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Capability Analyzing of Solar Energy Based on Climatic Criteria Recognition in Iran's Architectural Design by the Use of Fuzzy Analytical Hierarchy Process Method (FAHP)

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ABSTRACT: Developing a comprehensive document based on the utmost use of renewable energy efficiency in the architecture design is the first step in national level to follow the goals of sustainable architecture and this is not possible without having a deep trend of the climatic compartment. The modeling of comprehensive energy plans in the architecture without having a quantitative approach is incomplete and inefficient in all of these areas without accurate scrutinyAlso, one of the main challenges regarding the climatic compartment in architecture is the qualitative approach of designers and researchers of architecture towards this science; which has a basic contradiction with quantitative data of climate science. Hence, through the quantitative potential climatic investigation and integrating it with qualitative components affecting architecture, a suitable approach to architectural design is obtainable. The purpose is to measure and evaluate solar energy in the design of the architecture of buildings in Iran with a climatic approach. The first step in achieving this purpose is to identify and prioritize the relevant factors and criteria for utilizing the solar energy capability in the design of architecture and climate. The variables of this model with the above objective function include 5 main criteria and 15 sub-criteria. In the next step, we define and eliminate non-usable areas and then draw a fuzzy hierarchy structure. After that, the relative weight of criterion is determined using the FAHP technique and based on the views of a group of academic, governmental and industrial experts in the Super Decision analysis software.

Keywords: *Discourse analysis, Institutional analysis, Exclusive space production, Institutional discourse analysis.*

INTRODUCTION

For a long period, renewable energies have been utilized in architecture and in the city. Although the use of these types of energy indirectly is very long in traditional buildings of our country, but today we see the use of this kind of free energy in various forms for the supply of heat, cold and light, which relies on the consumption of electricity individually and specifically. The global trend is also to exploit the local networks and even self-fulfillment of the energy needs of buildings through the use of renewable resources. It is also not possible that buildings, in addition to providing their own energy, assists the city and the area located in to supply the required power.

Since designing Zero Energy Buildings (ZB), everybody has believed that making zero the energy consumption is not feasible under any circumstances, however providing the idea that any building can provide its required energy supply from natural resources. The existence of wind, solar radiation, and heat of the earth assist this. It is not far from the point that the use amount and production is limited in these conditions. The

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first congress was the use of solar energy through photovoltaic systems. In addition, the use of wind and heat of the earth was of high significance. Today, in practice, the utilization theories of renewable energy sources have been proven to be individualized, especially in urban and architectural settings (Heidari, 2015, 181).

Solar energy is one of the best and most economical types of renewable energy in Iran, which not only meets many human concerns, such as environmental pollution, followed by new diseases, removing out the fossil resources and so forth, but can be expanded with regard to the climate and weather of the country. In Iran, in an area of 2000km2, it is possible to install 60 GW solar thermal powers. In recent years, the use of solar energy systems is being developed for its simplicity, easy transportation, high reliability, and lack of mechanical components, environmental compatibility without any need for the fuel (Noorollahi et al., 2016).

Solar energy is exploited to convert sunlight into energy forms. The sun's energy is supplied through atomic combinations at the nucleus core. In a hybrid reaction, two atomic nuclei are coupled together and make a novel nucleus (New Energy Organization of Iran, 2015). Solar Photovoltaic (PV), Centralized Solar Power (CSP), Solar Thermal Power, and Solar Heating and Cooling are among the consolidated solar technologies (Global Status Report, 2015).

Photovoltaic solar systems are considered as one of the most popular technologies in the field because they convert solar energy directly into electricity. The industry increases to 177 GW in 2014, with more than 60% of its capacity in the three years leading up to this year. Germany, China, Japan, Italy and the United States are among the top five countries in this area, with only three countries such as China, Japan and the United States adding 26 GW in 2014 to the final capacity by the end of 2013 (Global Status Report, 2015).

According to experts in this area, Iran has been introduced by having 300 sunny days in more than two thirds of its area, and an average radiation of 4.5-5.5 kV/m2 in one day, one of the countries with high potential in solar energy. According to studies conducted in an area of 2000 km2, it is possible to install more than 60 GW of solar thermal power plants for household, industrial, power plant and power generation using equipment such as flat plate collectors and photovoltaic cells. In addition to the use of these power plants, small photovoltaic systems are used to illuminate roads and streets, traffic lights, electricity and telecommunication systems in the villages (Office of Planning Electricity and Energy, 2013). In the study of solar systems utilization in Iran, major factors such as intense sunlight, the relatively high temperature difference between night and day in the central plateau, the presence of dust and monsoons and low rainfall in vast areas of Iran have significant influence (Office of Planning for Electricity and Energy, 2013) and (New Energy Organization of Iran, 2015).

This article aims is to measure and evaluate solar energy in the architecture designing of building in Iran with a climatic approach. The criteria defined by using the study and compilation of the literature review as well as experts points of view in this field are examined in five categories of the main criteria and the 15 sub -criteria. The relative defined weight of the criteria and sub-criteria by the Fuzzy Analytical Hierarchical Process (FAHP) is based on ten-member team opinions of academic, governmental and industrial experts related to the energy planning area in architecture. For this, a closed-ended questionnaire is developed by setting up a pairwise matrix consisting of criteria and sub-criteria based on fuzzy theory which is available for the experts. Then, to investigate and analyze experts' points of view based on the model, Super Decision software is used to analyze the pair comparisons. Finally, the relative weights of the criteria and sub-criteria are extracted. In the end, with the prioritization and weighting of the macro criteria and the relevant sub-criteria, it is possible to determine the essential fields for determining the coefficients of the influential criteria and sub-criteria on the ability to exploit solar energy, and provide the results to managerial planners and Educational Architecture, too.

In the next section of this paper, the literature review is conducted; then the research methodology is presented and the results and research findings are discussed. Finally, conclusions and suggestions for future research are presented.

Literature Review

Decentralized energy planning (DEP) is affordable, cheap, and environmentally friendly, as an option to meet the energy requirements of rural areas and those areas that need a small scale of energy. One of the main aspects of energy planning is the decentralization of the preparation of regional affairs based on the energy requirement and the development of alternative energy sources with minimal cost and environmental damage. In a paper by Hiremath et al. using a goal-planning methodology to analyze affairs through a bottom-up approach in an Indian region, an analysis of the village level, the urban level, block level and area level from bottom to top was done (village to region) and allowed to provide a detailed description of energy services and therefore the demand for various types of energy and supply technologies. Different scenarios were considered in four decentralized scales for 2005 and considered in developmental terms for analysis by 2020 (Hiremath et al., 2010).

Regarding the characteristics and specificity of the issues raised in the energy field, it has been determined that meeting these issues necessitates the application of multiple attributes approaches. The use of Multi-Criteria Decision Analysis (MCDA) techniques is increasingly being considered by planners and policy makers in the field of energy management, renewable energy planning, allocation of energy resources and so forth (Prasad et al., 2014).

Lee et al have applied the AHP and DEA method to prioritize energy technologies in the national energy planning unit for a long time span (Lee et al., 2010). Using the analytical process, AMD and DOM have evaluated the replacement of renewable sources with alternative sources of fossil fuels for electricity production in Pakistan. In fact, using the AHP method, prioritizing and selecting between wind, photovoltaic-solar, solar thermal, and biomaterials have been made according to technical, economic, social, environmental and political criteria. The results show that the use of selected technologies could significantly improve the country's ability to meet the lack of electricity, improve living standards in the society, improve the country's economic growth, improve rural economy, reduce energy imports and Ensure environmental sustainability. Also, the proposed model for assessing various renewable technologies for use in the process of generating electricity in each region can be applied and is so appropriate for the formulation of national policies in the field of renewable energy and national and regional development (Amer & Daim, 2011).

To prioritize and select the most appropriate renewable energy source for exploiting in renewable projects and achieve a 12% renewable resource share in Spain in 2010, Cristobal combines both VIKOR and AHP. The combination of VIKOR with the AHP method for weighting the importance of different criteria allows the decision maker to systematically allocate relative importance values based on their preferences to the indicators (San Cristóbal, 2011).

One of the key indicators for the growth of the economy and the social and industrial development of countries is the use of renewable or green energy sources; Datta et al in an article aimed at identifying the major challenges facing green energy sources (GES) in Future energy systems have been focusing on this. The proposed model uses the AHP method to select the most suitable source from photovoltaic, generator, biodegradable and small hydroelectric power, according to the 7 criteria considered. Also, using the MATLAB simulation, the explicit effects of different criteria on the best choice in uncertainty conditions are presented (Datta et al., 2011).

Jannatiypour and Cyrus in an article about renewable energy priorities with a multi-criteria decision-making approach and AHP method examined the status of renewable energy sources in Iran. The results of this research indicate that, according to experts, economic and technological criteria are the most significant factors in ranking energy. Considering the economic situation in the country, experts emphasized on the sub criteria of investment costs, operating costs and maintenance and repairs of the economic criteria. Also, technological criteria, sub-criteria of reliability and development rate were considered more significant than other sub-criteria. Finally, photovoltaic, wind and solar energies were identified as the most desirable renewable energy sources in Iran (Janatipour & Mohammad Cyrus, 2016).

In an article, Razini et al have reviewed the priority of renewable energy sources with the MCDM approach, including wind, solar, geothermal, biogas, and hydrogen sources for power generation in Iran. The reason for not choosing aqueous material is the high capacity of this source compared to other sources, whose presence in this analysis will make the comparison unlikely. To select the most suitable option in this paper, the analytical methodology has been used. In this study, the authors evaluated the scores of options and criteria. Each member separately performs comparisons and then, using Expert Choice software, the aggregated opinions and the final matrix of the decision, which indicates the score of each option in each criterion and the total score of each of the options was calculated. In this study, the total compatibility rate was 0.04, which indicates that the compatibility is very high in comparisons. The most significant feature of this assessment is to consider the country's conditions and to introduce various criteria in addition to economic issues in decision-making, too. In this study, wind and biomass energies were identified as the first priorities for the development of renewable sources of energy for electricity production (Razeghi et al., 2011).

Olfat and Turkestani have used analytical-hierarchical methods in a paper on support for decision-makers to prioritize renewable energy sources in Iran. The stages of the AHP implementation in this study are: Stage 1: Paired comparisons. Step 2: Extract Priorities. Step 3: Check the inconsistency rate. The paired comparison of this project was carried out in four phases, according to several experts from this field: Phase I: Between the available projects, based on the defined criteria, two-by-two comparisons were made. Phase II: The two-by-two comparisons were determined by their own criteria and the weight of each criterion was determined. Phase III: To utilize the obtained tables in the previous steps, they should be converted into normal tables. For normalization, in mathematics, there is a very precise method called a precise vector; however the other methods, such as the arithmetic mean, can also be used. In this paper, the mean arithmetic method is used to normalize the tables. Phase IV: The matrix of the preference criterion in the matrix of project preferences is multiplied after normalization to determine which project is more appropriate. Then, the inconsistency rate for all tables was calculated and the amount was confirmed to be acceptable. Based on the results of this study, it has been suggested that in deciding future investments in renewable energy sources, priority should first be given to solar photovoltaic energy and then to a significant distance to energy Wind, solar thermal energy, and ultimately geothermal energy and hydrogen energy (Olfat & Turkestani, 2006).

Kahraman et al used two fuzzy Axiomatic Design (AD) and fuzzy Analytic Hierarchy Process (AHP) design methods in fuzzy model to select the most suitable renewable energy source in Turkey. The FAHP method was used to evaluate the scores given by the experts and the FAD method was used to evaluate the options according to quantitative or qualitative criteria based on the information obtained through the experts (Kahraman et al., 2009).

The 2010 Kaya in his paper uses the VIKOR-AHP method in fuzzy mode to determine the most suitable renewable energy source in Istanbul and choose the optimal energy location for the power plant. In the proposed VIKOR-AHP method, the weight of the criteria is determined based on the pairwise comparison of the AHP matrix. Also, due to the vagueness of decision making judgments and the lack of clarity in energy decision making, fuzzy logic has been used to model these cases (Kaya & Kahraman, 2010). In 2015, an amendment to the Kaya article was presented by SaeedPour and Wafadarnikjoo, in which the first source of energy was selected first and then, the resource priority was adopted, according to which the prioritization table was changed (Saeedpoor & Vafadarnikjoo, 2015).

Mirzaie and Bagherinejad, in a paper aimed at prioritizing renewable energies, selected the best energy policy to improve the environmental planning by a fuzzy approach. In this article, regarding the uncertainty conditions as well as the range of changes monitoring the problematic attribute, one of decision-making method is AHP in fuzzy mode. In this paper, after the weighting of the criteria, CO2 emission with the highest score was identified as the most significant criterion for measuring renewable energies. NOx emission criteria, operating and maintenance costs, energy efficiency, investment costs, social costs, and technical efficiency were ranked in the next order, respectively. Also, the paired comparison of energy options versus defined criteria indicates that wind energy is selected as the best renewable energy source with the highest score. Other sources also prioritized solar, biomass, geothermal and hydroelectricity respectively (Mirzaei & Bagherinejad, 2012).

Sadeghi et al. in an article on The Optimal Combination of Energy Sources, using Fuzzy Analytical Hierarchical Process approach and through sustainable development attributes determined the optimal energy mix for power generation in Iran. In this paper, the results were calculated using the fuzzy analytical hierarchical method and the BOCR network, too. Accordingly, there should have a large share of electricity produced by the country's power plants (about 36%) through renewable energy sources. Considering the low share of renewable energy in the current energy basket of the country (about 3.4%), it is essential to focus the emphasis on the development and implementation of renewable power plants. Also, based on the findings of this research, the share of nuclear energy in the optimal basket of energy resources of the country's power plants is negligible and only about 5 percent. The results of this study also indicate that revision of the use of fossil fuels, especially natural gas, is necessary. The share of natural gas in the energy basket of the country's power plants should be reduced from about 73% at present to about 41%. (Sadeghi et al., 2012)

Mohajeri and Astaneh, in another paper on Prioritizing Renewable Energy Resources using the Hyper-Diffraction Analysis Process (FAHP), after recognizing the initial list of evaluation criteria, according to experts, selected final evaluation attributes. To determine the final evaluation attributes, the attributes are matched to Iran's conditions and the data access. The renewable energy options considered in this research are as follow: 1. Wind energy, 2. Solar energy, 3. Biomass energy (biodegradable), 4. Marine energy (waves), 5. Geo-thermal energy, 6. Narrow water energy. After the preparation of a questionnaire for making paired comparisons and completing by experts, the analysis of attributes priority of renewable energies has been studied by means of fuzzy linguistic scales. Also, to ensure the compatibility of expert answers for each pair comparison table, the incompatibility rate is calculated using the mean value of fuzzy triangular numbers and it is observed that in none of the cases the rate of inconsistency is higher than the standard level (1 / 0) was not. The results of this study indicate that wind energy and small water energy are the most important in the country as compared with other renewable energy sources; hence, they are more appropriate for investment and improvement of utilization practical capacity (Mohajeri & Khaksar Astaneh, 2013).

MATERIALS AND METHODS

AHP's systematic model based on fuzzy theory is presented to analyze the influential criteria and sub-criteria on solar energy utilization in building architecture design. The general process steps are indicated using the proposed model in Fig.1.

Step 1: Define an objective function based on the research purpose: "Identifying and prioritizing influential factors and criteria on the capacity of utilizing solar energy in designing a building architecture with a climatological approach";

Step 2: Divide the problem into the influential levels of macroeconomics based on the studies conducted in the subject literature based on the analytical-descriptive research method (Table 1);

Step 3: Fuzzy Analytical Hierarchy Design (FAHP) based on the identified attributes and sub-attributes (Fig. 2);

Step 4: Formulate a questionnaire based on the paired comparison logic to evaluate the attributes and sub-attributes;

Step 5: Formation of a team of ten academic and governmental officials and industry experts to plan the identification process, evaluate the criteria and sub-criteria, and conduct paired comparisons;

Step 6: Fuzzy Dynamic Hierarchy Network Modeling in Super Decision Software (Fig. 3);

Step 7: Computations for weighting and synthesizing the results of the proposed network in the software and determining the weight of the evaluation criteria using the Fuzzy Dynamic Analyzer Process (FAHP). (Fig. 4);

Step 8: Removing areas of non-exploitable solar energy with a climatic approach (Table 2);

Step 9: Define the thresholds for sub-attributes based on the textual model of Makhdoom and the analytical-descriptive studies of the subject literature (Table 3);

Step 10: Calculations on the weighting of the subcategories of the Meccot model (Table 7);

Step 11: Preparation of a quantitative checklist of the final criteria for the attributes and sub-attributes and qualitative tables for solar energy assessment (Tables 7 and 8).

In this stage, in order to evaluate the potential of solar energy use in the country, after identifying the criteria and sub-criteria affecting solar energy utilization using the process of analyzing the energy efficiency, the relative importance of the criteria, taking the opinion of the experts into account, is determined. Locational metrics are usually studied in different groups

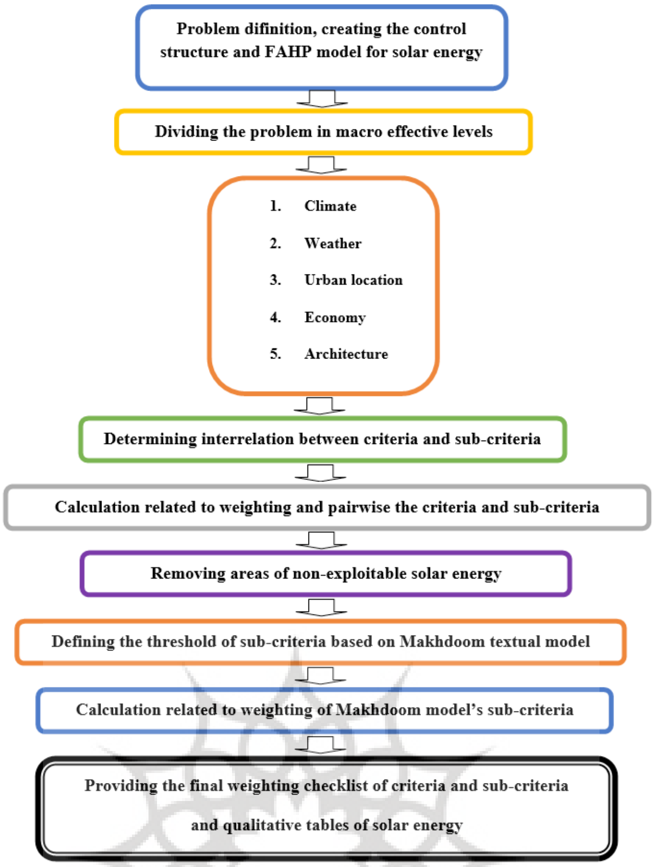

Fig.1: General stages of proposed model.

such as: environmental, economic, geographic, demographic, land use, hydrological, security, technical, and so on. In this research, based on the literature and the review of the criteria used for solar energy capability, questionnaires were prepared to ten relevant experts to answer five criteria as the most effective criteria. And 15 related sub-attributes were identified in this study and classified according to the dynamical structure shown in Fig. 2. The following is a description of the defined criteria.

Distance from distribution lines: Due to the high cost of building power distribution lines, one of the important criteria in determining the ability to utilize solar energy in designing a building architecture is the distance from the distribution lines. Generally, electrical power distribution lines are effective in determining the capability for safety, network security, as well as the rapid availability of equipment and repairs. Studies have indicated that the best distance from the electricity grid for safety of solar and network systems are 0 to 3 miles. In other words, the proximity of the systems installation to the electric energy distribution lines is a significant economic advantage.

Solar Radiation: The most significant climatic parameter is the amount of absorbed energy of the regions from the sun. Sunny hours are the total monthly or annual hours of an area.

Zone Temperature: One of the photovoltaic systems' components is the energy converter, the solar panel, because this system provides the required power and energy, it needs to be designed properly. One of the cases which is effective in determining the panel size is its efficiency. The efficiency of the solar panels relies on its temperature, and the panel's temperature is also due to ambient temperature and the intensity of the sun's radiation. The feasibility of the photovoltaic system model declines as air temperature increases. For every 1 degree increase in cell temperature at temperatures above 25 degrees, the amount of produced energy declines about 0.4 to 0.5 percent.

Slope: is one of the most significant factors in photovoltaic farms' potential, with an average of 11% in Iran. Objects with a slope of more than 4% are less preferable because the panels shade on the next row and influence on the system efficiency.

Height: As much as the regional elevation is lower than the sea level, the thickness of the atmosphere increases. Thick barley contains more concentrations of compounds and absorption or reflection factors. Since thicker materials are gathered in the lower floors, the atmosphere above the mountains is thinner and the thickness of the atmosphere is lower. The thickness and composition of the atmosphere, in spite of entering the energy of the short wave of the sun, controls the energy of the long wave of the earth. Therefore, highlands have higher potentials

Table 1: Classification of criteria and sub-criteria of the proposed solar model.

Row	The criterion name	Sub- criterion name
1	Climate	Solar radiation
2		() Temperature degree
3	Weather	(%) Humidity
4		(Cloudy (day
5		(Dust (day
6	Urban location	(Height (m
7		(%) Slope
8		(distances from distribution lines (Km
9		Building shade
10	Economy	(Economic System Life (Year
11		(%) System efficiency coefficient
12	Architecture	(Architectural angle orientation (degree
13		Integrated Design System
14		System locations
15		Combined system

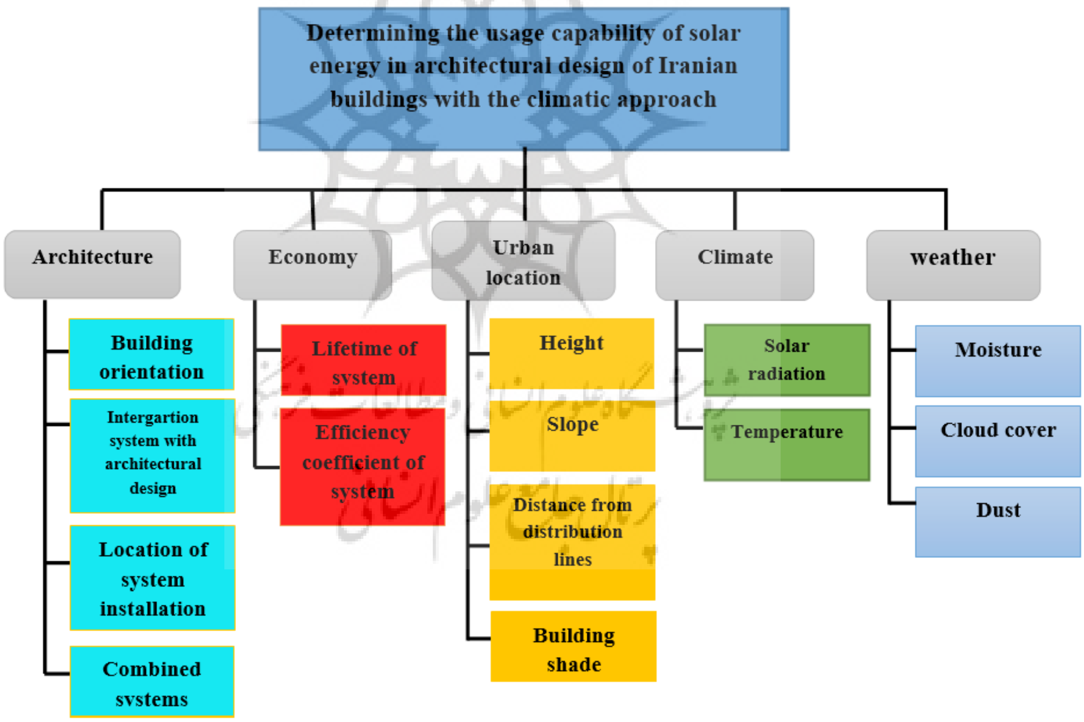

Fig. 2: FAHP Solar Model.

than postal areas due to their high energy consumption.

Dust: Compounds of significant atmospheric pollutants, especially near the surface of the earth, are non-gas and solid compounds called aerosols. Humidors absorb 15% of the sun's short wave energy. Considering environmental changes in recent years and the introduction of dust systems in the south and southwest of the country, it is important to utilize solar energy for areas that have the fewest days of dust pollution per year.

Clouds cover: One of the criteria applied in this study is the number of cloudy days per year. Given the fact that the number of cloudy days has a significant impact on the number of sunny hours and subsequent production of panels, it is clear that as the number of cloud days in a region is greater, due to the minimization of received radiation, production declines sharply and may occasionally reach zero. The average sulfur content is about 40 percent in Iran.

Moisture: There is moisture in the amount of water in the air. On a global scale, an average of 1% of the volume of the atmosphere is water vapor. However practically, this may vary in different regions. Water vapor and carbon dioxide are radiant energy absorbers in the atmosphere. Thus, maximizing moisture content has a negative relationship with the efficiency of solar panels. Relative humidity also alters inversely with temperature change.

The eighth step of this proposed model is the elimination of unlicensed geospatial solar energy bases relied on very high weighing criteria based on library studies and relying on expert opinion. For this, inappropriate limits for the use of solar energy in Iran are presented in Table 2 as follows.

In the ninth step of the proposed model, the definition of thresholds for sub-attributes is based on a model called "Textual Model", which is an "ecological model of urban and industrial development for Iran". The general framework of this textual model involves the derivation of the influential components on the objective function and then, their qualitative valuation in three levels such as: "appropriate, a little appropriate and inappropriate". Therefore, in the third model, based on the objective function, five qualitative levels as "a little appropriate, appropriate, good, very good and excellent" are corresponding to the quantitative levels, in accordance with the quantities derived from library studies for the fifteenth mentioned network metrics and sub-attributes, whose description is indicated in Table 3.

Descriptive variables are selected after defining the appropriate criteria for evaluating the criteria by utilizing energy experts in architecture field. Then, the chosen options are converted by the scales in Table 4, which include triangular fuzzy numbers,

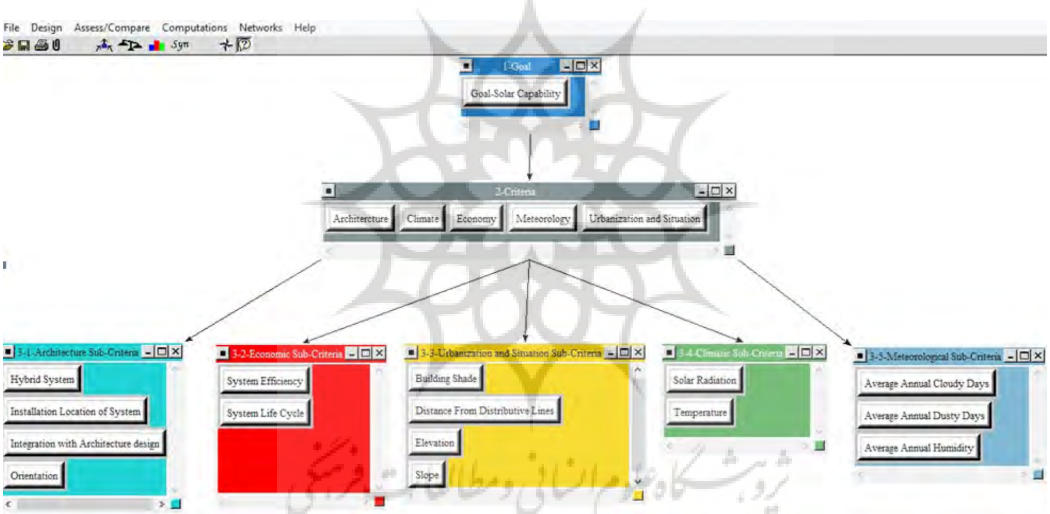

Fig. 3: Modeling of the proposed fuzzy hierarchy network in Super Decision software

Table 2: The inappropriate geographic areas determination for solar energy in Iran.

Row	The criterion name	Sub-criterion name	Defining quantitative thresholds of inappropriate ranges
1	Climate	Solar radiation $\frac{Kwh}{m^2-year}$	X<1300
4	Weather	Cloudy (day)	X>170
5		Dust (day)	X>168

Table 3: Definition of qualitative levels and criteria thresholds for the FAHP Solar Model.

Row	The criterion name	Sub- criterion name	Defining quantitative thresholds in solar energy decision-making system					
			Inappropriate	A little appropriate	Appropriate	Good	Very good	Excellent
1	Climate	Solar radiation	X<1300	1300-1700	1700-1900	1900-2000	2000-2100	x>2100
2		Temperature degree (°c)	-	X>28	27-28	26-27	25-26	24-25
3	Weather	Humidity (%)	X>83	60-83	50-60	42-50	35-42	26-35
4		Cloudy (day)	X>170	120-170	80-120	50-80	30-50	X<30
5		Dust (day)	X>120	100-120	70-100	50-70	30-50	X<30
6	Urban Location	Height (m)	-	0-200	200-450	450-750	750-1200	X>1200
7		(%) Slope	-	4-11	3-4	2-3	1-2	X<1
8		Distances from distribution lines ((Km	-	X<36	36-46	46-56	56-76	X>76
9		Shadowing of a Building	Full shadow of the South Fixed obstacles	Full shading East Fixed obstacles	Shadow temporary obstacles	Shadowing of natural obstacles	Shadow of winter and summer	Without shadowing
10	Economy	Economic System Life (Year)	-	X<12.5	12.5-20	20-25	25-30	X>30
11		System's efficiency coefficient (%)	-	X<10	10-20	20-30	30-40	X>40
	Architecture	Architectural angle orientation (degree)	Other geographical directions	South- ° 45 east	South- ° 30 east	South- ° 30 west	South- ° 45 west	south
12		Integrated Design System	roof + roof windows + atrium + views + canopies					
13			No Integration	Space 1	Spaces 2	Spaces 3	Spaces 4	All possible spaces
14		System locations	-	Flat roofing	The straight wall	Roofing 60 °	Roofing 45 °	Roofing 30 °
15		Combined system	System 1	Systems 2	Systems 3	Systems 4	Systems 5	More than 5

and are generalized for to do calculation and analyze results. The Analytical Hierarchy Process was developed by Thomas L.Saaty (Besarati et al., 2013) and was utilized by many researchers in various fields. The Analytical Hierarchy Process

Table 4: Verbal variables and corresponding numerical numbers (Source: Saaty, 1980)

Triangular fuzzy numbers	Verbal scales' values
Very high	(1,1 ,0.9)
Top	(0.7,0.9,1)
Medium high	(0.9 ,0.7 ,0.5)
Medium	(0.7 ,0.5 ,0.3)
Medium low	(0.5 ,0.3 ,0.1)
Low	(0.3 ,0.1 ,0)
Very low	(0.1 ,0 ,0)

is one of the Multiple Attributive Decision Making methods (MADM) which has the capability to solve complex problems in different qualitative and quantitative fields. To meet the data ambiguity or problems in judgments and comparisons, fuzzy set theory is applied as an appropriate tool. Many researchers have applied the analytical hierarchy process as a potent tool to determine the appropriate options priority (Uyan, 2013).

In this research, the experts' team comprises 10 members among the academic and state experts for designing and implementing the criteria identifying process and conducting the paired comparisons using the language variables based on Table 4. To sum up the obtained comments in the decision-making process, a group of geometric mean methods is applied in accordance to equation 1. In the rest of the article, for defuzzyfying through centeroid technique, the non-fuzzy value of the obtained results are calculated according to equation 2.

Equation 1) $$\tilde{F} = \left((\prod_{t=1}^{K} l_t)^{\frac{1}{K}} , (\prod_{t=1}^{K} m_t)^{\frac{1}{K}} , (\prod_{t=1}^{K} u_t)^{\frac{1}{K}} \right)$$

Where l_t , m_t, u_t is the t expert's view (t = 1, 2, 3, ..., k).

Equation 2) $$n^* = \frac{[(u-l)+(m-l)]}{3} + l = \frac{l+m+u}{3}$$

Based on the results, the final calculations are done to determine the relative criteria's weight using the Super Decision software. The results of the defined criteria categorization as well as the obtained weights from Fuzzy Analytical Hierarchical process are described in Table 5.

RESULTS AND DISCUSSION

In meeting the objective function, identifying and prioritizing the influential factors on utilizing solar energy in architecture design of buildings in Iran with the climatic approach, the following obstacles and problems can be mentioned:

Extensive geographic and climatic levels covered by the model;

The enormous research problems in integrating macroeconomic metrics such as energy, architecture and climatology;

Lack of accurate information about internal energy systems and references to external resources.

Based on the research methodology and the research steps, five main criteria and 15 sub-criteria were weighed and then prioritized by the experts in the process of comparative analysis conducted by the experts. Thus, the results can be analyzed as follows:

Main criteria: Among the five main criteria of the research, rather than the objective function of "Solar energy utilization in Iran", the climatic criterion with relative weight of 33.86, architecture with 21.65, location and urbanization with 20.36, weather with 18.90 and the economy with 5.23 are in the first to fifth priorities.

Climate sub-measures: Among the climatic sub-criteria, the amount of solar radiation with a relative weight of 0.8041 and a final weight of 27.226, and a temperature of the region with a relative weight of 0.1959 and a final weight of 6.633 are in the first and second priorities in their sub-networks.

Sub-criteria for location and urbanization: Among the sub-criteria of location and urbanization, the height with relative weight of 0.3521 and the final weight of 7.168, the slope with the relative weight of 0.3478 and the final weight of 7.081, the shading of the relative weight of 0.1908 and the final weight of 3.884, and the distance from the distribution lines with a relative weight of 0.1093 and a final weight of 2.225 are in the first to fourth priorities.

Climatic sub-criteria: Among the sub-criteria of the climate, the supernova with a relative weight of 0.3969 and a final weight of 7.501, a dust with a relative weight of 0.3256 and a final weight of 6.153, and a relative humidity of 0.2775 and a final weight of 5.244 are in the first priorities up to third ones.

Architectural sub-criteria: Among the architectural sub-criteria, the relative orientation angle of 0.4753 and final weight of 10.290, positioning system with a relative weight of 0.2641 and a final weight of 5.717, an integrated system with an architectural design with a relative weight of 0.1604 and a final weight of 3.472; utilizing the combined systems of solar energy extraction with a relative weight of 0.1002 and a final weight of 2.169 are in the first to fourth priorities.

Economic sub-criteria: Among the economic sub- criteria, the

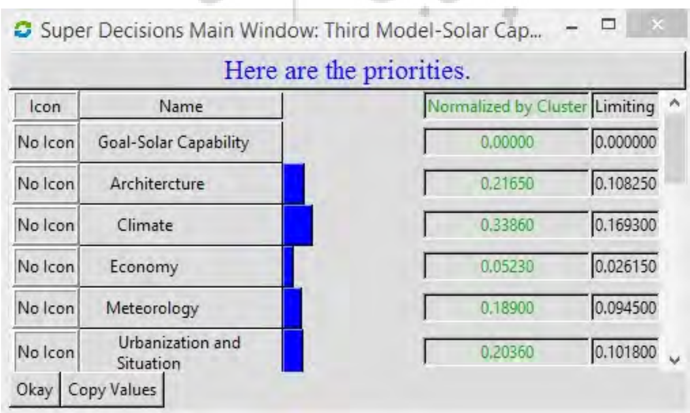

Fig. 4: Prioritizing the main criteria of the proposed model.

lifespan of the solar energy system with a relative weight of 0.5347, final weight of 2.796, solar system efficiency with a relative weight of 0.4653 and a final weight of 2.433 are in the first and second priorities in the sub-network.

The final weighing of the proposed model is presented in Table 5.

In the next step, the sum of peak algebra of each of the thresholds of the sub-criteria was defined based on textual model and Table 3 as the threshold of the main criteria, the detailed description of which for each of the third and fourth models is represented in Table 7. Finally, with algebraic summation, the maximum limit of the thresholds of the criteria, the threshold of the objective function was defined and presented in Table 8 as the answer to the questions and the result of the mode.

Table 5: Final weighing of the criteria and sub-criteria of the proposed model.

Purpose	Obj.	Relative weight	Final weight	Criterion	Relative weight	Final weight
Determining the capability of solar energy in architectural design with climatic approach in Iran	**Climate**	0.3386	33.86	Solar radiation (Kw.hr/ m2.Year)	0.8041	27.226
				Regional temperature degree (C)	0.1959	6.633
	Urban location	0.2036	20.36	Distances from distribution lines (km)	0.1093	2.225
				Height (m)	0.3521	7.168
				(%) Slope	0.3478	7.0812
	Weather	0.189	18.9	Shadowing of the building	0.1908	3.884
				Humidity (%)	0.2775	5.244
				cloudy	0.3969	7.501
				Duct	0.3256	6.153
	Architecture	0.2165	21.65	Building's Orientation angle	0.4753	10.290
				Integrated system with design	0.1604	3.472
				Location of the system	0.2641	5.717
				Combined system	0.1002	2.169
	Economy	0.0523	5.23	Lifetime of the system	0.5347	2.796
				System efficiency coefficient	0.4653	2.433

Table 6: Results of defined levels and calculated weights for the proposed model evaluation criteria.

Purpose	Obj.	Relative weight	Final weight	Criterion	Relative weight	Final weight	Makhdoom Sub-criterion range	Relative weight	Final weight
The architecture designing of utilization capacity of solar energy in a building by climatic approach in Iran	**Climate**	**0.3386**	**33.86**	**Solar radiation (Kw.hr/ m^2.Year))**	0.8041	27.226826	<1300	0	0
							1300-1700	0.054545	1.4850872
							1700-1900	0.149091	4.0592747
							1900-2000	0.196364	5.3463685
							2000-2100	0.28	7.6235113
							>2100	0.32	8.7125843
				Regional temperature degree (^oC)	0.1959	6.633174	Without limitation	0	0
							X>28	0.1	0.6633174
							27-28	0.15	0.9949761
							26-27	0.19	1.2603031
							25-26	0.23	1.52563
							24-25	0.33	2.1889474

Continue of Table 6: Results of defined levels and calculated weights for the proposed model evaluation criteria.

Purpose	Obj.	Relative weight	Final weight	Criterion	Relative weight	Final weight	Makhdoom Sub-criterion range	Relative weight	Final weight
The architecture designing of utilization capacity of solar energy in a building by climatic approach in Iran	**Urban location**	**0.2036**	**20.36**	**Distances from distribution lines (Km)**	0.1093	2.225348	Without limitation	0	0
							X<36	0.107143	0.2384305
							36-46	0.133929	0.2980386
							46-56	0.160714	0.3576446
							56-76	0.258929	0.5762071
							X>76	0.339286	0.7550294
				Height (m)	0.3521	7.168756	Without limitation	0	0
							0-200	0.047183	0.3382434
							200-450	0.071074	0.5095122
							450-750	0.121157	0.868545
							750-1200	0.242222	1.7364304
							X>1200	0.518419	3.7164193
				Slope (%)	0.3478	7.081208	Without limitation	0	0
							4-11%	0.05	0.3540604
							3-4%	0.1	0.7081208
							2-3%	0.15	1.0621812
							1-2%	0.25	1.770302
							X<1%	0.45	3.1865436
				Shadowing of the building	0.1908	3.884688	Southern perfect shading of stable obstacles	0	0
							Eastern perfect shading of stable obstacles	0.061666	0.2395532
							Shading of temporary obstacles	0.123133	0.4783333
							Shading of natural obstacles	0.169156	0.6571183
							Summer and winter shading	0.213666	0.8300257
							without intervene shading	0.433333	1.6833635
	Weather	**0.189**	**18.9**	**Humidity (%)**	0.2775	5.24475	X>83	0	0
							60-83	0.097561	0.5116831
							50-60	0.121951	0.6396025
							42-50	0.171732	0.9006914
							35-42	0.219512	1.1512856
							26-35	0.389854	2.0446868
				Dusty	0.3969	7.50141	X>170	0	0
							120-170	0.034483	0.2586711
							80-120	0.068986	0.5174923
							50-80	0.155172	1.1640088
							30-50	0.293103	2.1986858
							X<30	0.448276	3.3627021
					0.3256	6.15384	X>120	0	0
							100-120	0.041494	0.2553474
							70-100	0.103734	0.6383624
							50-70	0.145228	0.8937099
							30-50	0.211469	1.3013464
							X<30	0.498925	3.0703046

Continue of Table 6: Results of defined levels and calculated weights for the proposed model evaluation criteria.

Purpose	Obj.	Relative weight	Final weight	Criterion	Relative weight	Final weight	Makhdoom Sub-criterion range	Relative weight	Final weight
The architecture designing of utilization capacity of solar energy in a building by climatic approach in Iran	Architecture	0.2165	21.65	Building's Orientation angle	0.4753	10.290245	Other geographical directions	0	0
							South-east ° 45	0.117647	1.2106165
							South-east ° 30	0.17647	1.8159195
							South-west ° 30	0.17647	1.8159195
							South-west ° 45	0.23529	2.4211917
							South	0.29411	3.026464
				Integrated system with design	0.1604	3.47266	Without integration	0	0
							space 1	0.048586	0.1687227
							spaces 2	0.133333	0.4630202
							spaces 3	0.17291	0.6004576
							spaces 4	0.212666	0.8385167
							All the possible spaces	0.433153	1.5041931
				The location of the system	0.2641	5.717765	None	0	0
							Flat roof	0.07526	0.430319
							Straight wall	0.102363	0.5852876
							roofing ° 60	0.17546	1.003239
							roofing ° 45	0.2316436	1.3244837
							roofing° 30	0.415313	2.3746621
				The combined system	0.1002	2.16933	system 1	0	0
							systems 2	0.06666	0.1446075
							systems 3	0.133333	0.2892433
							systems 4	0.2	0.433866
							systems 5	0.266669	0.5784931
							More than 5 systems	0.333338	0.7231201
	Economy	0.523	0.52	System lifetime	0.5347	2.796481	Without limitation	0	0
							X<12.5	0.112856	0.3155997
							12.5-20	0.153333	0.4287928
							20-25	0.211638	0.5918416
							25-30	0.225694	0.631149
							X>30	0.296533	0.8292489
				The efficacy coefficient of system	0.4653	2.433519	Without limitation	0	0
							X<10	0.05656	0.1376398
							10-20%	0.097903	0.2382488
							20-30%	0.12645	0.3077185
							30-40%	0.226096	0.5502089
							X>40%	0.493333	1.2005352

Table 7: Results of leveling attributes solar energy utilization in architectural design of Iranian buildings.

The results of solar energy utilization in architectural design of Iranian buildings with a climatic approach and FAHP method level				
Row	Criterion	Qualitative level	The qualitative threshold of the final weights	
1	Climate	Inappropriate	2.1	-
		A little appropriate	5.05	2.148404624
		Appropriate	6.59	5.054250815
		Good	9.13	6.606671531
		Very good	10.89	9.1491413
		Excellent	*	10.90153174

Continue of Table 7: Results of leveling attributes solar energy utilization in architectural design of Iranian buildings.

The results of solar energy utilization in architectural design of Iranian buildings with a climatic approach and FAHP method level				
Row	**Criterion**	**Qualitative level**	**The qualitative threshold of the final weights**	
2	Urban location	Inappropriate	1.16	-
		A little appropriate	1.89	1.170287445
		Appropriate	2.93	1.994004884
		Good	4.9	2.945489032
		Very good	9.33	4.912965294
		Excellent	*	9.342655843
3	Weather	Inappropriate	1.019	-
		A little appropriate	1.78	1.25701613
		Appropriate	2.95	1.795453216
		Good	4.649	2.958410075
		Very good	8.47	4.651317728
		Excellent	*	8.477693458
4	Architecture	Inappropriate	1.95	-
		A little appropriate	2.149	1.954265644
		Appropriate	3.849	3.153470567
		Good	5.059	3.853482223
		Very good	7.619	5.062685188
		Excellent	*	7.628439313
5	Economy	Inappropriate	0.449	0
		A little appropriate	0.659	0.452229494
		Appropriate	0.889	0.667041622
		Good	1.179	0.899560.123
		Very good	2.019	1.181357895
		Excellent	*	2.02978412

Table 8: The results of total solar energy utilization level in architectural design of Iranian buildings with a climatic approach.

The results of solar energy utilization in architectural design of Iranian buildings with a climatic approach and FAHP method level			
Macro decision	**Qualitative level**	**The qualitative threshold of the final weights**	
Leveling the utilization capacity of solar energy in architecting design	Inappropriate	6.749	0
	A little appropriate	12.659	6.75189821
	Appropriate	17.259	12.66422511
	Good	24.949	17.26361297
	Very good	38.369	24.95746741
	Excellent	*	38.37880448

CONCLUSION

Regarding the global energy crisis and the effective steps taken by the international community to address the adverse effects of this category, Iran has been condemned to adopt management decisions and long-term plans for moderating this global crisis. Based on the results of the studies conducted on supply and demand, more than 43% of the total energy consumption in Iran is allocated to the building sector (i.e., residential and commercial), and this is a major issue for the construction industry. Thus, the Iranian architectural community, as the constructivist leader, should consider designing operational and design solutions to overcome this issue, too.

The first step in achieving this goal is to identify and prioritize decentralized renewable energy in building design. In this regard, in the present paper, in order to measure and evaluate solar energy by defining 5 criteria and identifying 15 sub-criteria, using multi-criteria decision-making (FAHP) method, we analyze the dynamics of selected criteria from library-based studies On Fuzzy Theory. Then, the relative weighing of the criteria and sub-criteria defined using the fuzzy-analytic process analysis technique, based on the ten-member team opinions of academic experts and public administration associated with The field of energy planning was carried out.

In the next step, through the proposed structure modeling of the research in Super Decision software, the paired comparison was made between the experts and the prioritization of the criteria and sub-criteria. As it was expected, the climate criterion with relative weight of 33.86, architecture with 21.65, location and urbanization with 20.36, climate with 18.90 and economy with 5.23 were first to fifth priorities; the results show the reciprocal effects of climatic criteria, architecture and urbanization in the decision-making system in building architecture design.

Based on these studies, one of the factors of Iran's contemporary architectural deviation from the goals of energy efficiency optimization and application of renewable energy potential is the qualitative approach of architects with a perfect quantitative category entitled the climate. Thus, it is the first step towards coming off the global goals of energy-based planning in Iran, reestablishment of the concepts and priorities of native architecture in the above-mentioned country and the involvement of designers and students of architecture with the quantitative climate categories. One of the major crises in architectural design community in the world is to justify the constructive projects for the benefit of renewable energy systems. Unluckily, in various projects, unpardonable justifications are perfectly personal, or imitation of disparate global patterns. This is due to the lack of the real and legal entities' ownership in the projects and the need for scientific and quantitative reasoning, which makes it unjustifiable to use these systems. Therefore, it is expected that by utilizing commonly used tables from the third and fourth models and preparing operational checklists, a step towards the increasing influence of climate factors on architectural design and rate growth of utilizing clean and renewable energy.

The results of this study can provide a developing outlook for energy application in the constructive industry as well as optimizing energy consumption via making a developmental perspective, and present a deep attitude to the programmers. Due to the ability to decline, enhance and alter the criteria and sub-criteria in the proposed model, as well as the compensatory property of the criteria in a simple summation method, using other applied techniques of multi-criteria decision-making and comparing the results with the method used in this research is proposed as a background for future research.

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