Creative City Design */ Vol. 1, No. 1, 2018, 9-28.*

Understanding and Presenting Principles of Climatic Design in the Architectural Design of Golbahar City

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Submit Date: 2018.11.19, Accepted Date: 2019.03.09

Abstract
Architecture and climate are two man-made and natural systems that have a strong impact on each other. The current study assesses the impact of the wind and solar energy on the formation of urban tissue and building blocks in order to sustain and optimize the energy consumption in Golbahar City. According to the studies, Golbahar City is a blockade and the orientation of the northern-to-southern masses is to the current climate of the city. But the results of the current study identify East-to-West orientation for optimal climate design. That is why the buildings created in this city have high energy dissipation due to inadequate design. Hence, the choice of this city is considered necessary for energy analysis. The research method was quantitative in this research. Design based on literature review, field researches, climate studies and photography by study instrument Ladybug for analysis was determined to complete this article's contents. First, by using the weather consultant software “Climate”, effects of such factors as sunlight and the wind blowing from different directions and seasons have been analyzed to calculate energy consumption in a building. Then by evaluating the best strategy for the two mentioned factors, the way of sustainable architecture design was presented. Results were expressed in terms of different architectural design items such as cover surface area, plan, exterior surface coating, heat storage material, heat dissipation, shading, ventilation, double-layered heat, and materials.
Keyword: *Sustainability, Energy, Climate Software, Golbahar City*

1. Introduction
Following the massive growth of the population on the planet, modern society has been forced to use energy and natural resources. While these resources are being used uninterrupted and will not last forever, it won’t take long for the current human behavior to become catastrophic for global ecosystems. Accordingly, paying attention to the sustainable development and consequently sustainable architecture and design are one of the important issues in the contemporary world. For mankind today, sustainable architecture or environmental architecture is a compulsion; therefore, paying attention to this need is significant. Limited resources of fossil fuels, concern for environmental issues and limiting the energy consumption of buildings have made researchers look for solving the issue. In this case, the use of the sun and wind energy which are among the most available renewable energy sources in Iran are considered as founders of building sustainability systems. The present study investigates the influence of solar and wind energy on building formation to optimize energy consumption in the new city of Golbahar. There are few studies on the sustainability of buildings in Golbahar as a new city.

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In addition, looking at the current situation of Golbahar’s buildings, it seems that they are built without considering the climate and they do not fit into the ecological characteristics of the city which will increase the consumption of fossil fuels. In this study, the Climate Consultant software was used which introduces the regional weather and the unique weather features as well as its impact on buildings design, by receiving statistical data. For sustainable building design, first, the sustainability and its related concepts and principles should be considered.

2. Sustainability and Sustainable Development
Today, the discussion of sustainable development is one of the most important and common debates internationally. One of the principles of sustainable development is paying attention to culture, native features, and past experiences, by the use of non-renewable energy sources [12]. From the perspective of the World Commission on Environment and Development, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. In a statement by the Commission on the Environment and Development, the main goals of sustainable development areas are summarized as:

renewing and changing the quality of growth and the requirements for jobs, food, water, health facilities, the provision of a sustainable level of population, maintaining and increasing resources, combining environment and economy in making decisions and international economic relations. Creating sustainable development is divided into three general areas:
1.Social Sustainability
2.Economic Sustainability
3.Environmental Sustainability [8]
Up to three decades ago, there was an optimistic feeling that with the advancement of technology, all problems can be overcome. But in recent years, on one hand with the fall of the post-modern era fever and on the other hand by the increase in environmental problems such as global warming, deforestation, soil fertility decline, environmental pollution, the loss of biological diversity, increasing population and adverse environmental impacts have directed the attentions to the architecture and urbanization to meet human needs and follow a more humane process. In fact, such problems, rapid changes and appeals for a higher quality of living standards became the context to consider sustainability and sustainable development [13]. David Chapman () states that the concept of sustainability has been taken into consideration by politicians and consultants, at two national and international levels. According to Macintosh (), "Sustainability has a simple concept: Living with each other among natural resources”. He continues that we must reduce the consumption of resources and the production of wastewater and waste and make sure everyone can live well. He also says in his book on the sustainability of Breton land quotation, a development that will meet today's needs without losing the ability to meet the needs of the next generation, is sustainable development. El Cane and Mc Laren in the book of City Rebirth propose four principles for sustainable urban development: Prospects, Environment, Justice, and Participation [14].

2.1 Sustainable Design

In order to achieve the goals of sustainable development, “Environmental sustainability” () is very important in relation to architecture, and environmental issues that threaten the future of mankind have got architects to develop solutions. The general purpose of sustainable design is to reduce the negative effect of building on the environment by the correct use of natural resources and energy efficiency. A sustained plan (at the same time) is in pursuit of the aesthetic, environmental, social, economic, moral and spiritual values. Therefore, the following patterns can be presented in sustainable architecture:
•Minimizing the exploitation of non-renewable resources
• The use of natural and renewable energies
• Promoting the quality of the environment
• Expansion of the natural environment
•Preservation of native culture and identity
•Conscious use of the land and the consistency of the shape of the building with the environment
•To be economical in construction using efficient alternative technologies
As a result, a sustainable architecture using such patterns will help in creating a healthy environment based on resource efficiency, protecting non-renewable resources, reducing renewable energy consumption and improving quality of life [12].

2.2 Energy Sources

Lechner (2001, p.) says in relation to energy, “We can divide all energy resources into two main groups of renewable and non-renewable. We use mainly non-renewable resources; these are the only sources that cause the pollution and warming of the planet. It is our duty to shift our use of non-renewable resources to renewable sources as quickly as possible." Lechner (2001) says the following sources all share the very important value of being renewable and of not contributing to global warming. Solar, wind, hydroelectric, and biomass energies are renewable because they are all variations of solar energy. Of the renewable energy sources, only geothermal energy does not depend on the sun [1]. Lechner also stated the three-tier design approach, as shown in Table 2.1 From a variety of renewable energies, solar and wind energies are the most accessible and the most productive at the present study and in the area that is under study. Energies such as hydroelectric and biomass require suitable bedding, which does not exist in Golbahar. In addition, according to statistics, wind speed is high throughout the year, and sunlight can be used in almost all seasons. Both solar and wind energies have certain characteristics that must be introduced and recognized before entering the analysis section.

2.2.1 Solar Energy

Solar energy refers to the use of solar radiation in several different ways. In each solar system used for space heating, three functions are expected: 1. collecting solar energy, 2. storing the energy in a storage or capacitor, 3. distributing the energy in space. There are two different types of solar energy systems, which include active systems and passive systems. In both cases, the three functions mentioned (gathering, storing and distributing the energy) are performed, but with different methods. An active solar system uses mechanical appliances to circulate air or fluids within collectors and thermal stores. Also, a fan and a pump are required to send the heat stored in the stores to the desired space. Active systems are a bit complicated and require external resources to operate. The operation of passive solar systems does not depend on electrical energy or fossil fuels. It uses natural heat transfer methods including thermal conductivity, convection, and radiation. In these systems, sunlight first hits a heat absorbing surface that is located in the south side of the building. It is then stored in the space between the absorbent surface and the building. Eventually, this stored heat is transferred to the building using natural methods [7]. There are many factors that determine the best option among static solar heating systems. The climate, type of building, user preferences and the cost are some of the main considerations. Often, it's best to use a combination of these systems to meet the needs of a particular problem. Other times, a variety of systems will be better. It is also likely that other good ideas will be invented in this field. However, it is certain that most of the buildings that need to heat can benefit from a kind of static heating system.

•Maximize south-facing skylights because southern windows collect much more sunlight during the day than they lose at night and absorb much more sunlight in winter than in summer.

•Passive solar heating consists essentially of south-facing skylight and thermal mass.

•In a direct-gain system, the more mass receiving direct or reflected solar radiation, the better. The mass should have a large surface area rather than depth.

•Passive solar system includes orientation system up to 80 percent [1].

•Based on the writings of such people as Leckner (2001), Ghiyabaklu (2014) [4] and Szokolay 2014 [2], and such books as Heating, Cooling and Lighting, The Basics of Building Physics 2, An Introduction to Architectural Science, The Basics of Sustainable Architecture, passive solar systems are divided according to the following chart (chart2.1).

2.3 Passive Cooling

Norbert Lechner (2001) says passive cooling is much more dependent on climate than passive heating. Thus, the passive cooling strategies for hot and dry climates are very different from those for hot and humid climates. Passive cooling uses natural forces, energies, and heat sinks. When some fans and pumps are used, the systems are sometimes called the hybrid. However, the author uses the word "hybrid" only for those systems that use large pumps or fans which require significant amounts of energy. Since the goal is to create thermal comfort during the summer (the overheated period), one could attempt to 1. Cool the building or 2. Expand the comfort zone sufficiently to include the high indoor temperature and humidity. In the first case, the heat has to be removed from the building by finding a heat sink. In the second case, one of the thermal environmental factors have to be modified to feel the comfort zone shifts in higher temperatures. In this second case, people will feel more comfortable even though the building is not actually being cooled [1]. According to Lechner (2001) and Ghiyabaklu (2014) [4 the passive cooling of wind energy can be categorized based on the following chart. (chart 2.2).

2.4 The Introduction of Weather Consulting Software

Climate Consultant software is a useful software for geographers, architects, builders, and contractors. The software, which reads 8,760 hours of data in the EPW (Energy plus Weather) file format, is now available to thousands of weather stations around the world. This tool displays a variety of graphic images of different weather features for every weather type and then provides design strategies for the unique characteristics of that type of climate [3]. The goal of the Weather Consultant software is not just to chart the weather data, but to organize and provide this information simply for a better understanding of users by showing the unique features of the weather and its impact on the shapes made. It helps users optimize their energy consumption in buildings, each of which is designed for a specific spot on our planet [9].

2.5 Golbahar New City

The new city of Golbahar is located between cities of Mashhad, Golmakan and Chenaran. Golbahar was located at the latitude of 36, 30 to 36, 37 and longitude 52, 2 to 59, 14, with an altitude of 1250 meters above sea level between the Mount Hezar Masjed and Mount Binalod which is 45 km far from Mashhad City. Golbahar is located in the lower parts of this moderate weather position. It is expected for Golbahar while having the same weather conditions as in the cities of this area like Golmakan and Chenaran, to have a fairly colder condition than Golmakan. Golbahar due to its location in the mountains of northeast Iran has cold winters and fairly modest summers, but in the summer, the condition during the mid-day hours may become intolerable [6].

3. Research Method for Climatic Analysis

Understanding the climatic elements such as wind direction, amount of solar energy, humidity, and temperature has a great impact on providing ideal solutions. As with the possession of the weather information, initial analyses are done to identify the environmental factors of the site. Then each of the early strategies in architectural design can create solutions for optimal design. As an example of analysis tools, the Grasshopper Energy Plugins like Ladybug can be mentioned, which is a plugin for analyzing the initial design process, including weather information, shading, amount of solar energy, thermal comfort parameters, psychometric chart and general data that can help a designer to start the process of their design. Ladybug is a free and open source environmental plugin for Grasshopper3D. Grasshopper3D is a graphical algorithm editor (grasshopper3d.com) plugin for Rhino, a 3D modeling tool which is becoming an increasingly preferred modeling tool for designers, architects, and students. Ladybug benefits the parametric platform of Grasshopper to allow the designer to explore the direct relationship between environmental data and the generation of the design through graphical data outputs that are highly integrated with the building geometry. There are currently four environmental analysis tools, for Rhino/Grasshopper, available to the public (excluding Ladybug). Table 3.1 compares the existing environmental analysis tools for Rhino/Grasshopper based on the analysis types that they provide during the different stages of an environmental design process. As it is shown in Table 3.1, none of the tools provide the full spectrum of the environmental studies, and there is almost no support for weather data analysis [15].

3.1 Wind

The direction and velocity of the dominant winds of Golbahar in different months show that the wind percentage and speed during the summer are more than the other seasons. Although autumn winds have a lower percentage and speed, respectively, but because of the coldness of the area, and the importance of warming the interior spaces compared to cooling them, the wind directionshould be considered as a matter of great concern because winds add to the heat dissipation of the building and raise the need for adding much more fuel to the heating system, so winds are noticeably effective in reducing the tangible temperature, in relation to the cold weather. Based on these statistics, the wind diagram has been illustrated to show the main winds of the site during the various seasons of the year, by observing which the following results are obtained: (figure3.1) In spring and summer, the main winds of the region are first the southwest wind and next the southern wind. In summer, though, the amount of main wind blowing is higher than other seasons, but the wind blowing decreases in other directions. In spring and autumn, the winds blowing are gradually increasing in other directions and after the two main directions, the northeast is of secondary importance. The lowest probability of blowing in these two seasons is from the northwest. In winter, the wind direction changes completely, and intense wind blows from the southeast and south sides. At the same time, winds blown from the northeast, north, and northwest and west gain strength. In this season, it is most probably for the winf\d to blow from northeast and least probably form south. The 5-year-old wind-rose average which is the result of averaging four seasons of the year, determines the direction of the regional winds in the whole year, as follows:

1. Southwest wind
2. South wind
3. Northeast wind

It should be noted that all winds have a very low speed per year, but they are almost continuously blowing, and only 7% of the year, they are sustained. Considering Figure 3.4 and the following factors related to the city of Golbahar, according to the annual climatic data, it can be estimated that nearly 10% of the year is located in the comfort zone. Approximately 31% of heat loads can be carried out inside the building, bringing the situation closer to comfort. Also, there are other solutions with fewer shares such as evaporative cooling in dry summers and the use of materials with high thermal capacity as a thermal mass and natural ventilation. Also with regard to results obtained from the Climate software, there are a number of factors and percentages that need to be mentioned here: (table 3.1`) According to Figure 3.5, some percentages that are slightly different from Ladybug software are obtained. Based on the information obtained, the climate software shows a totality, and details are not included in it. However, because only the inactive system factors were considered in Ladybug software, a few percentages obtained differed from this Table. (table 3.2). Figure 3.6 shows the climatic characteristics of Golbahar City in general and in rows, based on which the average of the minimum temperature in winter (December until February) is below zero and, on January (the coldest month of the year) it reaches 4 ° C. Of course, the low average of the minimum temperature starts from a month before and continues until a month later, but this quarter should be expected to be glacial. The average minimum temperature which is devoted to midnight hours will not reach +17° C, even in the hottest months of the year. The temperature of the night hours will never be terrible in terms of heat, but on the contrary, the average of the maximum temperature that belongs to the middle hours of the day, in the warmest month of the year, rises to 32.7 ° C, but it does not reach even to 10 ° C in cold months, and after leaving behind March, the maximum temperature reaches an appropriate level of 10, and gradually increases its heat to reach the top of the 30 degrees by approaching to summer season (June-August). Then the road goes down, and by mid-October, the average hourly temperatures of the day remain at the right level. In Figure 3.7, the yellow points show the temperature, the green points show relative humidity, and the gray line shows the comfort zone every month. In the study of relative humidity changes, it is observed that the maximum relative humidity in cold months is about 85 percent. The average monthly maximum in the warm months is reduced to 50%, which corresponds to the number of hours at night when the temperature is 14 degrees. And in contrast to the average temperature of the mid-day and warmest days of the day, it is about 35% in warm months and 85% in cold months. Since the accompaniment and the effect of humidity on temperature can change the feeling of humans to heat, checking temperature changes and their results without considering the relative humidity will be misleading. Plenty of or fewer relative humidity during the hot or cold conditions can increase the effects of critical conditions, and excessive deficiency causes a feeling of dryness. In the general survey of temperature changes during the year, there are two main points: 1.Continuity and heat intensity are not high in any of the months of the year. In hot months, despite the high temperatures during the middle hours of the day, the night hours have a good temperature.

2. In spite of the relative moderation of the air in summer, the area faces cold winters at least three months from the year. In night hours, the temperature is below zero or zero degree, and in the middle hours of the day, it is less than 10 degrees Celsius in the three months of the year, which is cold even with warm clothing and sunlight.

3.3 Check the Air Temperature Day and Night

In the preceding sections, checks were made on the overall air temperature. It was concluded that, in general, paying attention to the cold weather in Golbahar is more important. In this section, the air temperature is investigated in all days and nights of every month regarding the human comfort. accordingly, the proposed monthly method has been used. In this method, the human comfort was studied considering two factors of temperature and humidity of the air. In this study, first, the average maximum, average minimum and daily air temperature difference for each month of the year are displayed in a table and given these factors, the average annual air temperature is calculated. Also in Figure 3.8, the degree of temperature is displayed throughout the day, in hours of sunrise and sunset. Similarly, according to the maximum, minimum and average relative humidity of each month, the humidity group of that month is determined. The following diagram shows the relative humidity and temperature: (figure 3.9). In Figure 3.9 the gray line displays the comfort range, and the temperature and humidity in different months are also shown in the diagram. So taking into account the average annual air temperature and humidity group, the approximate increase zone is obtained for every month. By comparing the average maximum and the average minimum temperature of each month to the comfort zone in that month, the thermal condition of the air is obtained on all days and nights of the month. According to the results obtained from this method, as well as the above diagram which displays the air temperature daily and monthly by coloring temperature difference in different parts of the year, the daily weather conditions in the two months and about 15 days of the cold year, that is below zero degree, which is about 6 percent of the year, and in the optimal quarter meaning about 19 percent of the year, it is between 21 and 27 degrees, and in just four months, only in the middle of the warm day meaning about 13% of the year, it is between 27 and 38 degrees. It is only undesirable during the day, and it will reach the proper temperature at night. The temperature of the air is cool at night for two months of the year and, it is desirable for seven months, so the need to cool the air is necessary only in four months of the year, and it is also necessary during the days, while in seven months of the year, and in five months at night, the air should be warmed up. It is noteworthy that the weather is favorable on summer nights. In other words, the exterior of the building on summer nights can be quite useful.

3.4 Solar Radiation

Solar radiation is one of the most important issues affecting building physics so that the heating energy of the sun can be important in case of penetration into the building or conversion of energy into electricity by solar cells. Of total amount of solar radiation, one-third is reflected in atmospheric conditions and about 20% reaches to the ground surface as radiation, and the rest is received, hitting the main surface, as direct radiation. Generally, solar radiation can be reflected in three forms of direct radiation, dispersed radiation and reflected radiation. The following graph shows the annual sunlight temperature, the base unit being Celsius. In this chart, the state of sunlight throughout the whole year and the total hours of the day in general are analyzed; a small circle on the lines shows the sun position in these hours. The colors from blue to orange mean that it is cold from morning to dusk. They are presented beside the table and the basis of calculating them is in watts per cubic meter, which displays the amount of sunlight. As shown in Figure 3.10, the north direction is displayed by a mark upward and graded. The amount of annual temperature from winter to summer is displayed. At summer annual warmth, the sun's position is relatively vertical, which is almost desired. And this was a point that should be taken into account in the design, which is shown on the spheres displayed in red, and as we go down the color become close to blue which shows the location of the sun in winter. According to solar radiation status charts, we come to a conclusion that on which points in our work we can have the optimal use of sunlight. That is, we could have the best sunlight absorption in winter and the lowest heat absorption in summer in a desirable manner. In fact, conclusions might be made by simulating solar position and the temperature of the sun. Also, Figure 3.11 shows the climate application of the solar radiation situation: (figure 3.11). Figure 3.11 shows the direct solar radiation monthly, which is displayed as a percentage in all hours of the day and night. It shows that 52% of sun radiation is not strong. The yellow lines displayed on the chart show the hours of sunrise and sunset in different months. Figure 3.13 shows sunlight, using Sun software. This chart displays the sun's state in winter. According to this diagram, we find that the red lines show the hot temperature which is above 27 ° C, yellow lines show a comfortable temperature of 18 to 20 degrees, and blue lines show a temperature below 20 degrees. According to this chart, the city of Golbahar is very cold in winter, which is much lower than comfort level, meaning that some useful and efficient suggestions should be applied for making buildings warm. Figure 3.14 shows sunlight in summer, and it also means that the comfort and temperature range is higher in summer, which makes the need for cooling less, and the sun's own position will provide a moderate summer temperature. Given these arrangements, as well as the sun's diagrams, we can understand that winter heating is extremely important. According to Golbahar climate studies, the first proposal for the site was presented.

4. The First Proposed Option

According to the criteria presented in the ideas of the design, the first proposed option was selected after examining its features and its disadvantages. They were investigated in Ladybug software. After examining the micro focus of the original concept in Ladybug software, the shading and solar radiation in summer and winter were investigated, the results of which are shown in Figure 4.1. According to Figure 4.2, at first, the volume stretch was designed without the observance of the East-West directions, the output of which was not suitable for absorbing the sunlight, and also the gardens created very little shadow during summer, which was why the summer sun absorption was very high.

4.1 Shadow Analysis and the Site Solar Diagram

To depict the elements surrounding the building that cause shadowing, analyses can be carried out by generating a version of the solar diagram with respect to the surrounding barriers. This chart shows how the sun results in shading in a year, such as the state of the sun; however, this simulation is based on the proposed building form. In this chart, it is important to note that the amount of sunlight is almost visible in the south on all things. With regard to the chart and the proposed volume of radiation, it can be seen that sunlight is a bit somewhat miles away on this site.

4.2 The Site's Climatic Analysis

With the help of climate software, which is a kind of climatic consultor**,** and given the latitude and longitude of the city of Golbahar and the initial climate data**,** a number of solutions and priorities that can be considered in the design were obtained. The diagram below summarizes the design priorities as a whole and, finally, some other things will be shown by illustration:

The list of Residential Design Guidelines applies specifically to this particular climate, starting with the most important first. The following is a sketch of how this Design Guideline shapes building design: (table 4.1).

4.3 Prioritization Designed by the Climate Software

The first priority that can be into consideration is proposed in the following image. In the suggested strategies to maximally use solar radiation, increasing the number of skylights and glasses on the south side is suggested, of course, with an appropriate overhang to control radiation in the summer. As evidenced by the image, the elongation of the western-eastern building is proposed. The second priority, which is suggested for the area, is the use of double-glazed windows to control the temperature and radiation on the building. The emphasis on using this type of glass is more on the western and northern walls, and the number of opening should be minimized as far as possible. The next issue that is proposed is using the indoor comfort temperature to get comfort in the space to a significant extent, as well as controlling the nighttime temperature inside the space.

5. The Second Suggested Option

Given the analysis of the initial proposed option and the analysis of the problems arising from the energy analysis of the original concept, new alternatives were designed and attempts were made to eliminate the problems of the initially proposed option and minimize the disadvantages and climatic and functional problems in the plan, so the proposed proposal below was selected. After presenting the final concepts, the second proposed volume was analyzed. At this stage, the volume was better than the first stage for shading in summer. Due to the early climate arrangements, the final volume, completed in a structured manner, is simulated in the software, which displays shades between 10:00 a.m. to 15:00 p.m. in summer.

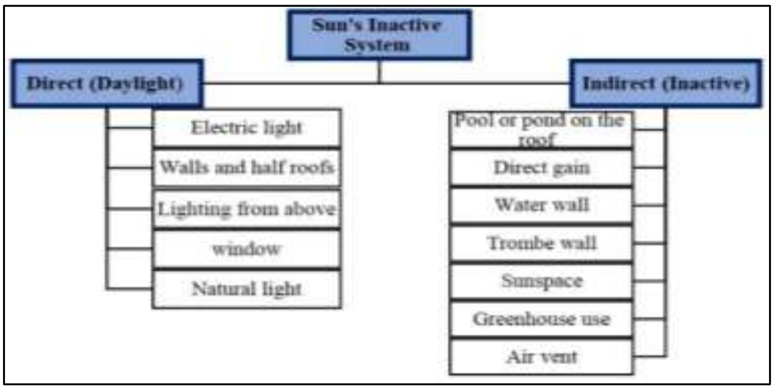


Chart 2.1: Supplying the Building Thermal Requirements out of Sun

Table 2.1: The Three-Tier Design Approach

	Heating	**Cooling**	**Lighting**
Tier 1	Conservation	Heat avoidance	Daylight
Basic Building Design	1. Surface-to-volume ratio 2. Insulation 3. Infiltration	1. Shading 2. Exterior colors 3. Insulation 4. Mass	1. Windows 2. Glass type 3. Interior finishes
Tier 2	Passive solar design	Passive cooling	Daylighting
Natural Energies and Passive Techniques	1. Direct gain 2. Trombe Wall 3. Solar space	1. Evaporative cooling 2. Night-flush cooling 3. Comfort ventilation 4. Cool towers	1. Skylight 2. Clerestories 3. Light shelves
Tier 3	Heating equipment	Cooling equipment	Electric light
Mechanical and Electrical Equipment	1. Furnace 2. Boiler 3. Ducts/Pipes 4. Fuels	1. Refrigeration machine 2. Ducts 3. Geo-exchange	1. Lamps 2. Fixtures 3. Location of fixtures

Chart 2.2: Supplying the Building Thermal Requirements out of Wind

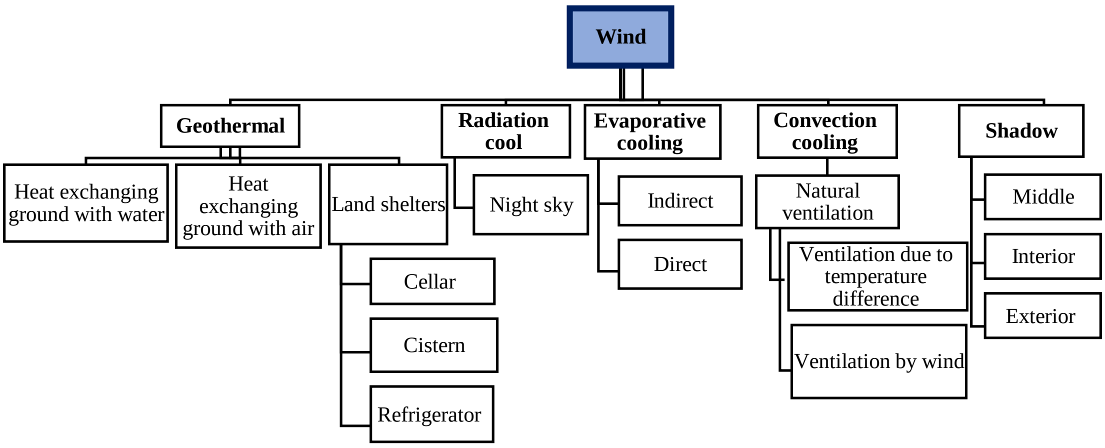


Table 2.2: Golbahar Urban Specifications

New city	**The name of the mother city**	**Distance from mother city (km)**	**Area (ha)**	**Expected population**	**Population in the year 2007 (people)**	**Year of construction of a civil company**	**The Year that the master plan passed**
Golbahar	Mashhad	35	4000	43000	8000	۱۹۹۰	۱۹۹۳

Figure 2.1: Golbahar City

Figure 2.2: Golbahar City

Table 2.3: Climatic Features of Golbahar City (Source: Varesi & Colleagues (2010))

Climate	Dry and cold
Orientation	East to West
Plan type	Dense and compact
Building density	High density with minimal external surface
Building volume	The form should be in a way that reduces its external surface contact with the cold weather outside so that less heat is transferred from inside to outside; therefore, a cubic form should be used
Contact with the land	Often a basement with a short height acting as a thermal insulation
Openings	In order to prevent the heat exchange between the inside and the outside of the buildings, they use a few small openings. If bigger windows are used on the south side, the use of the sunshade is mandatory
Material Types	High thermal capacity and moisture resistance: Concrete
Color of materials	Ranging between dark and bright colors

Table 3.1: Comparison of the Existing Environmental Analysis Tools for Rhino/Grasshopper

Processes		**Analysis Tools**				
		Ladybug	**Heliotrope**	**Geco**	**Gerilla**	**Diva-for Rhino**
Climate Analysis	Analysis	✓	✓			
	Visualization	✓	✓			
Massing/Orientation Study		✓		✓		✓
Daylighting Study		✓		✓		✓
Energy Modeling		✓			✓	✓

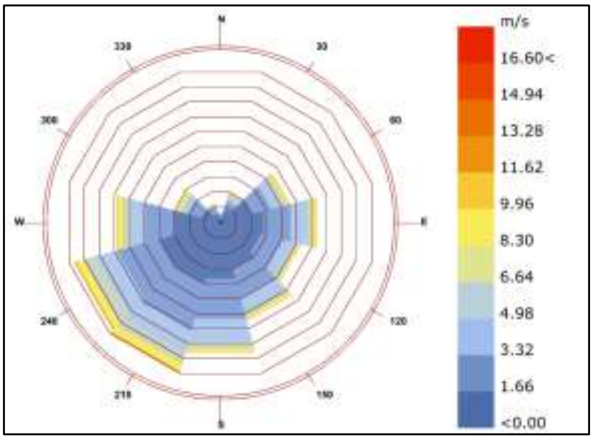


Figure 3.1: Mashhad Wind-Rose Chart for Annual Wind Speed and Direction (Based on Ladybug Software Analysis)

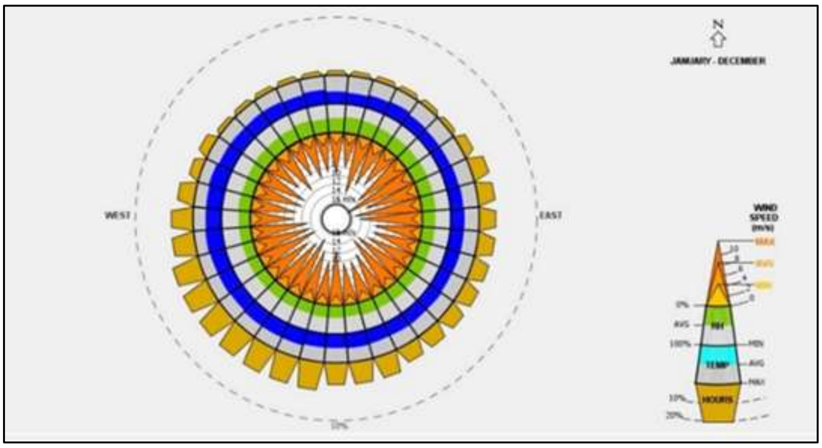


Figure 3.2: Annual Average Velocity of Wind Graph (Based on Climate Software Analysis)

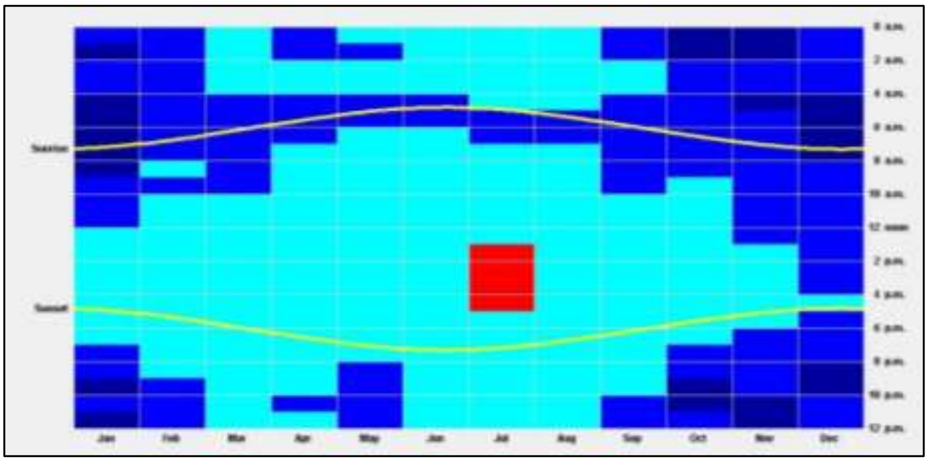


Figure 3.3: Monthly Average Wind Speed Chart (Based on Climate Software Analysis)

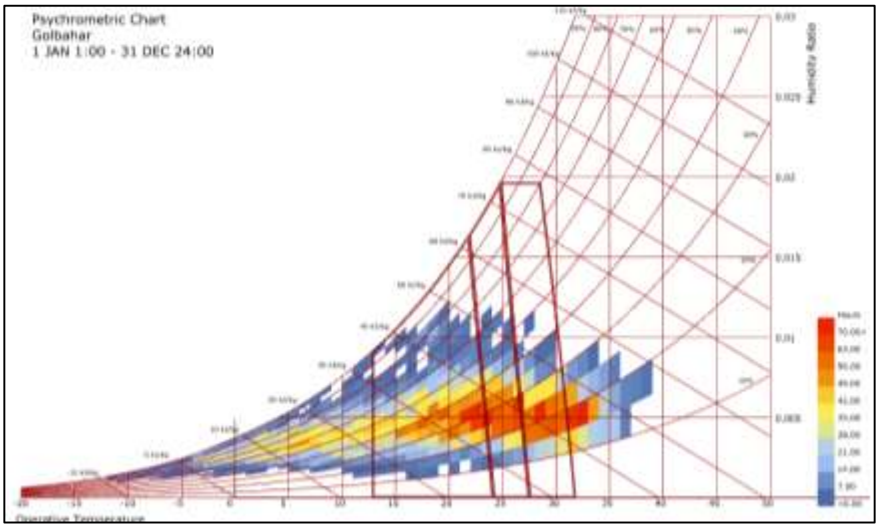


Figure 3.4: Golbahar Psychometric Graph (Based on Ladybug Software Analysis)

Table 3.1`

0 Comfort	**0: 9.634703**
1 Occupant Use of Fans	1: 9.303653
3 Internal Heat Gain	2: 31.678082

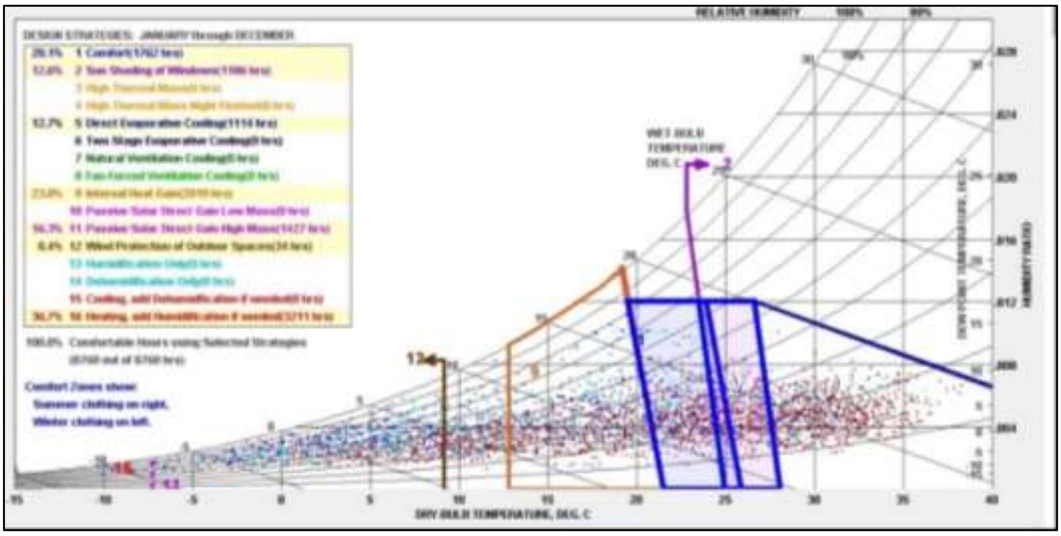
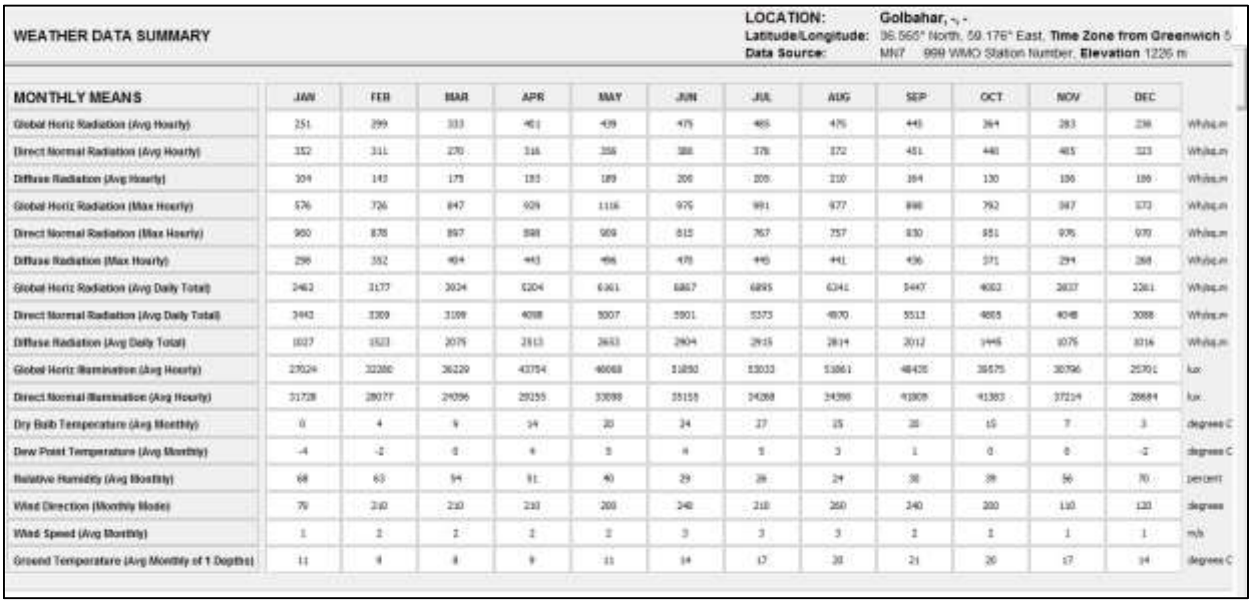


Figure 3.5: Psychometric Diagram Based on Vertical Sunlight (Based on Climate Software Analysis)

Table 3.2: Percentage of Design Factors

20%	**Comfort**
12/6%	**Shadow**
	Thermal mass and night ventilation
12/7%	**Direct Evaporative Cooling**
23%	**Internal load**
16/3%	**Direct use of the sun**
4%	**Wind protection**
36/7%	**Heating and moisture use is required**



WEATHER DATA SUMMARY

LOCATION: Golbahar, -, -
Latitude/Longitude: 36.565° North, 59.176° East, Time Zone from Greenwich 5
Data Source: MN7 999 WMO Station Number, Elevation 1226 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	251	299	333	401	439	475	485	475	445	364	283	238	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	352	311	270	316	356	388	378	372	451	440	485	323	Wh/sq.m
Diffuse Radiation (Avg Hourly)	104	143	175	193	189	206	205	210	164	130	106	100	Wh/sq.m
Global Horiz Radiation (Max Hourly)	576	726	847	929	1116	975	991	977	898	792	587	573	Wh/sq.m
Direct Normal Radiation (Max Hourly)	960	878	897	898	909	815	767	757	830	851	976	970	Wh/sq.m
Diffuse Radiation (Max Hourly)	298	352	404	443	496	478	445	441	436	371	294	268	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2462	3177	3934	5204	6361	6867	6895	6341	5447	4002	2837	2261	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	3442	3309	3109	4098	5007	5501	5373	4870	5513	4805	4048	3088	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1027	1523	2075	2513	2653	2904	2915	2814	2012	1445	1075	1016	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	27024	32280	36229	43754	46068	51850	53033	53861	48435	39575	30796	25701	lux
Direct Normal Illumination (Avg Hourly)	31728	28077	24096	29255	33098	35155	34268	34398	41809	41383	37214	28684	lux
Dry Bulb Temperature (Avg Monthly)	0	4	9	14	20	24	27	25	20	15	7	3	degrees C
Dew Point Temperature (Avg Monthly)	-4	-2	0	4	5	4	5	3	1	0	0	-2	degrees C
Relative Humidity (Avg Monthly)	68	63	54	51	40	29	26	24	30	39	56	70	percent
Wind Direction (Monthly Mode)	70	210	210	210	200	240	210	260	240	200	110	120	degrees
Wind Speed (Avg Monthly)	1	2	2	2	2	3	3	3	2	2	1	1	m/s
Ground Temperature (Avg Monthly of 1 Depths)	11	4	4	9	11	14	17	20	21	20	17	14	degrees C

Figure 3.6: Chart of the Climatic Characteristics of Golbahar (Based on Climate Software Analysis)

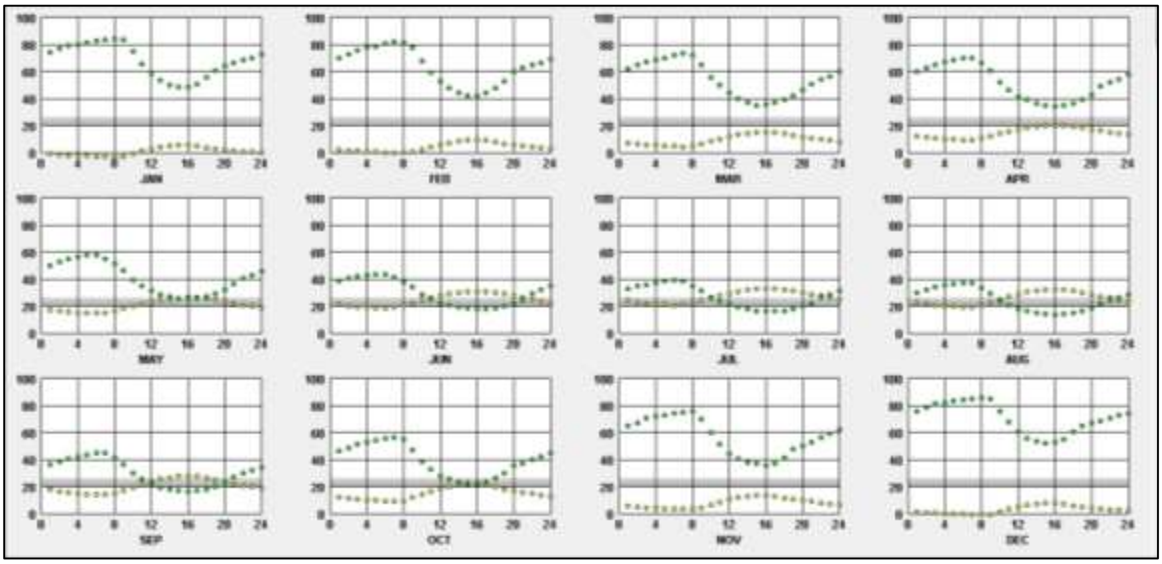


Figure 3.7: Temperature and Relative Humidity Diagram on a Monthly Basis, Relative to Each Other (Based on Climate Software Analysis)

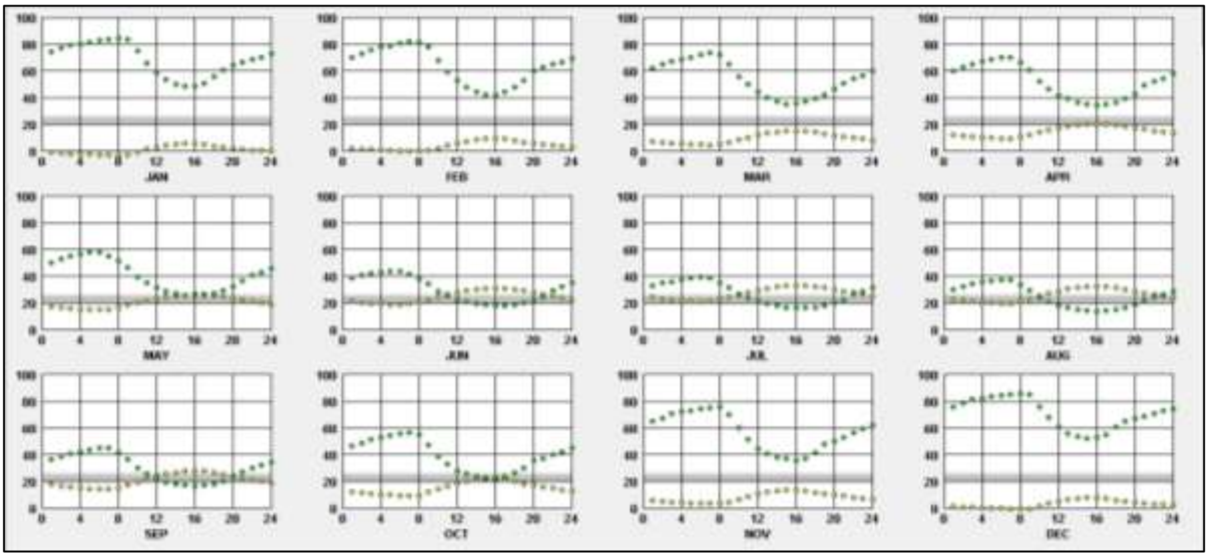


Figure 3.8: Average Monthly Temperature Graph (Based on Climate Software Analysis)

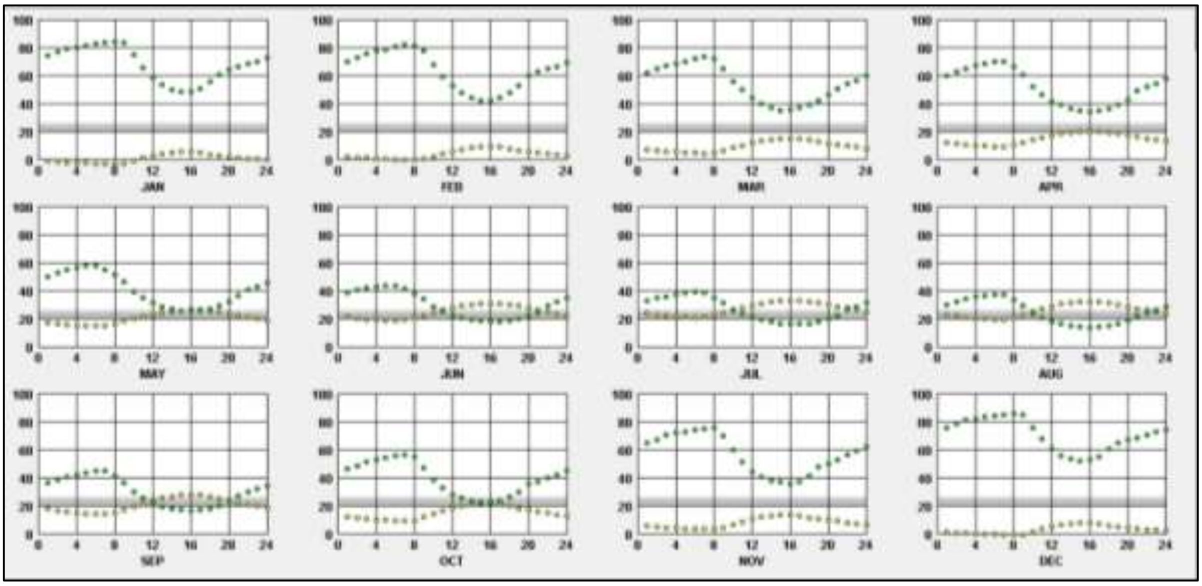


Figure 3.9: Average Monthly Humidity and Temperature Graphs (Based on Climate Software Analysis)

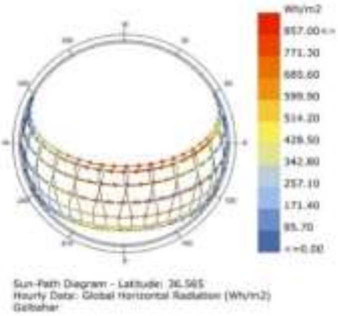


Figure 3.10: The Annual Solar Conveyer Chart of Golbahar City (Based on Climate Software Analysis)

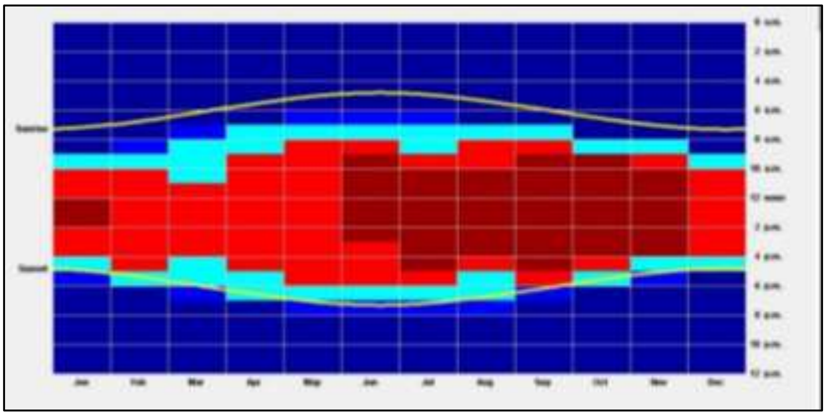


Figure 3.11: Monthly Direct Solar Radiation Diagram (Based on Climate Software Analysis)

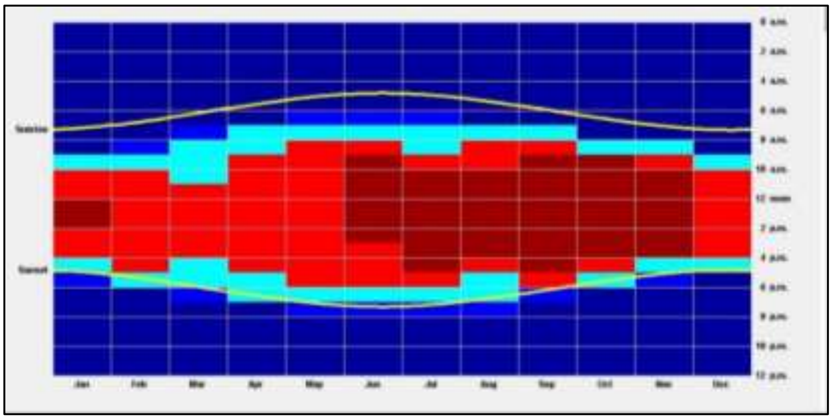


Figure 3.12: Monthly Dispersion of the Solar Radiation Diagram (Based on Climate Software Analysis)

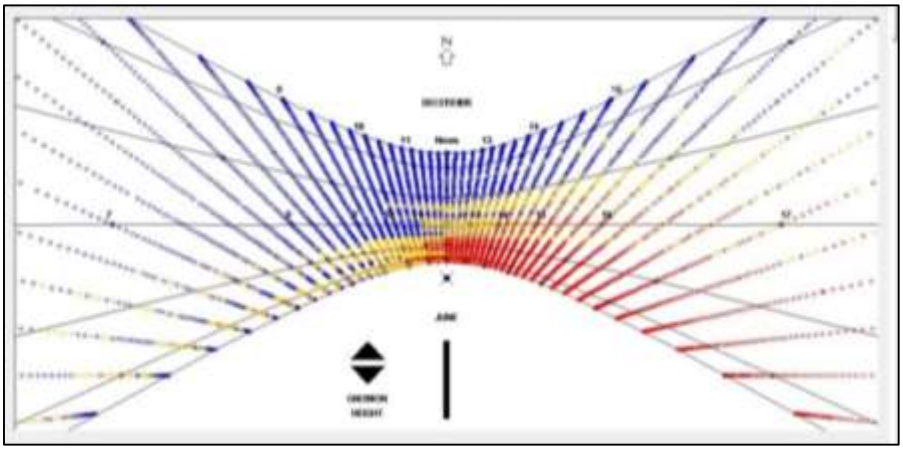


Figure 3.13: Winter Sunlight Pattern Diagram (Based on Climate Software Analysis)

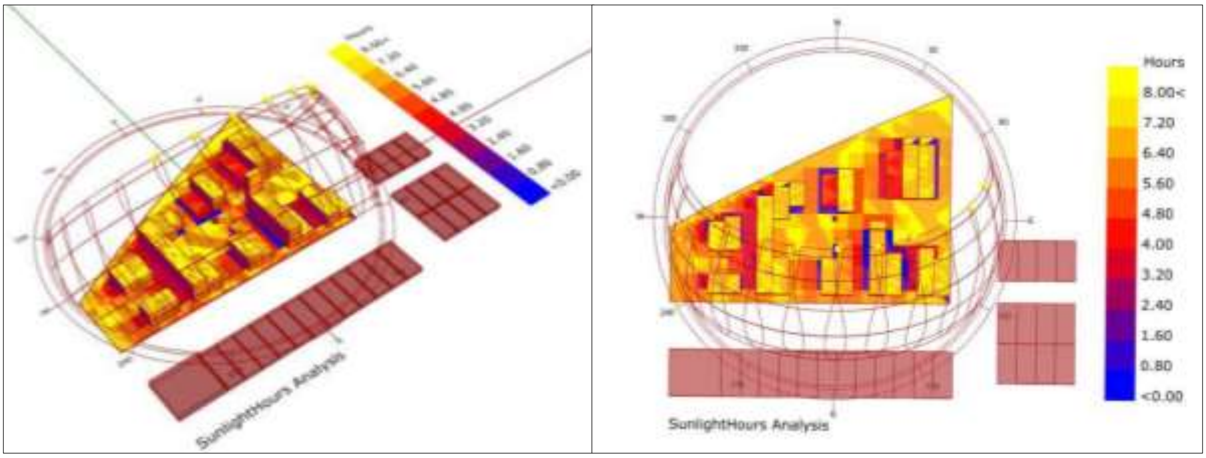


Figure 3.14: The Summer Sunlight Chart (Based on Climate Software Analysis)

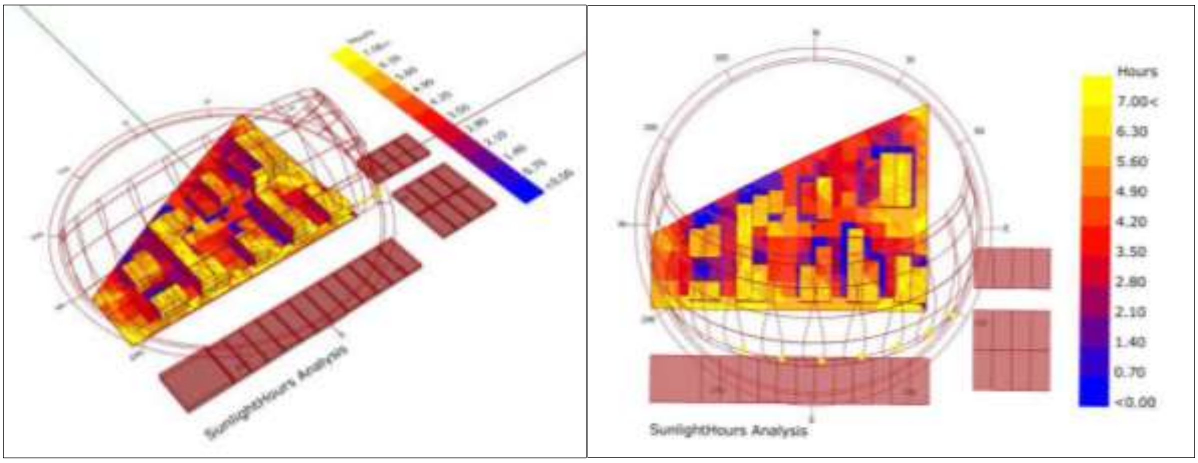


Figure 4.1: The Position of the Sun and the Summer Temperature Ranging between 8 and 14 in the Initial Proposed Building Form (Based on Ladybug Software Analysis)

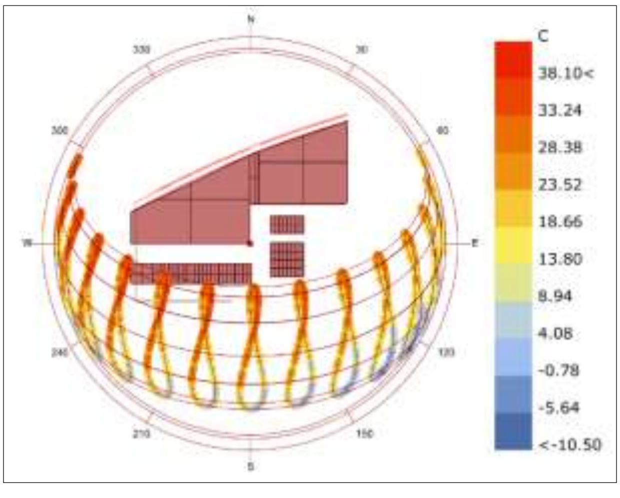


Figure 4.2: The Position of the Sun and the Winter Temperature Ranging between 8 and 14 in the Initial Proposed Building Form (Based on Ladybug Software Analysis)

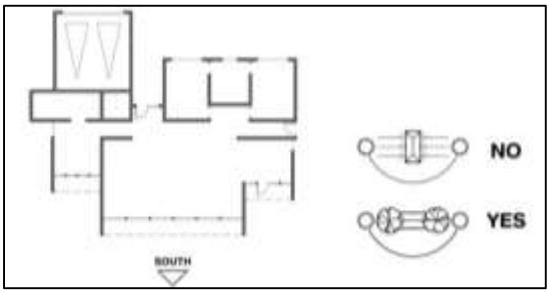


Figure 4.3: The Solar Diagram of the Selected Site (Based on Ladybug Software Analysis)

Table 4.1: Residential Design Guidelines

1	For the passive solar heating, the amount of glasses should be more on the south side to maximize winter sun exposure, but overhangs should be designed to fully produce shade in summer
2	Using double-glazed high-performance low-e glass on the west, north, and east walls of the project, and double-glazed transparent glasses on the southern walls to use maximally the sun radiation.
3	Lower the indoor comfort temperature at night to reduce heating energy consumption (lower thermostat heating setback) (see comfort low criteria)
4	Heat gain from lights, people, and equipment greatly reduces heating needs, so keep home tight and well-insulated (to lower Balance point temperature)
5	Organize the floorplan, so winter sun penetrates into daytime-use spaces with specific functions that is consistent with the solar orientation
6	Traditional passive homes in temperate climates used lightweight construction with slab-on-grade and operable walls and shaded outdoor spaces
7	Sunny wind-protected outdoor spaces can extend living areas in cool weather (seasonal sunrooms, enclosed patios, courtyards, or verandahs)
8	High-Efficiency furnace (at least Energy Star) should prove cost-effective
9	Keep the building small (right-sized) because excessive floor area wastes heating and cooling energy
10	Tiles or slate (even on wood floors) or a stone-faced fireplace provides enough surface mass to store winter daytime solar gain and summer nighttime 'coolth'
11	Good natural ventilation can reduce or eliminate air conditioning in warm weather if windows are well shaded and oriented to prevailing breezes

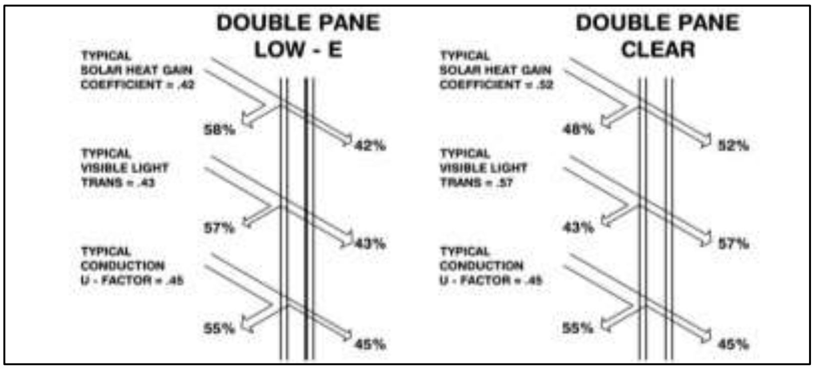


Figure 4.4: Eastern-Western Orientation of the Masses in Golbahar City (Based on Climate Software Analysis)

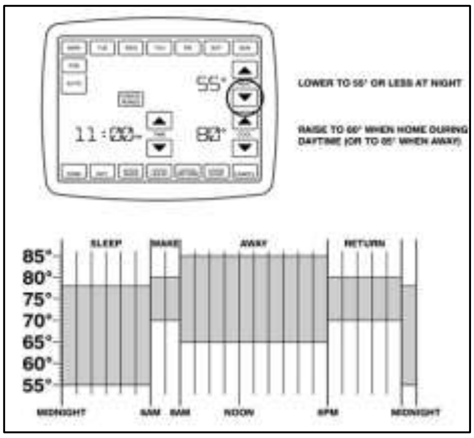


Figure 4.5: Use of Double-glazed Windows (Based on Climate Software Analysis)

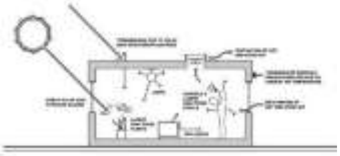
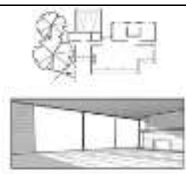
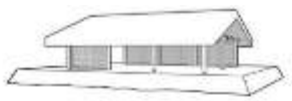
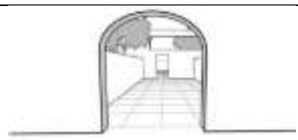
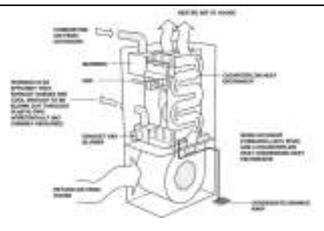
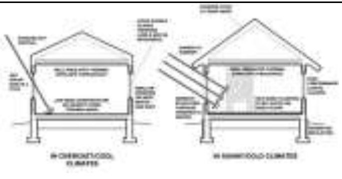
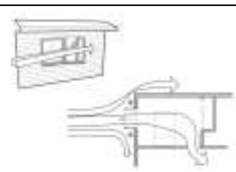
 4- Heat gain from lights, people, and equipment greatly reduces heating needs so keep home tight, well insulated(to lower Balance Point temperature)	 5- Organize floorplane so winter sun penetrates into daytime use spaces with specific functions that coincide with solar orientation
 6-Traditional pasiive homes in temprature climates used light weight construction with slab on grade and operable walls and shaded outdoor spaces	 7- Sunny wind-protected outdoor spaces can extend living areas in cool weather(seasonal sun rooms, enclosed patios, courtyards, or verandahs)
 8-High Efficiency furnace (at least Energy Star) should prove cost effective	 9- Keep the building small(right-sized) because excessive floor area wastes heating and cooling energy
 10- Tiles or slate (even on wood floors) or a stone-faced fireplace provides enough surface mass to store winter daytime solar gain and summer nighttime 'coolth'	 11- Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes

Figure 4.6: Use of the Indoor Comfort Temperature (Based on Climate Software Analysis)

Table 4.2: Prioritization of Design in Golbahar City (Based on Climate Software Analysis)

4. Heat gain from lights, people, and equipment greatly reduces heating needs, so keep home tight and well-insulated (to lower Balance Point temperature)	5. Organize floorplane so winter sun penetrates into daytime-use spaces with specific functions that are consistent with solar orientation
6. Traditional passive homes in temprature climates used light weight construction with slab-on-grade and operable walls and shaded outdoor spaces	7. Sunny wind-protected outdoor spaces can extend living areas in cool weather (seasonal sunrooms, enclosed patios, courtyards, or verandahs)
8. High Efficiency furnace (at least Energy Star) should prove cost effective	9. Keep the building small (right-sized) because excessive floor area wastes heating and cooling energy
10. Tiles or slate (even on wood floors) or a stone-faced fireplace provides enough surface mass to store winter daytime solar gain and summer nighttime 'coolth'	11. Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes

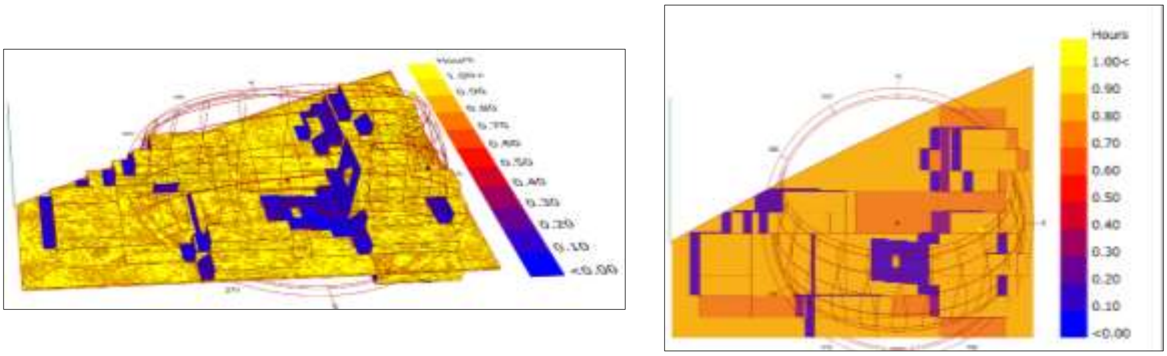


Figure 5.1: Simulation of the Amount of Radiation and Solar Energy on the Surfaces of the Building According to the Adjacency, Shape, and Direction of the Building in Summer at 10 a.m. in the Final Proposal (Based on Ladybug Software Analysis)

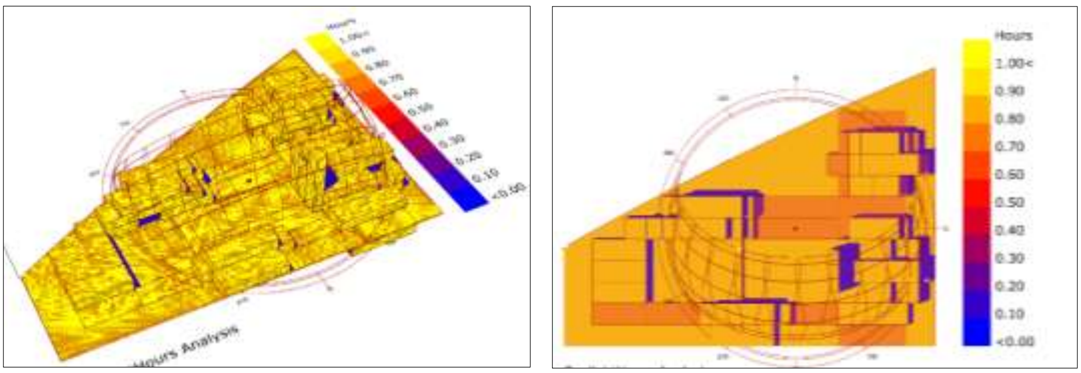


Figure 5.2: Simulation of the Amount of Radiation and Solar Energy on the Surfaces of the Building According to the Adjacency, Shape, and Direction of the Building in Summer at 15 p.m. in the Final Proposal (Based on Ladybug Software Analysis)

Table 6.1: List of Solutions

Ideas	Climatic Strategies
Exterior surface coating	In the outer surface of the building, it is better to use rough texture and dark colors (To absorb as much energy as possible)
Cover surface area	The surface area of the openings is reduced to a minimum. In windows, multi-layered glasses are recommended so that the number of walls will be proportional to the increase in cold intensity. It is concluded that the heating system of the building is very important in considering the architectural issues
Plan	The design of the building should be created in a way that uses the daily cycle of the sun.
Heat storage material	The success of passive solar heating and some of the inactive cooling systems depends heavily on the proper use of heat storage materials. In order for a material to be a good medium for storing heat, it must have a high thermal conductivity and high conductivity coefficient. That's why bricks and concrete are some of the best options (Norbert Leckner (2001)).
Site terms	Buildings, walls, and trees adjacent to a site have an impact on the flow of air in a building.
Prevent high heat	Two main methods to prevent high heat: 1. Avoid sun exposure with glass: Using ceiling hangers, awnings or vegetation cover. 2. Use special glass covers - "special glasses" – that filters out harmful rays of sunlight that hit the glass.
Double-acting shells for heat transfer	When a wall or double-glazed roof is located in front of the sun, the hot air balloon in the middle layer starts to rise. Due to the position of the air vents, this system can be used to provide heat, ventilation or a combination of both.
Selection of materials with high thermal capacity to control heat through the building shell	The thermal storage of building materials and their thermal phase delay are good tools for climatic designers. Therefore, in the design of the building, the thermal reactions of the walls and roof of the house should be according to the position of the sun.
Ventilation	In order to prevent a sudden internal temperature rise and prevent the wind from entering the building, it is recommended to install the controlled inputs in the building.
Shading	-Fixed Shadow: an ideal shadow element blocks the maximum sun's rays. And at the same time, it is still possible to open the window into the breeze. All of these shadows are slightly altered either in the form of a horizontal or vertical blade, or a blended canopy, which is a combination of two primitive examples. -Natural Shadows (Leaf Trees): Before air conditioning was expanded, awnings were used to effectively shade the windows in summer. Awnings are used in many buildings. Live trees like deciduous trees and grape scaffolding are very good canopy devices. They are consistent with annual heat and with seasonal changes, with or without leaves. While shadows that only need to be regulated, it is usually the practice of many landscapes to consider deciduous trees as the best kind of shadows, most of which are in harmony with the year of the heat because of their leaves in the picture The operation has brought about and changed temperature changes. Another advantages of deciduous trees is the low cost, aesthetically pleasing quality, the ability to reduce dullness and to visualize the ability to cool the air through evaporation from the surface of the leaves.

6. Conclusion

There are many factors that determine the best option among static solar heating systems. The climate, type of building, user preferences and cost are some of the seasonal considerations. Often, it's best to use a combination of these systems to meet the needs of a particular problem. In other times, a variety of systems will be better. It is also likely that other good ideas will be invented in this field. However, it turns out that most of the buildings that need to heat up can benefit from a kind of passive heating system. Passive cooling strategies have the greatest potential in hot and dry climates. Just about every cooling technique will work there. In very humid regions, only comfort ventilation will be very helpful. However, many regions that are considered hot and humid are humid for only part of the overheated period. There are often many months that are hot but not humid. In such regions, night flush cooling and night-radiation cooling can be beneficial. Most of the Eastern United States has this moderately humid climate, where a mix of various passive cooling strategies can replace or reduce the need for air-conditioning during much of the summer. However, in every climate, the first and the best strategy for summer comfort is heat avoidance. Depending on the amount of solar and wind radiation, inactive architecture can provide a significant amount of heating and cooling and will not cost much to create the building. Most of the people prefer buildings constructed by inactive architectural design due to comfort and security in terms of pollution. Considering these principles in the context of reconstruction and design is of importance. The primary design is important and the goals that follow the design of the climate in line with the climate conditions are:

• Avoid heat exchange in the outer walls of the building.

• Avoid the influence of cold weather on the interior by reducing the impact of the load on the heat dissipation of the building.

• Utilize solar energy and building heating.

• Protect the building from exposure to hot sunlight and hot air.

Objectives can be achieved with the following measures:

• Forecast of compact and dense plans.

• More use of shared walls and the creation of interconnected and dense textures in building collections.

• Building materials with high heat capacity and moisture resistant (brick, concrete, and rock) are suitable.

• The coating color of the outer surfaces of the building is usually dark, and the height of the interior spaces is low.

• Use of suitable thermal insulations in external walls and roofs.

• It is necessary to consider moisture insulation in the floor-to-ground connection.

• Forecasting fewer important spaces such as warehouses, as thermal insulation on the walls of the building.

• Avoid large windows, especially in the northern views.

• Use of wooden valves or movable insulation networks behind the windows.

• Predict the proper form to reduce the impact of the wind on buildings.

• Minimize the number of entrance doors against the wind and install the main entrance on the side back to the wind.

• Full protection of the main entrance to the wind.

• The use of integrated and insulated doors in windshields.

• Sealing all doors, windows, and openings. Installing the vent or grille of thermal insulation behind the windows. Using inside curtains.

• Paying attention to the prevailing winter winds for determining the direction of building construction.

• Establishing the building where the solar energy in cold weather is maximized.

• Establishing the building where the solar energy in hot hours is minimized.

• Orientation according to the angle of the sun (45 ° south-east to 20 ° southwest).

• The building should be expanded to the east-west axis.

• Develop a plan that allows the penetration of the sun into public and indoor spaces.

• Pay attention to the depth of the interior spaces and the location of the windows in the view, so that in winter sunlight penetrates into the interior.

• Predicting the location of the porch or external spaces where the sun shines.

• Creating a complex area, park and fountain is very suitable for this region.

Climatic strategies are one of the things that need to be use in this project. The following is a list of solutions: (table 6.1)

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