young cities

Developing Urban Energy Efficiency

Tehrān-Karaj

Young Cities Research Briefs | 06

# SOLARCHVISION Studies on Young Cities Project

Mojtaba Samimi, Farshad Nasrollahi

# Table of Contents

# Foreword

The natural as well as the artificial environment affect a building's energy balance. Together with the vegetation and water bodies, these natural and artificial features produce microclimatic conditions that not only influence the energy-related aspects, but also the comfort conditions of a building. Alongside the effects of the natural environment in a microclimate, buildings interact on behalf of the received solar radiation and both the wind direction and speed; with the solar radiation, however, being the most influential factor. Buildings in an urban complex can, overshadow each other at different times of the day and year; on the other hand, they can reflect solar radiation and thus generate greater incidence on different surfaces, which is one of the key factors characterizing a building's energy balance.

In order to minimize the heating and cooling energy demands in continental climates, the building envelope (especially the transparent parts) must generate maximum solar gain during the heating period and minimum solar gain during the cooling period. The amount of solar heat reaching the different surfaces of the building's thermal envelope at different times of the day and year depends on the orientation of each surface as well as the shading created by the surrounding natural and built environment.

The urban form of a neighborhood unit, a building cluster and an individual building affect the solar heat gain.

Due to the fact that incident solar radiation plays a positive role in winter and a negative role in summer, only the intensity of solar radiation incidence on the outer surfaces of a building throughout the whole year cannot contribute in an energy-efficient design. Therefore, the SOLARCHVISION computer program has combined the amount of solar radiation and the air temperature as an energy-related factor. This factor presents the advantages and disadvantages of any surface from the viewpoint of received solar radiation at different times.

This factor can be calculated and plotted for different surfaces in neighborhood units or for single buildings.

The decisions that can be made based on this factor in urban planning and building design lead to energy-efficient buildings and comfortable urban fabrics. SOLARCHVISION analysis can contribute to environmental design in different scales from urban scale to building details.

Since the analysis of the urban and building form by SOLARCHVISION is a planning and design method for energy efficiency, it does not increase the investment costs of the buildings; on the other side it can optimize building technology, materials and function.

Alongside the SOLARCHVISION analysis of the New Generation Office Building, other studies are performed for energy optimization of architectural design of this Building. For these studies other simulation software tools, mainly DesignBuilder, are used. Application of the results of these analyses, including SOLARCHVISION analysis, leads to a high reduction of energy demand of New Generation Office Buildings.

After a scientific introduction to SOLARCHVISION analysis, this Young Cities Research Brief analyses the commercial mixed-use as well as New Generation Office Building regarding the intensity and duration of received solar radiation in different seasons.

# 1 From the Sun to Architect

While the sun is the center of the solar system, the earth because of its specific conditions such as having water, air, day-light and night-dark is the only appropriate place of emerging all existing living kinds, from a cell to variety of plants and animals.

The human which is a weak-body creature gets on the earth on the best time; and upon his power of thinking he gradually gets on unfavorable in his surrounding environment. Here the role of human-made from the primitive dress and shelters to what which is called today as *"Architecture"* are essential to meet human demands as well as his comfort.

The sun as one of the most important members forming different climates on the earth, with its kind and unkind faces, has put human race into several challenges. Thousands of years past that the human got down from the trees and out of the caverns migrating to find favorable conditions or settled down in some places by means of agriculture. In several villages, however people live in standing houses but migration still exists between summer and winter parts.

But from the last decades, human interferences in the cycles of the environment, have became so fast and strong that today a clear future could not be considered to live on the earth in the way of polluting the globe by wasting the resources and time. Therefore today we, as small particles in the universe have a great mission to respect all natural members of the environment; even as a client, user or designer.

## Introduction

Regarding the importance of paying proper attention to the local properties of each location, basic and applied researches are needed to help the architects, the urban planners and the clients for more accurate decision making and decision taking.

SOLARCHVISION is a computer program which defines a new method in architectural solar analysis. In addition to calculating and mapping solar radiation models, this program brings a brand new vision for discovering the advantages and the disadvantages of design decisions about the kind and unkind faces of the sun in each location and through any period of time. In this vision, different points of building skin and outdoor areas are analyzed simultaneously to find out the proper or improper solar response of architectural design inside different climates.

However there are several local parameters which affect the result of this analysis such as sun path, direct/diffused radiation according to atmospheric factors, changes in outdoor temperature and humidity, building program, the geometry of the building and its surroundings, etc., today it is possible to apply SOLARCHVISION through the whole design process in a variety of design fields ranging from basic design and urban design to architectural design and landscape architecture. The intelligent design of shading or reflecting devices in different façades, form finding process of membrane structures and optimization of single and group of solar collectors can be done by this program.

This process results in developing healthy, comfortable, energy saving and cost effective living spaces of tomorrow.

“In regard to the sun and climate, what are the optimum orientation and form of buildings ?” is one frequently asked question in the very first steps of architectural and urban design. However there are several answers to this question available right now; the main idea has not been changed much from what Socrates told: *“Now in houses with a South aspect, the sun’s rays penetrate into the porticos in winter, but in the summer the path of the sun is right over our heads and above the roof, so that there is shade. If, then, this is the best arrangement, we should build the South side loftier to get the winter sun and the North side lower to keep out the winter winds.”* [1] But here we want to point toward the complexity of this problem from an integrated design approach as well as the urban point of view. Since no architecture could stand without a proper structure, the life of no architecture could be considered without the essential effects of the sun. In the country of Iran, the sun had an extraordinary role in Persian life, culture and architecture; worshiped as MITHR goddess, acted as the foremost environmental factor in forming Persian traditional architecture amongst other important aspects. Consequently the word MEHRAZ which means architect in Persian language is based on two words of “MEHR (the sun)” and “RAZ (the mystery)”. Thus, ancient Persian architects were regarded as the ones who knew the mystery of the sun.

Besides, in most of locations, the sun has different effects during the year-cycle: The kind face of the sun which appears in cold times; and its unkind face which appears in hot times. Therefore, *“one of the greatest challenges of architects is to design buildings not only receive more from the kind face of the sun; but also protect themselves from the unkind face of the sun.”* [2]

Considering buildings as standing objects, the urban design should be intelligent enough to provide comfort both inside and outside through the whole cycle of the year. The significance and complexity of optimizing the orientation and proportion of building masses at the scale of neighborhood and city greatly increases when we take into consideration the comfort factor outdoors beside indoors. The comfort and discomfort inside a building have a direct effect on the building energy consumption and the energy costs paid by the occupants, while in outdoor spaces the problem is more related to the health and safety rather than energy and money. Thus, even though orientating long rows of building masses toward the South direction is a common idea to achieve maximum solar radiation in winters and to minimize summer gains, in most cases it results in developing uncomfortable areas between building blocks (i.e. paths and yards) where these parts will be in long-time shade in winters as well as long-time radiation in summers. Although these negative effects could be corrected by proper shades, reflectors, planting, etc., different and more enhanced optimizations would be gained from sound integration and distribution of indoor and outdoor spaces within the design. Therefore, the main goals of SOLARCHVISION studies are:

1. Producing basic design guidelines using the available data of different climates;
2. Evaluation of alternatives for urban fabric, building skin and interior spaces through design process from point of view of the sun and climate.

[1] http://greenpassivesolar.com/2010/04/socrates-and-passive-solar-in-greece/

[2] “A new approach for solar analysis of buildings”, Samimi M., Parvizsedghy L. & Adib A., WORLDCOMP ’08—Proceedings of The 2008 International Conference on Software Engineering Research & Practice, Editors: Arabnia H.R. & Reza H., CSREA PRESS

# 2 Basics for Solar Design

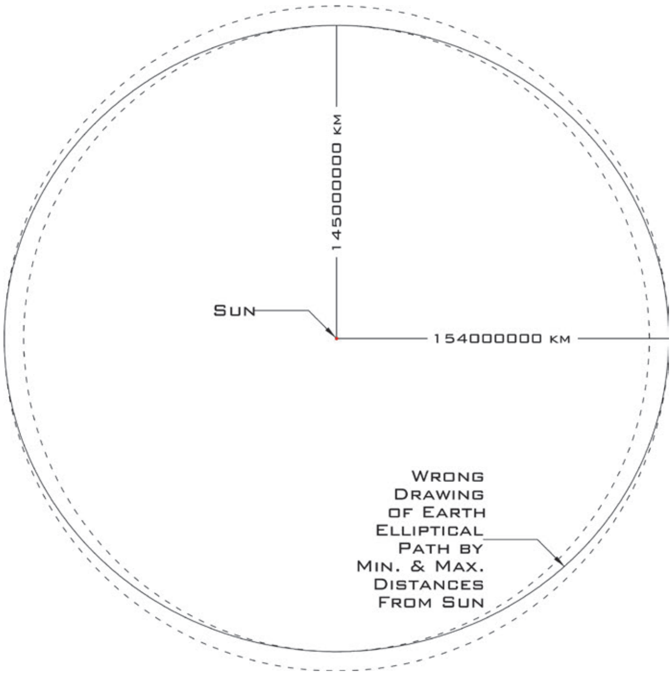



Fig. 1: Wrong imagination of an elliptical path of the orbit of the earth around the sun

## 2.1 Orbit of the earth around the sun

The earth sphere with the radius about 6,357 km orbits around the sun sphere with the radius of 700,000 km (which is 110 times bigger than the earth radius) on a large circle with approximate radius of 150,000,000 km (which is 214 times bigger than the sun radius) by speed of 30 km/s (107,500 km/h) which is so fast than the earth pasts 17 times of its radius in each hour as well as more than 6.5 times of the distance to the moon in 24 hour!

In this orbit the distance between the earth and the sun changes between 145,000,000 km and 154,000,000 km; therefore it is quite probable that the path of orbit of the earth around the sun is considered as an ellipse shape where the sun is located at the center of the path, which is completely wrong in real!

However the path of orbit of the earth around the sun has an elliptical shape in theory but it is necessary to pay attention to the fact that it is very close to a circle while proportion between small and long diagonals is 0.9998 and the reason for changes in the distance between the sun and the earth is that the sun is not located exactly at the center!
One remarkable phenomenon resulted from not being of the sun at the center of the orbit path is changes in speed of the orbit of the earth in different parts

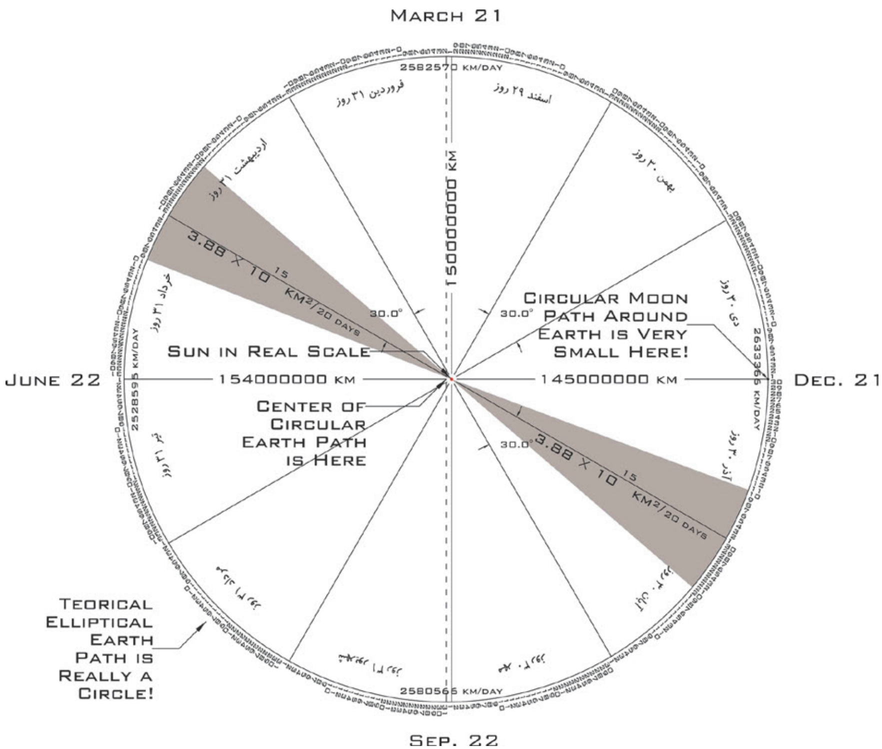



Fig. 2: Accurate drawing for the path of the orbit of the earth around the center with distance to the sun

of the path which could be defined by the Kepler's second low; so when the earth reaches its closest distance to the sun on the 21st of December it reaches its highest speed and on the other side it reaches its minimum speed on 21st June when its distance to the sun is at maximum point. That 's the reason behind changes in number of days in different months of the year which is best reflected in Persian calendar where the months of the warmer side of the year have 31 days instead of 30 days in the colder side.

Another remarkable phenomenon resulted from not being of the sun at the center of the orbit path is changes in solar radiation reaches to the earth in different parts of the path about ±3.34 percent.

Through the orbit of the earth around the sun which is called a year the earth is rotating around its South-North axis which creates phenomenons of day, night, sunrise, noon and sunset. This orbit as well as the round shape of the earth also creates different geographic regions from the equator to each pole because of differences in amount of solar radiation received in different slopes of the surface of the earth.

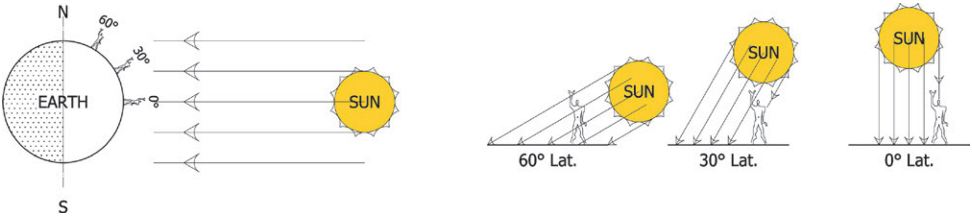



Fig. 3: Differences in amount of solar radiation received in different slopes of the surface of the earth

**What is the reason for different seasons on the earth?**
Opposite to the public imagination that consider the changes of distance between the earth and the sun as the reason for creation of different seasons on the earth, these changes are not only effectible in this case but also have a reverse effect whiles the earth reaches its closest distance to the sun on the 21st of December and its maximum distance point on 21st June!

Regarding to orbit of the earth around the sun the remarkable note is the declination angle between the South-North axis of the earth and the plane of the year orbit which could be considered as a constant value in decades as 23.45°.

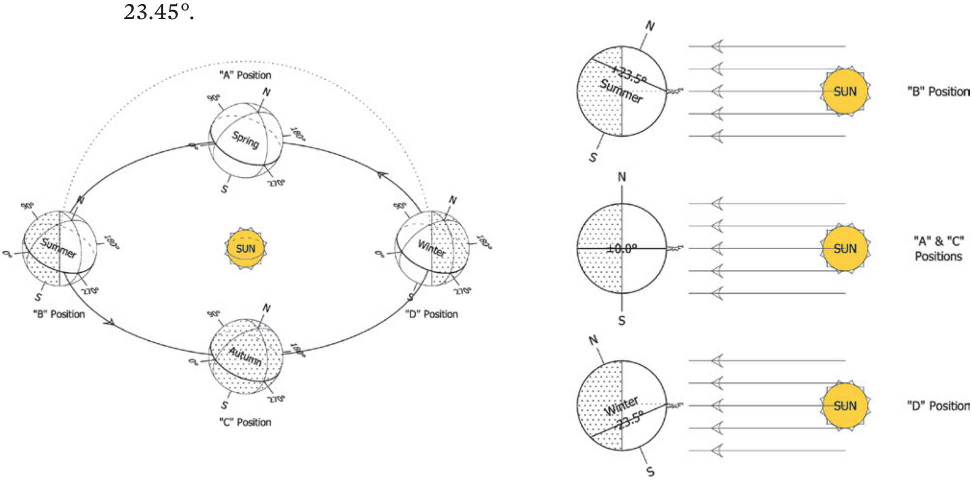



Fig. 4: Differences in received solar radiation in southern and northern semi-spheres of the earth through the year

## 2.1 Movements of the sun around the earth

Considering the earth as the static center of universe, it seems that the sun is rotating once a day. In this case it is necessary to be aware of its pendulum-movement through the year as it reaches its nearest point to the South Pole in 21st December and also it reaches its nearest point to the North Pole on 21st June.

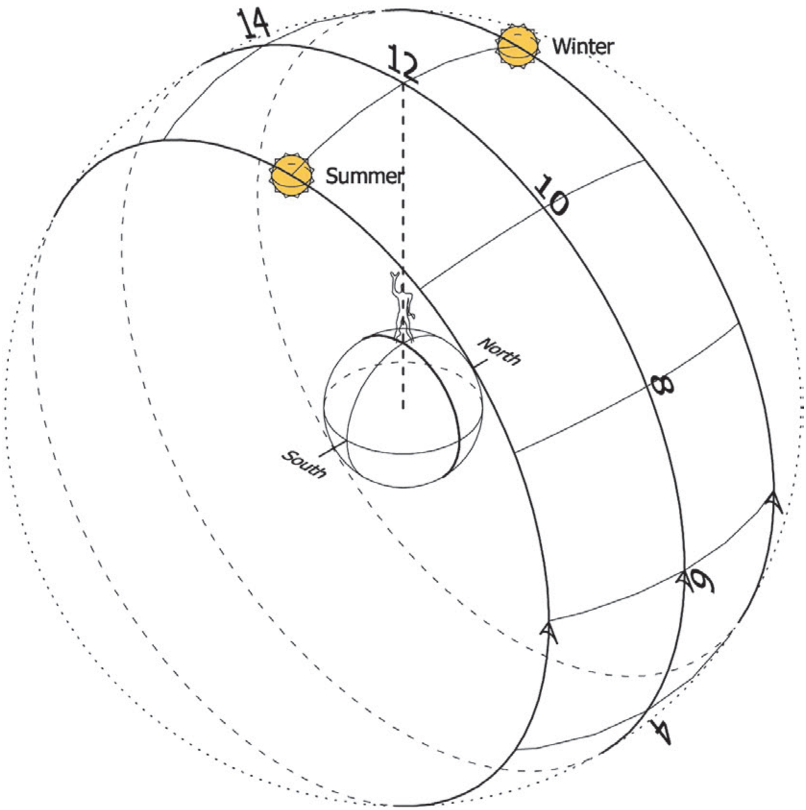



Fig. 5: Movements of the sun around the earth

The position of the sun in the sky is described by two factors of the Azimuth angle and the Altitude angle. Different points on the earth in regard to their latitude have different sun paths.

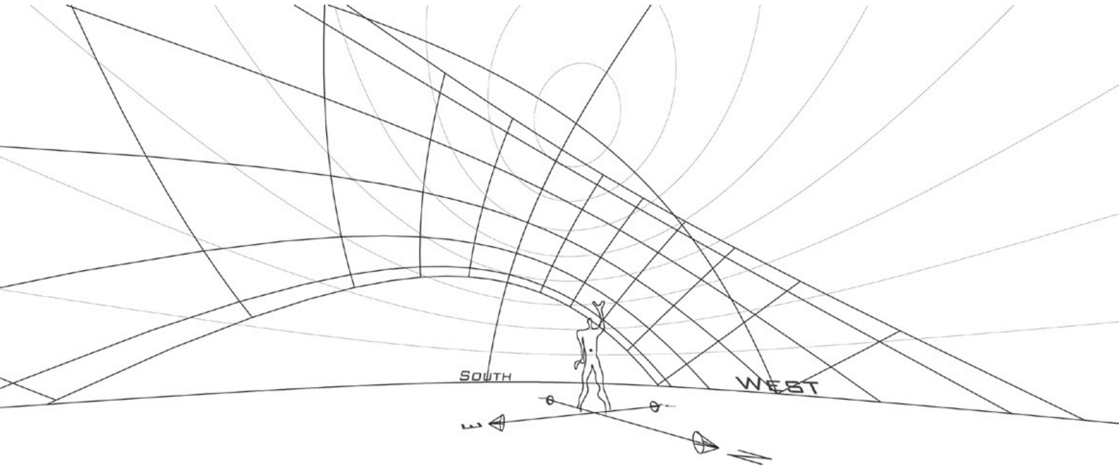



Fig. 6: Perspective view of the movements of the sun in the sky at the earth surface, Latitude=30°N

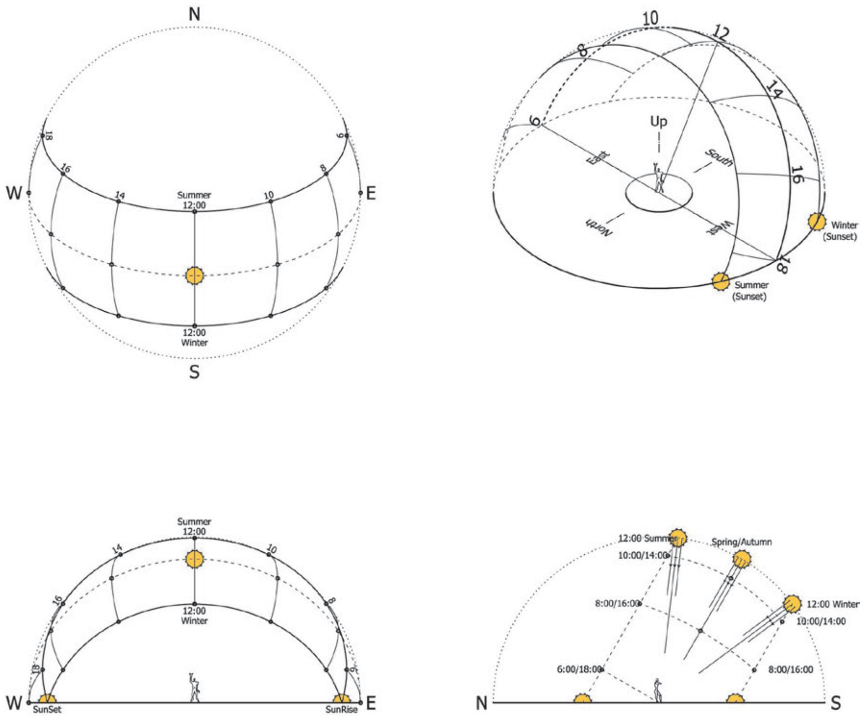



Fig. 7: Top, front, left and isometric views of orthographic path of the sun in the sky for the latitude of 30°N

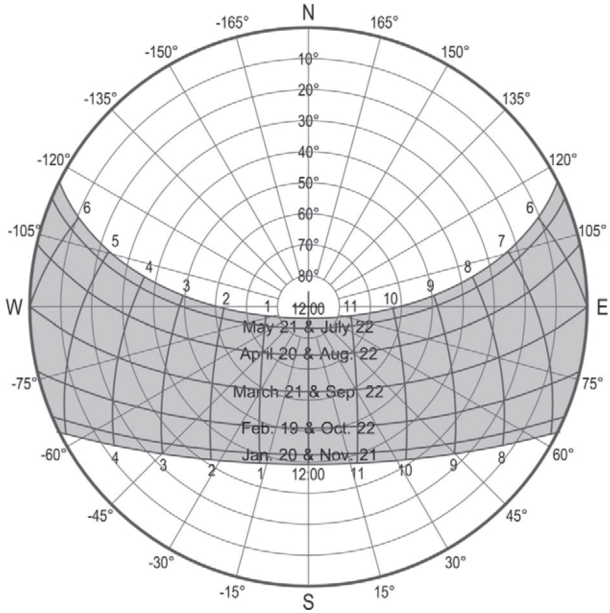



Fig. 8: Equidistant sun path, Latitude = 30°N

Above diagram shows equidistant sun path diagram for the latitude of 30°N. To calculate the position of the sun in the sky, instead of using classic unsafe formulas of Azimuth and Altitude calculations, SOLARCHVISION computer program uses its original algorithm to calculate solar position in the sky by means of a 3-dimentional vector matrix as published in “A New Approach For Solar Analysis of Buildings—WORLDCOMP 2008”.

```
function SOLARCHVISION_SunPosition  StationLatitude  DATE_angle
HOUR = {
    DEC = 23.45 × sin(DATE_angle - 180.0)
    a = sin(DEC)
    b = cos(DEC) * -cos(15.0 × HOUR)
    x = cos(DEC) *  sin(15.0 × HOUR)
    y = -(a × cos(StationLatitude) + b × sin(StationLatitude))
    z = -a × sin(StationLatitude) + b × cos(StationLatitude)
    return [x,y,z]
}
```

# 3 Hashtgerd Solar-Climatic Information

## 3.1 Solar Radiation Data in Iran

It is necessary to be aware of the accuracy of the data to be used in any building simulation software. About solar radiation data of Iran there are different references exist which can be used, but there are notable problems with some available data which is necessary to be considered. These problems are:

1. Lack of data for different locations in the country
2. Lack of data about separated direct and diffuse solar radiation
3. Lack of hourly measurements
4. Inaccurate measurements and lack of quality control

However, the major goal of this report is not the discussion about estimation of solar radiation for Hashtgerd New Town but similar problems found in solar radiation data for Hashtgerd New Town which was extrapolated using the data of Tehran and Karaj stations.

In this section different references are described in order to achieve the most accurate solar radiation models for the cities of Iran. Some of these references are:

1. Estimation of Global Solar Radiation in Iran based on Climatic Data, Monthly Journal of Geographical Researches, Ali Khalili, Hasan Rezaei Sadr, 1998, Iran
2. Iran Meteorological Organization - Data Processing Center, 2003
3. FU University Information for Hashtgerd based on Karaj and Tehran Data
4. Meteonorm 6.0 Interpolated Model for Hashtgerd
5. Meteonorm 6.0 Data of Tehran
6. U.S. Department of Energy EneryPlus format (taken from BHRC of Iran)

**Ref. #1: Estimation of Global Solar Radiation in Iran**

Table and graph below show the average daily value of total solar radiation on a horizontal plane in different months in different cities of Iran. This estimation is based on Climatic Data and is introduced by Ali Khalili and Hasan Rezaei (Ali Khalili & Hasan Rezaei, Monthly Journal of Geographical Researches, Sadr,1998).

| cal/cm².day | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Kcal/cm².year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Orumieh | 281 | 387 | 497 | 595 | 698 | 702 | 624 | 529 | 358 | 244 | 186 | 203 | **161** |
| Tabriz | 283 | 392 | 505 | 617 | 729 | 739 | 658 | 558 | 372 | 249 | 186 | 204 | **167** |
| Zanjan | 275 | 369 | 468 | 542 | 604 | 591 | 538 | 462 | 334 | 236 | 189 | 210 | **147** |
| Ramsar | 193 | 227 | 298 | 361 | 392 | 378 | 333 | 262 | 204 | 164 | 132 | 152 | **94** |
| Bojnord | 243 | 317 | 417 | 490 | 552 | 543 | 509 | 417 | 301 | 214 | 168 | 182 | **132** |
| Mashhad | 253 | 327 | 420 | 511 | 585 | 577 | 530 | 438 | 312 | 225 | 178 | 193 | **138** |
| Kermanshah | 288 | 374 | 454 | 520 | 586 | 575 | 532 | 456 | 344 | 249 | 203 | 219 | **146** |
| Hamedan | 256 | 344 | 443 | 512 | 584 | 575 | 527 | 450 | 327 | 228 | 180 | 200 | **141** |
| Tehran | 280 | 370 | 467 | 542 | 607 | 590 | 537 | 463 | 339 | 244 | 193 | 209 | **147** |
| Tabbas | 318 | 411 | 501 | 577 | 626 | 611 | 567 | 489 | 382 | 279 | 227 | 244 | **159** |
| Birjand | 340 | 434 | 528 | 611 | 655 | 644 | 601 | 518 | 413 | 306 | 251 | 272 | **170** |
| Esfahan | 339 | 430 | 509 | 581 | 638 | 620 | 573 | 500 | 388 | 288 | 241 | 263 | **163** |
| Yazd | 385 | 479 | 589 | 700 | 791 | 777 | 735 | 644 | 489 | 347 | 274 | 291 | **198** |
| Kerman | 333 | 407 | 491 | 568 | 611 | 602 | 567 | 501 | 404 | 307 | 253 | 265 | **161** |
| Shiraz | 350 | 444 | 519 | 598 | 638 | 618 | 576 | 515 | 421 | 320 | 272 | 290 | **169** |
| Bushehr | 305 | 412 | 489 | 574 | 614 | 583 | 538 | 491 | 407 | 309 | 249 | 271 | **159** |

Tab. 1: Daily value of total solar radiation in different months ([Ref. #1])

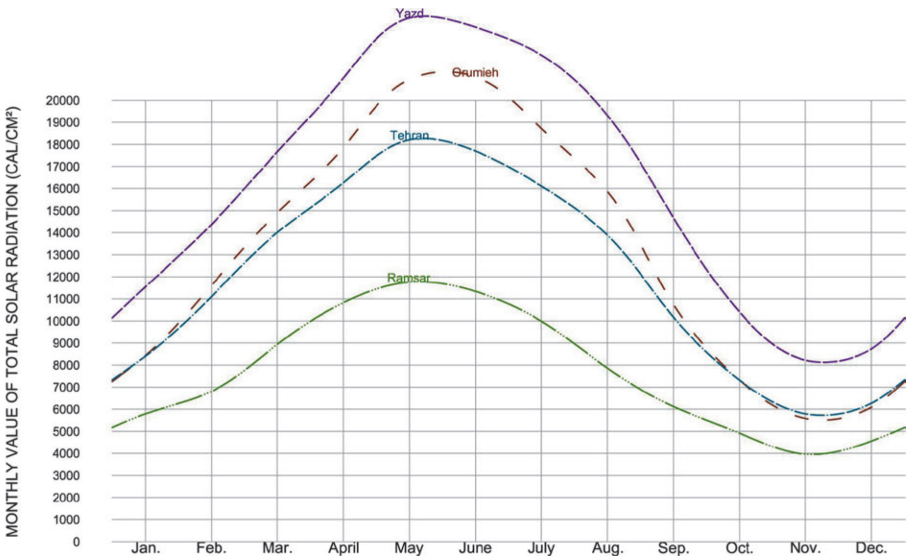



Fig. 9: Daily value of total solar radiation in different months

Dr. Khalili's work has resulted the map of yearly horizontal radiation in Iran which shows Yazd (31:54N, 54:17E) at the maximum point of yearly horizontal radiation in Iran with 180 $^{Kcal}/_{cm^2.year}$. Another Maximum point is estimated around the city of Orumieh (37:32N, 45:05E) with 170 $^{Kcal}/_{cm^2.year}$. Tehran is located between the contour lines of 150 and 160 $^{Kcal}/_{cm^2.year}$. The minimum solar radiation is considered in the areas near the Caspian Sea with 100 $^{Kcal}/_{cm^2.year}$.

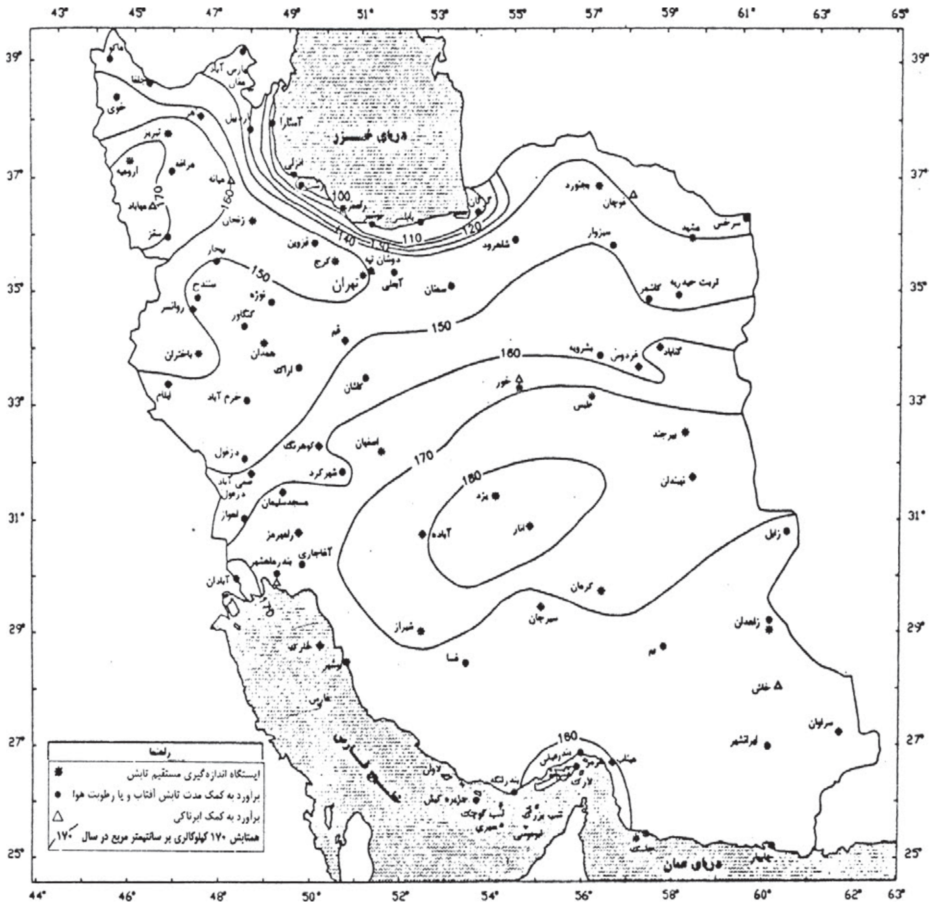



Fig. 10: Map of Yearly Horizontal Radiation in Iran—Kcal/cm².year ([Ref. #1])

**Ref. #2: Iran Meteorological Organization**

In 2003 Iran Meteorological Organization was published the yearly monthly data of global horizontal solar radiation for different stations in "txt". Below table shows the mean values for monthly global horizontal solar radiation which is taken from mentioned files. Except the incredible values for Tehran (Mehrabad) and Birjand other values present different situations in Iran which are plotted in the graph in follow of the table.

| City\Month | Jan. | Feb. | Mar. | April | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oroomieh | 7313 | 8500 | 11046 | 13265 | 17104 | 18546 | 17955 | 14925 | 12317 | 9765 | 7233 | 6732 |
| Bojnurd | 8005 | 8428 | 11111 | 13349 | 16259 | 17060 | 17067 | 16252 | 13673 | 11650 | 8131 | 7361 |
| Ramsar | 6675 | 7162 | 8728 | 10118 | 11157 | 11881 | 11470 | 9956 | 9571 | 8190 | 7708 | 6786 |
| Zanjan | 6949 | 7722 | 9967 | 11870 | 14785 | 16664 | 16342 | 14808 | 12760 | 9499 | 6224 | 5530 |
| Karaj | 7559 | 9130 | 11934 | 14235 | 16612 | 18227 | 18514 | 17555 | 15148 | 11504 | 9674 | 7698 |
| Shomale Tehran | 6856 | 8321 | 11202 | 14018 | 17405 | 19477 | 18332 | 17831 | 14386 | 10953 | 8427 | 6556 |
| **Tehran Mehrabad** | **8232** | **10160** | **14830** | **16846** | **21264** | **22592** | **21355** | **21002** | **17720** | **13413** | **10297** | **7562** |
| Hamedan | 6594 | 8819 | 10894 | 13183 | 16948 | 19046 | 19165 | 17776 | 15510 | 11268 | 8531 | 6479 |
| Kermanshah | 6896 | 7604 | 10731 | 12431 | 14472 | 16616 | 16313 | 15021 | 12989 | 10479 | 7547 | 7001 |
| Khoor | 7058 | 8480 | 11144 | 12627 | 15826 | 16284 | 15564 | 14759 | 12750 | 10439 | 7604 | 6598 |
| Tabass | 8435 | 9214 | 12251 | 15118 | 17445 | 18993 | 19027 | 17765 | 15349 | 12504 | 9125 | 7908 |
| **Birjand** | **11271** | **10587** | **14579** | **16176** | **20277** | **20551** | **21685** | **22740** | **19914** | **15490** | **13768** | **13367** |
| Yazd | 8339 | 11220 | 12627 | 15013 | 19408 | 20842 | 20959 | 19654 | 17205 | 12938 | 9358 | 8391 |
| Kerman | 8967 | 10554 | 12720 | 15930 | 19055 | 20111 | 20481 | 18556 | 16841 | 13877 | 10435 | 9740 |
| Shiraz | 10281 | 10325 | 13495 | 15436 | 17160 | 18196 | 18821 | 17843 | 16081 | 13794 | 9945 | 10492 |
| Zahedan | 9819 | 10815 | 11872 | 15043 | 16453 | 16940 | 17808 | 17605 | 14843 | 12614 | 9971 | 9105 |
| Bushehr | 7805 | 9773 | 12908 | 14867 | 17117 | 19267 | 18308 | 18026 | 15581 | 13320 | 9892 | 7903 |
| Bandarabass | 9056 | 10024 | 12320 | 14861 | 17144 | 15742 | 15135 | 14330 | 13481 | 12178 | 9809 | 8616 |
| Jask | 9690 | 10318 | 13479 | 15328 | 16670 | 16841 | 16902 | 15140 | 13493 | 11822 | 10756 | 10586 |

Tab. 2: Monthly value of total solar radiation (cal/cm²) ([Ref. #1])
(Attention: Incredible values of the cities of Tehran and Birjand are marked in magenta)

About the incredible information of Tehran (Mehrabad), as above table and graph show, the values for this station has no relation with two near station of Shomale_Tehran and Karaj and also exceed the values of the Yazd which is well known as the most sunny city in Iran. As this study discover further by getting deeper in the data file of Tehran several high unacceptable values could be found between 1974 and 1977 which raised the mean values in result.

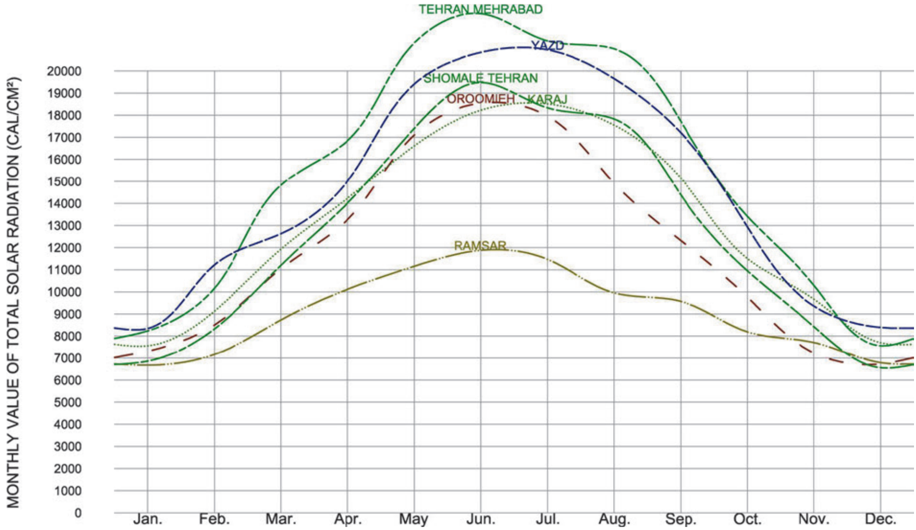



Fig. 11: Monthly value of total solar radiation (cal/cm²)

| City\Month | Jan. | Feb. | Mar. | April | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ramsar | 6675 | 7162 | 8728 | 10118 | 11157 | 11881 | 11470 | 9956 | 9571 | 8190 | 8190 | 6786 |
| Karaj | 7559 | 9130 | 11934 | 14235 | 16612 | 18227 | 18514 | 17555 | 15148 | 11504 | 11504 | 7698 |
| Shomale_ tehran | 6856 | 8321 | 11202 | 14018 | 17405 | 19477 | 18332 | 17831 | 14386 | 10953 | 10953 | 6556 |
| Tehran_ mehrabad | 7281 | 9373 | 12289 | 14655 | 17140 | 19075 | 18639 | 17053 | 14845 | 10950 | 10950 | 5764 |
| Yazd | 8339 | 11220 | 12627 | 15013 | 19408 | 20842 | 20959 | 19654 | 17205 | 12938 | 12938 | 8391 |

Tab. 3: Monthly value of total solar radiation (cal/cm²) ([Ref. #2, with data correction of Tehran_Mehrabad by not including 1973–77 incorrect data])

Below graph shows that by data correction of Tehran_Mehrabad (by not including 1973–77 incorrect data) the model of solar radiation for Tehran_ Mehrabad (Tehran West) become close to Shoamle_Tehran (Tehran North) and Karaj.

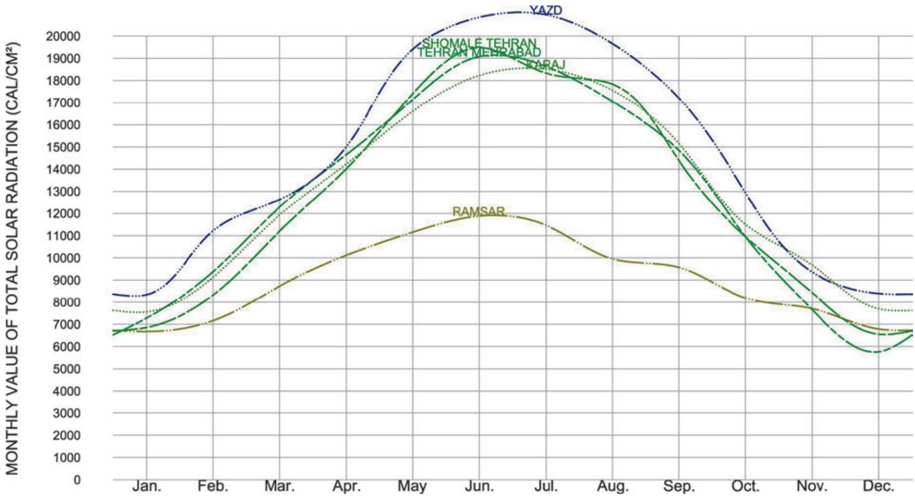
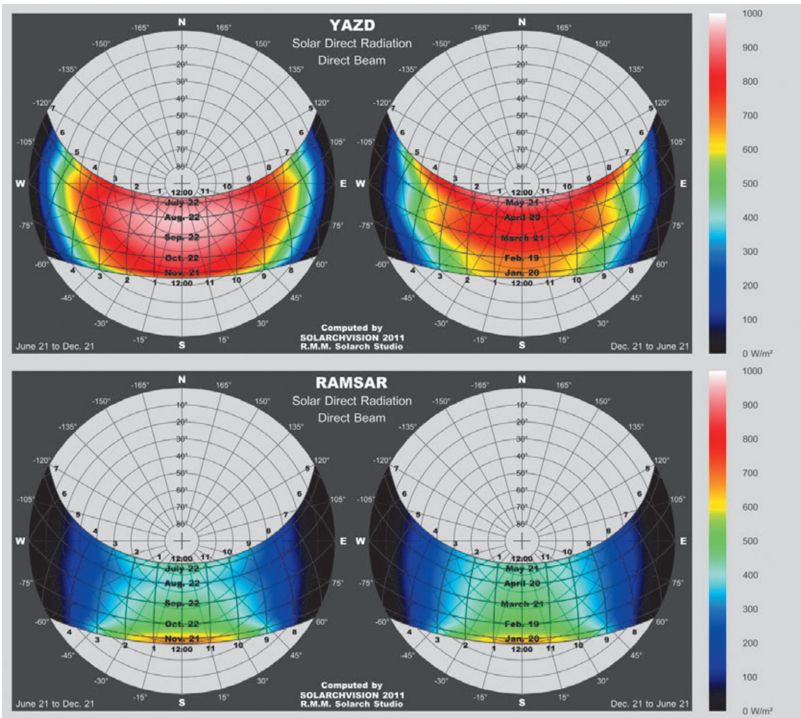



Fig. 12: Ref. #2 - Data correction of Tehran_Mehrabad by not including 1973–77 incorrect data

By using these values SOLARCHVISION computer program is able to estimate hourly direct and diffuse solar radiation for each city of Iran as follow:



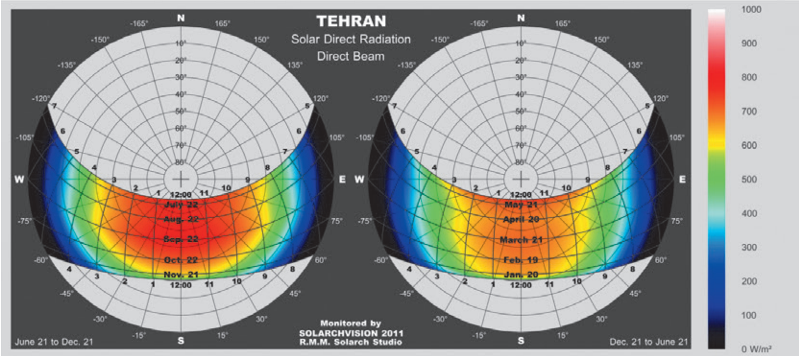



Fig. 13–15: Hourly direct solar radiation models for the cities of Iran computed by SOLARCHVISION

**Ref. #3: FU Information for Hashtgerd based on Karaj and Tehran Data**

***Solar Radiation***

Unfortunately solar radiation information provided by FU is not acceptable to be applied in analysis, as there are several problems with different solar radiation parameters (Global, Direct and Diffuse Radiation):

1. Lack of the solar data between the day numbers 89 to 124.
2. The values in January and February are greater than summer values.

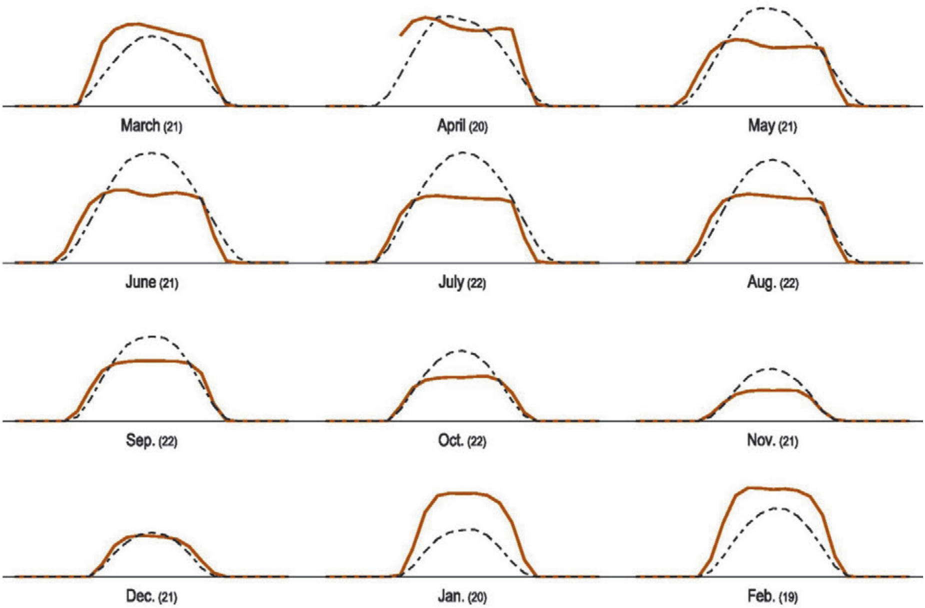



Fig. 16: Differences between Hourly Plots of FU data for Hashtgerd and Meteonorm data of Tehran (Brown: FU, Black: Meteonorm)

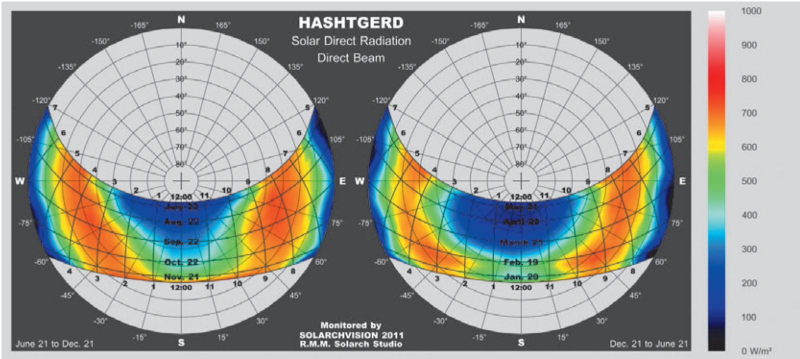



Fig. 17: unacceptable hourly direct solar radiation model for Hashtgerd resulted from FU information

3. Remarkable decline in the amount of direct horizontal solar radiation at noon. It is certainly possible that the solar measurement tool is simply covered by dust!

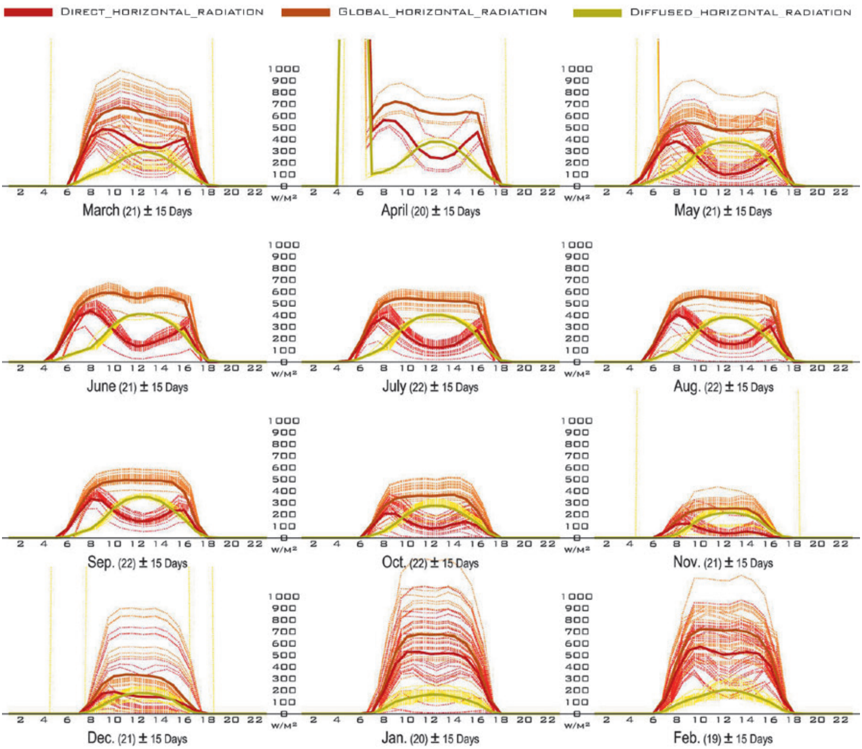



Fig. 18: 30-Day average hourly plots of direct horizontal, diffuse horizontal and global radiation (FU information)

**Ref. #4: Meteonorm 6.0 Interpolated Model for Hashtgerd**

Comparing solar radiation model resulted from Meteonorm interpolations and the measured values of Karaj, Tehran (Mehrabad) and Tehran (North) stations as described in Ref. #2 shows remarkable differences that direct solar radiation estimated by Meteonorm is quite lower than available data.

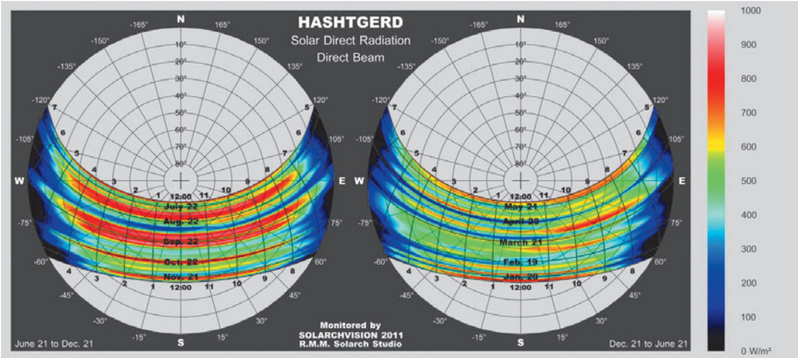



Fig. 19: (5-Day normalization) Direct solar radiation interpolation for Hashtgerd (Meteonorm 6.0)

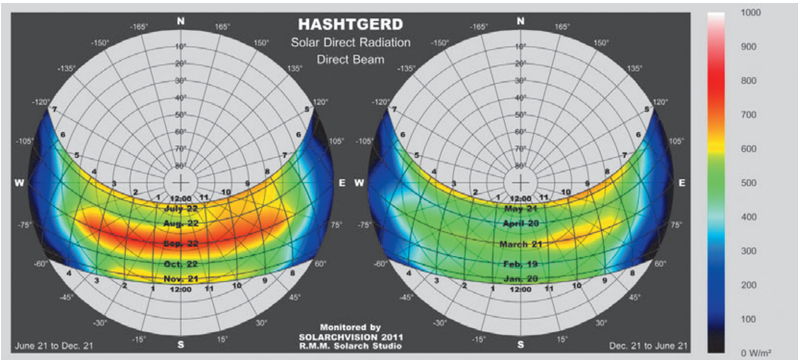



Fig. 20: (30-Day normalization) Direct solar radiation interpolation for Hashtgerd (Meteonorm 6.0)

Meteonorm interpolated model also estimates that the maximum value of direct solar radiation happens around September 22 which is not match the long-time climatic factors such as sunshine hours of Hashtgerd near stations of Karaj and Ghazvin.

**Ref. #5: Meteonorm 6.0 Data of Tehran**

The reason behind the inaccuracy of Meteonorm 6.0 models of temperature and solar radiation for Hashtgerd is the low density of Meteonorm 6.0 stations around this city. Therefore, in order to find out the values of solar radiation for Hashtgerd which is located close to Tehran, it is more accurate to use the solar radiation model of Tehran than using an interpolation between Tehran, Zanjan and Hamedan.

It is also necessary to mention that the whole file of Tehran should not be used in building simulation programs in Hashtgerd New Town while Tehran and Hashtgerd have different characteristics notably in temperature models.

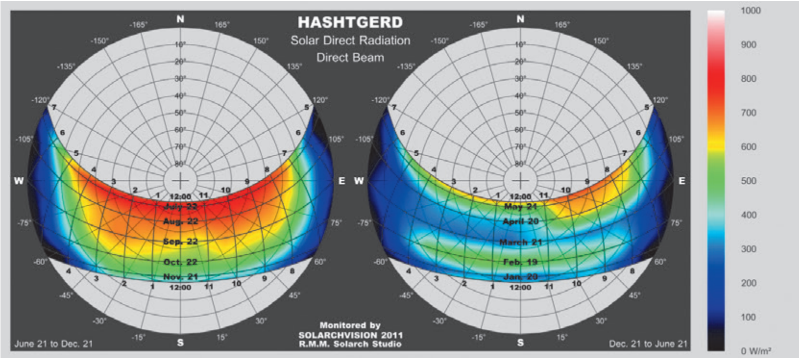



Fig. 21: (30-Day normalization) Direct solar radiation interpolation for Hashtgerd (Meteonorm 6.0)

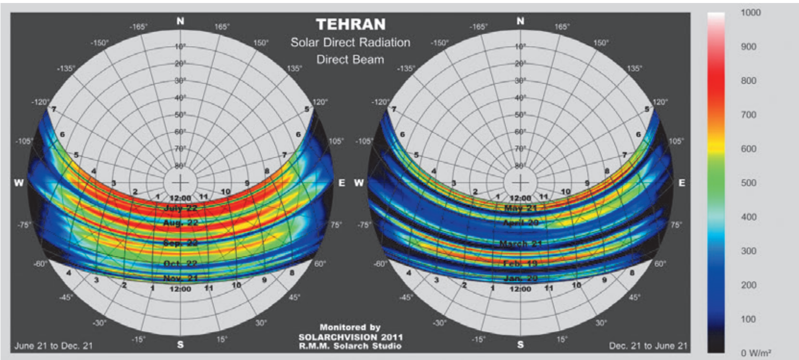



Fig. 22: (5-Day normalization) Direct solar radiation interpolation for Hashtgerd (Meteonorm 6.0)

**Ref. #6: U.S. Department of Energy ITMY[1] Data**

There were two versions of ".EPW" file available for Tehran on EnergyPlus website[2] before 2011. These two files were "IRN_Tehran.Mehrabad.407540_ITMY.epw" and "IRN_Tehran.Mehrabad_ITMY.epw". Both of these files contain almost the same information about solar radiation, temperature and other climatic parameters.

Except diffuse solar radiation other information of these files were seem to be correct.

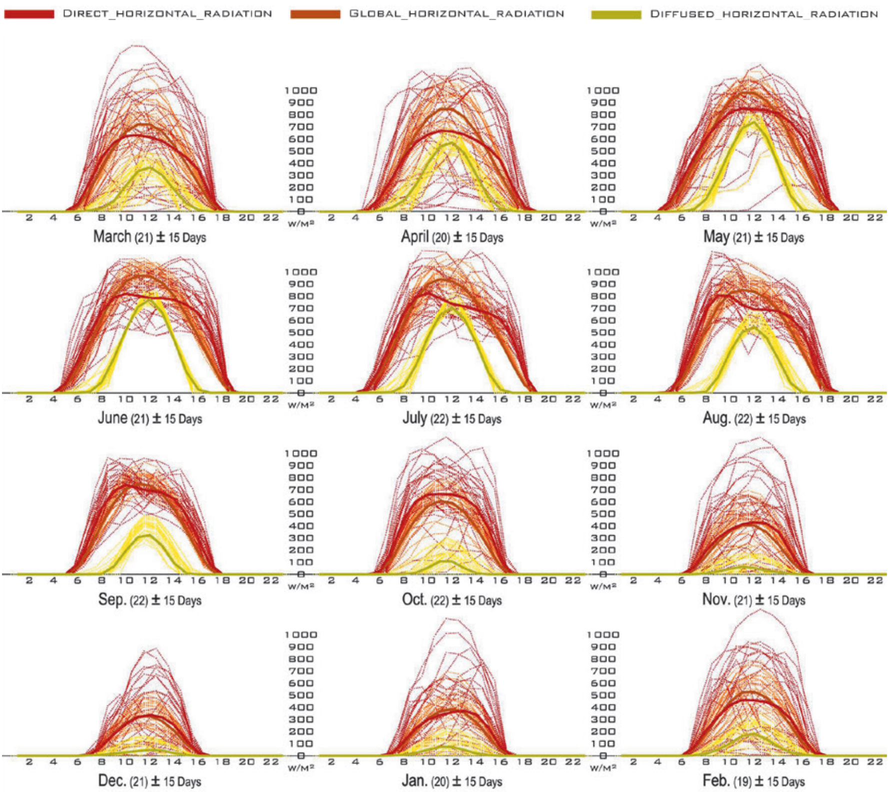



Fig. 23: 30-Day average hourly plots of direct normal, diffuse horizontal and global radiation of IRN_Tehran.Mehrabad.407540_ITMY.epw

Above diagram shows that the value of diffuse horizontal radiation in the file is not acceptable as it is too high especially from March to September.

It is worth noting that direct solar radiation model of this file is close to SOLARCHVISION calculations using Ref. #2

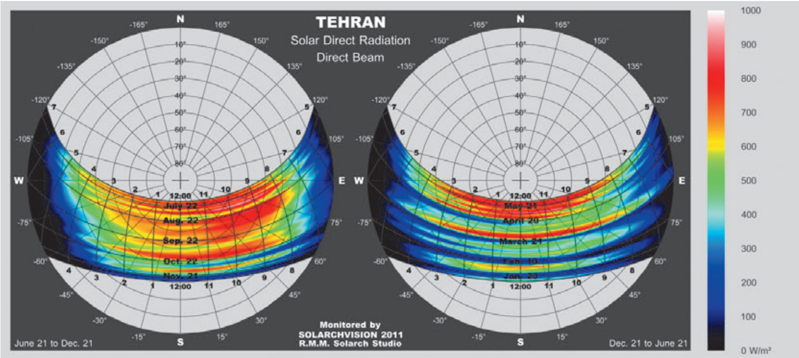



Fig. 24: (5-Day normalization) Direct solar radiation data for Tehran (ITMY)

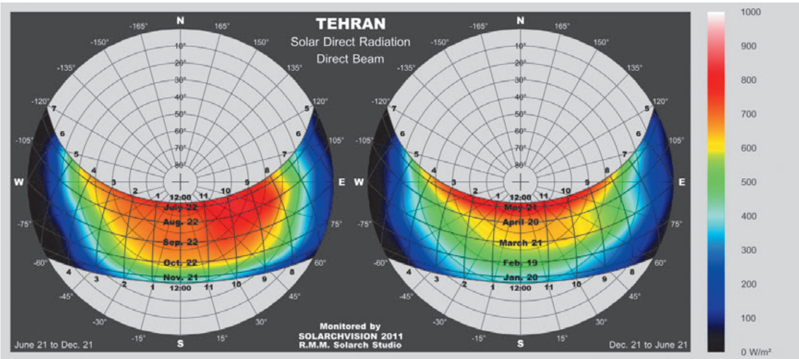



Fig. 25: (30-Day normalization) Direct solar radiation data for Tehran (ITMY)

In 2011 these files which were the only available information in Iran on this website were replaced by 6 files related to the cities of Tehran, Tabriz, Esfahan, Bandar Abass, Shiraz and Yazd. As this website noted: *"Weather data in TMY2 format for 6 cities (Tehran, Tabriz, Esfahan, Bandar Abass, Shiraz and Yazd) of Iran based of periods of record from 30 to 43 years. The ITMY files were created using TmyCreator by Abdulsalam Ebrahimpour of the Building and Housing Research Center (BHRC) of Iran. Development of the ITMY files is described in: A .Ebrahimpour, M. Maerefat, A method for generation of typical meteorological year, Energy Conversion and Management, 52 (2011), pp. 212–219."* [3]

But unfortunately these files contain absolutely incorrect data in the subject of solar radiation!

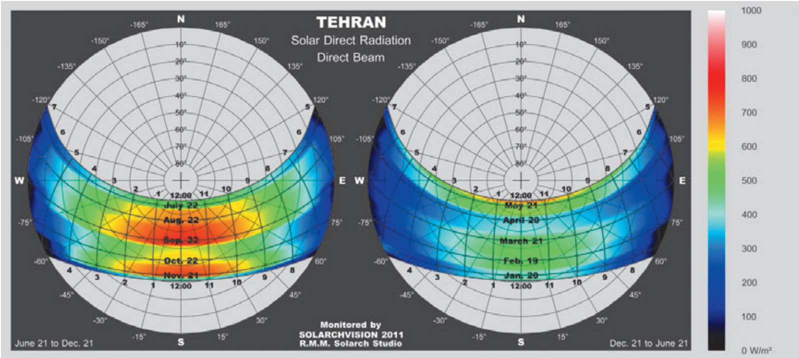



Fig. 26: Tehran incorrect direct solar radiation model (EnergyPlus website 2011)

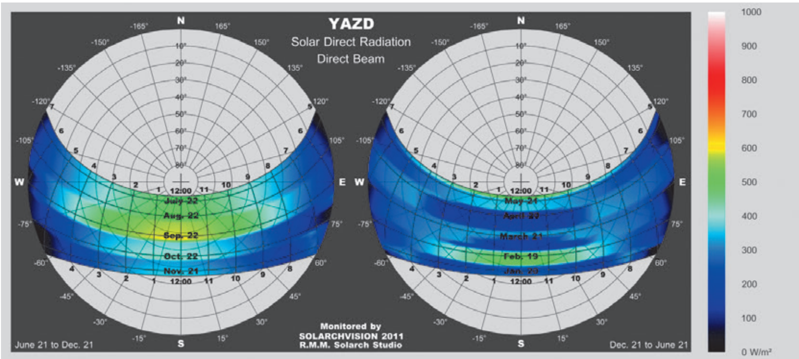



Fig. 27: Yazd incorrect direct solar radiation model (EnergyPlus website 2011)

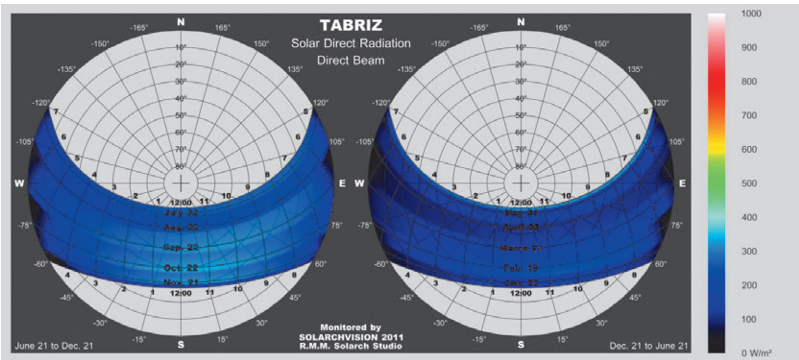
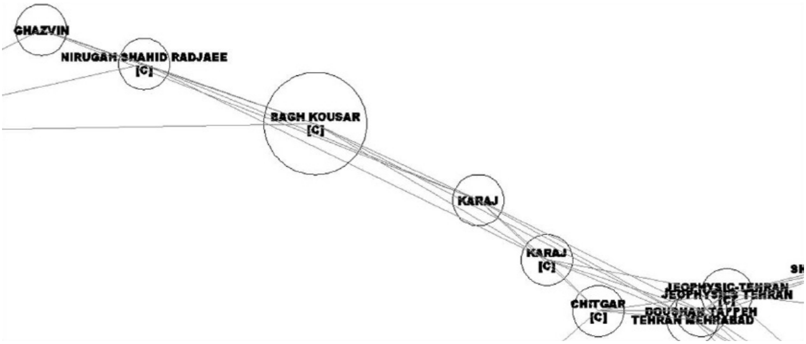


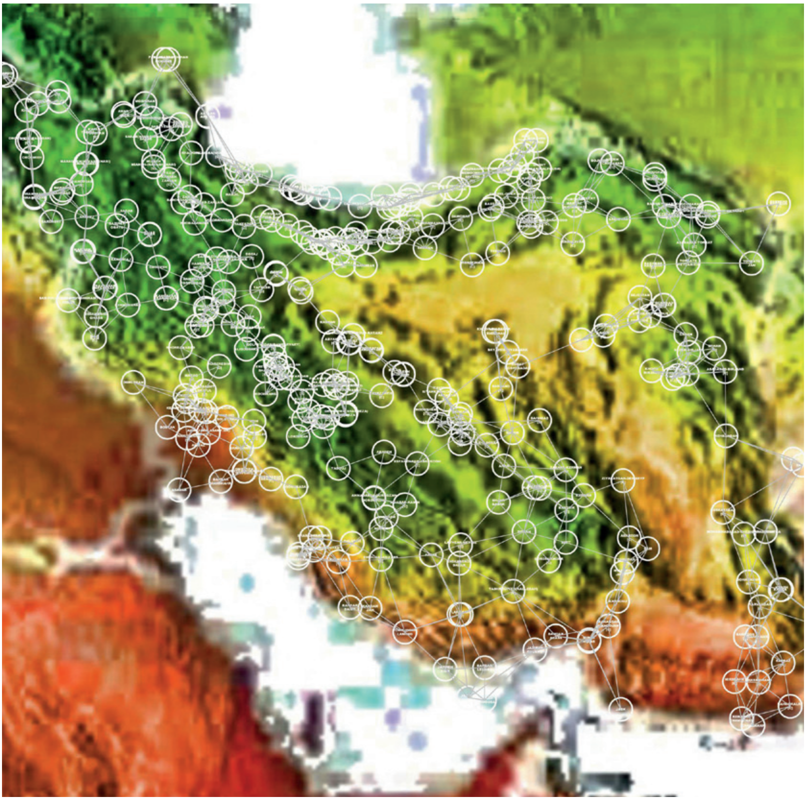

Fig. 28: Tabriz incorrect direct solar radiation model (EnergyPlus website 2011)

right page:
Fig. 29–30: Location map of climatology and synoptic station in Iran (created by R.M.M. solarch studio)

### 3.2 Temperature

The interpolated calculations of hourly temperature resulted from Karaj and Ghazvin which is done by FU are close to the available data of Hashtgerd's nearest climatology station of BAGH_KOUSAR which is founded in 1986. Amazingly this station was not noted before in the documents of young cities project! It is located at 36:04N and 50:35E on the elevation of 1,225 m.



| | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEP. | OCT. | NOV. | DEC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVERAGE OF MEAN DAILY TEMPERATURE IN °C | **0.9** | **3.3** | **7.0** | **13.4** | **17.7** | **23.1** | **26.1** | **25.7** | **21.2** | **15.6** | **8.9** | **3.6** |
| AVERAGE OF MINIMUM TEMPERATURE IN °C | -5.0 | -3.1 | 0.4 | 6.0 | 9.1 | 13.6 | 16.6 | 16.2 | 11.2 | 6.9 | 2.1 | -1.9 |
| AVERAGE OF MAXIMUM TEMPERATURE IN °C | 6.8 | 9.6 | 13.7 | 20.8 | 26.3 | 32.6 | 35.5 | 35.2 | 31.2 | 24.4 | 15.7 | 9.0 |
| DIFFERENCE BETWEEN AVERAGE MAXIMUM AND MINIMUM TEMPERATURE | 11.8 | 12.7 | 13.3 | 14.7 | 17.2 | 19.1 | 19.0 | 19.0 | 20.0 | 17.5 | 13.6 | 10.9 |
| ABSOLUTE OF MINIMUM TEMPERATURE IN °C | -21.0 | -26.0 | -11.8 | -7.0 | -1.0 | 5.5 | 9.0 | 6.0 | 2.0 | -8.0 | -10.0 | -19.0 |
| ABSOLUTE OF MAXIMUM TEMPERATURE IN °C | 17.5 | 20.0 | 24.5 | 31.0 | 36.0 | 39.0 | 41.5 | 40.5 | 39.5 | 34.0 | 24.5 | 20.5 |

Fig. 31: Mean and extremes for the period 1986 to 2003

| YEAR | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEP. | OCT. | NOV. | DEC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | 1.9 | 4.4 | 4.5 | 13.1 | 15.0 | * | * | 22.8 | 20.1 | 20.1 | 7.4 | 0.6 |
| 1987 | 4.1 | 7.0 | 6.2 | 11.6 | 19.4 | 23.2 | 25.2 | 24.5 | 20.5 | 11.3 | 8.9 | 4.9 |
| 1988 | * | 3.0 | 7.7 | 12.9 | 18.3 | 22.8 | 25.3 | 24.2 | 20.7 | 15.7 | 10.1 | 4.3 |
| 1989 | -4.4 | -7.1 | 7.6 | 15.9 | 17.4 | 23.3 | 26.7 | 26.7 | 20.3 | 15.8 | 10.1 | 5.6 |
| 1990 | -0.6 | * | * | * | 19.0 | 24.2 | 26.8 | 26.5 | 22.0 | 15.0 | 10.9 | 3.7 |
| 1991 | 1.0 | 2.6 | 7.3 | 15.3 | 16.9 | 22.6 | 26.1 | 25.3 | 21.0 | 15.3 | 9.7 | 1.0 |
| 1992 | -3.2 | 1.4 | 4.3 | 11.6 | 14.8 | 21.7 | 26.5 | 23.7 | 19.2 | 13.9 | 9.1 | 3.3 |
| 1993 | -1.6 | * | * | 13.1 | 17.0 | 21.9 | 25.4 | 24.8 | 21.8 | 13.3 | 5.6 | 4.0 |
| 1994 | 3.5 | 3.3 | 8.1 | 15.0 | 17.7 | 22.6 | 25.4 | 25.1 | 19.2 | 14.8 | 10.2 | 1.9 |
| 1995 | 4.5 | 5.7 | 8.6 | 13.6 | 17.9 | 22.1 | 26.1 | 26.9 | 21.8 | 13.4 | 9.2 | 1.4 |
| 1996 | -1.4 | 3.7 | 5.6 | 12.5 | 18.6 | 22.2 | 25.8 | 26.0 | 22.2 | 15.5 | 8.2 | 6.6 |
| 1997 | 3.4 | 2.6 | 5.3 | 12.3 | 18.6 | 24.2 | 26.7 | 27.3 | 20.4 | 17.0 | 8.3 | 4.1 |
| 1998 | -1.0 | 1.4 | 8.3 | 14.7 | 17.7 | 25.1 | 26.2 | 26.5 | 22.4 | 16.2 | 11.5 | 7.0 |
| 1999 | 2.7 | 6.9 | 7.5 | 13.2 | 19.9 | 24.2 | 25.2 | 27.6 | 21.4 | 17.3 | 7.6 | 4.3 |
| 2000 | 2.4 | 4.1 | * | * | * | 24.0 | 27.3 | 26.9 | 22.8 | 13.9 | 7.5 | 3.6 |
| 2001 | * | * | * | * | * | * | * | * | * | * | * | * |
| 2002 | 0.4 | 5.6 | 9.7 | 12.7 | 17.2 | 23.3 | 26.4 | 26.1 | 23.4 | 18.6 | 9.3 | 1.3 |
| 2003 | 3.6 | 4.5 | 7.4 | 13.6 | 17.3 | 22.8 | 26.8 | 26.1 | 21.5 | 18.3 | 8.1 | 3.5 |
| **MEAN** | **0.9** | **3.3** | **7.0** | **13.4** | **17.7** | **23.1** | **26.1** | **25.7** | **21.2** | **15.6** | **8.9** | **3.6** |

Fig. 32: Monthly average of mean daily temperature

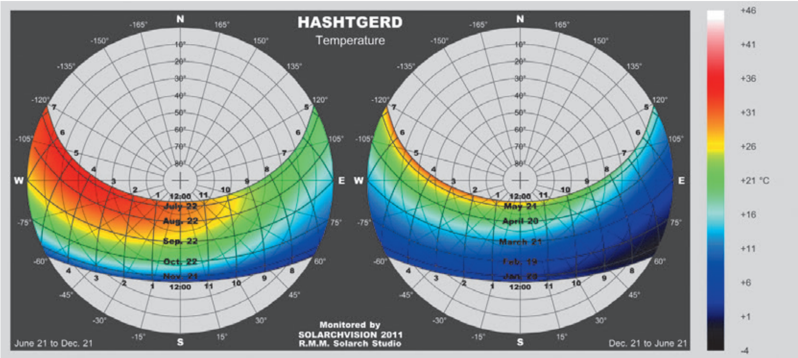



Fig. 33: Hashtgerd temperature model (Ref. #3—FU)

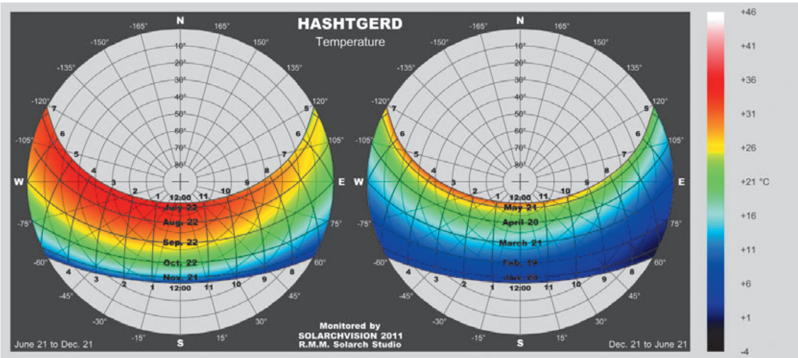



Fig. 34: Inaccurate Hashtgerd temperature model (Ref. #4—Meteonorm 6.0)

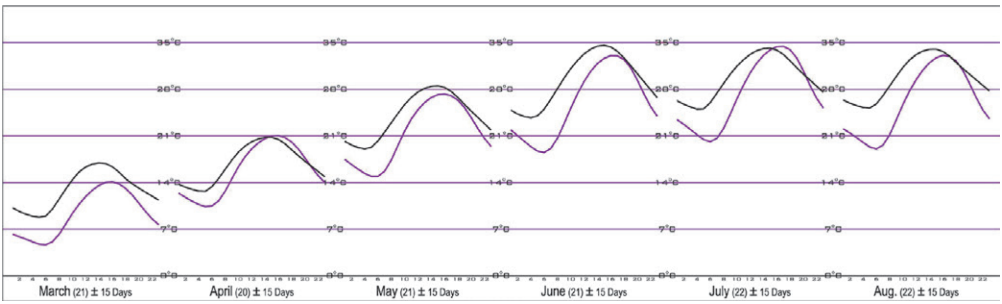



Fig. 35: Differences between hourly plots of FU data for Hashtgerd and Meteonorm data of Tehran in different Months (Magenta: FU, Black: Meteonorm) {from March to August}

Comparing temperature model resulted from Meteonorm and the measured values of both Bagh_Kousar station and FU information shows some differences as the temperature estimated by Meteonorm is quite higher than available data.

## 3.3 Conclusion of Study in Solar/Climatic References

### Solar Radiation

This study points out the lack of accurate solar information in Iran; to achieve more architectural design objectives in the Young Cities Project using SOLARCHVISION analysis, it was necessary to apply accurate information. As described before the information from FU and the measured data of Bagh_ Kousar station shows similar climatic properties of Hashtgerd; but in the field of solar radiation there are only two models which are proper to be used:

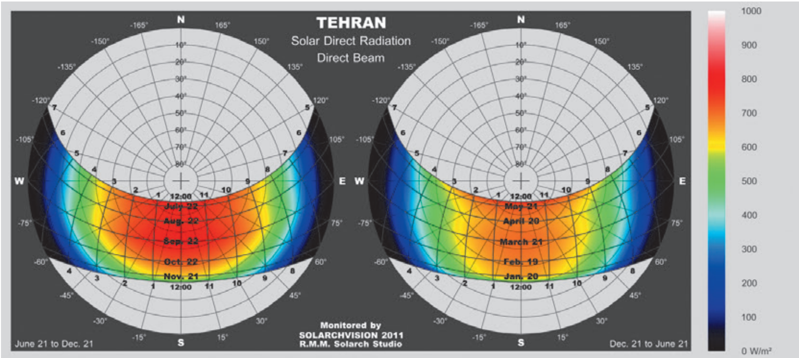



Fig. 36: SOLARCHVISION Estimation of direct and diffuse radiation using monthly value of total solar radiation from Ref. #2

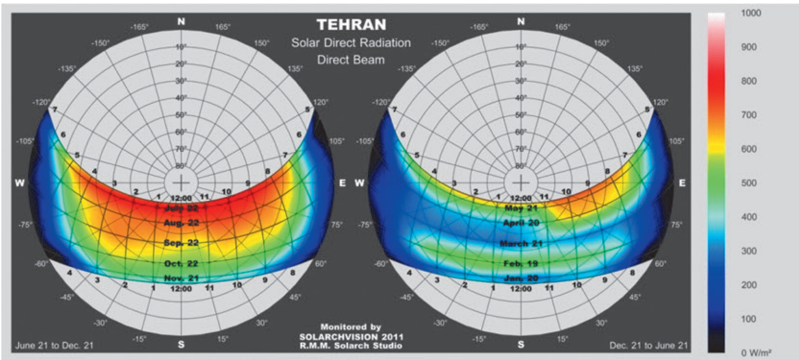



Fig. 37: Meteonorm 6.0 solar radiation data of Tehran instead of interpolated values of Hashtgerd

The SOLARCHVISION estimation uses monthly value of total solar radiation and Sun Path to calculate physical properties of the air in which the total direct and diffuse gains at the mid-day of each month equals to the long time data. Therefore the result shows average situation of the sky during several years.

There are some similarities and differences between SOLARCHVISION calculations and Meteonorm data.

On the other side Meteonorm contain the data of a normal year so it shows different status of the sky from sunny to cloudy; however a single year does not present the exact average of several years. As an example in the Meteonorm direct solar radiation of Tehran a cloudy situation between April 20 and March 21 is visible but it is quite possible that it was not a general condition for Tehran.

Finally Meteonorm solar model is selected as it is more realistic and contains following risk:

a) The risk of having a completely sunny day in summer.

b) The risk of having a completely cloudy day in winter

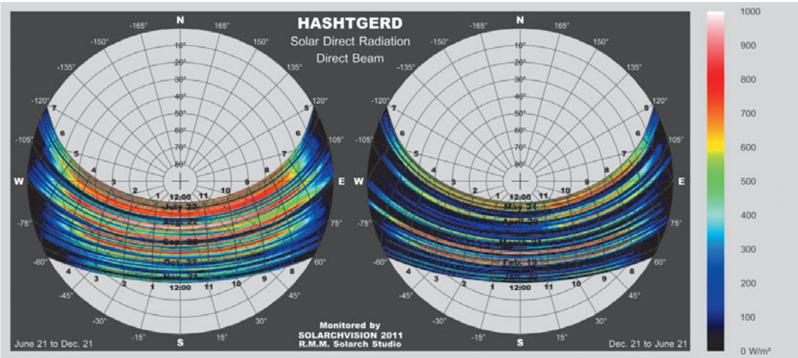



Fig. 38: Plot of changes in daily amount of solar direct radiation of Tehran (Meteonorm 6.0)

## Degree of Need to Shade or Shine

Using 21°C as the base line for calculating degree of need to shade/shine following diagram is resulted which discovers different positions in which the sun shows a kind or an unkind face.

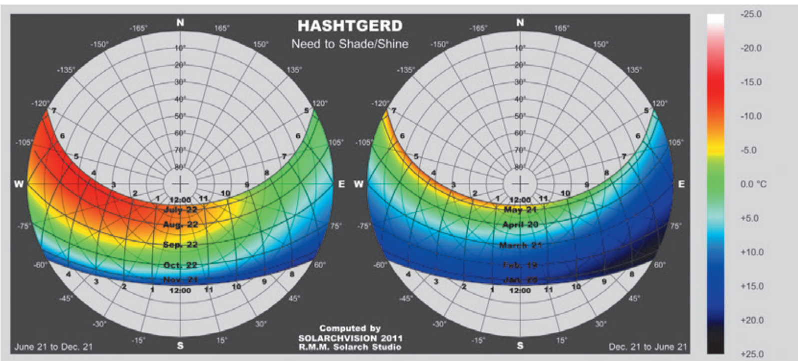



Fig. 39: Hashtgerd degree of need to shade/shine model

Above diagram shows how in temperature between 18°C and 24°C, which are printed in green color, the degree of need to shade/shine may has a slightly effect; but in the temperatures outside this zone the effect is remarkable. It is also necessary to mention that the degree of need to shade or shine is defined only in relation with thermal comfort effect of solar radiation and it is not related to day lighting subjects. Also the effect of wind and humidity is not defined here in order to simplify the model; therefore they could be considered later as the layers which may soften or sharpen the situation.

1 Iran Typical Meteorological Year.
2 http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_sources.cfm
3 http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_sources.cfm

# 4 SOLARCHVISION Analysis on Young Cities

### 4.1 Solar ± Effects

*"The sun's kind/unkind face at each moment depends on two parameters: radiation received and need to shade or shine."* [1]

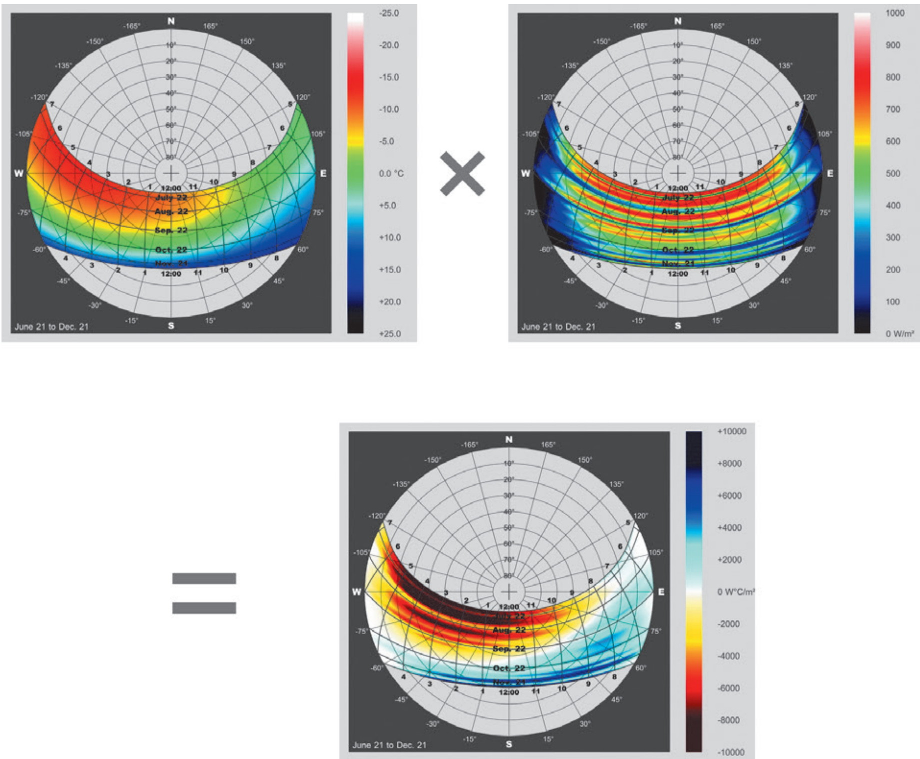



Fig. 40: Calculation of the model for direct solar positive/negative effect based on need to shine/shade and direct solar radiation models

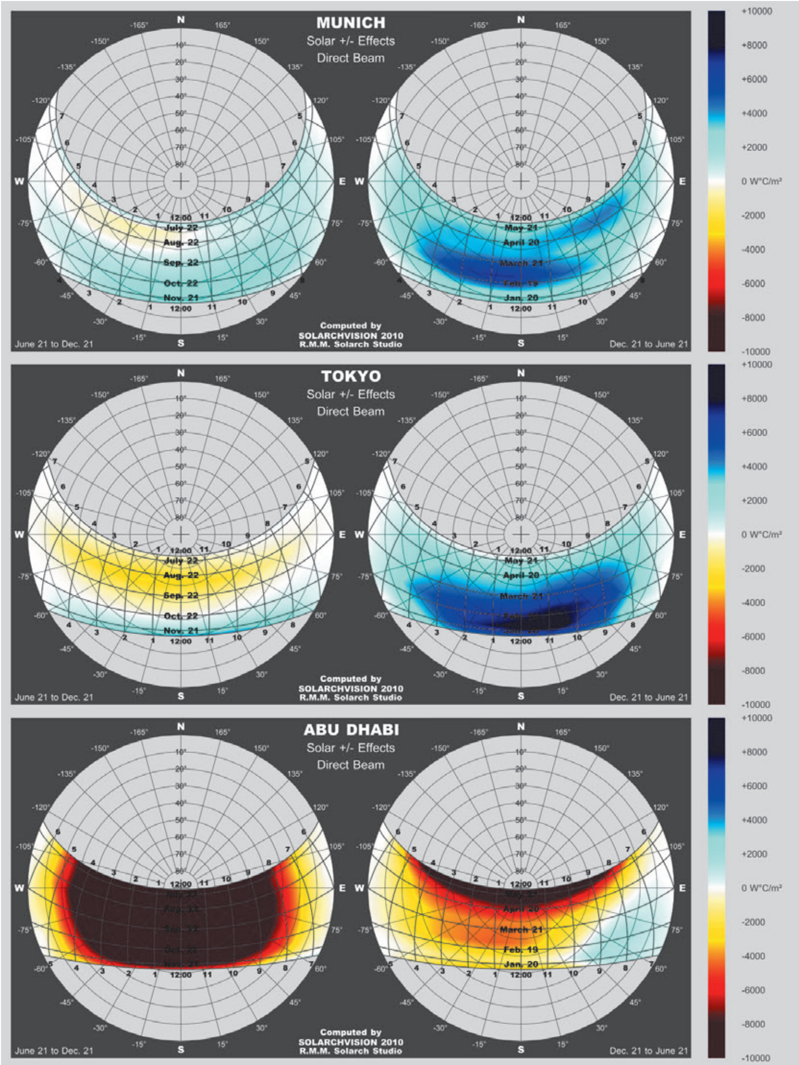



Fig. 41–43: Calculation of Solar ± Effects of Direct Radiation for Some Cities of the World, Data Source: U.S. Department of Energy

Comparison of different situations around the world about Solar ± Effects with the cities of Iran, illustrates the complexity of climates in Iran where the sun has both strong positive and negative effects.

By comparing Solar ± Effects of Tehran and Hashtgerd some critical differences of the climates of these two cities would be illustrated. Therefore it is necessary to pay attention to cold mornings of Hashtgerd even in summer; moreover, considering the low temperatures in winters the sun can play much essential role in Hashtgerd in comparison with Tehran.

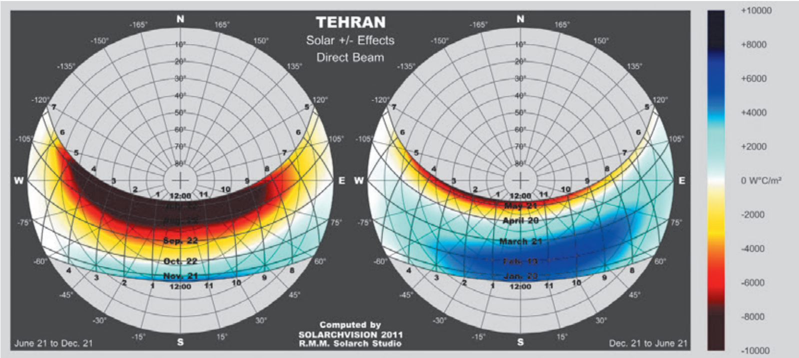



Fig. 44: Solar ± Effects of direct radiation in Tehran

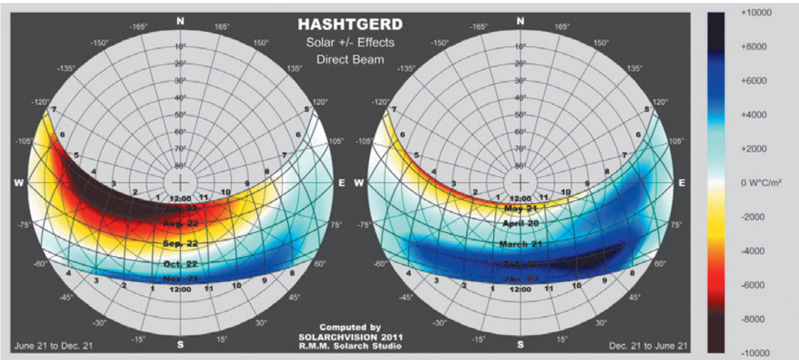



Fig. 45: Solar ± Effects of direct radiation in Hashtgerd

The diagram of Hashtgerd contains the interpolation of normal amount of solar direct radiation and degree of need to shade or shine calculated using the differences between the value of outdoor temperature and 21°C which is called Solar ± Effects. The Solar ± Effects diagram discovers the most valuable positions of the sun in cold times as blue and dark blue areas. These areas are results of the times with both low temperatures and high solar radiation; so in the mornings however the temperature is at the minimum point, because of low solar radiation, the positive effect of the sun is not remarkable. Besides, the most valuable direct solar radiation is estimated from 8:00 to 14:00 in February in Hashtgerd.

Although as a common consideration, shading profile lines in winter are drawn as the minimum of the altitude of the sun at Noon in December 21 (which is about 30° in Hashtgerd), it would be better to consider lower profile angles such as (e.g. 15° or 20° for Hashtgerd) in order to control the shading effect of building volumes. That's simply because during a winter day the sun is always lower than where it is at noon.

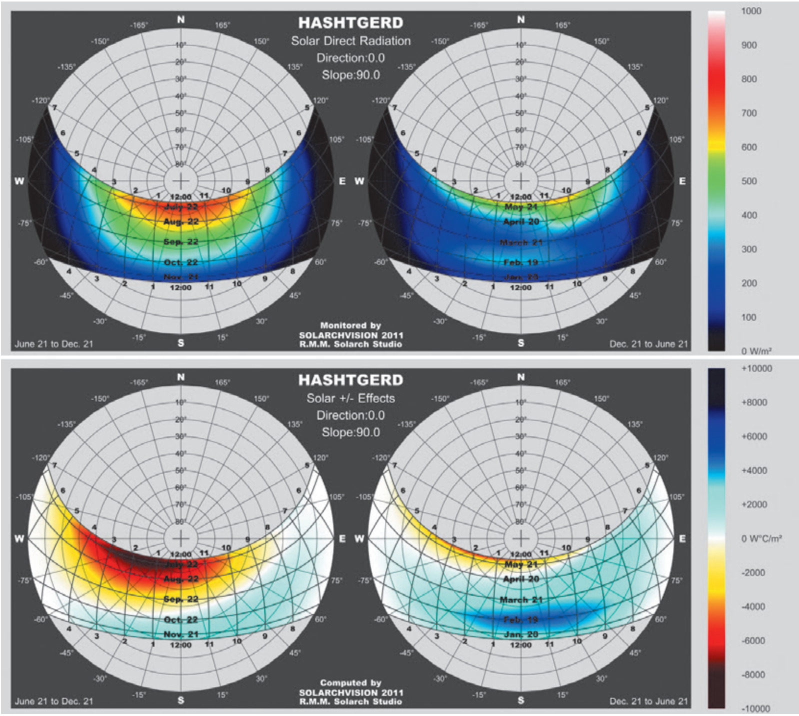



Fig. 46–47: Slope 90 (Horizontal Plane) direct solar radiation and its ±Effects

On the other side the Solar ± Effects diagram also discovers the most undesirable positions of the sun in hot times as red and dark red areas. These areas are results of the times with both high temperatures and high solar radiation; so around the Noon and before sunset as the temperature and direct solar radiation are at high values the negative effect of the sun increases significantly.

Beside local atmospherical effects which affects Hashtgerd Direct (Normal) Solar Radiation Beam and the ± Effects as well, the geometrical effect of low sun altitudes decrease the amount of direct horizontal radiation and it positive and negative effects. The diagram of Solar ± Effects shows the remarkable decline in value of positive effects of the sun on horizontal surfaces in comparison with direct normal effects.

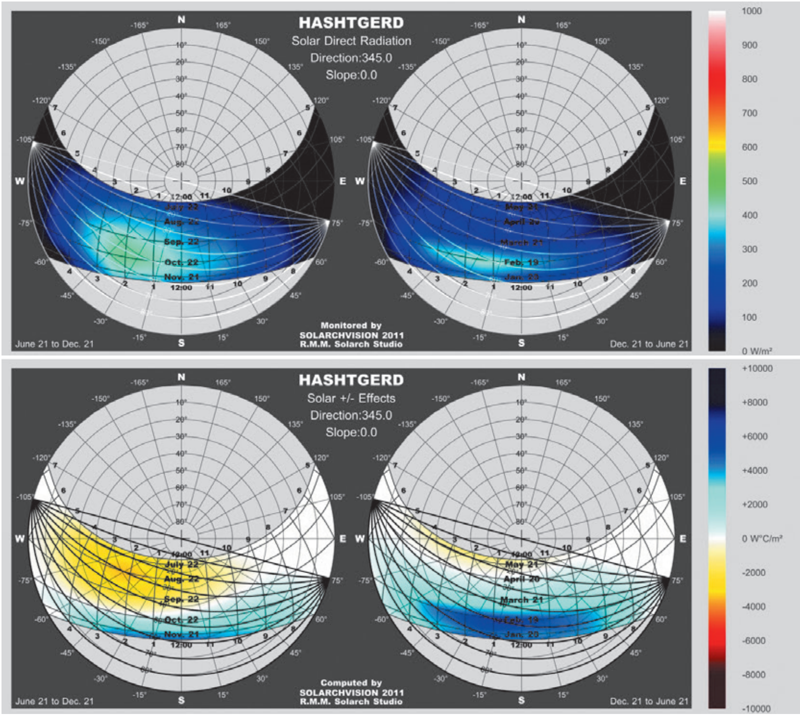



Fig. 48–49: Direction 345 (General South side in 35 ha site) direct solar radiation and its ± Effects

Above diagrams show the situation of the general South side of 35 ha site in Hashtgerd New Town. Regarding to the upper diagram the maximum normal amount of direct solar radiation in this direction is around 400 W/m² when the sun is on the altitudes between 30° and 50°. It is also necessary to pay proper attention to the little value of solar direct radiation in May, June and July when the sun reaches high altitudes and it is almost parallel to the South direction.

Lower diagram also shows the different positions and intensity of solar positive and negative effects. So the most valuable effects of the sun in this direction happens in winter between altitudes of 20° and 40°. This diagram also shows undesirable radiation on this direction which is painted in yellow between altitudes of 20° and 80°; therefore a horizontal shading device can be suggested to prevent the beams with profile angles of 40° and less.

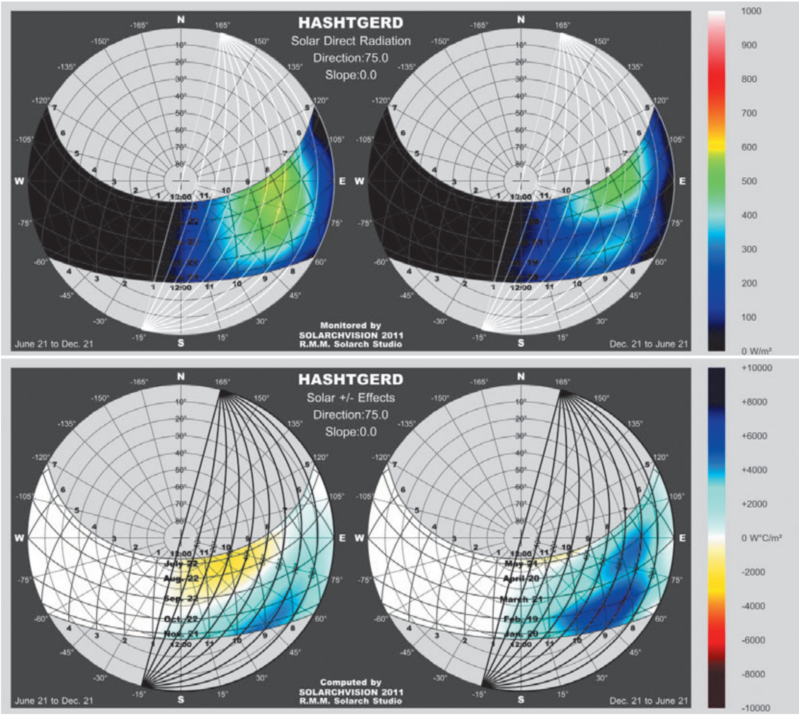



Fig. 50–51: Direction 75 (General East side in 35 ha site) direct solar radiation and its ±Effects

Above diagrams show the situation of the general East side of 35 ha site in Hashtgerd New Town. Regarding to the upper diagram the maximum normal amount of direct solar radiation in this direction is around 500 W/m² when the sun is on the altitudes between 20° and 50°. Lower diagram also shows the different positions and intensity of solar positive and negative effects. So the most valuable effects of the sun in this direction happens in almost all mornings between altitudes of 10° and 40°. This diagram also shows undesirable radiation on this direction which is painted in yellow between altitudes of 50° and 80°; therefore a horizontal shading device can be suggested to prevent the beams with profile angles of 40° and less. In case of use of such fixed shading devices, they would better to be installed slightly upper than windows in order not to prevent low valuable rays of the sun in cold mornings and winter.

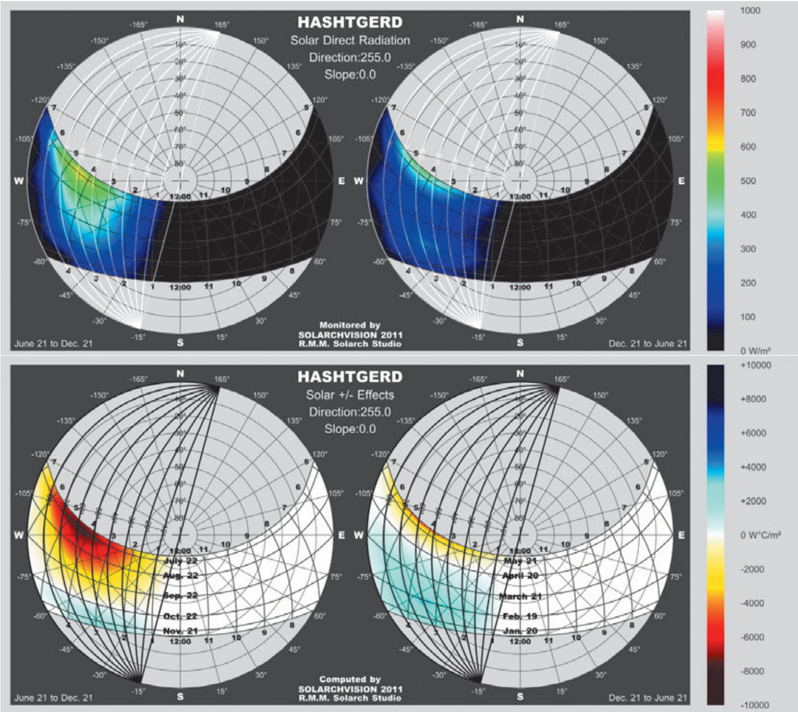



Fig. 52–53: Direction 255 (General West side in 35 ha site) direct solar radiation and its ±Effects

Above diagrams show the situation of the general West side of 35 ha site in Hashtgerd New Town. Regarding to the upper diagram the maximum normal amount of direct solar radiation in this direction is around 500W/m² when the sun is on the altitutes between 20° and 50°. Lower diagram also shows the different positions and intensity of solar positive and negative effects. So the most undesirable effects of the sun in this direction happens in almost all afternoons between altitudes of 10° and 80°. This diagram also shows valuable radiation on this direction which is painted in light blue between altitudes of 10° and 60°.

Considering different intensities of positive and negative points of this direction horizontal shading device can be suggested to prevent the beams with profile angles of 75° and less. In case of use of such fixed shading devices, they would better to be installed exactly over the windows in order to prevent low undesirable rays of the sun in hot afternoons and summer. On the other side using vertical shading devices orienting to the direction -60° can help only in the afternoons and has little effect in hours between 12:00 to 14:00.

**Hashtgerd—The Effect of Different Building Faces on Solar ± Effects**

The below diagram shows the effect of different building faces in 35 ha Hashtgerd New Town on Solar ± Effects. The yellow line which presents the value of sun ray contains different characteristics from about -7,500 negative effects in summer to about +6,500 positive effects in winter. The characteristics of Roof are similar to sun ray but it changes more in the winter. The curve which is plotted in gray presents the Roof performance from about -5,500 negative effects in summer to about +3,000 positive scores in winter. The blue curve which presents the performance of General South in 35 ha Hashtgerd New Town which is rotated 15° to the West shows the maximum positive gains within different building faces here that collect about +4,000 positive points in winter; this is also remarkable that the negative points of this direction in summer only reaches -2,000. On the other side the East direction in summer collects only -500 negative points; it also collects more than +2,000 positive points in winter. Therefore it can stand beside South direction as the most proper directions to be opened. West direction curve which is plotted in dark violet collect more -3,000 negative scores in summer while hardly reaching +1,000 positive points in winter so it can be easily considered as the worst option for openings in general. Green plot which presents the situation of general direction of North in 35 ha Hashtgerd New Town also shows its slightly positive performance from March 21 to June 21 as a result of cold mornings and its 15° rotation to the East.

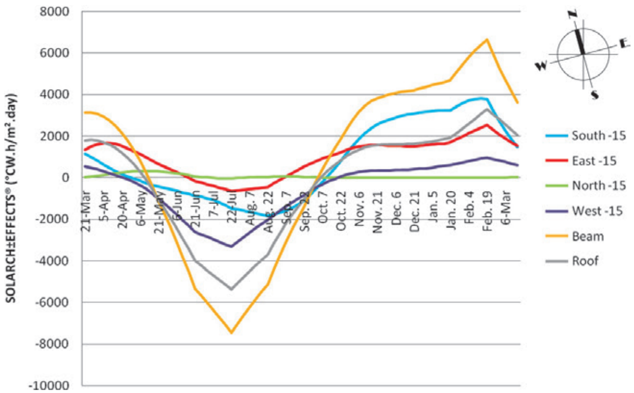



Fig. 54: Orientation effect on direct solar effects

## 4.2 Active/Passive Strategies and Internal/External Analysis

In architecture and in relationship with the sun there have been always questions about the form and orientation of buildings, the amount of openings in each direction, and the layout of building masses beside each other. From one side the answer to these questions relates to the passive or active strategy that architect approaches.

In an active strategy, form and orientation are designed so that the building façades receive more energy from the sun; while this energy is useful directly in cold times, also it can be used in cooling systems in hot times.

Therefore, in an active strategy the sun would better be considered as a friend; and the best active orientation is the orientation which receives maximum total solar radiation. Taking the example of Hashtgerd, although the South direction is publicly considered as the direction which receives maximum solar radiation between different vertical surfaces, in optimizing a cubic building much more solar radiation could be gained by S.E., S.W., N.W. & N.E. directions instead of S., W., N. & E. directions. This is why the amount of solar radiation on the South façade is too low in summer (see diagram of June on the next page).

On the other side in the passive strategy the situation is much more complex while relating to the low and high temperatures during the year the sun has positive and negative effects.

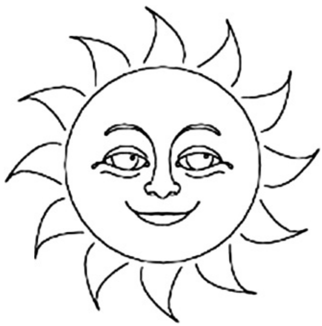


Fig. 55: The kind face of the sun in active strategy.

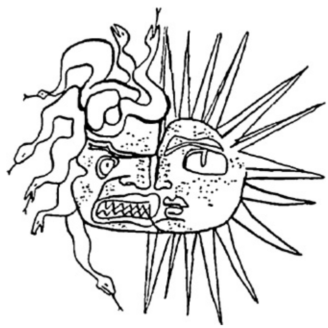


Fig. 56: Kind and unkind faces of the sun in passive strategy (1948 Le Corbusier Sketch)

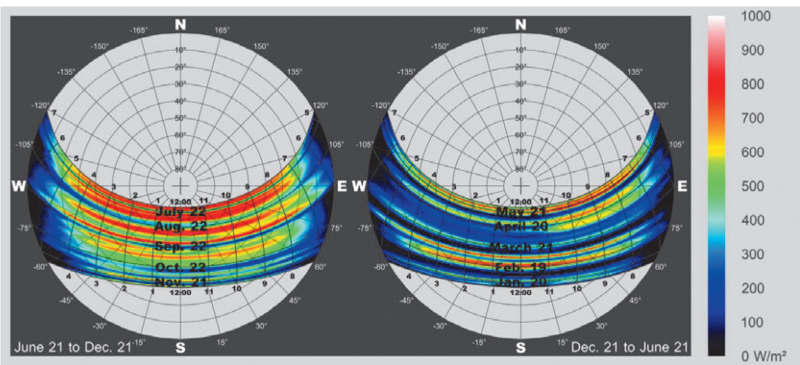



Fig. 57: Direct radiation of Hashtgerd (5-Day normalization)

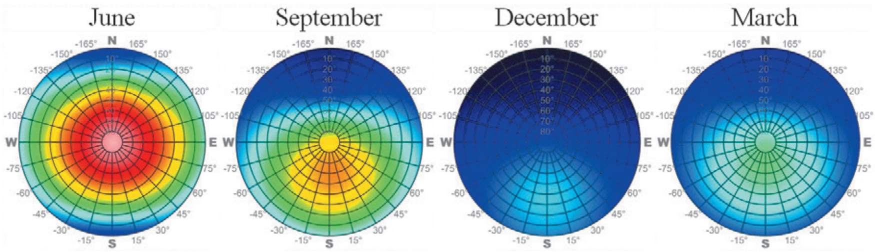



Fig. 58: Hashtgerd monthly global solar radiation on different directions and slopes

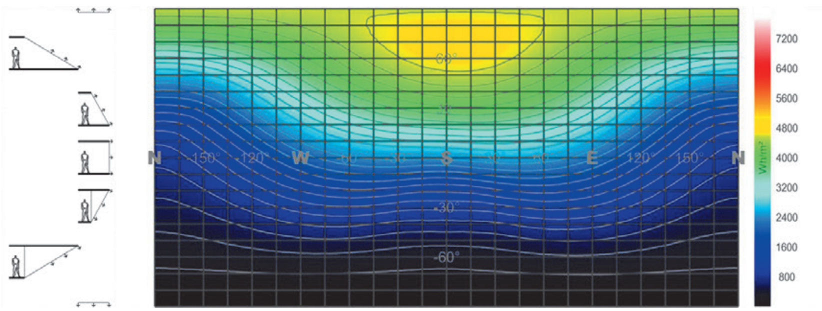
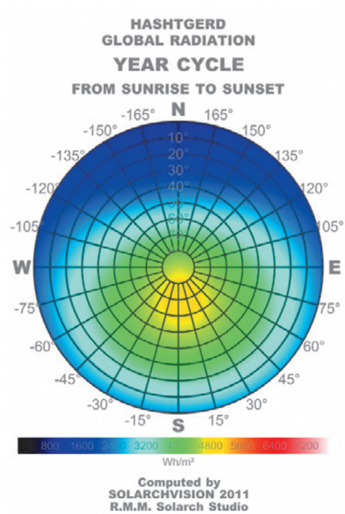



Fig. 59: Hashtgerd year-cycle global solar radiation of different directions and slopes



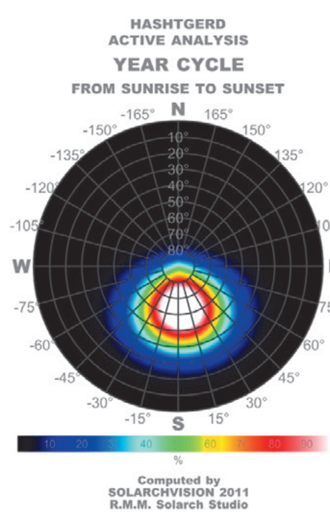




Fig. 60–61: comparison of total year-cycle radiation and optimum year-cycle performance

Left diagram shows the amount of total direct and diffuse solar radiation collected trough the year; the maximum value is collected by surface with 60° oriented to true South. However, there is large area ploted in green but only some part of this area can be suggested as the optimum angles to use in active strategy. Right digram shows optimized orientations to use in active strategy such as collectors and PVs. The area relating maximum performance is calculated by SOLARCHVISION around 65° true South with ±15° changes in slope and ±20° changes in direction.

The figures on the next page present monthly solar positive and negative effects on different directions and slopes in Hashtgerd using 21°C as the base comfort temperature. In 7 months of the year the positive effect of the sun has a remarkable intensity maximized on tilted surfaces oriented between S.E. and S.W.; while in 5 other months of the year the negative effect of the sun is maximized between the horizontal plane (roof) and the Western direction. In these warm months the Eastern direction receives much lower negative solar effect in comparison with Western direction, however the amount of global solar radiation received by the Eastern side is equal to that of the Western side.

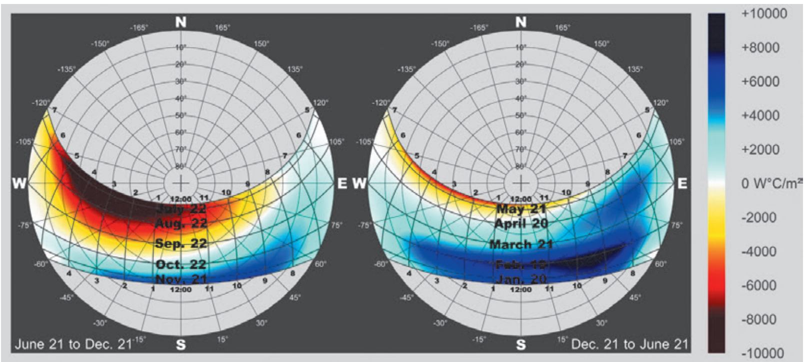



Fig. 62: Solar±Effects in Hashtgerd calculated by SOLARCHVISION (30-Day normalization)

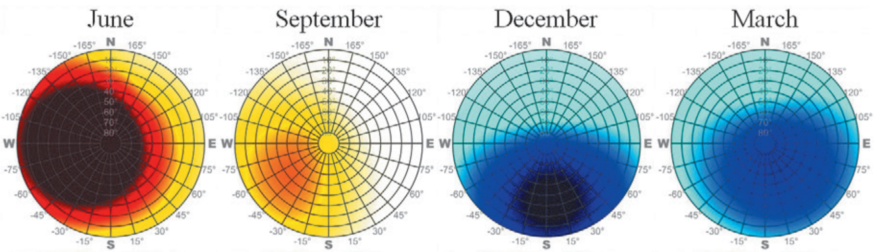



Fig. 63: Hashtgerd monthly global Solar±Effects on different directions and solpes

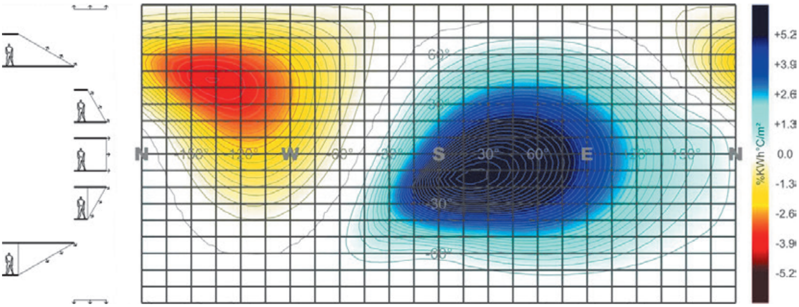


Fig. 64: Hashtgerd year-cycle SOLARCHVISION scores of different directions and slopes

The year-cycle analysis in the bottom of this page illustrates most positive orientations of building façades between South and East inside ±30° slopes as the dark blue area. This table also shows the most negative orientations in Hashtgerd in a passive strategy about N.W. between slopes of 0° and +70°. These orientations receive considerable negative solar effects in summer, however in winter they receive almost no positive solar effect. So the red, orange and yellow negative areas contain the worst building façades which would better not be opened. On the other side, a proper decision must be taken for façades located in the middle areas as plotted in white colour, in regard to their different monthly and hourly situations, such as using static or interactive shading devices.

Two remarkable questions here are:

1. What will happen to the building envelope when building masses are oriented to these optimized orientations?
2. What will happen to the urban fabric when building masses are oriented to these optimized orientations?

Figures 65–73 of solar-climatic performances of different alternatives in Hashtgerd illustrate that by shaping building masses toward optimized orientation resulted from energy efficient point of view (which is a orientation between South and East), the comfort level of urban spaces between blocks decreases significantly. That's simply because, the building volume receives most of desirable energy of the sun in cold times and do not block most of undesirable energy of the sun in hot times.

However the comfort level at the undesirable points of urban fabric which are presented in red could be improved using trees and secondary structures (such as shading and reflecting devices), an enhanced optimization of the proper orientation and form of the site should be considered as the main objective of solar-climatic design of new urban fabrics while several practical possibilities are available to improve the performance of each façade.

Table 4 also shows how the changes in proportion and direction of a cubic building can affect comfort conditions of the space around the building

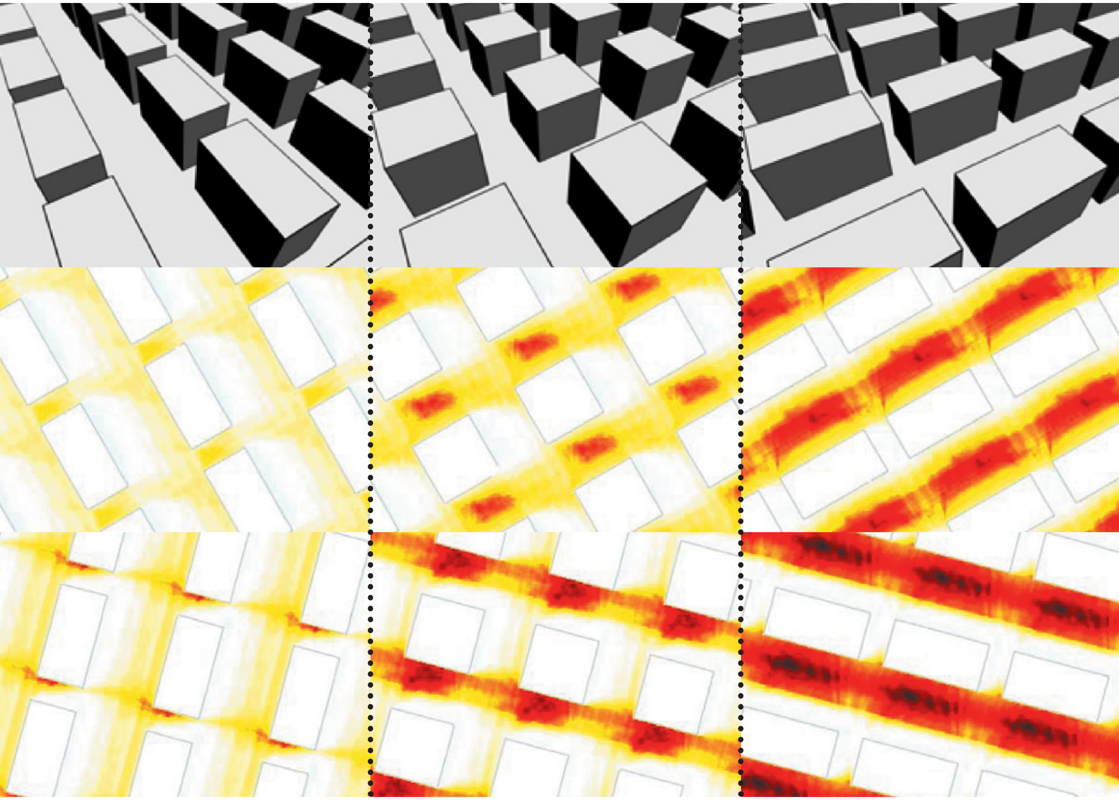
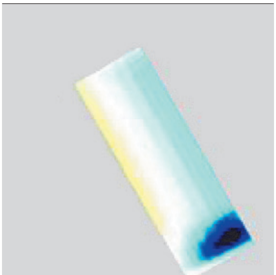
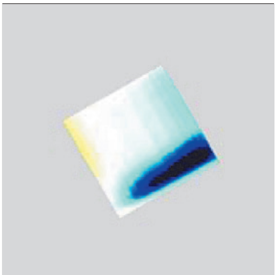
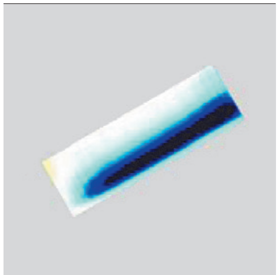
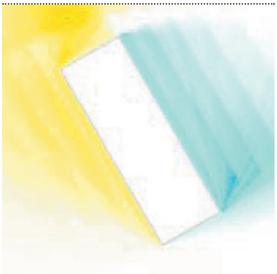
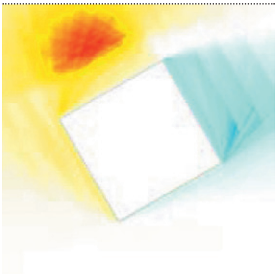
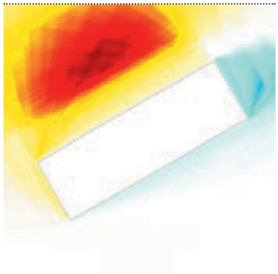
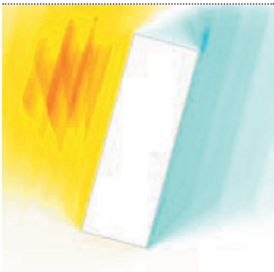
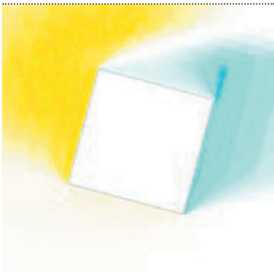
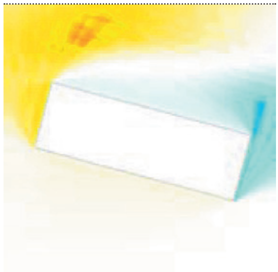
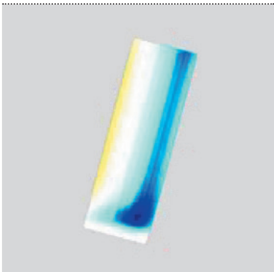
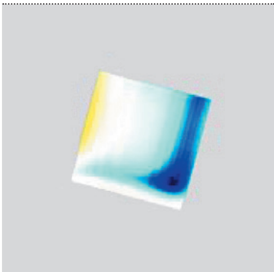
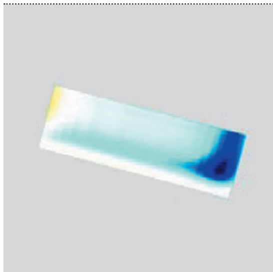
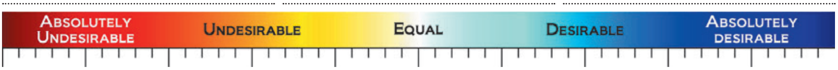


Fig. 65–73: Year-cycle outdoor analysis of different alternatives of urban fabric in Hashtgerd

volume. In general, selecting the most proper alternative needs overlaying several layers (e.g. architectural, structural, construction, day lighting, etc.); and there are some alternatives exist which create both internal and external proper conditions from the solar-climatic point of view.

| | Proportion #1 (7m, 28m, 14m) | Proportion #2 (14m, 14m, 14m) | Proportion #3 (28m, 7m, 14m) |
|---|---|---|---|
| **Orientation #1 (+30°) Interior (h = 3.5m)** |  |  |  |
| **Orientation #1 (+30°) Exterior** |  |  |  |
| **Orientation #2 (-15°) Exterior** |  |  |  |
| **Orientation #2 (-15°) Interior (h = 3.5m)** |  |  |  |




Tab. 4: Internal and external solar-climatic analysis of different proportion and orientation of a cubic building

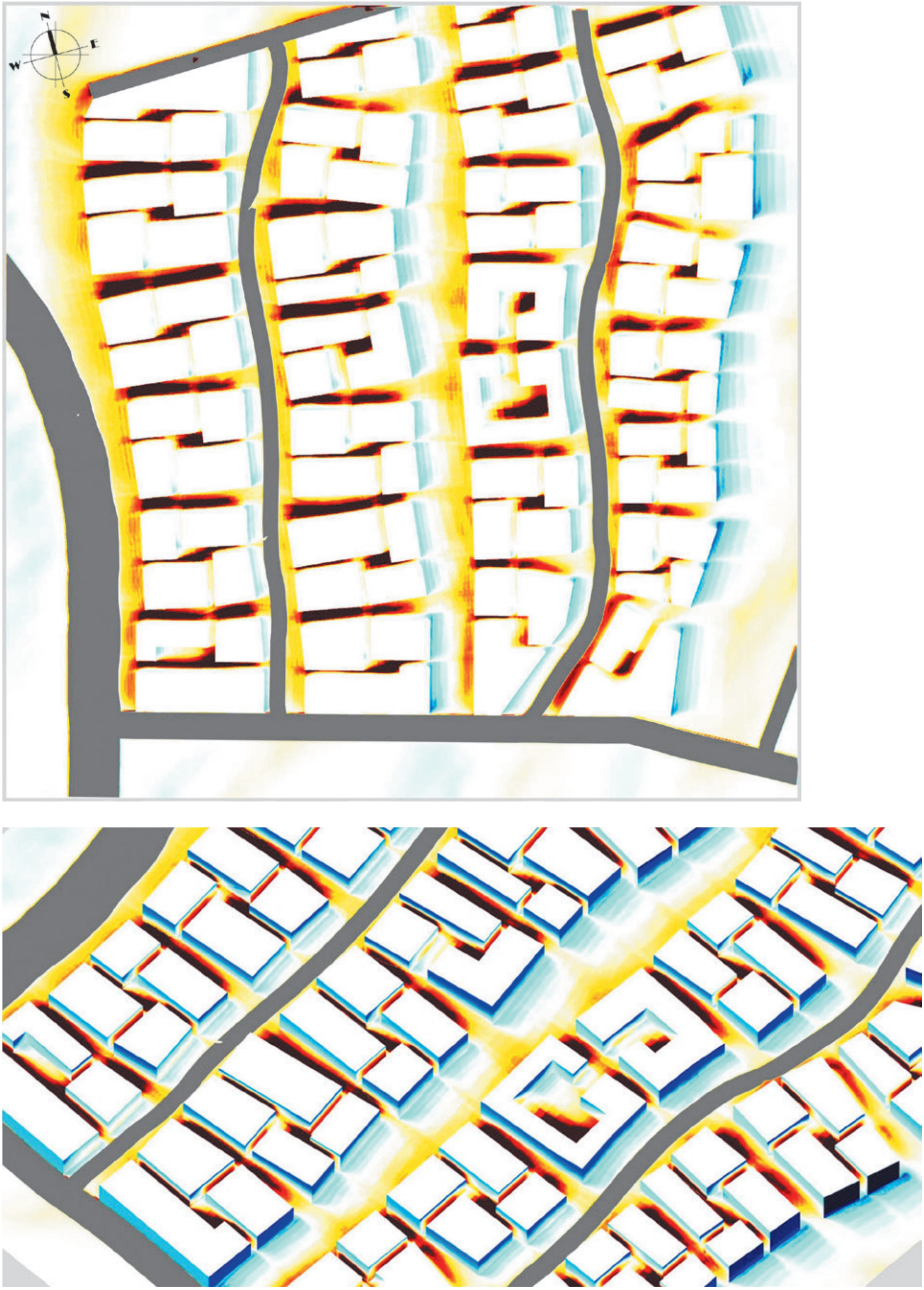



Fig. 74–75: Plan and S.E. isometric views of year-cycle SOLARCHVISION passive solar-climatic analysis of 35 ha site of Young Cities—Developing Urban Energy Efficiency in Hashtgerd New Town

In SOLARCHVISION Passive Analysis (see Figures 74–75), the points are rated from red in the most undesirable situation to blue in the most desirable situation, while the middle values are displayed in colors such as yellow and cyan. On the other side in SOLARCHVISION Active Analysis (as the diagrams on the next pages), the levels of radiation received at each point is simulated.

Considering the main aims of this pilot project which are the reduction of energy consumption in comparison to existing office buildings in Iran and the improvement of internal thermal comfort predominantly by means of architectural design as the main source of saving energy, different simulations are used for studying the thermal behavior of this office building. Besides regarding the importance of effects of the sun both indoor and outdoor spaces were studied and evaluated by SOLARCHVISION.

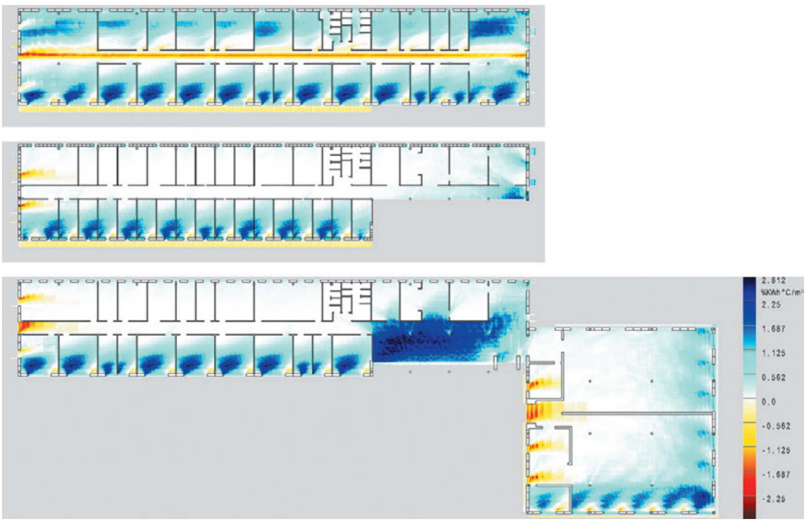
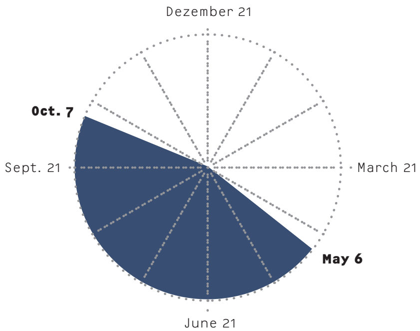
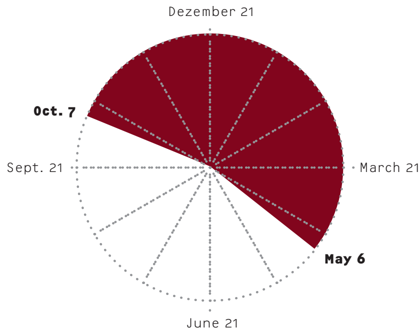



Fig. 76–78: Year-cycle SOLARCHVISION passive analysis of the office building 2nd, 1st and GF plans

The above diagrams show the year-cycle SOLARCHVISION Passive Analysis of the 3D-model of this building in a case where all radiation is transmitted through windows and is blocked by walls. These models discover the general capacity of different spaces of the building in receiving positive and negative solar effects. This data can help the architects to develop the interior spaces or change the design of the building skin where required. This analysis also may help in selecting and positioning suitable mechanical system of the building.

Regarding the temperature model of Hashtgerd, heating and cooling periods are separated between the May 6 and October 7.



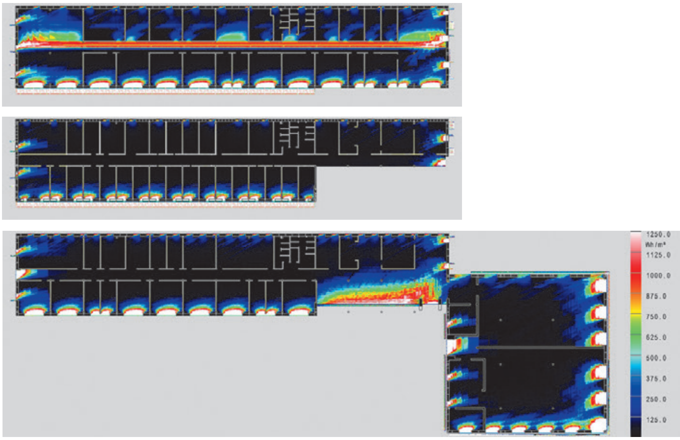




Fig. 79–83: Cooling period SOLARCHVISION active analysis of the office building 2nd, 1st and GF plans

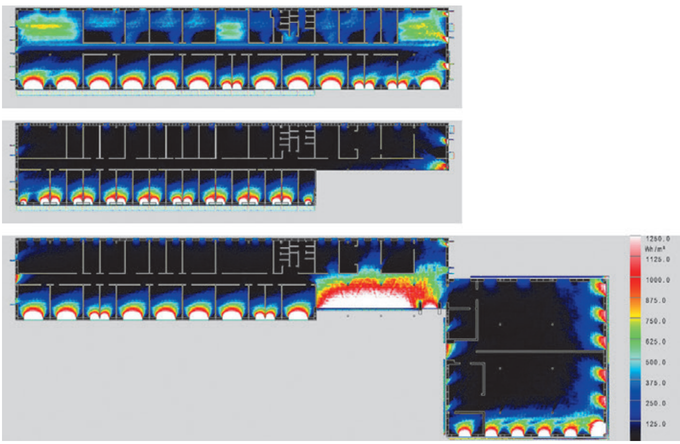



Fig. 84–86: Heating period SOLARCHVISION active analysis of the office building 2nd, 1st and GF plans

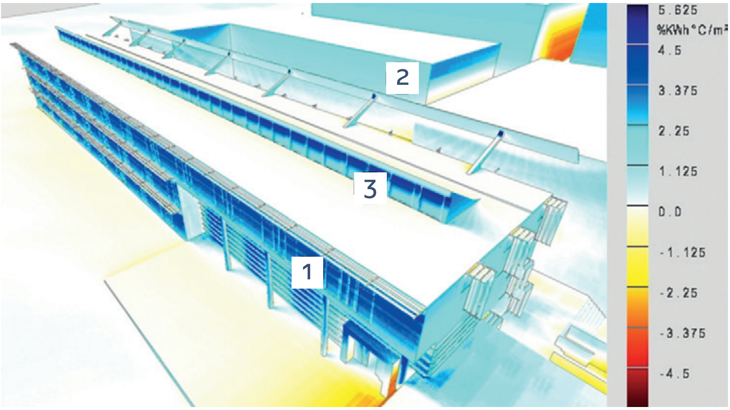
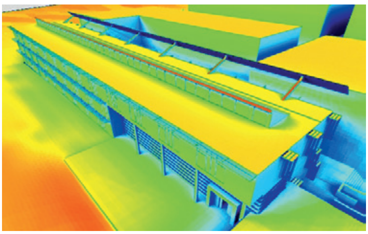



Fig. 87: Year-cycle SOLARCHVISION passive analysis of the office building

Above diagram shows the positive year-cycle performance of South façade of the Office building 3D-model which is resulted from being sun exposed in the heating period and shaded in the cooling period.

The positive performance of the designed South façade of the office building, which is almost in dark blue [point #1] can be compared with the light blue situation of simple South façades of the neighborhood, who perform less well [point #2].

On the other side the depth of shading device of skylights on the roof of office building can be increased to change situation of skylight form light blue to dark blue [point #3].



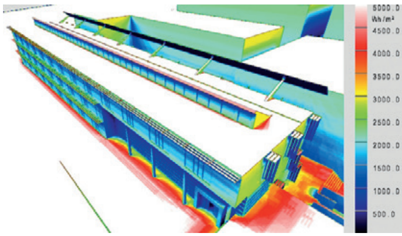



Fig. 88–89: Heating period (left) and cooling period (right) SOLARCHVISION active analysis of the office building

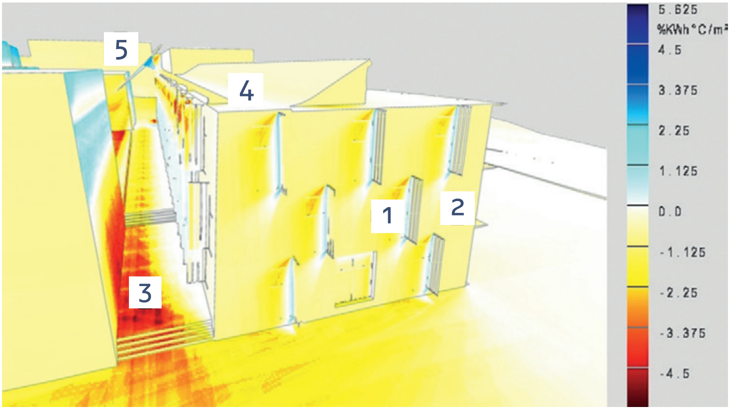



Fig. 90: Year-cycle SOLARCHVISION passive analysis of the office building

Above diagram shows the year-cycle performance of the Western part of the Office building 3D-model as well as North walk way path between blocks. The positive and negative effects of designed shading devices in this façade [point #1] can compared with the situation in parallel faces with no shading [point #2].

On the other side there are some negative areas on north side of the building like the north façade and the path between blocks [point #3]. The performance of these areas could be slightly corrected by inteligent design of reflectors on the roof and the upper part of North side of New Generation Office Building [points #4 & 5]. In this part the use of shading devices and trees may help in reduction of the negative effects resulted from being exposed to the sun during the cooling period as well.

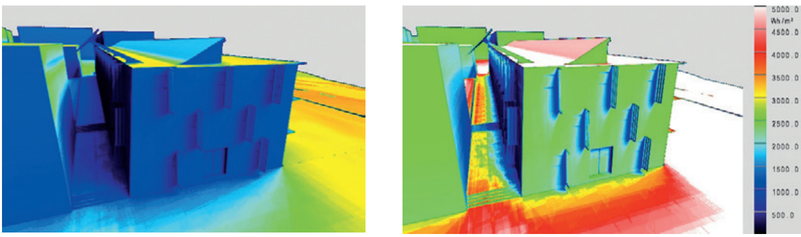



Fig. 91–92: Heating period (left) and cooling period (right) SOLARCHVISION active analysis of the office building

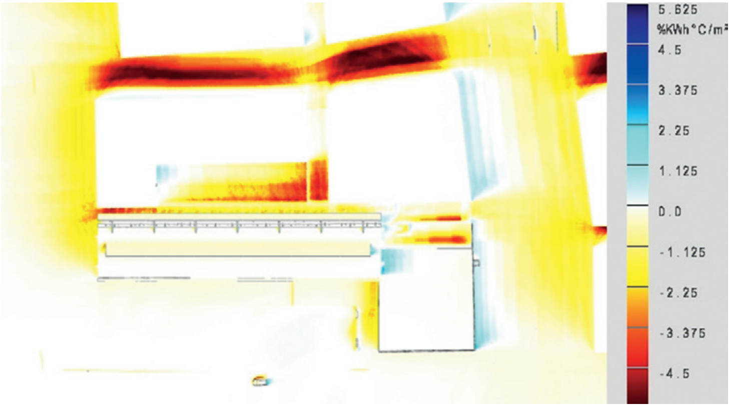



Fig. 93: Year-cycle SOLARCHVISION passive analysis of the office building and residential neighborhood

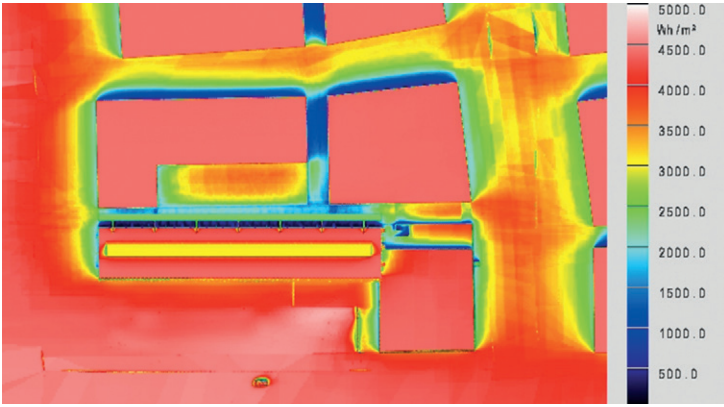



Fig. 94: Year-cycle SOLARCHVISION active analysis of the office building and residential neighborhood

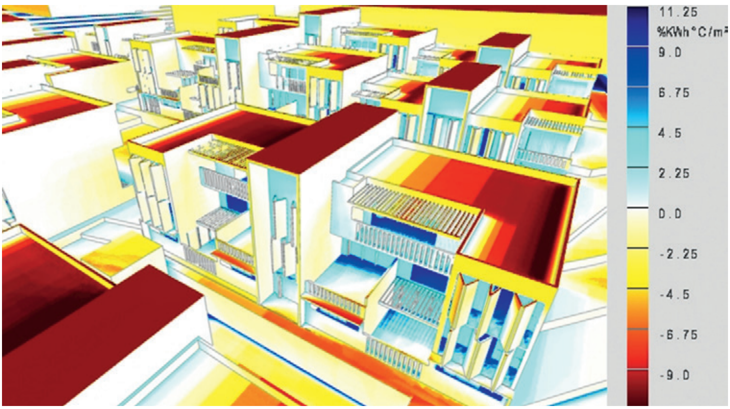



Fig. 95: Cooling period SOLARCHVISION passive analysis of residential building blocks—S.E. view

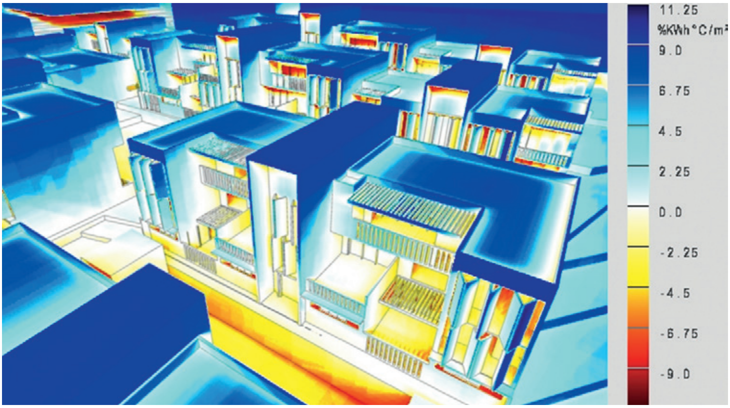



Fig. 96: Heating period SOLARCHVISION passive analysis of residential building blocks—S.E. view

Above diagrams show solar-climatic performance of residential building geometries in both cooling and heating periods. The positive performance of shading devices in cooling period as well as their negative effects in heating period are simulated separately.

### 4.3 SOLARCHVISION Analysis of Different Types and Proportion of Shading Devices

In further diagrams in this chapter different proportions of horizontal and vertical shading devices are analyzed in different general directions of 35 ha Hashtgerd New Town site to find out the most proper types and proportions of shading devices in each direction. Figure 97 shows the ratio of width and height of these louvers to their depth. It is also necessary to mention that upper part of this model has no shading device; so the comparison between different situations of these models is possible.

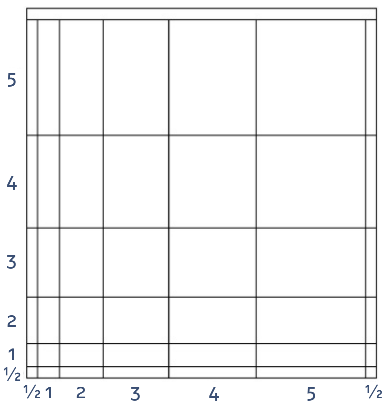



Fig. 97: Ratio of width and height of shading devices

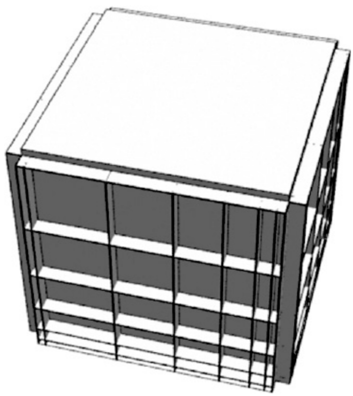


Fig. 98: Ratio of width and height of shading devices to their depth

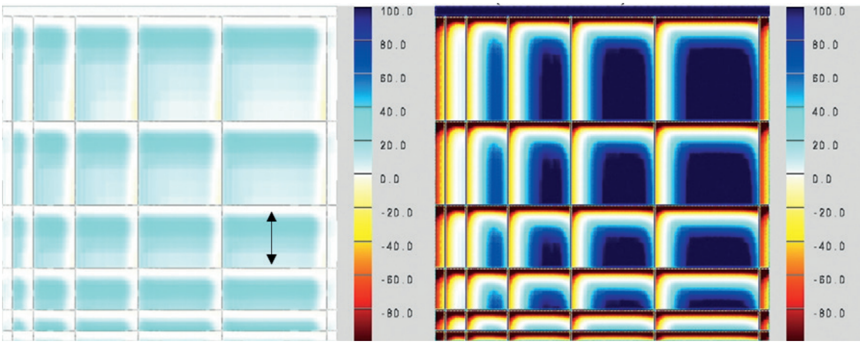



Fig. 99–100: SOLARCHVISION passive analysis: left: cooling period, right: heating period

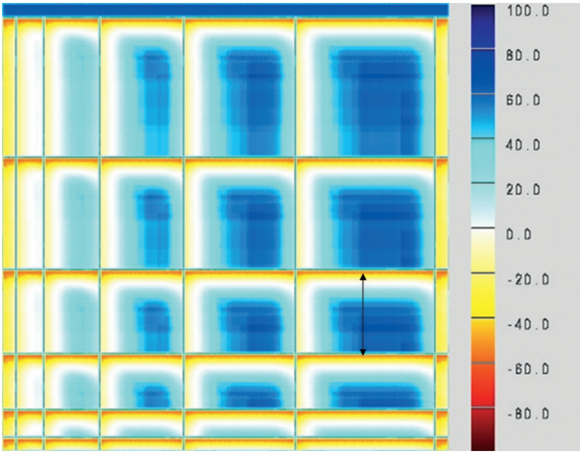



Fig. 101: SOLARCHVISION passive analysis: year cycle

**General East in 35 ha site (Direction 75)**

Figures 99–101 show that using fixed horizontal shading devices in the general East direction of this site can help building skin in cooling period in comparison with fixed vertical shading devices. As these fixed horizontal devices reduce positive solar gains in heating period, they should not be used too dense. Therefore a removable shading device is the best alternative for this direction.

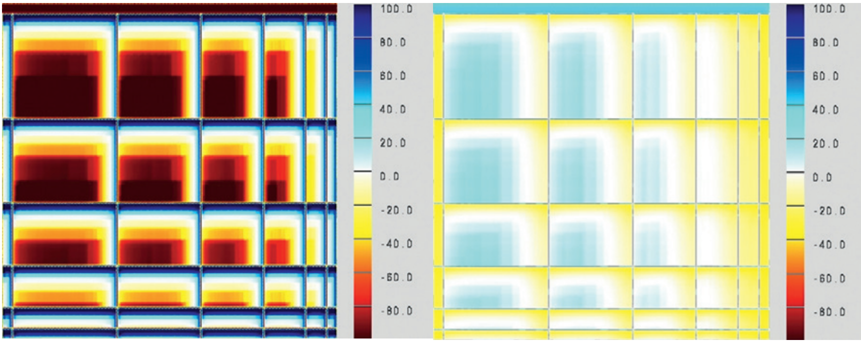


Fig. 102–103: SOLARCHVISION passive analysis: left: cooling period, right: heating period

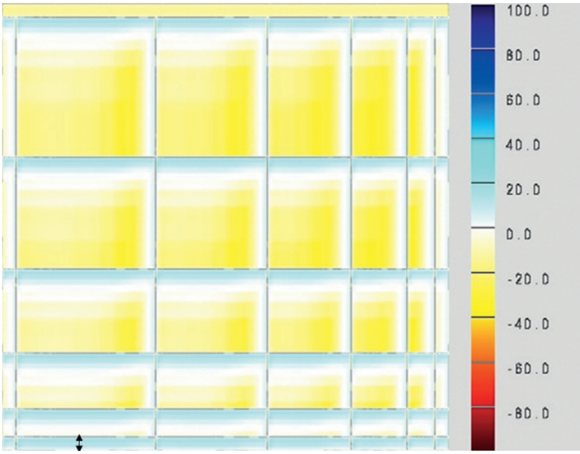


Fig. 104: SOLARCHVISION passive analysis—year cycle

**General West in 35 ha site (Direction 255)**

Figures 102–104 show that using dense horizontal shading devices in the West direction of this site can help building skin in cooling period, however they reduce desirable solar gains in heating period. Instead of using dense horizontal shading devices (Depth/Height = 2) it is also to use tilted horizontal louvers (Depth/Height = 1) to create such effect.

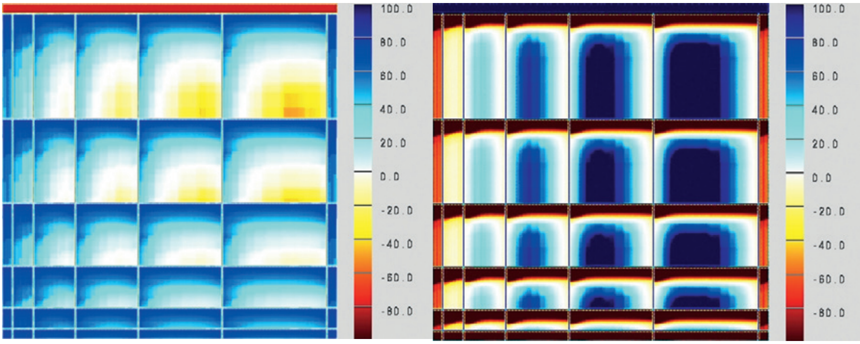



Fig. 105–106: SOLARCHVISION passive analysis: left: cooling period, right: heating period

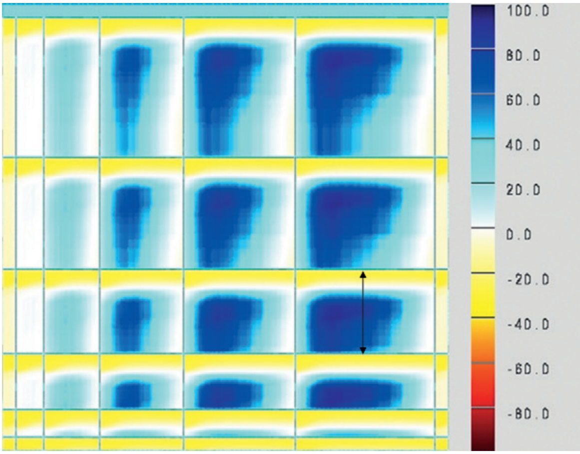



Fig. 107: SOLARCHVISION passive analysis: year cycle

**General South side in 35 ha site (Direction 345)**

Below diagrams show that using horizontal shading devices in the general South direction of this site can help building skin in cooling period. On the other side vertical fixed shading devices are not suggested because of their great negative effect in heating period as well as their little effect in cooling period. Considering the complexity and importance of shading control in South direction more studies are done as described in the next pages.

## Analysis of Different Alternatives for Shading Devices for South Direction

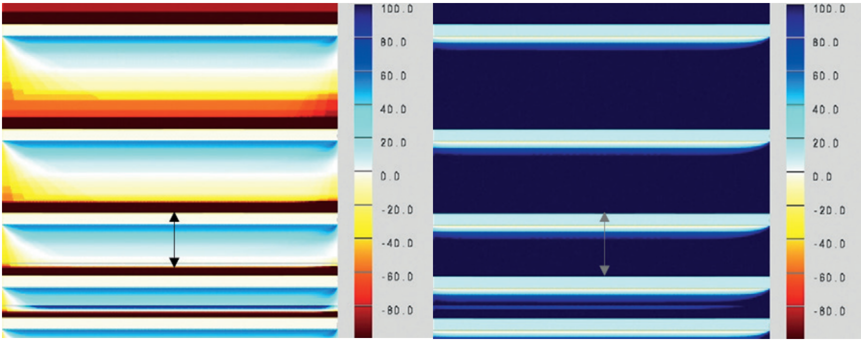



Fig. 108–109: SOLARCHVISION passive analysis: left: cooling period, right: heating period

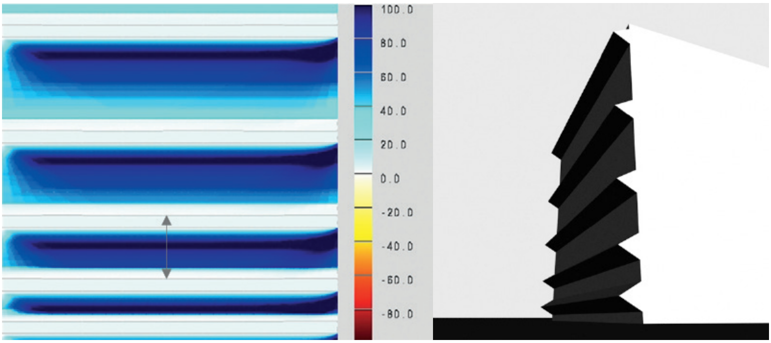



Fig. 110–111: SOLARCHVISION passive analysis: year cycle

The proposed fixed horizontal shading device for the South direction shows remarkable positive effects both in heating and cooling periods. Another way to decrease negative effects of shading devices is to use 20° tilted louvers:

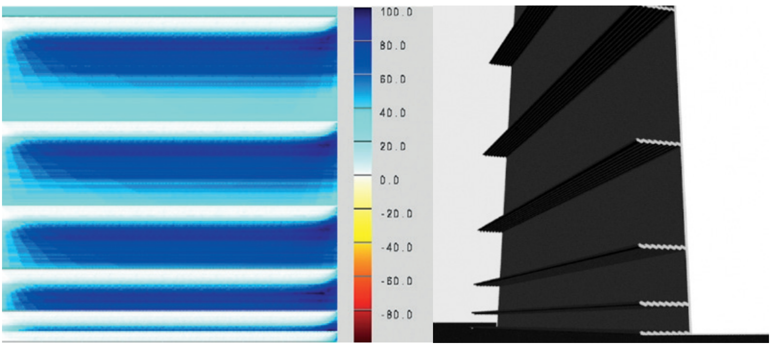



Fig. 112–113

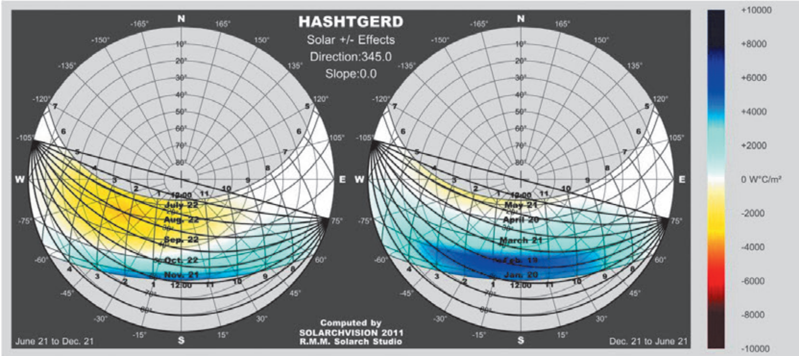



Fig. 114

Considering the fact that in Hashtgerd climate, the maximum profile angle of the sun in heating period is about 37° and the minimum profile angle of the sun in cooling period is about 50°, the design of shading devices should be so intelligent to work proper in both warm and cold situations. Therefore using blinds even movable is not suggested because of the dark and light effect inside the office in low sun altitudes as well as its improper performance on view. Also, these horizontal louvers would become dirty by dust.

Developed alternatives which presented in the bottom of the opposite page and enlarged below are better alternatives which are both problem solving and practical.

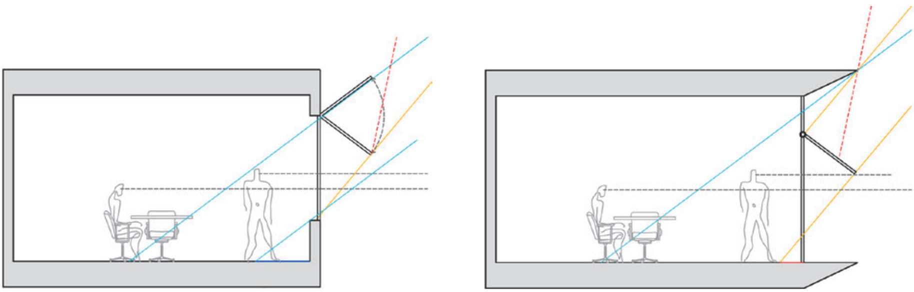
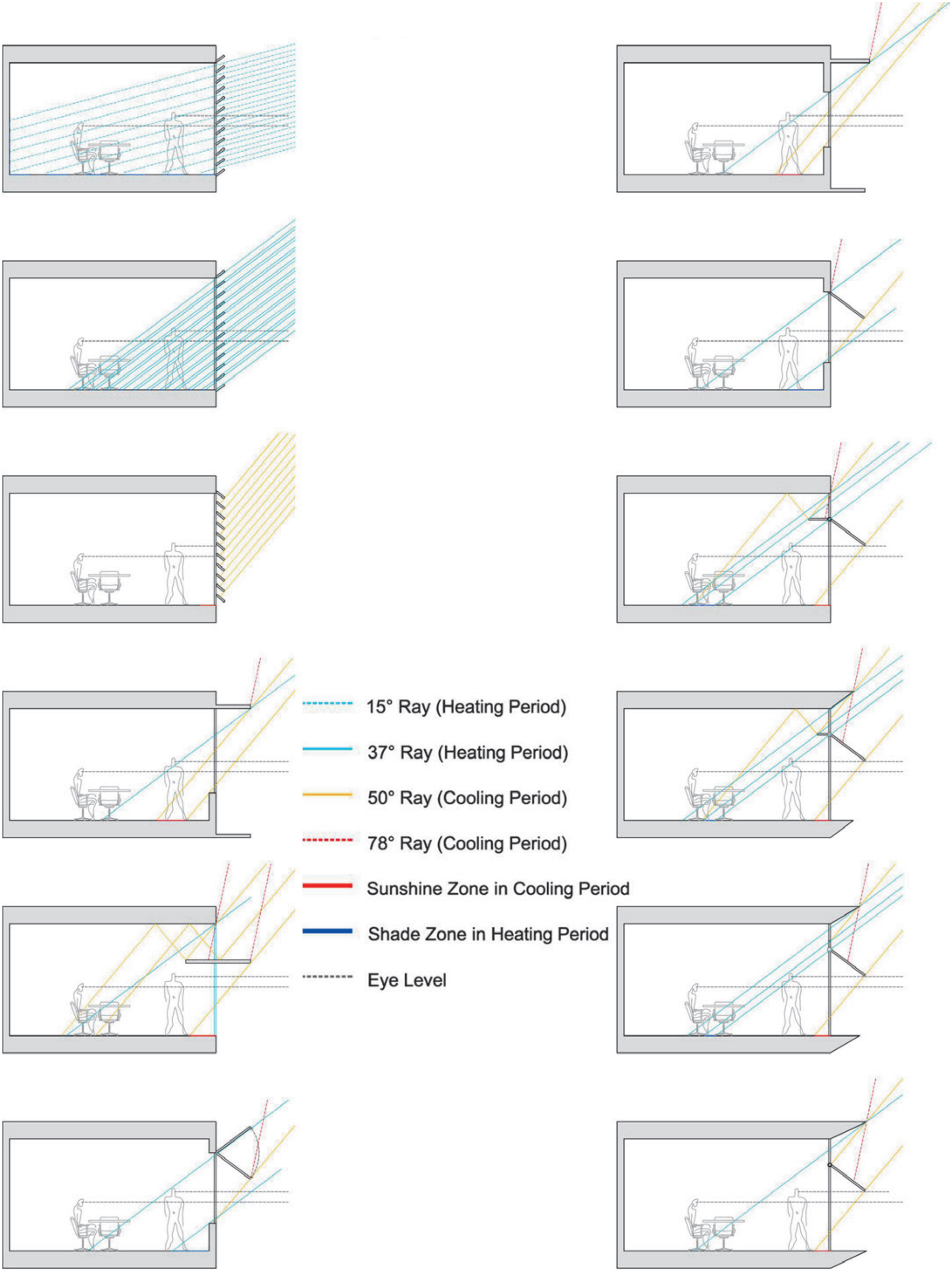


Fig. 115–116: Study of different shading devices for general South direction of 35 ha site in Hashtgerd

Fig. 117: Study of different shading devices for general South direction of 35 ha site in Hashtgerd


15° Ray (Heating Period)
37° Ray (Heating Period)
50° Ray (Cooling Period)
78° Ray (Cooling Period)
Sunshine Zone in Cooling Period
Shade Zone in Heating Period
Eye Level

## 4.4 Solar Reflectors

Use of engineered reflectors in architectural design of New Generation Office Building can bring better qualities and quantities to living indoor and outdoor spaces as well as solar collectors. Below study shows the essential effects of such collectors which improve the performances of North and South façades. Besides, another remarkable effect can be observed in the integrated use of the reflectors in front of solar collectors in comparison with the simple collectors.

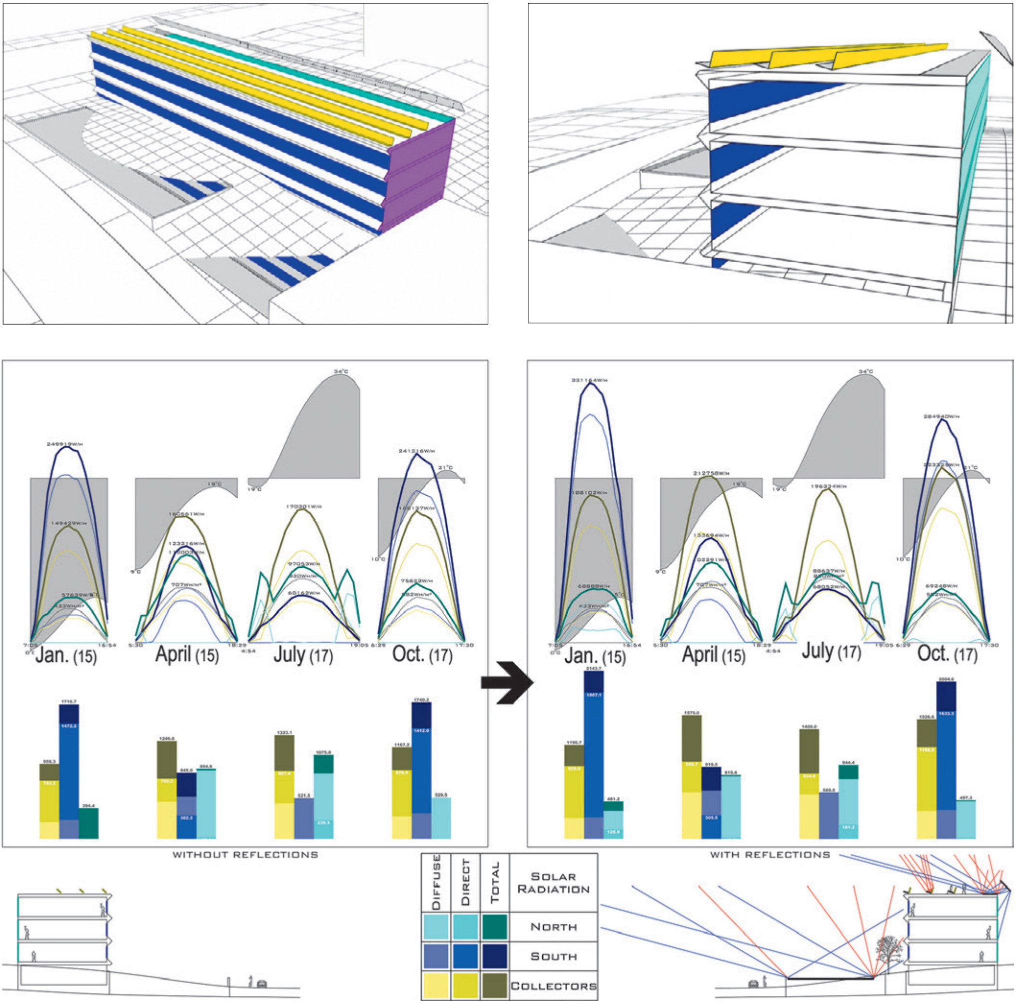



Fig. 118–120: Remarkable changes in receiving solar energy by different building parts during the year (South façade [Dark Blue], North façade [Light Blue] and the Collectors [Yellow])

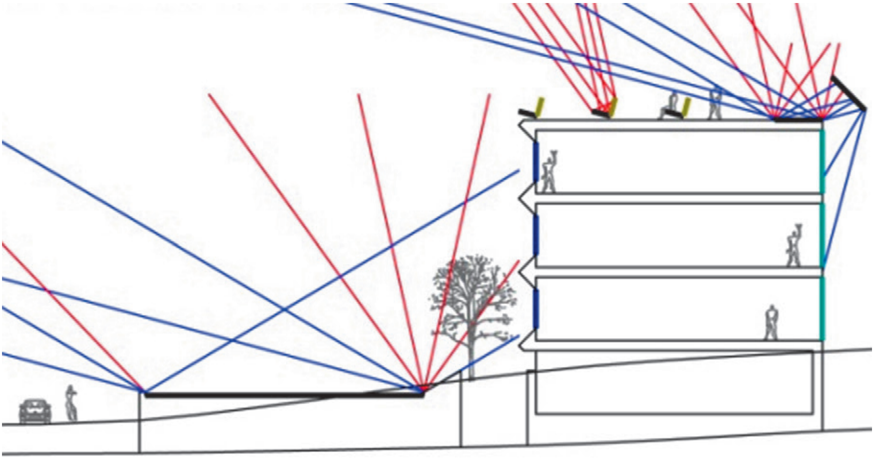


Fig. 121: Study of Reflections in Different Times During Heating and Cooling Periods

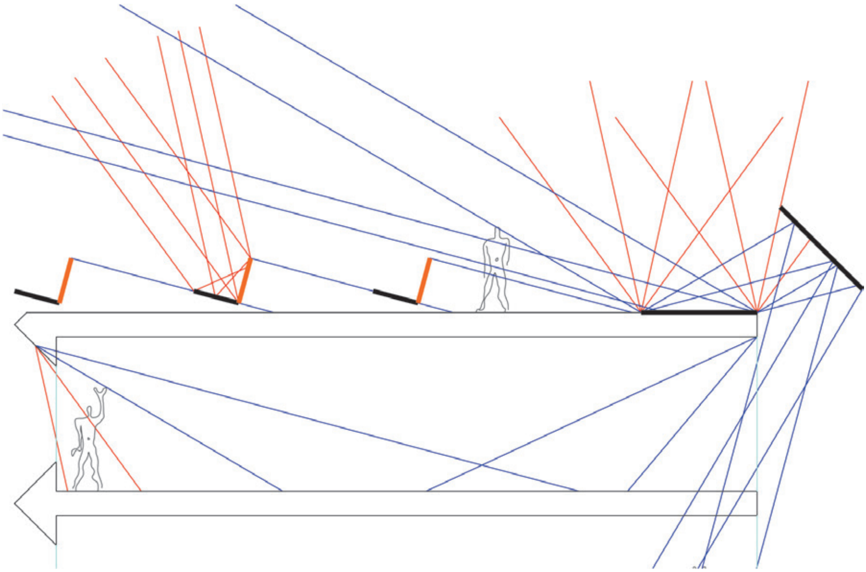


Fig. 122

Precise design and calculation should be considered in optimization the location and angle of reflectors. For instance the reflective pool should be located with a proper distance to the south façade in order to reflect the sun's ray during the cooling period to the sky and not to the south façade.

## Proposed Alternative of New Generation Office Building

Regarding to the previous studies, here another developed alternative for New Generation Office Building is presented which is resulted by 10° tilt of building geometry to the South. This rotation could create several advantages:

1. Self shading in the South side: in this case the amount of desirable solar gains in heating period is decreased just a little.
2. Receiving more amount of daylight in the North side as well as more performance of reflectors in heating period which brings the sun to the North side.
3. Achieving a friendly relation with the Earth and its slope from North to South
4. Achieving an integrated and simple form
5. Achieving a flexible space in the upper level for some extensions

About the windows, instead of using vertical windows, here horizontal windows are suggested which can provide better conditions from the day lighting point of view.

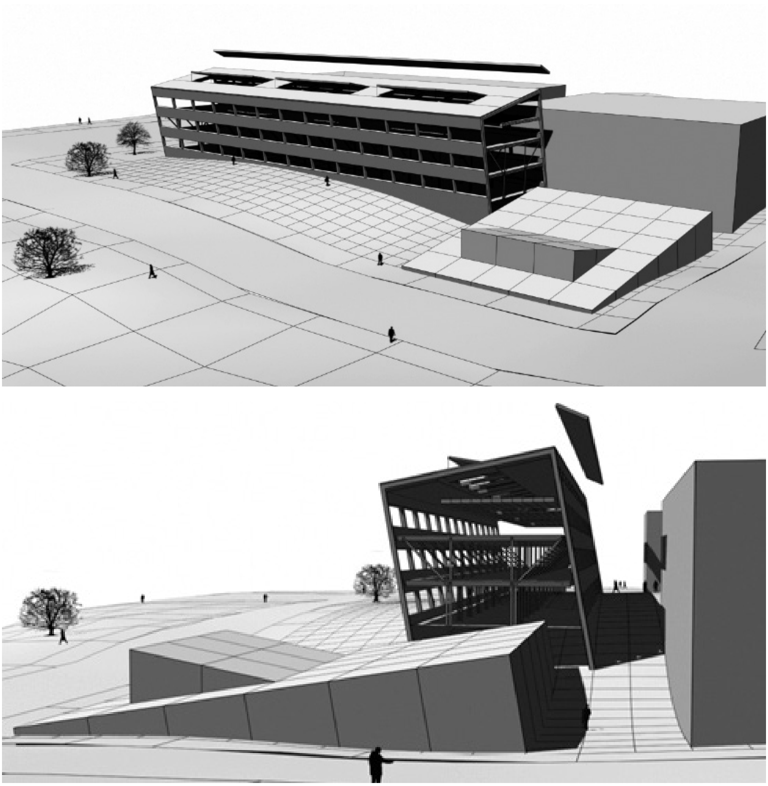


Fig. 123–124

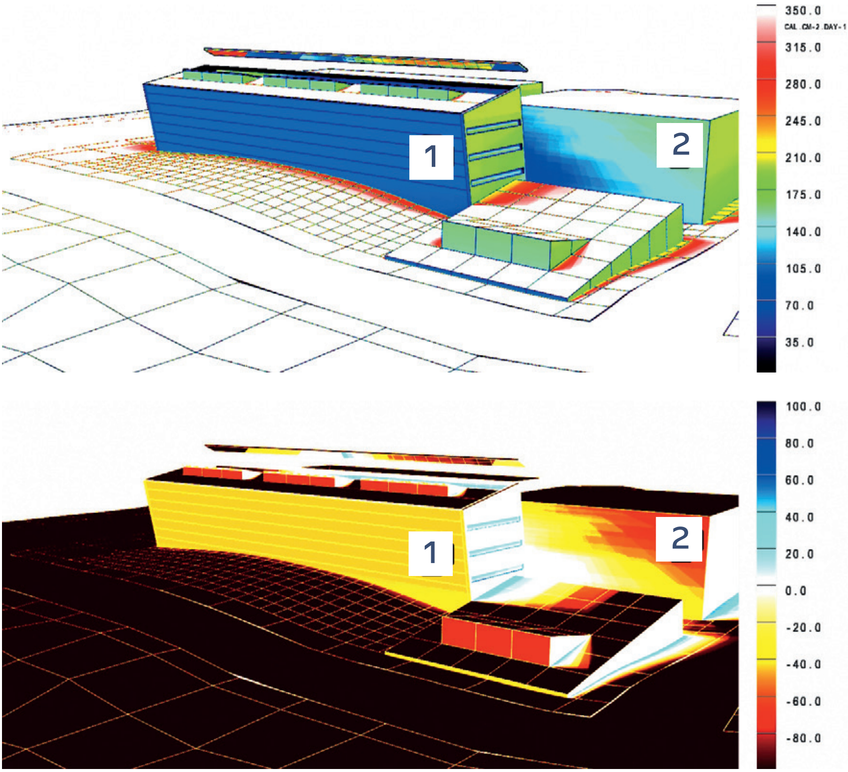



Fig. 125–126

Differences in situation of -10° sloped South façade of the proposed alternative [point #1] and the vertical wall [point #2] are remarkable in the above passive and active solar-climatic analysis in cooling period.

**Conclusion—Solar Architectural Vision**

*"The state of art of current architecture and urban design is to adjust both internal and external living spaces together and beside each other …"* [2] To achieve such design, all this aspects should be inward by the heart and the hand of the architect; and this study is an effort to bring a brand new vision to analyze of building skin and urban fabric from the point of the sun and climate. To build more comfortable, safe and healthy living spaces of tomorrow, which should certainly also be energy saving, an integrated optimization is needed through the design process to improve the quality of indoor and outdoor areas together. Consequently, the key to solar-climatic optimizations in architecture and urban planning would result from analyzing all the considerable alternatives; and the most appropriate alternative is one which responds in an optimum way to all requirements by use of "less" (e.g. less cost, less weight, less material, less energy, etc.). *"I suppose if we ever knew exactly where the light was coming from, getting there would be easy"* [Brian May, Back to the Light, 1993].

We all heard that we should never look directly to the sun; but I believe that we should look directly from the sun; using a solar architectural vision.

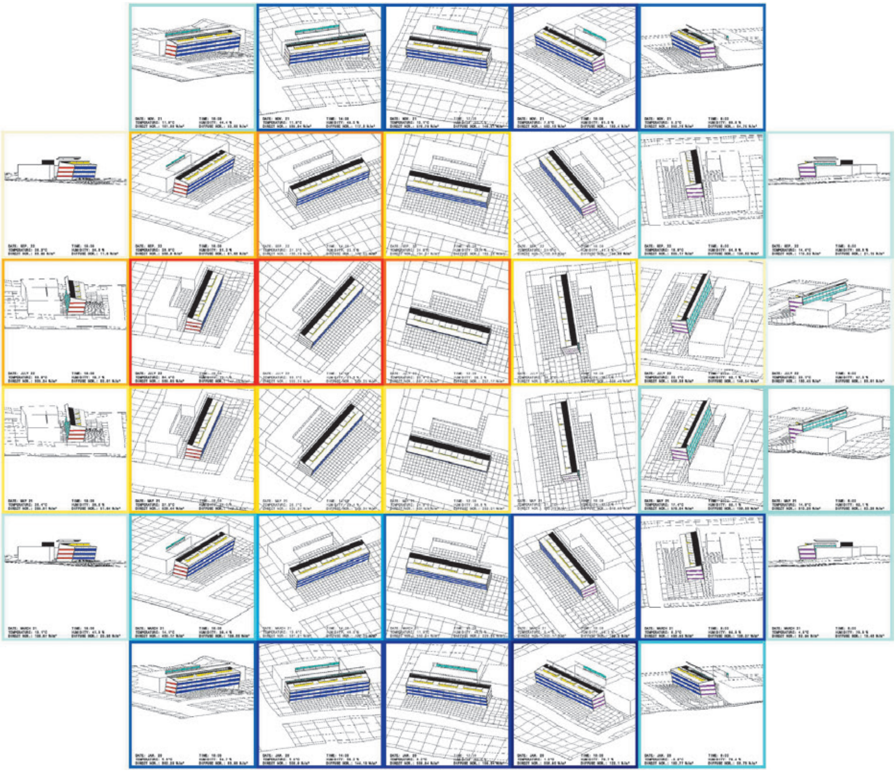


Fig. 127

Figure 129 presents different perspectives at which the sun looks the office building in different hours of the day through 12 months of the year. The blue to red pallets also presents the solar positive and negative effects at each hour. Such studies could be done in order to find out whether the reflectors and shading devices work correctly or not.

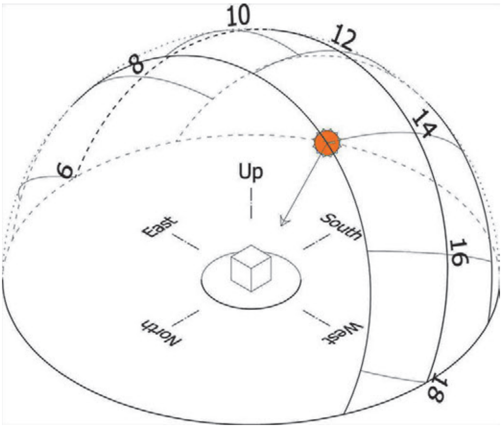



Fig. 128

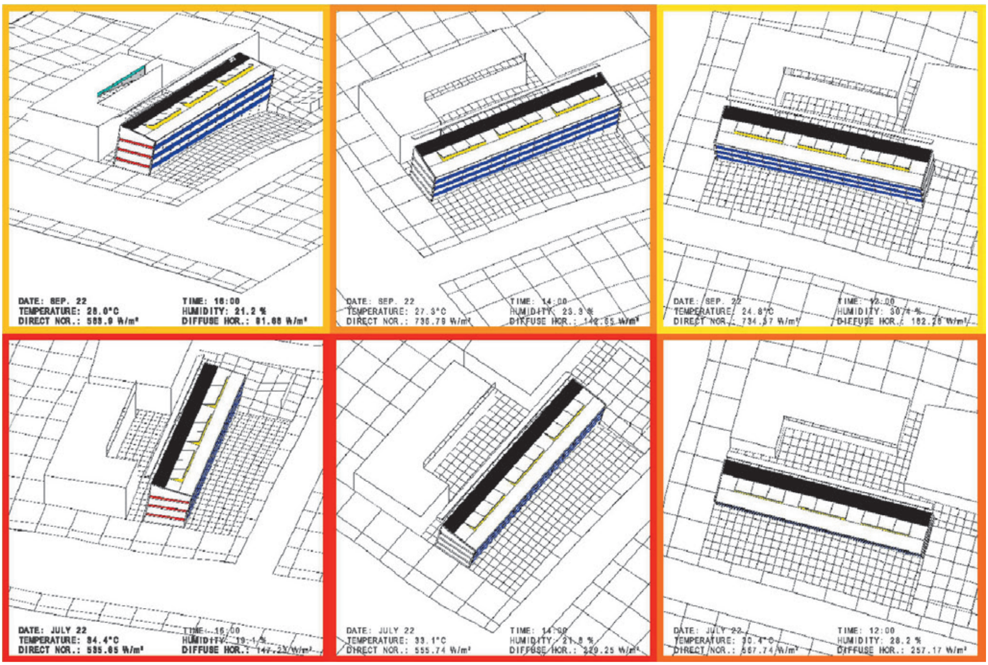


Fig. 129: Solar perspectives at extreme undesirable times

Figure 130 shows the proper effect of negative slope of South façade [Dark Blue]: while in the worst conditions it receives low value of direct radiation. Below table also discovers the proper reflection from North neighborhood to the Office Building North façade [Light Blue].

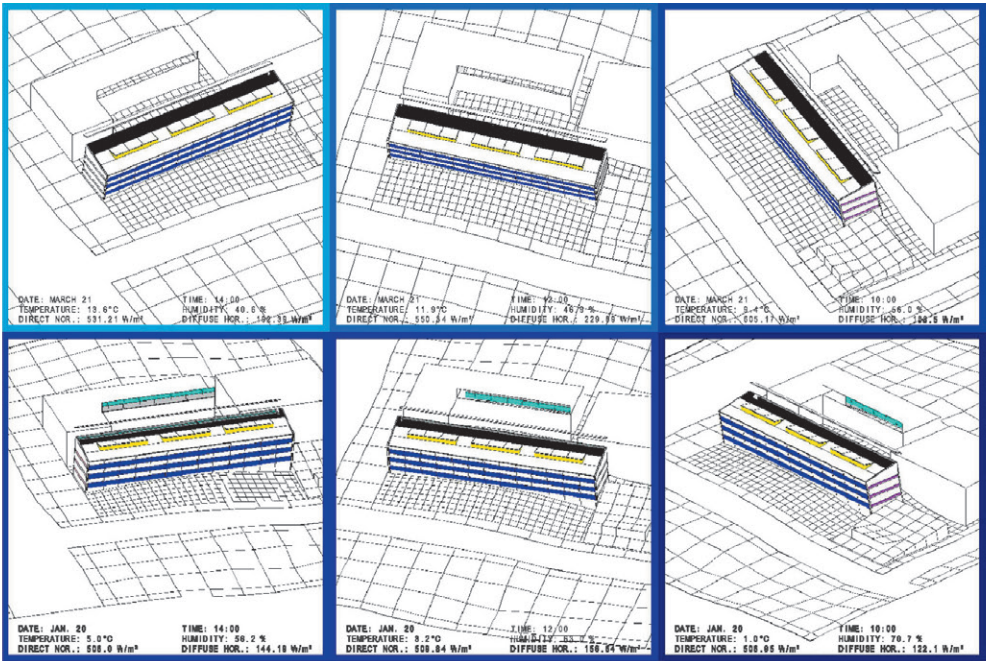



Fig. 130: Solar perspectives at extreme desirable times

1 “A new approach for solar analysis of buildings”, Samimi M., Parvizsedghy L. & Adib A., WORLDCOMP’08—Proceedings of The 2008 International Conference on Software Engineering Research & Practice, editors: Arabnia H. R. & Reza H., CSREA PRESS

2 Samimi M., Nili M.Y., Seifi S., “The Variety of Problems and Problems of the Variety” Book Chapter, “Sustainable Environmental Design in Architecture - Impacts on Health”, Editors: Rassia S. and Pardalos P., Springer, Series: Optimization and Its Applications, 2011

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