installing and the installation angle for each light so that it can easily be selected the most appropriate and the most efficient design economically, technically and aesthetically among the various designs[10]. It should be noted that the calculux indoor software uses Lumen method for processing the data.

2.4.Calculating the average of lighting for the residential applications:

According to Figure 1, we have the following small common spaces in the residential applications:

1-Living Room 2- Bedroom1 3- Bedroom2 4- WC 5- Bathroom 6- Entrance 7- Corridor1
8- Corridor2 9- Division1 10- Division2 11- Study Room 12- Kitchen

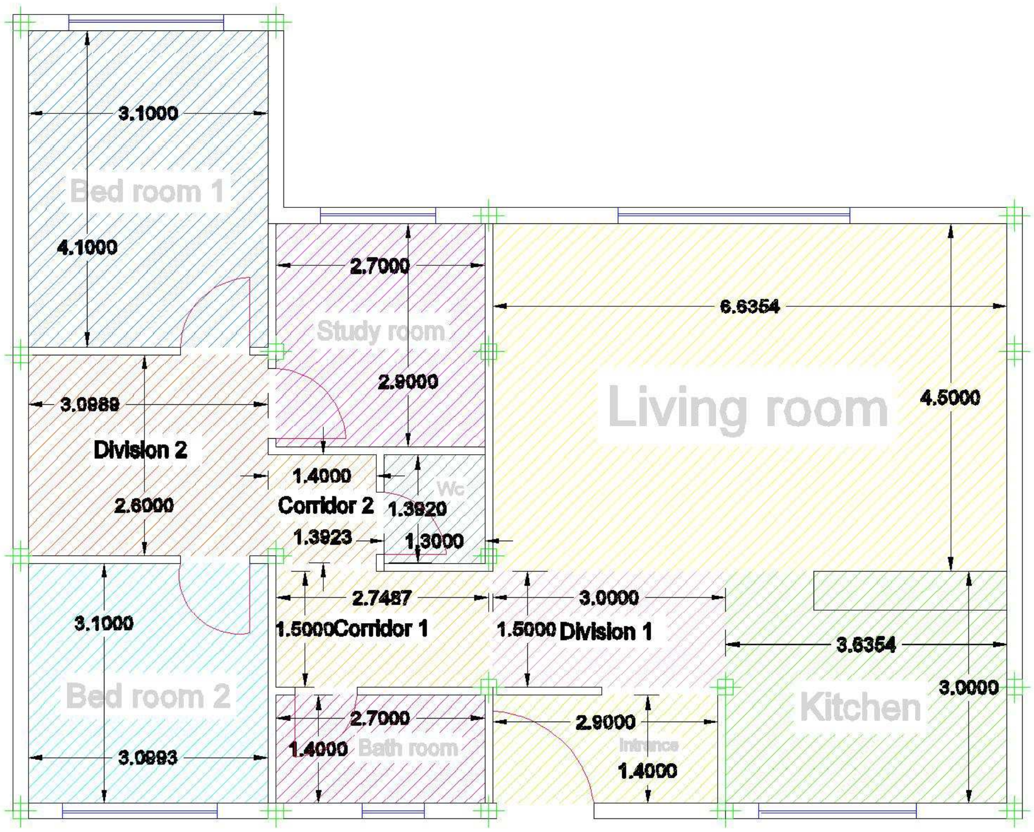


Figure.1. Small common spaces sample in Iran building plan

2.5. Inserting the required information to the calculux indoor software for analyzing the data:
We insert the basic spaces information including the length, the width, and the extracted height from Figure 1, as well as considering the surface work according to the table 1.

Table 1. The height of surface work in homes

Surface height	Small space	Number
0.5	Living room	1
0.5	Bedroom	2
0.8	Kitchen	3
0.5	WC	4
0.5	Bathroom	5
0.5	Corridor	6
0.5	Division	7
0.8	Study room	8
0.5	Entrance	9

The reflection room coefficient data based on common painting in Iran is as follows:
Floor: 20%, Walls: 50% Roof: 70%
Finally, by entering the luxury lighting requirements, each of the small spaces on Figure 2 as well as choosing two 18 watts sun and moon lamps the total power consumption of lights will reach to 38 watts and we have:

	Location	Iran	Iran	IES
		Min	Offered	Offered
1	Living room	70	200	160
2	Study room	150	500	320
3	Kitchen	100	200	540
4	Bedroom			
4-1	General lighting	50	100	
4-2	Drawer and Bed lighting	200	500	

Figure.1. Lighting standards offered by Iran light committee[5] and IES handbook[8]

3. RESULTS

Residential Lighting

Bath Room Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.14	0.42	0.70	0.98	1.26
2.48	115<	126	130	126	115
2.03	128	142	147	142	128
1.58	135	150	156	150	135
1.13	135	150	156>	150	135
0.68	128	142	148	142	128
0.23	115	126	131	126	115

Figure.3. Bathroom numerical calculations

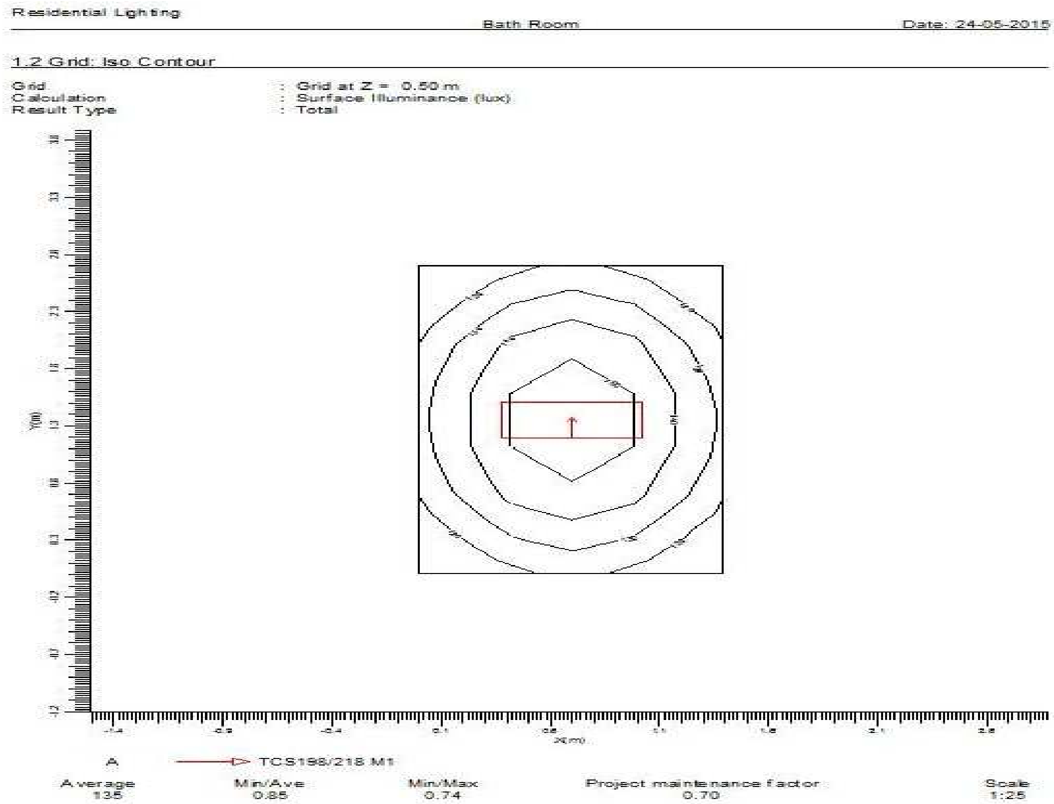


Figure.4. Bathroom lights layout designing output

Residential Lighting

Bed Room 1 Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.22	0.66	1.11	1.55	1.99	2.44	2.88
3.87	85<	106	127	137	127	106	85
3.41	95	121	144	155	144	121	95
2.96	106	134	161	174	161	134	106
2.50	115	146	176	189	176	146	115
2.05	120	152	183	198>	183	152	120
1.59	115	147	176	190	176	147	115
1.14	106	135	162	174	162	135	106
0.68	95	121	145	156	145	121	95
0.23	85	107	128	137	128	107	85

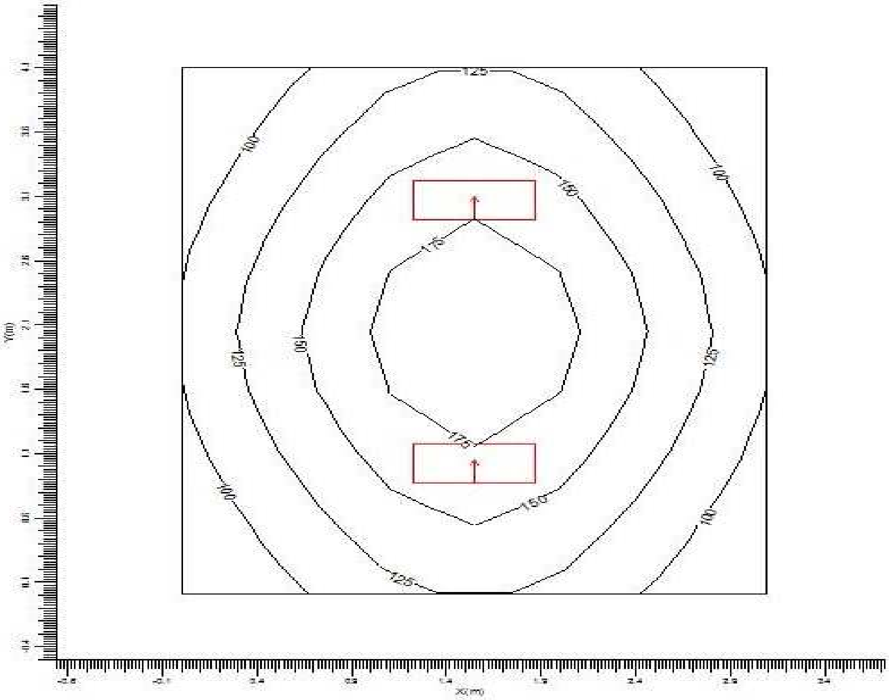
Figure.5. Bedroom 1 numerical calculations

Residential Lighting

Bed Room 1 Date: 24-05-2015

1.2 Grid: Iso Contour

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total



A ⟶ TCS198/218 M1

Average	Min/Ave	Min/Max	Project maintenance factor	Scale
135	0.63	0.43	0.70	1:25

Figure.6. Bedroom 1 lights layout designing output

Residential Lighting

Bed Room 2 Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.22	0.66	1.11	1.55	1.99	2.44	2.88
2.88	59	73	88	94	88	73	59<
2.44	65	83	100	109	100	83	65
1.99	69	88	107	116	107	88	69
1.55	69	90	109	119>	109	90	69
1.11	69	88	107	116	107	88	69
0.66	65	83	100	109	100	83	65
0.22	59	73	88	94	88	73	59

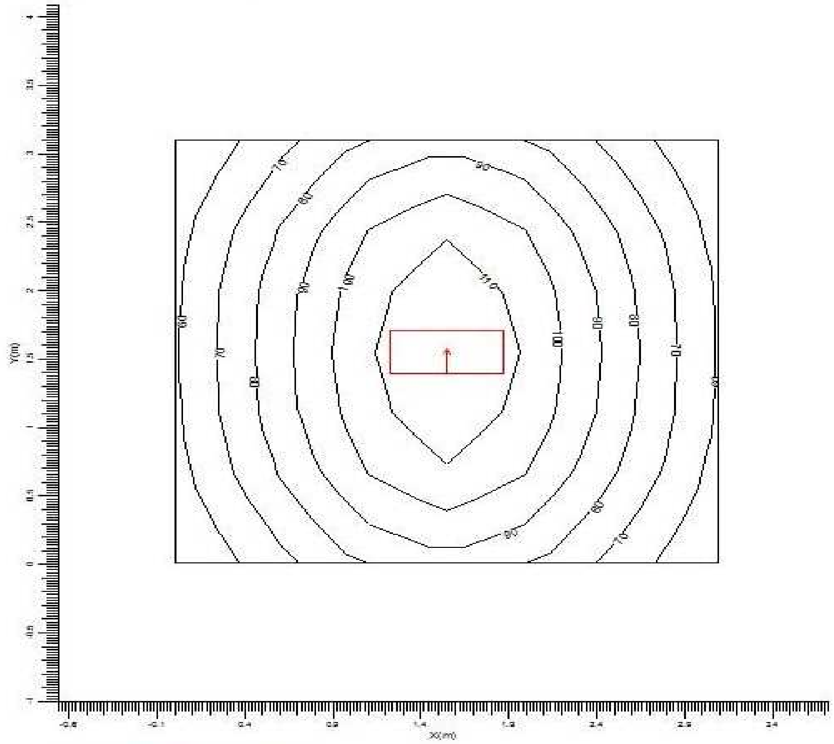
Figure.7. Bedroom 2 numerical calculations

Residential Lighting

Bed Room 2 | Date: 24-05-2015

1.2 Grid: Iso Contour

Grid	: Grid at Z = 0.50 m
Calculation	: Surface Illuminance (lux)
Result Type	: Total



A → TCS198/218 M1

Average	Min/Ave	Min/Max	Project maintenance factor	Scale
86.2	0.68	0.49	0.70	1:25

Figure.8. Bedroom 2 lights layout designing output

Residential Lighting

Coridor 1 | Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid	: Grid at Z = 0.50 m
Calculation	: Surface Illuminance (lux)
Result Type	: Total

X (m) Y (m)	0.15	0.45	0.75	1.05	1.35
2.52	106	117	122	117	106
2.06	118	131	136	131	118
1.60	123	138	143>	138	123
1.15	123	137	143	137	123
0.69	117	130	136	130	117
0.23	106<	117	121	117	106

Figure.9. Corridor (1) numerical calculations

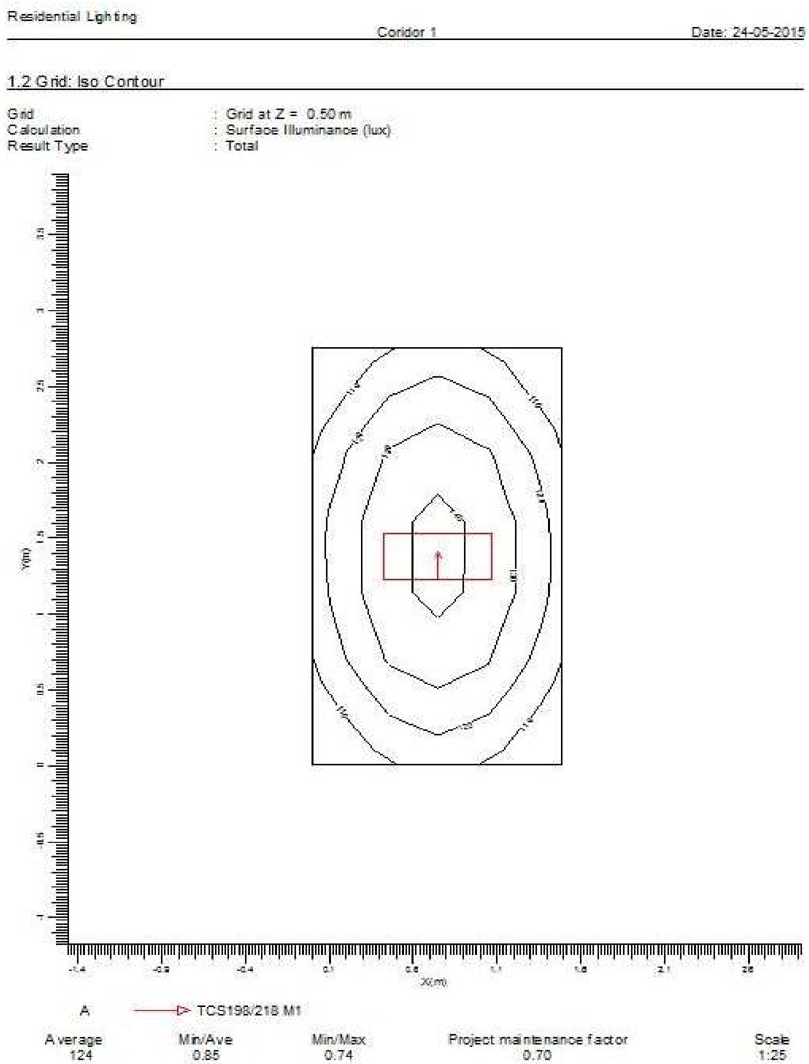


Figure.10. Corridor (1) lights layout designing output

Residential Lighting

Coridor 2 Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.14	0.42	0.70	0.97	1.25
1.26	136	151	157	151	136<
0.98	145	161	167	161	144
0.70	147	164	170>	164	146
0.42	145	161	167	161	144
0.14	136	151	157	151	136

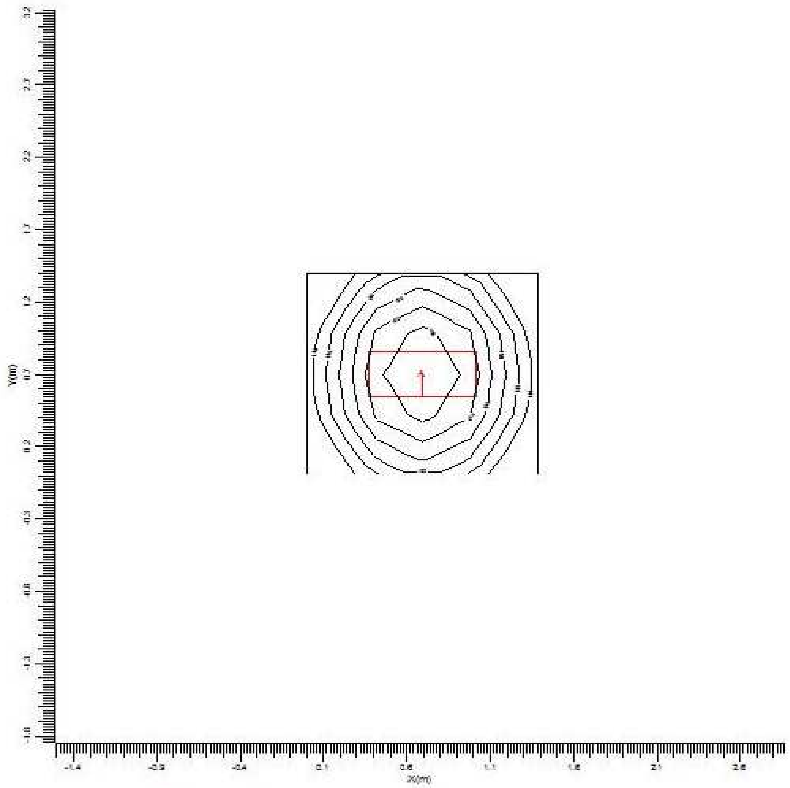
Figure.11. Corridor (2) numerical calculations

Residential Lighting

Coridor 2 Date: 24-05-2015

1.2 Grid: Iso Contour

Grid	: Grid at Z = 0.50 m
Calculation	: Surface Illuminance (lux)
Result Type	: Total



A TCS198/218 M1

Average	Min/Ave	Min/Max	Project maintenance factor	Scale
152	0.89	0.80	0.70	1:25

Figure.12. Corridor (2) lights layout designing output

Residential Lighting

Divission 1 Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid	: Grid at Z = 0.50 m
Calculation	: Surface Illuminance (lux)
Result Type	: Total

X (m) / Y (m)	0.15	0.45	0.75	1.05	1.35
2.75	99	110	114	110	99<
2.25	114	126	131	126	114
1.75	121	135	140	135	121
1.25	121	135	140>	135	121
0.75	114	126	131	126	114
0.25	99	110	114	110	99<

Figure.13. Division (1) numerical calculations

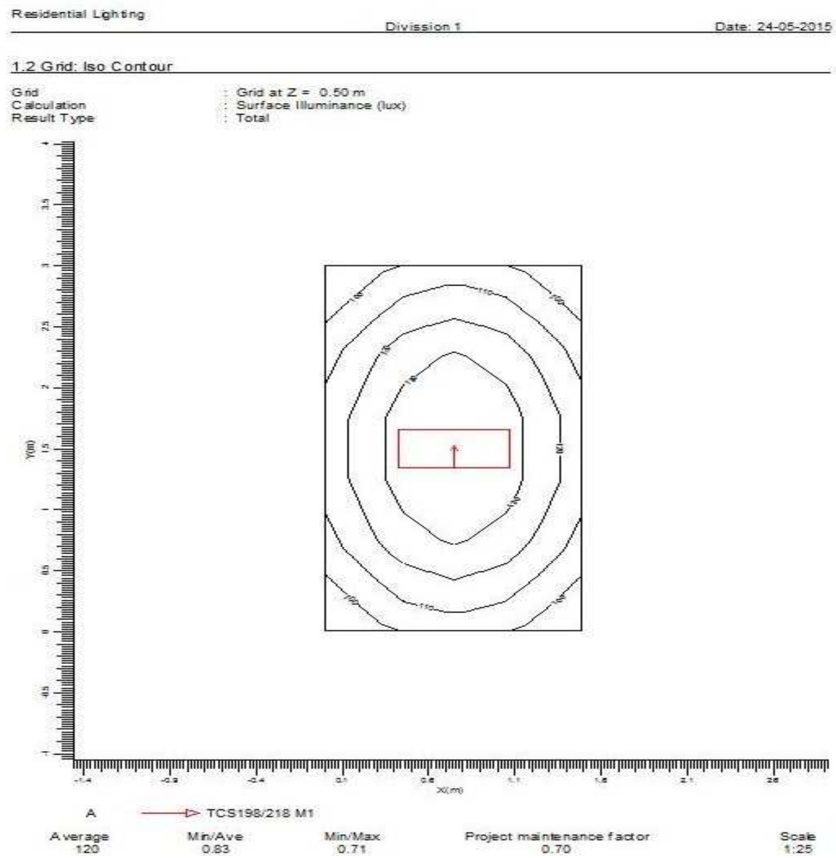


Figure.14. Division (1) lights layout designing output

Residential Lighting

Divission 2 Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.22	0.65	1.08	1.52	1.95	2.38
2.88	70<	85	96	96	85	70<
2.44	79	97	110	110	97	79
1.99	84	103	118	118	103	84
1.55	85	105	121>	121>	105	85
1.11	84	103	118	118	103	84
0.66	79	97	110	110	97	79
0.22	70<	85	96	96	85	70<

Figure.15. Division (2) numerical calculations

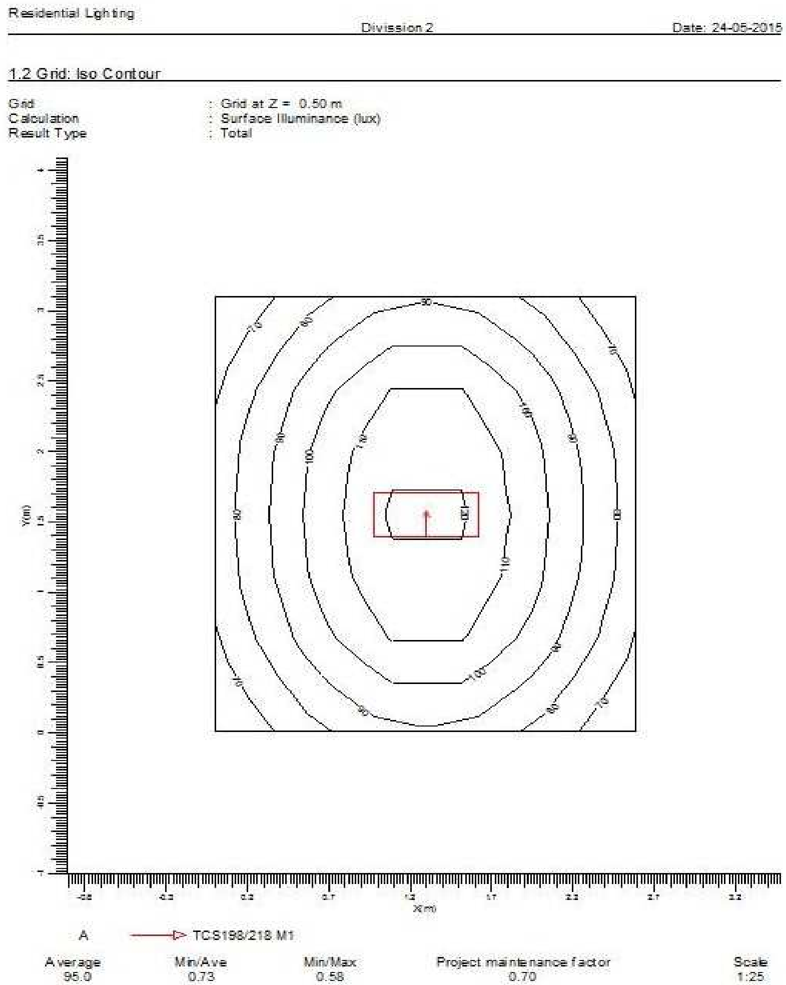


Figure.16. Division (2) lights layout designing output

Residential Lighting

Entrance Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.14	0.42	0.70	0.98	1.26
2.66	104<	114	118	114	104
2.18	118	130	135	130	118
1.69	125	138	143>	138	125
1.21	125	138	143>	138	125
0.72	118	130	135	130	118
0.24	104	114	118	114	104

Figure.17. Entrance numerical calculations

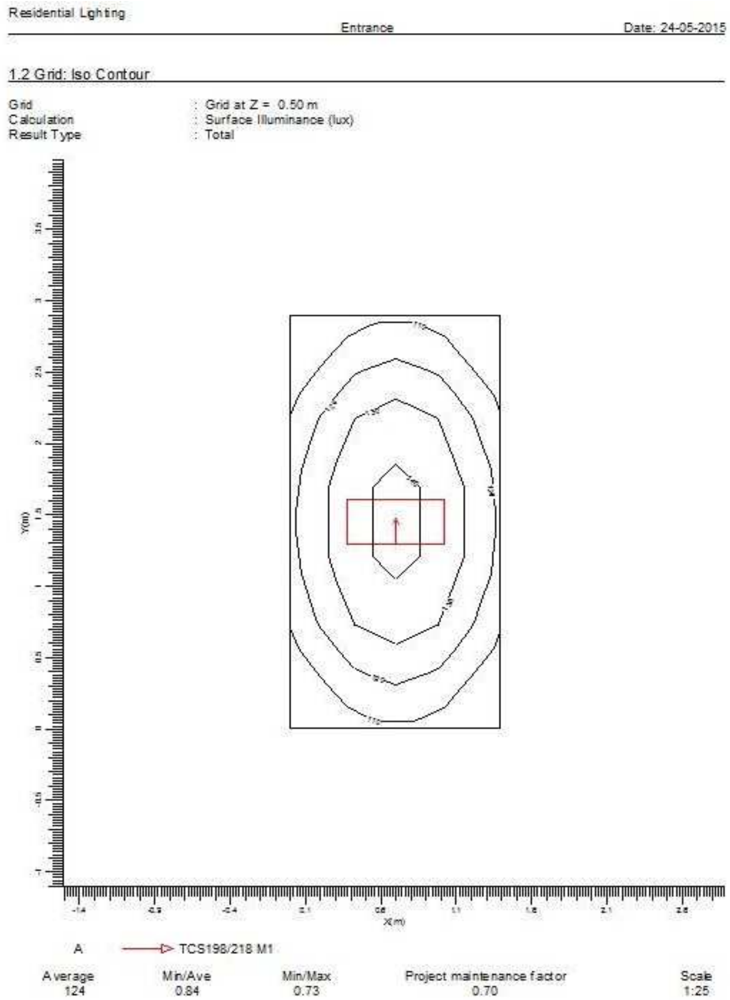


Figure.18. Entrance lights layout designing output

Residential Lighting

Kitchen

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.80 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.25	0.75	1.25	1.75	2.25	2.75
3.41	151<	204	251	251	204	151<
2.96	173	238	295	295	238	173
2.50	194	265	330	330	265	194
2.05	204	281	351>	351>	281	204
1.59	204	281	351>	351>	281	204
1.14	194	265	330	330	265	194
0.68	173	238	295	295	238	173
0.23	151	204	251	251	204	151

Figure.19. Kitchen numerical calculations

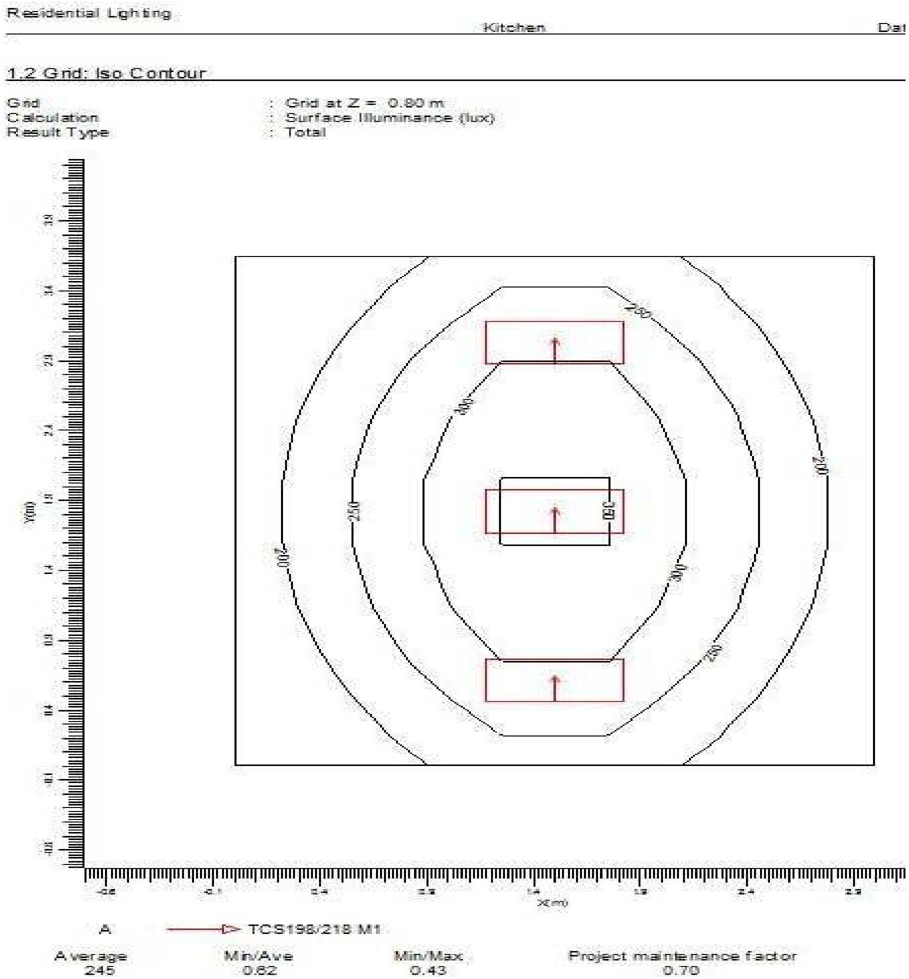


Figure.20. Kitchen lights layout designing output

Residential Lighting

Living Room Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25
6.36	127	153	169	170	168	170	170	154	127
5.81	144	177	195	194	191	194	195	177	145
5.25	164	200	221	220	217	220	222	201	164
4.70	179	221	244	243	240	243	244	222	180
4.15	185	227	251	251	247	251	251>	228	186
3.60	183	224	247	247	244	247	247	225	184
3.04	183	224	247	247	244	247	247	225	184
2.49	185	227	251	251	247	251	251	228	186
1.94	179	221	244	243	240	243	244	222	180
1.39	164	200	221	220	217	220	222	201	164
0.83	144	177	195	194	191	194	195	177	145
0.28	127<	153	169	170	168	170	170	154	127

Figure.21. Living room numerical calculations

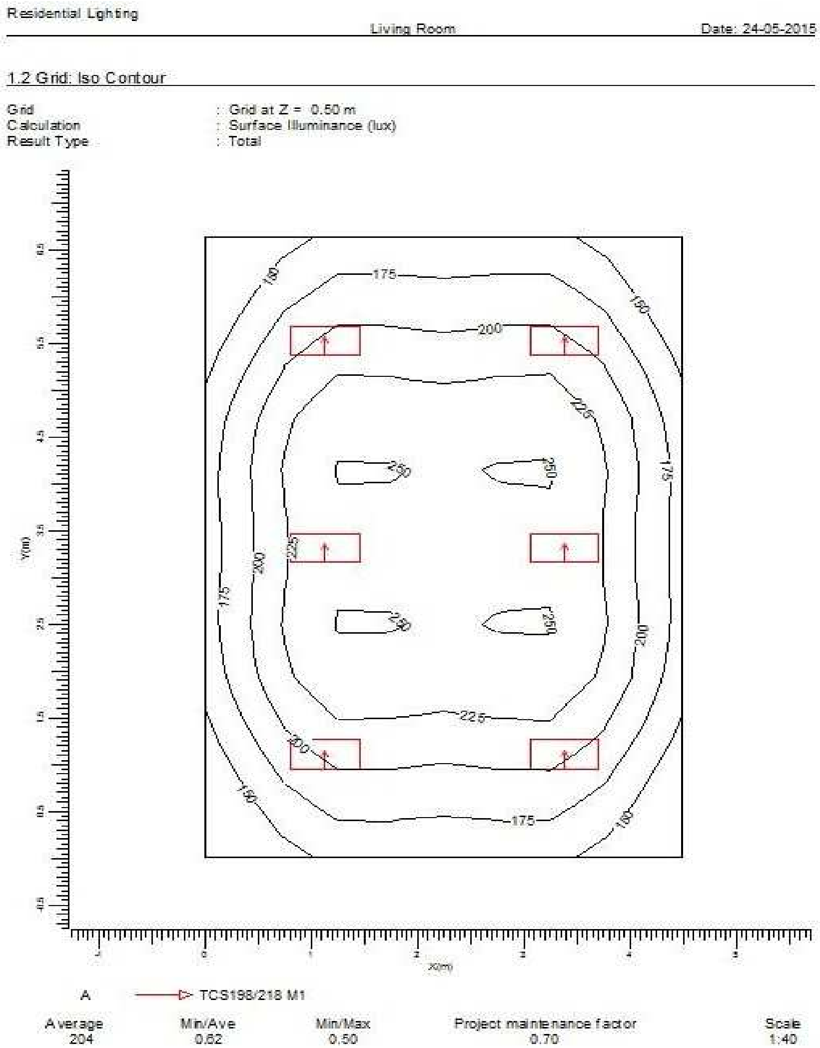


Figure.22. Living room lights layout designing output

Residential Lighting
Study Room
Date: 24-05-2015

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.80 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) / Y (m)	0.23	0.68	1.13	1.58	2.03	2.48
2.66	435	510	539	540	510	435
2.18	502	592	625	625	592	502
1.69	542	640	674	674>	640	542
1.21	542	640	674	674>	640	542
0.72	502	592	625	625	592	502
0.24	435<	510	539	540	510	435

Figure.23. Study room numerical calculations

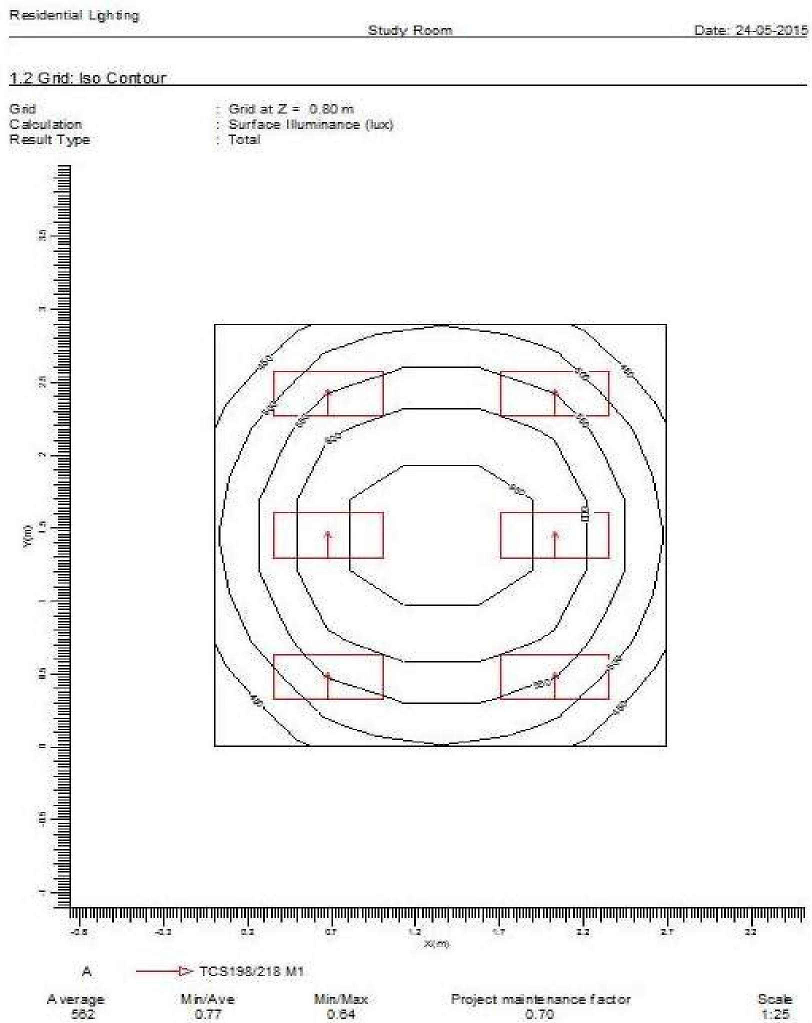


Figure.24. Study room lights layout designing output

Residential Lighting

WC

1. Calculation Results

1.1 Grid: Textual Table

Grid : Grid at Z = 0.50 m
Calculation : Surface Illuminance (lux)
Result Type : Total

X (m) Y (m)	0.13	0.39	0.65	0.91	1.17
1.25	149<	165	171	165	149<
0.97	159	176	182	176	159
0.70	161	179	185>	179	161
0.42	159	176	182	176	159
0.14	149	165	171	165	149

Figure.25. Bathroom numerical calculations

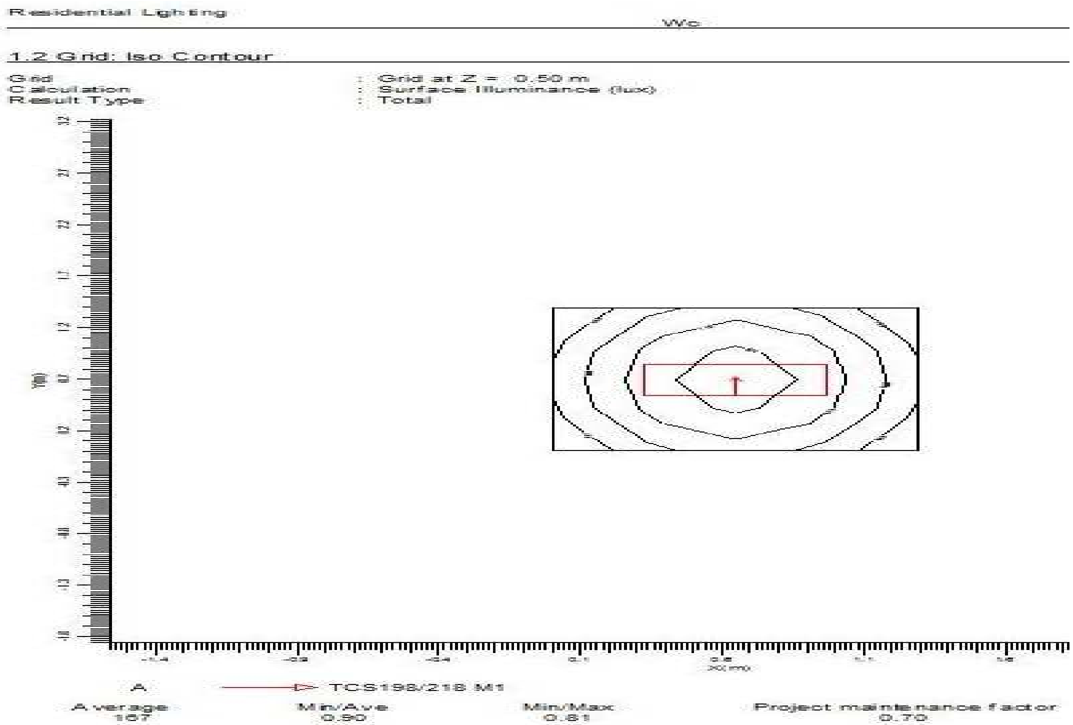


Figure.26. Bathroom lights layout designing output

To produce the visible light in fluorescent lamps it is used UV radiation with a phosphoric coating inside the glass tube lamp. In the narrowband fluorescent lamp cover it is used three types of phosphorus that is triband. This issue causes to increase the light quality and quantity[3]. The light features in this modeling has been shown in the Figure 27.

Finess 2

Specifications

• Type	TCS198 (rectangular and square version) TCS198 KIT (rectangular, ready to install version)
• Light source	Fluorescent: - 1 x, 2 x, 3 x or 4 x MASTER TL-D / G13 / 18, 36, 58 W
• Lamp included	Yes (lamp color 830 or 840) (optional) No
• Gear	Electro magnetic (low loss), 230 or 240 V / 50 Hz: - Inductive (I) - Inductive with additional connection block for capacitor (IK) - Inductive with additional connection block for capacitor in parallel (IKP) - Inductive, parallel compensated (IC) Electronic, 220 - 240 V / 50 - 60 Hz: - High Frequency Performer (HFP) - High Frequency Regulator (HFR) - Electronic Included (EI)
• Optic	High-gloss optic, double parabolic, limit 1000 cd (C6-1000cd) Matt optic, double parabolic louvers (M6) Matt mirror, ribbed cross louvers (M2)
• Connection	Push-in connector
• Option	Euro fuse (FU) included Emergency lighting: 1 hour (EL1), 3 hours (EL3) Ready-to-install versions (KIT), inclusive lamp(s) and installation material Counterweight (CW) to balance the luminaire
• Material	Housing: pre-lacquered steel, white End caps: plastic
• Installation	Individual or in line; screw mounting or clicking the luminaire into pre-screwed ceiling brackets (ready-to-install) Suspension facility optional
• Accessory	Suspension set
• Main applications	Office, retail, industry, recreational, public buildings

Figure.27. Technical specifications of the modeling lamp[9]

In manufacturing of the solar cells it has been used various materials which had different output and manufacturing costs. In fact, these cells should be designed to covert the sunlight wavelengths into useful energy with high efficiency. In the meantime, the poly-crystalline silicon with 250 watts power has been preferred because of its commercialization and less costs[2].

4. DISCUSSION

4.1. Analyzing the results

Considering the lighting in terms of luxury in specific calculations in figures 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23 and 25as well as layout designing output and the number of lights in figures 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24 and 26 and also considering the power of each light we have:

25 lights*38 watts=950 watts

950W/ 250 (power of each photovoltaic panel) ≈ 4 panels

5. CONCLUSIONS

One of the most important factors that can flourish using the sustainable energies and leads to the sustainable architecture is cost calculations and the consumer estimations. In this way, it will be recognized that the new clean source would be proper alternative for the previous pollutant energy source. In this study after collecting the data, software modeling and analyzing the data the following results have been achieved:

1- Solar energy is cost-effective economically because of removing the distribution and transfer costs and being infinite.

2- For providing the standard lighting of a residential unit with an area of approximately 100 square meters through fluorescent lamp it will be required 950 Watt-hours energy.

3- For providing the standard lighting of a residential unit with an area of approximately 100 square meters through photovoltaic system it will be required 4 panels as well as 250 watt photovoltaic.

List of signs:

AC: Alternative current **K_r:** Space index **L:** length of room **H:**Height of installation from the surface
W: Width of room **H:** Height of ceiling from the surface **E_{av}:** Average Energy **A:** Area
CU: Coefficient of utilization **MF:** Maintenance factor **Φ:** Luminous Flux **DC:** Direct current

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