Establishment of Optimum Designing Pattern in Buildings Roofs Shapes to Achieve Heating Energy Efficiency

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Abstract
Contemporarily, energy demand is considered as a vital economic characteristic; hence, an increasing trend in energy price comes to existence due to energy resources limitation and costs in extraction and exploitation. Accordingly, there are methods to decrease energy demand and improve energy consuming techniques. To serve a sample, maximizing solar energy absorbed through roof covering is one of the impressive ways to fell energy consumption off. Therefore, it is essential to pay more heed on energy efficient design in building elements. Consequently, the paper intends to discuss on roof covering forms while comparing them in terms of solar radiation gain. The research method is based upon modeling and simulation. Modeled and analysed four roof coverings (flat roof, domed roof, pitched roof (30°-60°), pitched roof 45°), the result shows that although the flat shape roof appears in an appropriate thermal performance, (30°-60°) pitched covering is regarded as the optimum form in Tehran cold and moderate area, Velenjak.

Keywords: Energy; Energy Efficiency; Roof Covering; Solar Architecture; Roof Types.

1. Introduction
Presently, energy supplement is considered as a pivotal economic and political characteristic in government; so that, an increasing trend in energy price appears in Iran due to energy resources limitation and costs in extraction and exploitation. From the year 1983 to 1997, there was an annual 13 percent growth in energy cost in Iran representing the importance of topic to address with. Therefore, parallel to efforts made to tackle the energy upgrading costs, improving energy efficiency and conservation in buildings are considered as main solutions to deal with the following problem [1]. As an investment, saving energy leads to reduce public expenses and costs which seem to be affordable enough in energy matters.

The rate of energy consuming in buildings depends on various factors including: 1) Air exchange and infiltration. 2) Temperature differences between conditioned space and environment in different times of a year. 3) Non-paid energy intake in time periods in a year and 4) Surface heat transfer coefficient in building envelope. So the exterior covering namely roofs plays an important role in buildings’ heat transfer rate regarded as main elements of constructions. Roof coverings compose a large area of buildings envelope; accordingly, it has a major impact on energy consumption and thermal comfort in buildings. Thus, roof geometry including domed, flat and pitched roofs are main criteria to determine the thermal performance in buildings; so that, aforementioned parts are extensively utilized in the building industry. Noteworthily, there is a large use of domed and angled roofs construction in Middle East architecture [2].

2. Energy, Climatic Architecture and Roofs
2.1. Building Energy. Contemporarily, there is an increasing demand in energy consuming on one hand and fossil resource constraints on the other hand leading to environment contamination caused by the fuel burning.
Moreover, acid rain, increased carbon dioxide and the greenhouse effect, global warming and polar ice melting are further dire consequences of fossil fuels consuming. Therefore, the altering of energy resources and consuming methods will be an essential need in upcoming future. Here are solutions to tackle with the problem:

2.1.1. Natural Resources conservation and optimum consuming. To achieve the goal, there are some solutions:

- Minimizing need and demand for energy.
- Equipping buildings by energy-efficiency design and technology.
- Coordination of Energy Efficiency and Renewable Energy [3].

2.1.2.2. Utilization of Clean and Renewable Energy. Presently, utilization of renewable energy resources is essential why it is not possible to meet world energy demand through fossil energy resources (New energy organization, 2008, pp 4-6). In comparison with nuclear energy technology, the use of renewable energy needs simply technology to work with. Moreover, clean energy resources do not spell serious environmental disaster.

2.1.2.3. Optimum Use of Heating Energy. There are basically two distinct approaches to the solar heating of buildings: active and passive.

In general, active systems employ hardware and mechanical equipment to collect and transport heat. Flat plate or focusing collector (usually mounted on the roof of the building) and a separate heat storage unit (rock bin, water tank or combination of two) are often major elements of the system. Water or air pumped through the collector, absorbs heat and transports it into the storage unit. This heat is then supplied from the storage unit to the spaces in a building by a completely mechanical distribution system [4].

Passive systems: the following systems rely on a coordinated approach in buildings design in which different elements of buildings including windows, walls and floors convey different function. There are three types of approach to get the system. 1) Direct gain, 2) Thermal storage wall and 3) Sunspace [5]. Through the mentioned system, elements of building simultaneously meet all architecture, energy and structure needs in a construction.

2.1.2.4. The Essence of Energy Efficiency Use. However fossil fuels meet the energy demand in latter decades, there is an increasing trend in energy price and urban pollution which results significant changes in the energy consuming policies of the world to prove the intelligence of ultimate consumer to save energy. There are several ways and methods to conserve the energy. One the most effective ones is to have appropriate architectural design in urban space and residential units (Nielsen, 2010, pp. 10-12). The design relies on endemic energy resources and buildings, optimum using the energy, accustomed to environmental and climatic condition.

The buildings use solar energy; there are two types of constructions (19 topics National Building Regulations, 2010, pp 17 -18):

- Buildings with possibility in use of solar energy.
- Buildings with limitation in use of solar energy.

Comparing to other industrialized countries, there are a large range of nonrenewable energy resources in Iran but more important, they are not permanent further ones while decreasing in amount. Hence, it is absolutely necessary to remove the concern about the issue. In first glance, it would be better to use renewable energy resources mainly solar one. To achieve the goal, it is essential to have solar architecture adapting to climate zone in building design as in traditional Iranian architecture. There are strategies to do so:

- Reducing building heat loss over winter through keeping the heat in and cold out.
- The use of solar energy through desirable design serving as east-west orientation of the building.
- Reducing wind effect in heat loss.
- Taking advantage of the daily fluctuations of air temperature.

2.2. Roof. It is defined as the space settled between ceiling area and floor. Since the edges of the building’s roofs are formed by the overhead level, the final shape of the element is defined by form and size of overhead surface and height over ground floor.

The shape of roof interior space displays the system structure while bearing the over floor and roof area. Moreover, the control of form, color, texture and roof shape improve acoustical qualities of living space (D. K. Ching, 1988 , pp. 130-134). Hence, roof element is the most effective one against climatic condition. Factors such as sun radiation and snowfall mostly affect roof in comparison to other buildings elements.

2.2.1. Roof Roles. Roof plays a protecting role in buildings namely sun protection, heating storage and evaporative cooling.

2.2.2. Sun Protection. In buildings, the temperature of roofs increases through solar radiation absorption in surface. So, final roof transfers heating into interior, exterior and sky dome. The increase of surface temperature up to ambient temperature depends on solar
2.2.3. Heating Storage. The sunlight absorbed by the mass (including wall, partition, floor and roof) is converted to thermal heat and then transferred into living space. The process causes interior temperature to be steady.

2.2.4. Evaporative Cooling. When sweat evaporates from the skin, a large amount of heat is required. This heat of vaporization is drawn from the skin, which is cooled in the process. This sensible heat in the skin is turned into the latent heat of the water vapor.

As water evaporates, the air next to the skin becomes humid and eventually even saturated. The moisture in the air will then inhibit further evaporation. Thus, either air motion to remove this moist air or very dry air is required to make evaporative cooling efficient. Buildings can also be cooled by evaporation. Water sprayed on the roof can dramatically reduce its temperature. In dry climates, air entering buildings can be cooled with water sprays (Leckner, 1979, p39).

2.2.5. Roofing and Air Temperature Control. Directly exposed to climate change, roof is a building element. There are thermal exchange between roof and ambient temperature including: 1) Heating ignorance 2) Heating absorption 3) Solar reflectance (Brown and D.K., 2010, p.221). If no suitable alternative method, all changes transfer into inner space causing to waste of energy.

2.2.6. Design Solution and Roofing Envelop. There are 3 categorized ways to optimum design roof:

1) Building envelope design based on separating building interior space from outside through thermal resistance (thermal insulating).

2) Considering building reaction time (Thermal mass).

3) Building envelope design as a thermal channel to absorb, transfer and distribute energy.

Unlike two first method, building envelop plays an important role to increase heating energy transfer in whole building (Nilson, 2010, pp. 98-100). In general, there are some items to appropriately design roof building envelop: Air conditioning, lower floor height in a building, desirable architectural design to protect building roof from rainfall.

2.2.7. Roof Types. Different types of buildings roof shape facing different climatic condition result in various thermal behaviour. To choosing the right form of the roofs, it is necessary to following considerations:

- Protection against exposure to solar radiation to decrease solar gain.
- Air movement across living space to promote cooling process.
- Rainfall protection.

2.2.7 A. Simple (Uniformed) Roof. There are 3 types of simple roof in building: Flat roof, pitched roof and arched one:

- **Flat Roof:** Material and colour are effective factors in flat roof to receive solar energy on surface. Moreover, to have more efficient thermal behaviour in this type, it is necessary to have ventilation in building.

- **Pitched Roof:** Depending on the angle and direction of roof slope, the covering gains different rates of solar radiation. Pitched, arched and domed roof adjust heating gain through solar radiation why small parts of the roof surface is exposed to the sun.

- **Arched (Domed) Roof:** Opposite the flat roof, a large area of arched covering will see shadow over a day. Making use of domed roof cause to increase roof covering area so that in heating transfer process, roof area increase results in thermal exchange and gradual heat loss which lead heating load reducing in day time and restore and return energy loss at night (Nylson, 2006, pp55-56) Soon all three mentioned roofs composed of one layer shell, all is called simple roof.

2.2.7 B. Composite Roof. Roof composed multilayer structure is named composite roof.

Fig. 1. Different types of roofs design, by Nilson, 2010, p54.
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- **Double skinned roof**: There are some ample samples of previous architecture using the method including attic and doubled layer dome. While presently; it is used as false ceiling in flat roofs (Kasmayi, 2003, p.45).The roof is constructed from two layers and there is an air gap between roof and ceiling.

- **Pond roof**: In this roof-pond system, water is stored in black plastic bags on a metal deck roof, and during a winter day the sun heats the water bags. The heat is quickly conducted down and radiated from the ceiling into the living space. At night, movable insulation covers the water to keep the heat from being lost to the night sky. This concept is similar to the trombe wall except that in this case we have a thermal-storage roof (Leckner, 1979, p166).

- **Green roof**: The roof utilization leads to replace destroyed urban landscape in buildings, to improve local microclimate, to stabilize indoor temperature and to reduce heat transfer through roof covering. Roof covering elements are:
  1) Plants, 2) Infrastructure, 3) Waterproof layer, 4) Insulation and 5) Roof structure [3].

  Totally, there are various solutions to reduce energy loss through roof covering:
  1. Appropriate building orientation, roof slope, roof area which influence the rate of solar radiation gain.
  2. Bright colour in final covering to reduce solar radiation gain.
  3. Roof shading to reduce solar radiation gain.

3. Methodology.

3.1. **State of Issue.** Studying on endemic buildings displays that preceding types constructed base on climatic design principles leads to optimum use energy. Considering to different uses and capabilities of vernacular architecture, there is an effort in space compartments design to be specifically situated in place in different times of a day which provides users with maximum thermal comfort. Moreover, energy crisis is the most critical concern, with which many are dealing so that it is definitely worldwide problems to supply energy demand security and durability (Ahmadpour, 2009, p.34). To promptly achieve the goal, it is highly recommended to increase energy efficiency which absolutely is environment friendly. Talking about energy, there are two topics to focus on: Heat loss and heat gain. The paper intends to firstly describe design methods in cold and dry climatic zone which there is a wide rate of fossil fuel use in and secondly Study on design methods reducing energy loss which lead to decreasing energy use, environmental pollution and regional global warming.

On the other hand, efficient design methods, through which non-renewable energy resources are made use of, should be accurate so that they include all, building compartments and elements specifically roof and building final covering. Accordingly, roof element plays an important role to decrease energy consumption portion which lead to energy efficiency to appear in whole construction design. Ultimately, the main issue is to know how roof element affects the rate of solar energy absorption and which types of roof have more conclusive role in energy efficiency.

3.2. **Significance of Issue.** Considering to increasing demand of fossil fuels to meet heating, cooling and ventilation needs which depend on non-renewable resources, there is an extreme necessity to optimize energy consuming. Moreover; the consumption of renewable and non-renewable resources conveys environmental dire consequences which it is not possible for ecosystem to be easily omitted. While energy provision and consumption lead to social and environmental results, according to high-level of construction energy consuming portion, there is an essential need to tackle the problem through efficient solutions.

3.3. **Research Goals.** Presently, energy is considered as an economic indicator. Excessively, to consume in fuels and energy resources reduction result in growing cost related to mining and exploitation. So that many industrial and developed countries apply saving energy methods to compensate financial and economic problems related to. Furthermore, energy efficient design in building and its elements specifically roofs design plays an effective role to decline the rate of energy use in a construction. Subsequently, there are some purposes to increase energy efficiency:

  1. Preserving energy resource for further generation.
  2. Performing appropriate culture to use energy and fairly contributing energy.
  3. Saving money.
  4. Reducing environmental contaminants.

3.4. **Research Questions.** 1. Is there any relation between roof shape and energy consumption rate? If yes, what it is? 2. How is it possible to reduce the rate of energy consumption in winter through desirable design and selecting the optimum roof shape?

3.5. **Research Method.** Research approach is simulation and modeling and applied techniques are numerical-comparative ones according to case study selection [6]. Since climatic condition influential impact on the rate of direct solar gain, Velenjak area is considered as the site to study on while settled on north of
Tehran, mountainous climatic zone.

3.6. Case Study Selection. According to roof shape diversity in Iran, the paper intends to study on more common roofs constructed in country: Hence, there are four types including: 1. Flat roof; 2. Domed roof; 3. Pitched roof: 30°-60°; 4. Pitched roof: 45°.

Each type is separately simulated in all months of a year in Ecotect and EnergyPlus software and the result is illustrated on four days of summer and winter solstices — spring and fall equinoxes (March 21th, July 21th, September 21th and 21th December) in a final graph to be easily compared.

4. Simulation Process and Data Analysis

4.1. Simulation Process and Data Analysis in Ecotech Software. To design the models in software, there is a cube (20*20meter) which is same in all size, material and place which are simulated. The only difference in all modeling is the roof shape supposed to be analyzed. Previously mentioned, there are four types of building covering: 1) Domed roof, 2) pitched roof with 30°-60° angle, 3) pitched roof with 45° angle, 4) Flat roof.

To thermally compare 4 types of ceiling, the models analyzed in four days of summer and winter solstice—spring and fall equinoxes (March 21th, July 21th, September 21th and 21 December). To sufficiently analyze data in Ecotech software, the date, 21th September is considered as the simulation time in software.

4.1.1. Domed Roof Modeling in September 22th

In this case, sun exactly rises from east and sets through the west while there is the most radiation gain through the south side of dome and in an order, in comparison to south-east and south-west, there is a decline in rate of solar gain. East and west both convey a same function of solar gain whereas north-east and north-west gain the least rate of solar radiation. Ultimately, lying in shadow, north side absorbs low rate of energy at all. Showing in concise, the rate of solar energy absorption in domed roof follows subsequent order:

North< North-east = North-west< West=East < South-east=South-west< South

4.1.2. Flat Roof Modeling in September 22th

Unlike domed and pitched roofs which definitely face shadow in a side, flat type roofs are always steadily subjected to solar radiation. Undoubtedly, whether there is inappropriate insulating, all roof surfaces absorb solar radiation over a day or lose energy overnight time.

4.1.3. Pitched Roof Modeling in September 22th (30°-60°). On 20th of March, Sun exactly rises from east and sets through the west; So that, northern side lies on shadow fall (displayed in blue colour) and southern side get maximum solar radiation (displayed in yellow colour). On September 22th, according to cold climate and less solar absorption, energy rate absorbed in west side is as same as the rate in east part. The rate of solar energy absorption in flat roof follows subsequent order:

North< West=East < South
Fig. 4. Different views of pitched roof (30° - 60°) in September 22th, by authors.

Fig. 5. Different views of pitched roof (45°) in September 22th, by authors.

4.1.4. Pitched Roof Modeling in September 22th (45°). In the paper, it is supposed to have an angled roof facing south side. In another word, the roof slope is from north to south direction. While in roof angle 45°, the main side is from east side to west since most roofs designed in Tehran shapes as same as following form.

In mentioned model, east and southern sides gain more energy in comparison to west part and ultimately, the part located in north side absorbs the least energy. So, the rate of solar energy absorption in roof follows subsequent order: South≥East>West>North.

4.2. Simulation Process and Data Analysis in Energyplus Software

To appropriately analyze data in software, undoubtedly, there is an essence to have analysis on data output in graph format. Analysis data are in two forms. Data analysis based on watt or W/m² (watt per square meter). It means to calculate the rate of energy, it is necessary to have energy gained through all building surface based on watt or the rate energy obtained (watt) per m² (which means the area of the building is an effective parameter.)

Here are charts to analyze data for all types of roofs.

4.2.1. Chart Comparison and Data Analysis.

Table 1. Roof comparison in direct and indirect energy gain over a year (all types)-Unit: Watt

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Solar Incident (w) Dome</td>
<td>98.2</td>
<td>35.65</td>
<td>70.8</td>
<td>38.37</td>
<td>102.09</td>
<td>104.06</td>
<td>117.36</td>
<td>145.28</td>
<td>159.61</td>
<td>136.98</td>
<td>124.69</td>
<td>108.57</td>
</tr>
<tr>
<td>Surface Solar Incident (w) Flat</td>
<td>91.0</td>
<td>17.34</td>
<td>68.0</td>
<td>63.73</td>
<td>107.8</td>
<td>103.58</td>
<td>122.36</td>
<td>145.09</td>
<td>128.87</td>
<td>129.68</td>
<td>157.82</td>
<td>155.16</td>
</tr>
<tr>
<td>Surface Solar Incident (w) Slope 60</td>
<td>69.5</td>
<td>87.18</td>
<td>80.2</td>
<td>88.31</td>
<td>120.6</td>
<td>122.76</td>
<td>157.2</td>
<td>127.9</td>
<td>155.7</td>
<td>138.2</td>
<td>160.1</td>
<td>91.4</td>
</tr>
<tr>
<td>Surface Solar Incident (w) Slope 45</td>
<td>103.6</td>
<td>14.12</td>
<td>91.4</td>
<td>64.27</td>
<td>124.9</td>
<td>126.3</td>
<td>153.2</td>
<td>176.9</td>
<td>159.1</td>
<td>146.1</td>
<td>141.0</td>
<td>104.2</td>
</tr>
</tbody>
</table>

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**Figure 6.** Roof comparison in direct and indirect energy gain over a year (all types)-Unit: Watt

**Table 2.** Roof comparison in direct and indirect energy gain over a year (all types)-Unit: W/m²

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Solar Incident (w/m²) Dome</strong></td>
<td>113,818,9</td>
<td>150,130,7</td>
<td>197,940,7</td>
<td>239,561,6</td>
<td>283,817,7</td>
<td>311,861,6</td>
<td>284,563,2</td>
<td>279,809,6</td>
<td>243,584,5</td>
<td>179,902,2</td>
<td>145,905,5</td>
<td>106,015,9</td>
</tr>
<tr>
<td><strong>Surface Solar Incident (w/m²) Flat</strong></td>
<td>127,542,4</td>
<td>172,260,3</td>
<td>229,275</td>
<td>267,896,5</td>
<td>229,275</td>
<td>267,896,5</td>
<td>229,275</td>
<td>267,896,5</td>
<td>229,275</td>
<td>267,896,5</td>
<td>229,275</td>
<td>267,896,5</td>
</tr>
<tr>
<td><strong>Surface Solar Incident (w/m²) Slope 60</strong></td>
<td>115,105</td>
<td>146,055,3</td>
<td>183,013,5</td>
<td>218,546,5</td>
<td>254,982,2</td>
<td>278,584,4</td>
<td>252,000,6</td>
<td>221,411,9</td>
<td>171,002,3</td>
<td>144,115,9</td>
<td>112,935</td>
<td></td>
</tr>
<tr>
<td><strong>Surface Solar Incident (w/m²) Slope 45</strong></td>
<td>111,422,5</td>
<td>141,268,9</td>
<td>183,268,5</td>
<td>208,517,7</td>
<td>254,982,2</td>
<td>278,584,4</td>
<td>252,000,6</td>
<td>221,411,9</td>
<td>171,002,3</td>
<td>144,115,9</td>
<td>112,935</td>
<td></td>
</tr>
</tbody>
</table>

http://ccaasmag.org/ARCH
According to the graph and tables, whether energy absorption unit is watt, energy rate is calculated based on total area; so that the more roof area is, the more covering absorbs energy. Calculating total area, roofs area is:

Flat roof area: 400 m²
Domed roof area: 511/81 m²
Pitched roof (30° -60°): 604/554 m²
Pitched roof 45°: 634/038 m²

So the rate of energy absorption in buildings covering over different months is: Flat roof < Domed roof < Pitched roof (30°-60°) < Pitched roof (45°)

On the contrary, when calculating energy absorption based on watt per square meter (W/ m²), the rate of a meter energy absorption in an area equaling 1m² in roof surface subsequently, the result is vice versa. It means that calculating base on one square meter area causes total flat roofs to gain more energy over a year. In cold months including December, January and February, according to shading parts in domes, the rate of energy gain decrease. The rate of solar radiation in 30-60 pitched roof is more comparing to domes (although the area of 30-60 pitched roof is more than domed roof, the role of shading in domes plays more effective role in radiation gain) . Totally, owing to maximum area in 45° angled roof, the less energy absorption happens in aforementioned type. Based on w/m² unit, there is following relation in process:

The rate of solar radiation gain in December, January and February:

Pitched roof (45°) < Domed roof < Pitched roof (30°-60°) < Flat roof

The rate of solar radiation gain in November and March:

Pitched roof (30°-60°) < Pitched roof (45°) < Domed roof < Flat roof

The rate of solar radiation gain in April, June, July, August, September and October:

Pitched roof (45°) < Pitched roof (30°-60°) < Domed roof < Flat roof

To properly compare the roofs, it is recommended to have a comparison on energy gain in solstice and equinox days. The graph displays that solar gain in flat roof (illustrated in violent) is completely more than dome (illustrated in blue) receiving less solar radiation gain comparing to (30°-60°) angled roof (illustrated in green). Meanwhile, 45° pitched roof (illustrated in red) receives the least rate of energy in these days. Noteworthy, it is same energy gain in pitched roofs only differing on June, 21th. To ultimately conclude, there is following numerical relation in terms of solar energy absorption in solstice and equinoxes days: Pitched roof (45°) < Pitched roof (30°-60°) < Domed roof < Flat roof

Figure 7. Roof comparison in direct and indirect energy gain over a year (all types)-Unit: W/m²
Table 3. Roof comparison in direct and indirect energy gain over 4 days: Winter and summer solstices –spring and fall

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>20 March</th>
<th>21 June</th>
<th>22 September</th>
<th>21 December</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Solar Incident (w/m²) Dome</strong></td>
<td>203,568.3</td>
<td>312,686.6</td>
<td>232,936.2</td>
<td>103,375.1</td>
</tr>
<tr>
<td><strong>Surface Solar Incident (w/m²) Flat</strong></td>
<td>235,781.2</td>
<td>364,115.9</td>
<td>269,991.2</td>
<td>114,684.9</td>
</tr>
<tr>
<td><strong>Surface Solar Incident (w/m²) Slope 60</strong></td>
<td>187,639.8</td>
<td>286,387</td>
<td>214,142.5</td>
<td>106,278.7</td>
</tr>
<tr>
<td><strong>Surface Solar Incident (w/m²) Slope 45</strong></td>
<td>187,936.6</td>
<td>278,982.4</td>
<td>214,448.9</td>
<td>101,567.1</td>
</tr>
</tbody>
</table>

Figure 8. Roof comparison in direct and indirect energy gain over 4 days: Winter and summer solstices –spring and fall equinoxes.

5. Conclusion
To come to a consequence, it would be better to have a short look on roofs solar radiation gain rate in coldest days in a year (December, January and February). Consequently, the best choice would be (30º-60º) pitched roof. According to solar energy gain table based on w/m² unit; flat roof covering receives the most rate of solar gain while spontaneously has the most solar rate gain in summer which appears in a negative point. Moreover, locating in Velenjak site, where there is a large amount of rainfall in Tehran, undoubtedly, it is highly recommended to have pitched roof chosen as an optimum choice in the vicinity. Furthermore, designing roof form in cold climatic zone, the less area compass the roof, the more efficient thermal behavior appears in building envelope. Moreover, following reasons verify 30 º-60 º roof selections as the most appropriate one comparing to other ones building coverings:

1. The attic locating between pitched roof and interior flat covering thermally acts as a buffer space.
2. Consequently, attic plays role as a buffer space to reduce the rate of heat loss resulting in energy saving in building.
3. Aesthetically, 30º-60º angled roof performs an appropriately architectural covering in building form.
References