The Perception of Cooling Roofs among Professionals in Iran

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ABSTRACT

A large amount of energy in Iran is currently being consumed for heating and cooling purposes in buildings. Since building rooftop surfaces absorb most of the solar radiation, green roofs are among the solutions recommended by scholars. This study utilizes a survey amongst a targeted sample population of 40 built environment professionals to determine their perception on the use of green roof for environmental cooling purposes. They believed that green roofs could improve the ecology and the biodiversity of an urban area. Green rooftops are also believed to have the capability to reduce air pollution and urban heat island, and help reduce solar radiation and energy consumption in Iranian cities. The best choices for implementation include flat asphalt, flat concrete, and flat tile roofs. The study recommends further study on developing a green rooftop policy for Iran that would improve the quality of life for people living in cities of Iran.

Keywords: Green Roof Effect, Solar Radiation, Energy Consumption

1. INTRODUCTION

Iran is considerably a dry and semi-arid country where two third of the country is comprised of desert and semi-desert areas. The high temperature during the hot season in Iran is the greatest challenge in cooling down residential and official buildings in cities because heating and cooling consume the highest amount of energy at the expense of environmental quality. Moreover in the last decade (1990s to 2000s) the space left to the greenery in the urban landscape has decreased, allowing the uncontrolled growing of roads and buildings. The most worrying effects are the worsening of the air quality and the increasing average of the urban temperature (Abbaspour, 1998).

Rooftop and wall surfaces play a significant role in the ecological functioning of urban environment. According to Peck (2002) and Earth Pledge Foundation (2005), the solar radiation energy absorbed via rooftop can increase energy consumption and cooling costs. Rooftops cover a big area of the cities, but after the employment of green roof the heat will be reduced notably and the cost reduction for cooling of houses is remarkable (Wong, et al., 2003b).

The highest amount of energy consumption is for heating and cooling purposes in buildings in cities such as Tehran with a population of 12 million. It is even higher than the total energy consumed in the transportation, industrial and agricultural sections. Based on the annual statistics data, Iranian Fuel Conservation Organization (IFCO, 2004a) states that buildings consume nearly USD 9.6 billion of energy per year in Iran, which is about 40% of energy consumed in the country. Annual cooling cost across the country is USD 211 million which is 16% of the electricity consumption of the country. According to the report from House and Building Research Centre in Iran, more than 83% of houses in Tehran did not comply with energy saving regulations (Javanbakht, 2006).

Seeking professionals' perceptions ought to shed more light on the stated problem. This is carried out through several viewpoints by the questionnaire. As the phenomenon is still considered to be a relatively new field of inquiry, viewpoints of experienced professionals are of utmost value. Their perceptions regarding the problem are significance to researchers looking for solutions for the infrequent use of green roofs in Iran. Their experience is the result of a direct longitudinal exposure to the society's practice with green roof. These perceptions are carefully probed in this research project.

This paper first presents the background literature on Iran's energy crisis and current works on passive cooling practice with emphasis on green roof. Then, it describes the survey research methodology this study utilizes, presents the results, and concludes with future recommendations for further studies.

2. HIGH ENERGY CONSUMPTION ISSUE IN IRAN

Iran's economy relies heavily on oil export revenues which amount to 80-90 percent of the total export earnings and comprise of 40-50 percent of the government budget. Revenues have increased steadily, from USD 32 billion in 2004, to USD 45.6 billion in 2005, with the 2006 estimates at USD 46.9 billion (EIA, 2006). Iran is OPEC's second largest oil producer and holds 10 percent of the world's proven oil reserves. It also has the world's second largest natural gas reserves (after Russia). With almost unlimited natural gas production potential, Iran is looking at exporting large volumes of gas (Erik and Rkman, 2005).

Despite higher oil and natural gas revenues, Iranian budget deficits remain a chronic problem. Another problem for Iran is the huge increase in energy consumption over the past 20 years which has contributed greatly to pollution levels as Iran's carbon emissions have nearly tripled over the same time span (EIA, 2006). Energy in different forms have substituted labor or relieved people from routine or heavy work. The history is long. Fuel for domestic use for heating and cooking at the self subsistence level is not included in the commercial energy studied here.

Iran needs to attempt to diversify its economy by investing some of its oil revenues in other areas including petrochemicals production for sustainable economic and entrepreneurship for the unemployment of young people. Furthermore, with this prediction for high primary energy consumption in Iran, after around 15 or 20 years Iran will not have petroleum for export and all the petroleum will be used solely for the domestic consumption (Akherati, 2005). Moreover, Iran had signed the Kyoto Protocol for a stronger action in reducing the Green House Gas and global warming.

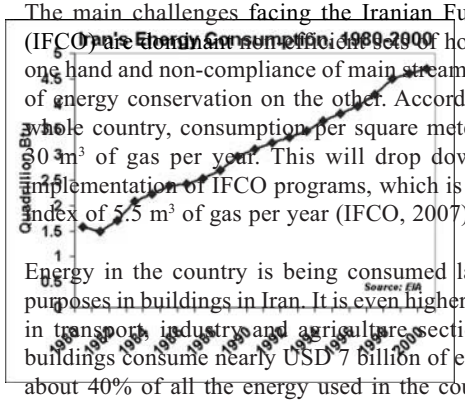


Figure 1: Iran Energy Consumption, 1980-2000 (Source: www.eia.doe.gov)

Commercial sector, houses and household appliances consume more energy than any other economic sectors in Iran. This consists of 22% of Oil Products, 67% of Natural Gas and 11% of Electricity. The value of energy consumed in year 2005 amounted to USD 9.898 billion (IFCO, 2007).

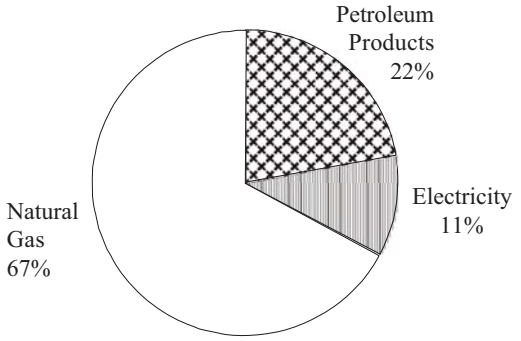


Figure 2: Bulk of energy consumption in Iran at year 2005. (Source: http://www.ifco.ir/english/index.asp)

The main challenges facing the Iranian Fuel Consumption Organization (IFCO) are dominant non-efficient sets of home appliances in the market in one hand and non-compliance of main stream home builders to the principals of energy conservation on the other. According to one survey covering the whole country, consumption per square meter of buildings is equivalent to 30 m^3 of gas per year. This will drop down to 20 m^3 in 2020 with the implementation of IFCO programs, which is still high compare to European index of 5.5 m^3 of gas per year (IFCO, 2007).

Energy in the country is being consumed largely for heating and cooling purposes in buildings in Iran. It is even higher than the total energy consumed in transport, industry and agriculture sections. IFCO (2005a) states that buildings consume nearly USD 7 billion of energy per year in Iran, which is about 40% of all the energy used in the country. The natural gas includes 60% of this total amount, petrol products amount to 28.8%, and electricity consumption equals to 10.9% (ibid.). It is estimated that Iran spends about USD 60 billion on energy between 2003 and 2012, but this huge spending can be reduced to USD 53 billion (IFCO, 2004b). If the appropriate strategies can be applied to Iranian houses and buildings, creation of heat isolation elements on the wall and roof is one of the most recommended solutions.

This can be used through creation of green roof (vegetated roof) that is the best acceptable choice and attractive idea for reducing energy consumption and solar radiation. Our recommendation is supported by recommendations by Del Barrio (1998), Theodosiou (2003), and Wong, et al. (2003b).

3. BACKGROUND OF PASSIVE COOLING PRACTICE

In most of the developed countries in northern America, Europe and Asia, green roof studies show positive effects of green roof on reduction of solar radiation as well as energy consumption and decrement of urban heat. Green roof has great potential to cool cities by providing shades and evapotranspiration. Plants have lower heat capacity and thermal conductivity than building materials and hard surfaces. Solar radiation is mostly absorbed in by the leaves so the reflected radiation is very small. Green roof utilization has been known since ancient times both in hot and cold climates. Nowadays, it has been reconsidered as an issue of energy saving and pollution reduction (Lazzarin, et al., 2005).

The other indirect effect of vegetated roof is the cost reduction of expenditure for cooling of houses due to the shades (Wong, et al., 2003a). Often, architects design rooftops with the singular purpose to provide open spaces. To date, the rooftops have been largely ignored as potential sources to provide green spaces for Iranian cities. While the surface of a typical asphalt roof can reach 160^{o}F (71.11^{o}C) on a hot summer day, green roofs and other vegetated surfaces on the other hand rarely exceed 80^{o}F (26.66^{o}C), Shade production and evaporative cooling by vegetated roofs reduce heat transfer into the building, making the inside cooler hence reducing the need for air conditioning. Peck (2002) showed that the cooling efficiency of the green space in the summer exceed the amount of heat entering the roofing system by 73%. This totally eliminates the cooling load on the roof and generates available total avoided cooling energy of 3,797 KW-hr per 1000 sq. feet of total roof area. This excess cooling is transferred to the surrounding microclimate and could reduce over USD 800 in cooling costs for buildings.

Green roof also absorbs carbon dioxide and air pollution and reduces heat effect in the building and urban areas. Carbon dioxide emission has become a limitation in the use of fossil fuels due to the threat of global warming. Even natural gas which is increasingly being used emits 50-70 percent carbon dioxide per energy unit compared to coal or oil, and hence, is still considered as a threat to the global climate. Therefore, fossil fuels including natural gas appliance should be restricted to heating purposes and not to electricity generation (Erik and Rkman, 2005).

Studies in Iran also show that traditional “clay-straw house” that is built with natural material utilizing the concept of sod roof for thermal comfort reduces the consumption of energy during summer and winter as well. Moreover, planting climber plants and vine minimize the employment of cooling tools in summer because of their shade-creating benefits, and as they lose the leaves in the winter, the sun light can enter through the windows, creating light and heat (IFCO, 2005b). Since green roofs have shown positive reduction of solar radiation, reduction of energy consumption, and decreament of urban heat, we would like to propose that a green roof policy be implemented in Iran. However, we would like to seek expert opinions on whether such application would be well received in the country.

4. RESEARCH METHODOLOGY

This study would like to investigate the attitudes and the perceptions of built environment professional towards the application of green roof concept in Iran. With the goal of formulating a planning or policy strategy at the conclusion of the main research where it is pertinent that Iranian built environment professionals support the green roof concept. Hence, the first part of the research was to gauge the perception of Iranian professionals in this matter. We hypothesized that if the built environment professionals could provide the base support for green roof application in Iran, then only would it be worthwhile to proceed into the next step on how municipal authorities could implement the concept in Iran.

A purposive sample population of 40 built environment professionals:
35 males and 5 females, was targeted for a semi-structure survey methodology sample. They were expected to provide answers based on their respective scientific and technical knowledge on the subject of energy consumption and passive cooling strategies. They were identified amongst those Iranians who were highlighted in published articles on energy-related articles such as in mass media and scholarly publications. In addition, most of them were involved directly with urban environmental problem, and high energy consumption in Iran. These professionals include landscape architects, architects, urban planners, civil engineers, horticulture engineers, municipal managers, professional academicians, and environmental experts.

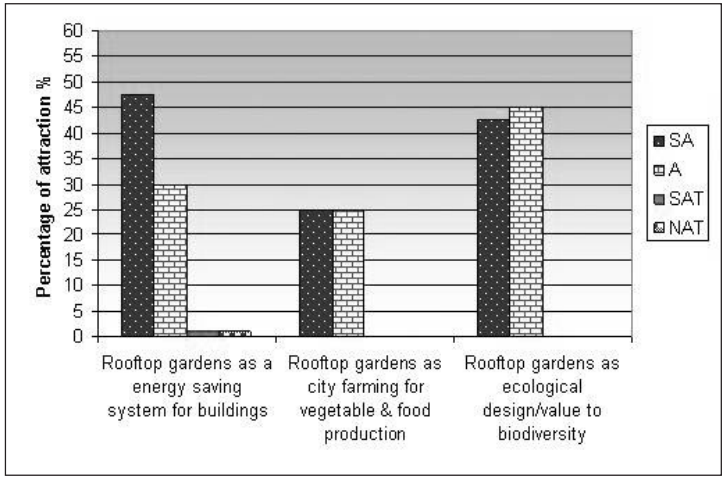
The survey instrument consists of several modular constructs on selected focal points for Iran. For the purpose of reporting in this article, we focus on reporting the professionals' perceptions on three matters: 1) the level of attraction towards advantages of green roof; 2) capability of green roof for environmental cooling; and 3) eligibility 1 of different type of roof structure for green roof in present building form. Data was collected via face-to-face interviews by the first author as the interviewer. The interviews were conducted fully in Persian. The response rate is 100%. Collected data from the survey were analyzed using descriptive statistical analysis using the Statistical Package Social Science (SPSS) program.

5. RESULTS AND ANALYSIS

We present the results of the survey in this section. The results are divided into three main points: 1) the level of attraction towards advantages of green roof; 2) capability of green roof for environmental cooling; and 3) eligibility of different type of roof structure for green roof in present building form.

Level of attraction towards advantages of green roof.

The professionals were asked to rate the attractive levels for the use of rooftops as energy saving system, for city farming and food production, and for ecological and biodiversity purposes. The response set for this question included "strongly attractive," "attractive," "semi-attractive," and "non-attractive." Based on the result obtained from the respondents (see Figure 3), about 97.75% of the respondents believed that there is the need to develop green roofs in Iranian cities and it can help reduce urban energy problems. In addition, about 85% of the respondents believed that green roof is applicable to the current building constructions and the possible damage is negligible. On the other hand, city farming for food production is the least attractive reason for utilizing rooftop gardens with 50% of the respondents finding it strongly attractive and attractive. Positive answers about rooftop gardens contributing in ecological design/value to biodiversity show that green roofs can bring nature to cities and also they are ecological design tool for buildings and cities to create more green space.

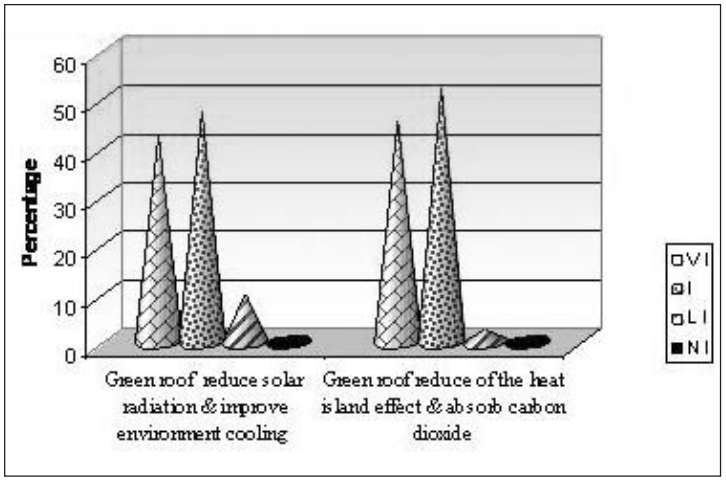


Note: SA = Strongly Attractive; A = Attractive;
SAT = Semi-Attractive; NAT = Non–Attractive

Figure 3: Attraction of green roof advantages from professionals' opinion.

Capability of green rooftop for environmental cooling.

The respondents were asked to rate the importance of green roof for reducing solar radiation and improving environmental cooling. They were also asked about the importance of green roof for reducing the heat island effect and for absorbing carbon dioxide. The response set for this question included "very important," "important," "less important," and "not important." The results show that 89.5% of the respondents believed that green roof is "very important" and "important" for reducing solar radiation and improving cooling in buildings and the environment. About 10% of the respondents believed that green roof is "less important." Similarly, very few respondents believed that green roof is "less" and "not important" for reducing the heat island effect and for absorbing carbon dioxide.



Note: VI = Very Important; I = Important;
LI = Less Important; NI = Not Important

Figure 4: Importance of green roof for environmental cooling.

Eligibility of different type of roof structure for green roof in present building form.

The respondents were asked to identify the different types of roof structure that would be eligible for green roof consideration in Iran. The measures composed of "flat sun-dried brick roofs," "flat asphalt roof," "flat concrete roof," "flat tile roof," "flat tarry roof," "flat brick roof," and "sloped roof." The response set for this question included "yes," "no," and "not sure." Survey results indicated that types of roof structure most eligible for green roof are flat asphalt, flat concrete, and flat tiled roofs with 92.5% of the respondents agreeing on them respectively (see Table 1). The flat tarry roof is the fourth highest choice with 87.5% respondents agreeing on its suitability. The most unsuitable type is the flat sun-dried brick roof, where 95% of the respondents disagreed. However, 27.5% and 25% of the respondents were unsure whether flat brick and sloped roofs respectively would be eligible for green roof in a building.

Table 1: Percentage of Eligibility of Different Type of Roof Structure for Green Roof in Iranian Present Building

No.	Statements	Y	N	NS
I	Flat sun-dried brick roof	-	95%	5.0%
II	Flat asphalt roof	92.5%	5.0%	2.5%
III	Flat concrete roof	92.5%	5.0%	2.5%
IV	Flat tile roof	92.5%	2.5%	5.0%
V	Flat tarry roof	87.5%	2.5%	10.0%
VI	Flat brick roof	57.5%	15.0%	27.5%
VII	Sloped roof	50.0%	25.0%	25.0%

Note: Y = Yes; N = No; NS = Not Sure

6. CONCLUSION

We conducted a survey amongst built environment professionals in Iran to inform us how they are inclined towards implementing green roofs for the purpose of reducing artificial energy dependency. In general, the professionals believed that green roofs as ecological design could improve the climate of an urban area. Green rooftops are also believed to have the capability to reduce air pollution and urban heat island when they become an extensive elevated green acreage. They also believed that green roofs could help reduce solar radiation and energy consumption in Iranian cities.

On the other hand, the built environment professionals thought that not all roof structures would be eligible for implementing green roof. Not all types of roof structure would qualify if Iran would implement a green roof policy. Although most flat roofs are eligible, the flat sun-dried brick roof does not qualify. The best choices for implementation include flat asphalt, flat concrete, and flat tile roofs. Despite being unsuitable for green roof application, we believe that the negative response to flat brick and sloped roofs are due to their technical challenges. Since green roof system must employ some technical layers including water proofing layer, root barrier, drainage system, it may compromise the structural integrity of the building. Therefore, we would like to recommend that for those eligible roof structure types, the authority would implement a green roof policy to encourage greening of elevated surfaces in cities in order to increase their green areas. We would

also like to recommend further studies in seeking technical solutions to the less eligible roof structure types, hence allowing Iran to increase the acreage of green rooftops.

In conclusion, green roofs can help establish healthier cities, and relatively increase the community's social welfare by reducing its energy consumption. The potential impact onto the urban climate should a green roof policy be implemented in Iran for cooling purposes is tremendous economically and socially. Whereas people's behaviors are hard to change, greening the rooftops would be a simpler alternative for solving an energy crises in Iran.

7. ACKNOWLEDGEMENTS

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8. FOOTNOTES

1 The term "eligibility" was a direct translation from Persian meaning "suitability."

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