RESEARCH ARTICLE OPEN ACCESS

Integrated Green Roofs System and its Role of Achieving Sustainability in Residential Buildings in Urban Area in Athens, Greece and Famagusta, North Cyprus

Seyed Mehran shahidipour
Department of architecture Eastern Mediterranean University (EMU), Gazimagusa, North Cyprus via Mersin 10, Turkey

Abstract
In this paper, the characteristics and importance of the green roof in urban area would investigate in some residential buildings in Athens, Greece and then, some strategies give to integrate green roof in residential buildings in Famagusta, north Cyprus due to the importance of energy saving and thermal comfort in residential buildings.

These days, sustainable architecture is spreading around the world. Therefore, Sustainable architecture has important role in design buildings and urban design due to high amount of energy use and global warming around the world. There are different methods in sustainable design and one of them that has significant role is design green roof. Green roof integrated to the roof of the buildings to provide the suitable indoor temperature without spending high amount of budget.

The methodology is qualitative type that trough the literature review and survey would be understood the importance and role of the green roof in both architecture and urban area. There are many significant architects like Wright that they understood how greenery would improve the function of the building in terms of provide thermal comfort and indoor temperature for the residences, and green roof as well. In Famagusta, there is not any green roof however, the design and integrating of green roof is inexpensive.

Green roof should design properly depend on the characteristic of the climate of every place so, the location, temperature, and humidity, location, and wind have influence on the design of the green roof.

Key word: Green roof, Sustainability, Urban area, energy efficiency, thermal insulation.

I. Introduction

From the annual design of the settlements, human being not only used natural material but also wanted to design garden to make their settlements beautiful and comfortable. In addition, they need to use the natural sources in their settlements to provide proper design. After, development of the technologies the meaning of using material have been changed due to all of changes human needs to review the traditional architecture and use the right method for designing buildings and one of the essential method is sustainable design. After that, sustainable architecture becomes widespread around the world. These days, the topics of the global warming and use high amount of the fossil fuels are popular. In addition, researches try to find new methods to save the energy and also in architecture and urban area designer need to consider these issues. Moreover, environment and climate have essential effect on the buildings and its components (Serraet. al., 2010). Consequently, water, wind, and solar energy are elements that should mention in the green architecture. Therefore, designers try to provide sustainable building to save energy and make thermal comfort in the buildings. There are several methods to have sustainable building and one of them is green roof system.

In this paper, at first, author would investigate green roof, importance of green roof, design principles, how designers can provide proper design, and finally, two residential buildings in Athens, Greece examined to understand the influence and method of green roof design for integrating it on residential buildings in Famagusta.

1.1.Problem and Field study

- **Problem:** Influence of green roof in two residential buildings in Athens, Greece and how integrate green roofs in residential buildings in Famagusta, North Cyprus.
- **Field of study:** residential buildings in urban area in Athens, Greece and Famagusta, north Cyprus

1.2.Aim and objective: utilize green roof systems in residential buildings to achieve sustainability.

Questions:

- What are the benefits of green roof systems?

- What is the role of green roofs system on sustainability?

II. Literature review

2.1.Sustainability and Urban design

There are different types of the sustainable roof system like; photovoltaic, reflective or white roof and green roofs. Green roof is preferable between three kinds of the sustainable roof design (Voelz, 2006). Now days, green roofs are the symbol of the sustainable and green cities. Moreover, they are becoming more popular in the urban design due to providing ecosystem services. Therefore, green roof change the face of cities from grey urban to green urban (Brebbia, 2013). Joel Towers refer that "Green roofs might, someday, be as common and essential as sidewalks which is to say they would become part of the urban lexicon; no longer extraordinary as spatial form but rather a matter of social process" (Earth Pledge, 2005, cited in Miller, 2008).

2.2.Green roof

Green roof is a kind of roof that including by greenery area and layer of the soil on the roof and it is an important feature of the sustainable design in architecture and urban design. In addition, roofs of the buildings have green area as well to prevent both heating in summer and inversion in winter. Furthermore, it can control the air pollution (Voelz, 2006).

2.2.1.Brief history of green roof Green roof is not a new subject and the base of the green roof belongs to the building design in Mesopotamia as known as the first civilization. After that ancient Roman and Greece integrated green roof to their roofs (Snodgrass et. al., 2006) and the other sample is one of the famous garden (hanging garden in Babylon) that is one of the seven wonders, had been used garden on terraces (Dalley 1993, cited in Miller, 2008). In middle ages, garden roofs used for its relaxation characteristics and beautiful area (Getter & Rowe, 2006, 1277, cited in Miller, 2008). North Europe Vikings integrated it to control their homes from the harsh weather (Peck & Callaghan, 1999, 11, cited in Miller, 2008). Some techniques of green roof used in the World War II for hiding military bases (Peck & Callaghan, 1999, 11, cited in Miller, 2008). In the United States, the first time green roof designed on Rockefeller Center buildings (New York City) in the 1930s (Getter & Rowe 2006, 1277, cited in Miller, 2008). The first modern green roof was in Scandinavia that protects building from the cold weather (Miller, 2008).

Frank Lloyd Wright was an organic architect that used the green roof in his building design for both visual view and the philosophy of organic. Wright designed many buildings by integrating green roof as Hollyhock House and Falling Water (Peck & Callaghan 1999, p12, cited in Miller, 2008) – Fig. 01. From 19th century, building has some components like; vegetation roofs. At first, H. Koch created new types of roof with characteristics of fire resistance by soil and gravel. After that, some grasses grow on the roof. Some researchers try to realize the philosophy of the green roof in 1960s and ReinhardBornkamm was one of them from Berlin's Free University who knows as "the father of modern green roofs" (Earth Pledge 2005, 108, cited in Miller, 2008). Therefore, researcher needs to improve the features of the green roof to provide positive effect on the environment and human life in urban scale.

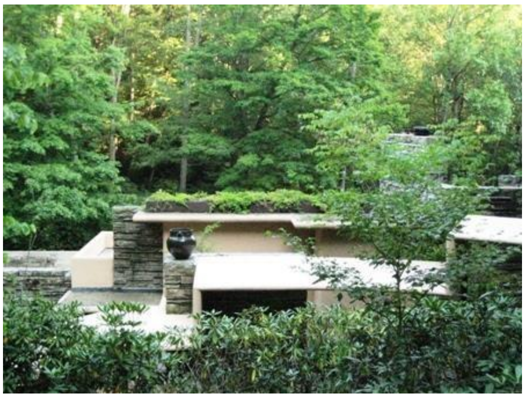

Figure 01. Falling Water (Source: URL 01, 2013)

2.2.2.Types of green roof There are three types of green roof depend on the thickness such as; intensive (heavy and thick), semi-intensive (average of intensive and extensive system), and extensive (thin is not heavy) (Zinzi et. al., 2012) - Table 01.

Intensive is same as the traditional garden style that the depth can be between 8 – 24 feets. This type of roof needs additional structure support around 59 – 199 pounds per square foot. It should have small trees, plants, pavements and grass, which is green during hot days and easy to irrigate depend on the location, soil depth, and kind of plants (Voelz, 2006). Extensive depth is 1.5 – 6 feets and additional load is around 14 – 35 pounds per square foot. There are usually plants on extensive type that needs additional irrigating during hot days and the disadvantage is that some plants might be dry during hot days (Voelz, 2006).

	ADVANTAGES	DISADVANTAGES
INTENSIVE GREEN ROOFS	• Allows greater diversity of plants/habitats • Good insulation properties • Visually attractive • More diverse uses (growing food)	• Greater weight loading on the roof spontaneously • Need for irrigation/drainage (more energy, water, materials) • Higher cost • More complex, expertise required
EXTENSIVE GREEN ROOFS	• Lightweight roof generally doesn't require strengthening • Suitable for roofs with up to 30 degree slope • Low maintenance • Often no need of irrigation/drainage • Little technical expertise needed • Suitable for refurbishment projects • Relatively inexpensive • Easier for planning department to demand green roof as a condition of planning permission	• More limited choice of plants • Usually no access for recreation, etc.

Table 01. Differences between intensive and extensive green roof (Source: Miller, 2008)

2.2.3.Characteristics of green roof Green roof has several Characteristics and three of them are important like; "aesthetics / amenities, environmental and economic" (Voelz, 2006).

Aesthetics / amenities

One of the essential characteristic of the green roof is m**ore beautiful view than typical roof design that provide** in terms of urban design. Moreover, eco-roofs provide some features that make people relaxed like; "stress reduction, lowered blood pressure, relief of muscle tension, and increased positive feelings" (Voelz, 2006) as integration of the eco-roof to the apartment block/commercial building in Portland, Oregon (City of Portland, ES 2006, cited in Voelz, 2006).

To provide amenities in green roof can make opportunities to have pleasure like; eating, reading, and taking fresh air, barbequing, and so on. For example, there are two examples building that one of them mentioned above and the Fairmount Hotel in Vancouver, BC (Paladino& Co.2004, cited in Voelz, 2006).

environmental

Green roofs both improve the sustainable environment and help to provide the suitable heating and cooling conditions inside the building."There are different factors that have influence on the performance of the green roof such as different technology, materials, environmental condition, orientation, and so on" (Zinzi et. al., 2012).

Green roof or eco-roof has influence on the indoor temperature by growing plants and trees on the roof. Moreover, green roof decline thermal loads to the buildings by the greenery and on the other hand, the soil function is as insulation layer to control the heat loads from the roof. Green roof has some layers such as; waterproofing layer on the top to control the humidity to transfer in the building, and drainage for saving water in hot days. Installation of filter fabric can use for preventing soil from movements (Zinzi et. al., 2012). One of the other characteristics of the green roof is to control the solar gain in the last level of the building, provide shadow (Zinzi et. al., 2012) and to reduce the air pollution (Voelz, 2006).

Economic

Owner can earn money from the plants on the green roof. Moreover, the significant subject is to decline the energy consumption so, it has influence on the energy costs in the building (Voelz, 2006).

2.2.4.Design principle There are many rules that have influence on the design of green roofs. First one is the effect of the climate which has some parts such as; temperature and humidity, wind, and orientation.

Temperature and humidity

At first, it is important to understand the local climate and it shows the features of the climate . Designer should examine the monthly and daily figures to get useful information . For instance , the highest temperature is more than 40℃ and humidity is 4 – 13% so, designer should control the humidification in Adelaide. Therefore, some strategies should consider for the water supply and irrigation (Hopkins et. al., 2011).

Wind

If green roof needs to attach on the roof of the high rise buildings so, the direction of the wind has important role on the design of green roof like; the isolation of the building and within the city and street creation. The other important aspect is air velocity would increase by the height of the building. When air flows is perpendicular to the high-rise building and it would rise, down, and around the building. Air velocities would change due to compressed on the corner of the building so, building needs wind shadows. If the air velocity is high on the roof netting should integrated to protect the soil and greenery (Hopkins et. al., 2011) – Fig. 02, and 03.

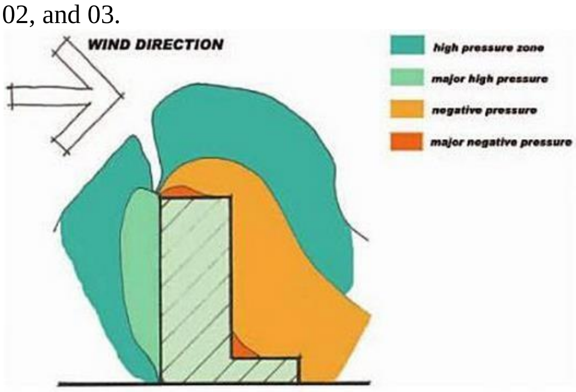

Figure 02. Wind direction (Ken Yeang)

(Source: Hopkins et. al., 2011)

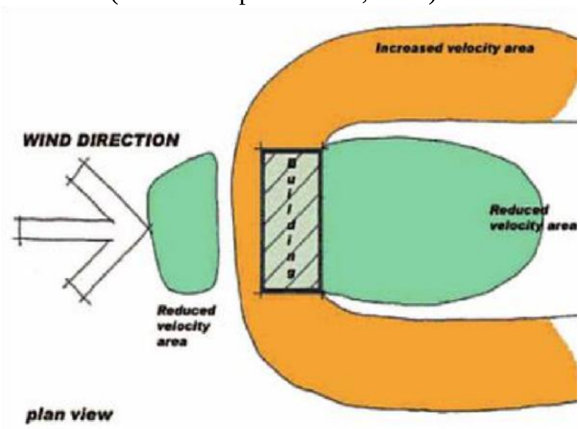

Figure 03. Wind direction plan (Ken Yeang)

(Source: Hopkins et. al., 2011) Direction and height of the building has influence on the air velocities around the building. Therefore, local wind should consider for design green roof (Hopkins et. al., 2011) – Fig. 04, and 05.

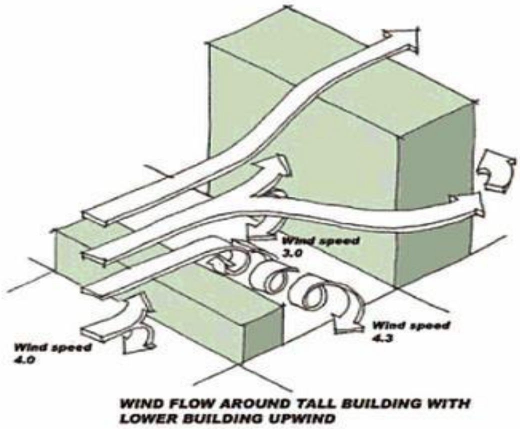

Figure 04. Wind velocity (Source: Hopkins et. al., 2011)

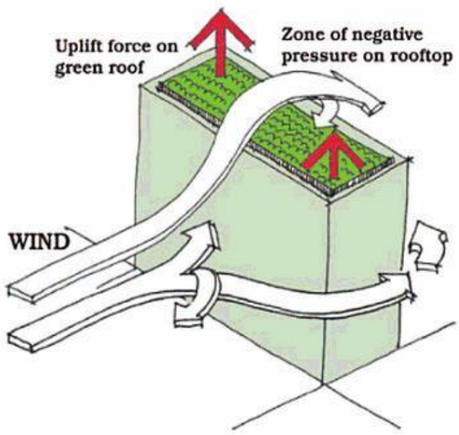

Figure 05. Wind effect (Source: Hopkins et. al., 2011)

Orientation

Orientation is another important feature that has influence on the green roof design. Moreover, designer should consider the situation of system on the roof of building (Hopkins et. al., 2011).

2.2.5. Types of green roof system There are different types of green system that should design depend on the climate and condition such as; "A waterproof membrane over the structural roofing system, a roof-protection barrier, a leak detection layer, a drainage layer, a filter layer, a water storage system (optional), a growing medium, irrigation, a mulch layer, a plant layer, and a netting system" (Hopkins et. al., 2011).

- There are different types of waterproofing layer but the performance of this layer is important to control the leaking of water. All of the roof should have waterproof layer but in green roof should be sure that there is not any damage.
- Root-protection barrier is to include with the waterproofing membrane as a chemical barrier. However, it is popular to use physical barrier like; geotextile fabric, often in the filter layer top of the drainage layer.
- There are several types of leak protecting layer that embedded into the waterproof layer which makes easy to repair the leaking.
- Filter layer which is between the drainage and growing medium to control the wet.
- Water storage system (optional) to helps water gaining for plants roots and absorb Oxygen as well – Fig. 06.

Figure 06. Wind effect (Source: Hopkins et. al., 2011)

2.2.6.Influence on the energy efficiency

Buildings are responsible of the around 33 percent of greenhouse gas emission globally and also approximately 40 percent of worldwide energy use is associated with the maintenance and construction of buildings. These days, due to the high amount of energy and resource consumption of buildings, various sustainable strategies and environmentally responsive energy efficient technologies have been suggested and implemented to realize low-energy buildings (Bianchini et. al., 2012).

Green roofs identified as a valuable strategy for making buildings more sustainable and in various studies indicated benefits of green roofs related to the mitigation of building energy consumption and reduction of urban heat island effect. These kinds of roofs are highly efficient in decreasing the variation of indoor temperature and reducing the rate of building energy consumption both in cold and warm climates (Berardi et. al., 2013) – Fig. 07.

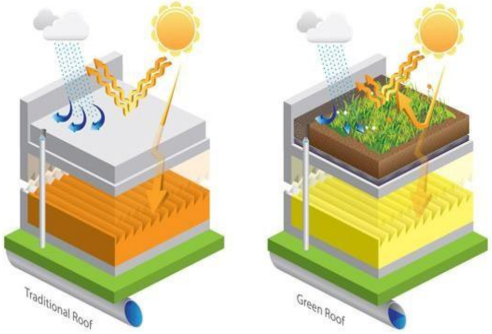

Figure 07. Green roof comparison

(Source: URL 03, 2013) in insulated building the impact of green roofs is much lower than in non-insulated ones, whereas the better the insulation of the roof, the lower the contribution of the green roof and also the characteristics of the energy load of the building (more cooling or heating load) help understanding the possible contribution of a green roof.In warm climates, this kind of roof potentially decrease the indoor temperature through shading the rooftop layer and avoiding the direct effect of solar radiations and also in subtropical regions with high temperatures and strong rain, has great potential (Moody et. al., 2013).

Recent studies investigated the temperature variations of a typical roof and a green roof which found that roofs reduce the energy utilized for cooling between 2% and 48% depending on the area covered by the green roof with an indoor temperature reduction up to 4 K.

The analyses show the positive influence of green roofs on reducing the variation of the surface temperature with regard to the air temperature, and make stable the temperature at different levels in the soil. According to the observed conversions in temperature at different levels, the study concludes that the most influential factors over effectiveness for the energy saving are biomass quantity and complexity. According to Olivieri et al in Mediterranean coastal climate in summer, found that the increasing the density of plants in a green roof, reduced cooling consumption of 60% in comparison to a typical roof.

The researchers found the green roofs in cold climates work well and has some benefits,even decrease the heat flow in extreme climates such as in snowy winters. In these regions beside the green roof structure, the insulation of the roof, may have negative effect. Based on use of a green roof, in the summer time heat gain, decreased whereas in the winter time reduction of the heat loss which was found to be advantageous in each climate. The impacts on the surface temperature and the heat flow in winter are 13% on average and by compared the summer are highly significant around 167% on average.Furthermore, the respective research recommends increasing the depth of growing medium layer and generating irrigation supplies for increasing evapotranspiration. The major function of green roofs is to pull up the solar radiation which heats the interior spaces of the buildings. Green roofs are capable to reflect 27 percent of solar radiation and attract 60% of solar radiation through photosynthesis and transmit the remainder as much as 13% to the growing medium .The integration of green roofs in buildings cause to energy saving purposes in different climates. although, the respective findings showed that these kinds of roofs significantly reduced the cooling loads while their influences on the reduction of heating loads, considering the heating degree days of that country, was marginal.The analyses indicate that the green roof causes more embodied energy in comparison to the typical roof. However, despite the higher consumed level of energy for green roof maintenance, the house integrated with green roof shows comparatively lower level of energy consumption than the typical with white roof. The initial cost of green roofs is substantially higher than the typical roofs because of the need for extra construction, maintenance, and operation. However, the cost of green roof over its lifetime is less than a typical roof.

The energy performance of green roof caused particularly improved by increases in the plantation density in every region and different climate. Green roof as a useful strategy reduces building temperature up to 20 ◦C and reduces the air conditioning energy between 25% and 80%.Green roofs are one of the most efficient energy savings in buildings (Razzaghmanesh et. al., 2014).

This particular type of roof would decrease building energy require through improvement of thermal performance of buildings. Green roof Improve the thermal performance, better insulation, shading, and higher thermal mass of the roof system.Green roofs save energy and consequently, save money. The value of savings depends on different agents such as type of green roofs, composition and depth of the growing Medias, plant selection, and type of irrigations, insulation specifications and climates. Moreover, based on previous literature the total amount of energy savings of green roof buildings are more significant for single-story structures than other types of buildings (Jaffal, et. al., 2012).

2.2.7.Thermal insulation Green roofs, also called eco-roofs. Green roofs used in vernacular architecture in different countries they use the foliage of plants to protect the building environment. In that buildings the thermal loads from the solar radiation limited before entering the buildings by the vegetation layer (Zinzi et. al., 2011).

For example, Northern European countries used green roofs to increase the indoor thermal insulation. After many centuries in the modern age, green roofs have been rediscovered in the twentieth century. Architects proposed green roofs as a method to integrate buildings and nature to generate thermal and sound insulation and save the natural energy. Heat transfer of a green roof is depending on leaf area index, plant height, albedo, fractional coverage and stomata resistance. vegetation keep the roof cool under the sun by prevented the absorb the sun radiation and reflecting the incident solar radiation away from the building and heat away at night and also take benefits of the additional thermal insulation which provided by the soil and of the evapo-transpiration to keep the roof cool under the sun (Zinzi et. al., 2011). Green roofs dissipate the heat, by evapotranspiration in the plant-substrate system and through long-wave radiation from leaves, plant photosynthesis, and heat storage by plants and the substrate – Fig. 08.

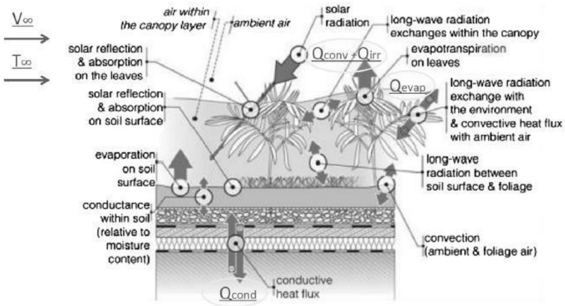

Figure 08. Wind effect (Source: Berardi et. al., 2014)

Generally, available studies show that green roofs improve summer thermal comfort and reduce cooling demand.
Different plant choices in green roofs lead to significant variations in the thermal insulation value and also some types of the vegetation have positive effect and improve the function of the green roof, it prevents the heat enter into the building, acts as a passive cooler by removing heat from the building and thickness of plants protects rooftops from different weather condition and work as an insulation layer for buildings. Thermal advantages is the most attractive function provided (Feng et. al., 2010). Green roofs with vegetation substrate are able to dissipate more heat than naked roofs. The surface and indoor temperatures of buildings with green roofs have less fluctuated but the outside of the building has smaller fluctuations, leading to energy savings and carbon emission reductions (Gomez et. al., 1998).

Energy savings among green roof types are different, however researchers totally estimated that, the green roofs save nonrenewable energy (natural gas) between 1.8 kWh/m2 to 6.8 kWh/m2 in cooling energy and 0.22 therms/m2 in heating.

Green roofs can decrease the environment air temperature around 0.5℃ in the spring , and 1.2℃ in the summer, 0.3℃ in the winter. Green roofs supply improves thermal . The maximum daily variation in bare roof surface temperatures is 35.4℃, but was much lower on green roof surfaces is around 3.5℃. In the hot climatic zone green roofs makes more valuable for mitigating internal and external building temperatures. In hot-humid climate zones, transpiration and evaporation rates are rapid (Fioretti et. al., 2010).

III. Methodology

This paper is qualitative type.

IV. Case studies

Through literature review and observations there is not any green roof in residential buildings, in Famagusta. At first, author would investigate two residential buildings in Athens, Greece due to same climate issues. Finally, some strategies would give for green roof that can attach to the residential buildings in Famagusta.

4.1. Residential buildings (Athens, Greece)

The two residential buildings locate in the Psichico and Peristeri coastal area of Athens which both of them have green roof. The Psichico buildings have two storey with 150 m² area. The Building orientation is northwest - southeast (main axis) and all of the sides of building gain solar radiation. Green roof and 5 cm insulation integrated 10 years ago. The layer of the green roof is like; plant level (sedum species, and trees), vegetation layer (mineral soil), filter layer, drainage for save water for dry times, moisture protection layer, and root barrier. “The used insulated material has a thermal conductivity value close to 0.11 kJ $h^{-1}mK^{-1}$” (Sfakianaki et. al., 2009) – Fig.09.

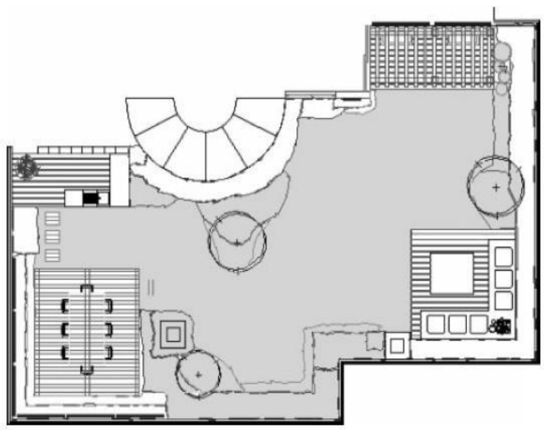

Figure 09. Plan of Psichico

(Source: Sfakianaki et. al., 2009) The Peristeri building is combination of a multistorey floor and a flat with 295 m² on last level and the roof of last level covered by green roof (just 100 m²) and it has 5 cm insulation layer. The orientation of the building is northwest - southeast (main axis) and all of the sides of building gain solar radiation. “The used insulated material has a thermal conductivity value close to 0.11 kJ $h^{-1}mK^{-1}$” (Sfakianaki et. al., 2009) – Fig. 10. The characteristic of the green roof is to provide thermal comfort in winter in both of them.

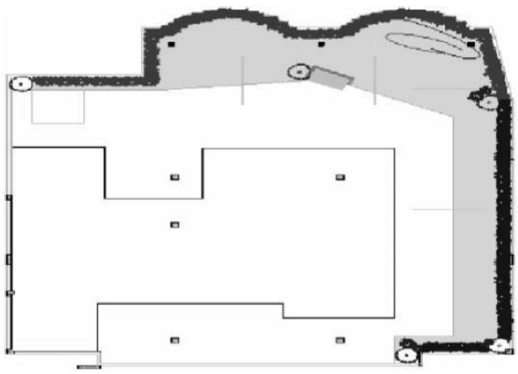

Figure 10. Plan of Peristeri
(Source: Sfakianaki et. al., 2009)

4.1.1.Data analyze

Thermal and energy use of these buildings investigated between March and May 2007. In addition, air temperature of outside and inside the building examined in different conditions. Infiltration measured by tracer gas methods and it is between 0.7 and 1.0 air changes per hour.

The air temperature environment in Peristeri area is 1℃ higher than in the Psichico, specifically at noon (Sfakianaki et. al., 2009).

“Surface temperature measurements have been performed using infrared thermographic cameras (Thermovision 570), while ambient air temperature was measured using calibrated self-recording thermometers with 1-min time step interval” (Sfakianaki et. al., 2009).

4.1.1.1.Analyze green roof temperature

The temperature in green area is 6.5 – 9℃ less on the green roof than tiles surface. If
the green area shaded the surface temperature
decrease 4 – 7℃ and temperature between dry and wet is around 1.4 k. During monitoring the average indoor roof temperature was around 20℃ (Sfakianaki et. al., 2009) – Fig. 11.

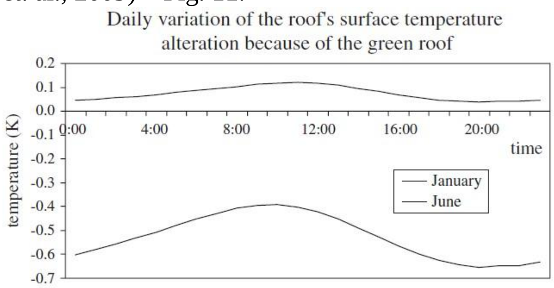

Figure 11. Calculated green roof surface temperature (Source: Sfakianaki et. al., 2009)

4.1.2.Energy and environmental performance (green roof) Those buildings examined with and without green roof for a year to understand the differences between them by TRNSYS. In the both residences, in early winter and summer green roof would decrease the indoor temperature and in winter may increase the indoor temperature. However, green roofs may have an adverse effect and decrease indoor temperatures slightly, if environmental temperatures are higher than the indoor temperatures (Sfakianaki et. al., 2009) - fig. 12, 13, and 14.

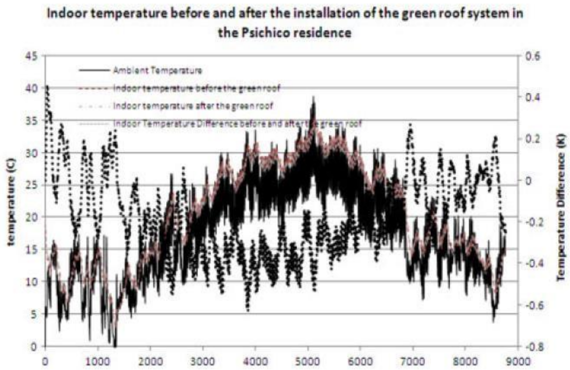

Figure 12. Calculated out and in temperature in Psichico (Source: Sfakianaki et. al., 2009)

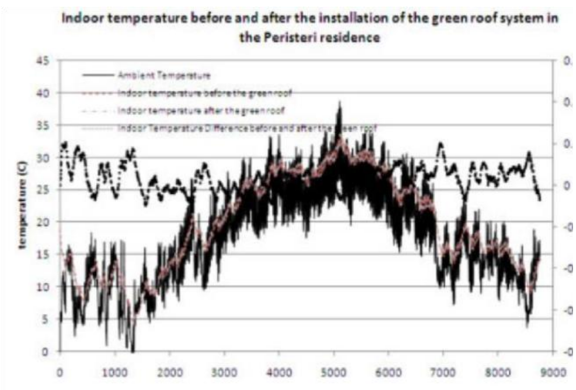

Figure 13. Calculated out and in temperature in Peristeri(Source: Sfakianaki et. al., 2009)

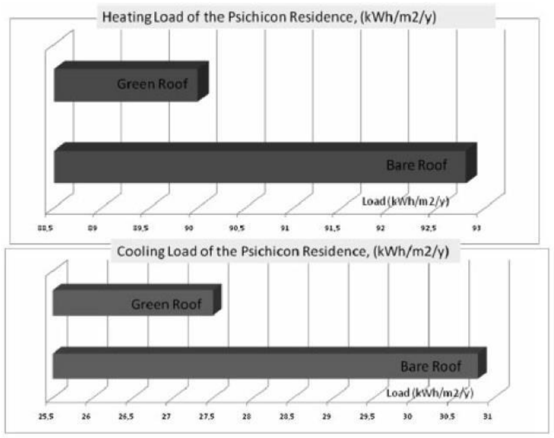

Figure 14. Calculated heating and cooling in Psichico (Source: Sfakianaki et. al., 2009)

4.2.Case study (Famagusta) Depend on the characteristics of the green roofs can provide to save energy in the building in Famagusta. Moreover, green roofs improve the thermal comfort inside of the building in cold and hot days. In addition, green roofs decline the heating on the both roofs and urban environment in hot days. This system has effect on reducing the air pollution by photosynthesis as well. However, Green roofs due to greenery can cause some problems like humidity on the roof, it can solve by using some materials and growing plants that do not need too much water on the roof of the residential buildings in Famagusta.

4.2.1.Temperature and humidity

Cyprus Island located in the north-eastern Mediterranean Sea and Famagusta located on the eastern coast. According to proximity to the sea and topographical values, Cyprus has hot–arid, hot–humid and composite both climates. Hot summers (high heat in the daytime), moderately cold winters (intense cold at night) and very high summer dryness with minimal yearly rainfall. During the summer, the temperatures ranges between 37 and 40 °C and in winter, temperatures range from 9to 12 °C, and approximate 60% relative humidity (Oktay, 2002). Therefore, green roof has positive influence on the indoor temperature in Famagusta. However, it is important to control the humidity from the roof of buildings by adding filter layers.

4.2.2.Wind

The wind direction is from west and southwest and the air velocity is 8 kts in Famagusta (URL 02, 2014) – Fig. 15. Therefore, roof netting should be integrated on the roof due to the speed of win between December and February in residential buildings in Famagusta.

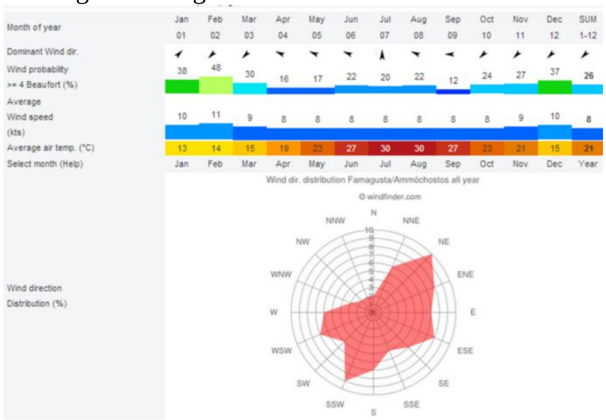

Figure 15. Wind characteristics
(Source: URL 02, 2014)

4.2.3.Orientation

As mentioned, Orientation is one of the essential features that have effect on the green roof design. Moreover, the situation of green roof system should consider. The main axis of the building is east west in Famagusta to absorb the sunlight from south face. Buildings should have distance with each other depend on the climate of Famagusta. Therefore, green roof can absorb the sunlight enough.

V. Conclusion

All around the world architects and designer try to find new solutions for saving the energy and provide thermal comfort in the building and one of them is sustainable design to improve the quality of the life in the residential buildings. In addition, sustain able design has an important influence on the energy consumption in Famagusta, North Cyprus. Therefore, green roofs have positive effect on the heating and cooling in different seasons. There are many important aspect that designer should consider on the design of the green roof such as temperature and humidity, wind, and orientation of the building. If designers do not notice above features, it can damage roof and makes problem for the apartment building and residences. The layers of green roof in residential buildings in Famagusta can be including plant level (sedum species, and trees), vegetation layer (mineral soil), filter layer, moisture protection layer, and root barrier. In addition, the drainage and irrigation of the green roof must be control in Residential buildings because of the humidity in Famagusta. Furthermore, Green roof can be integrated to old buildings by adding insulation layer more than before. Therefore, green roof can integrate to the residential buildings in Famagusta because it can help to save the energy and provide for the residences in urban area.

VI. Acknowledgment

It is kindly to appreciate Dr. HalilAlibaba due to guides and protecting me during course (MARC541) Integrated Systems In Architecture.

References

[1] Berardi, U. &GhaffarianHoseini, A.H. &GhaffarianHoseini, A. (2014). *State-of-the-art analysis of the environmental benefits of green roofs*. Applied Energy, 115, pp.411–428.
[2] Bianchini, F. &Hewage, K. (2012). *Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach*. Building and Environment, 58, pp.152-162.
[3] Bradley Rowe, D. (2011). *Green roofs as a means of pollution abatement*, Environmental Pollution, 159. pp. 2100-2110.
[4] Brebbia, C. A. (2013). *Sustainable development and planning VI*, Southampton : WIT.
[5] Feng, C. &Meng, Q. &Zhang,Y. (2010). *Theoretical and experimental analysis of the energy balance of extensive green roofs*. Energy Build. 42, pp.959-65.
[6] Fioretti, R. &Palla, A. &Lanza, L. G. &Principi, P. (2010). *Green roof energy and water related performance in the Mediterranean climate*. Build Environ, 45, pp. 1890904.
[7] Gomez, F. &Gaja, E. &Reig, A. (1998). *Vegetation and climatic changes in a city*. Ecol Eng. 10, pp.355-60.
[8] Hopkins, G. & Goodwin, C. (2011). *Living Architecture: Green Roofs and Walls*, CSIRO Publishing.
[9] Jaffal, I. &Ouldboukhitine, S. E. &Belarbi, B. (2012). *A comprehensive study of the impact of green roofs on building energy performance*. Renewable Energy, 43, 157-164.
[10] Miller, L. J. (2008). *Green Roof Policy: A Sustainable Space to Grow?*, Master of Arts, Urban and Environmental Policy and Planning, TUFTS UNIVERSITY.
[11] Moody, S. & David, J. (2013). *Development and application of a building energy performance metric for green roof systems*. USA Energy and Buildings, 60, pp. 262–269.
[12] Razzaghmane, M. &Beechama, S. &Kazemi, S. (2014) *Impact of green roofs on storm water quality in a South Australian urban environment*. Science of the Total Environment, pp. 651–659.
[13] Serra, V. &Zanghirella, F. &Perino, M. (2010). *Experimental evaluation of a climate facade: Energy efficiency and thermal comfort performance*. Energy and Buildings, 42, pp. 50–62.
[14] Sfakianaki, A. &Pagalou, E. &Pavlou, K. &Santamouris, M. &Assimakopoulos, M. N. (2009), *Theoretical and experimental analysis of the thermal behavior of a green roof system installed in two residential buildings in Athens, Greece*. INTERNATIONAL JOURNAL OF ENERGY RESEARCH; 33:1059–1069
[15] Snodgrass, E. C. & Snodgrass, L. L. (2006). *Green roof plants: a resource and planting guide*, Portland: Timber Press.
[16] URL 01: Falling Water. Retrieved from: (http://www.gskenney.com/ginger/travel/view sof-falling-water-8/) (used on:14.01.2014)
[17] URL 02: Wind characteristics (2014). Retrieved from: http://www.windfinder.com /windstats/windstatistic_famagusta_ammocho stos.htm (used on:14.01.2014)
[18] URL 03: Green roof (2013). Retrieved from: (www.greenroofguide.co.uk) (used on:14.01. 2014)
[19] Voelz, J. (2006). *THE CHARACTERISTICS & BENEFITS OF GREEN ROOFS IN URBAN ENVIRONMENTS*, Sustainability and the Built Environment.
[20] Wonga, P. & Prasad, D. &Behnia, M. (2008). *A new type of double-skin facade configuration for the hot and humid climate*. Energy and Buildings, *40*, pp. 1941–1945.
[21] Zinzi, M. &Agnoli, S. (2012). *Cool and green roofs. An energy and comfort comparison between passive cooling and mitigation urban heat island techniques for residential buildings in the Mediterranean region*. Energy and Buildings, 55, pp. 66–76.