

## Investigating factors affecting on designing zero energy residential complex in Tehran, with an emphasis on sustainable development

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### ABSTRACT

This study with the objective of investigating factors affecting on optimum design of residential buildings in Tehran that is one of the big cities and pollution of Iran, with the approach of sustainable development has been conducted. This survey is a combination study (qualitative and quantitative). From objective aspect, it is practical and from method aspect is descriptive-analytical. Library studies were used to collect theoretical information. After obtaining the theoretical basis, viewpoints of engineering and architecture organization experts in Tehran using field survey and a questionnaire are collected. The proposal by experts in this scientific field with a questionnaire and AHP analytical method was evaluated. To analyze the data and hypotheses, SPSS 22 software was used. The sample in this study is 386 members of the engineering and architecture organization. The sample size was calculated with Cochran formula. The results showed that designing zero energy residential complexes in Tehran, helping to reduce air pollution caused by fossil fuels, reduction of surface water pollution, soil pollution reduction and thereby reducing disease and mortality of this disease. Cost savings and high safety of this type residential complex, force architects and users to use these buildings.

**KEY WORDS:** Zero energy, sustainable development, energy zero architecture, Energy saving, renewable and non-renewable energy.

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### INTRODUCTION

The fine pollen from fossil fuels in large and industrial cities have been caused to increase temperature and respiratory disease and mortality in communities. Acid rain and agricultural soil pollution and its negative effects on drinking water and green tissue of Tehran having to modify source of energy. The relationship between the environment, energy, economics and research to solve the energy problem through new design ideas, new materials and intelligent energy systems affordable is expanding, continuously [1].

Now Germany is pioneering the use of solar energy. Some practices to solve "Energy problem" of the building are bioclimatic design and passive energy systems, solar thermal and photovoltaic, small wind turbines or the use of biomass and bio-gas energy. Using these cases cause to reduce the effects on the environment, humans and climate change [2].

Zero energy building is a goal that scientists are trying to design the new buildings based on its principles [3]. Many studies have been done on the zero energy building, which is mentioned below.

Soltani Arabshahi, studied on a comprehensive analysis of energy at close to zero energy home and the main objective of this study was investigating different efficient and integrated energy technologies to produce a zero energy house. Study method was the quasi-experimental and for designing design builder software which was under company of energy plus was used. The result showed 30% reduction in energy consumption [4].

Sakkas studied on the efficient design of the production systems and energy saving in buildings and his main purpose of study was energy resource management in buildings equipped with energy production and energy storage systems focused. Study method was the quasi-experimental and for designing transys software was used. The result showed an appropriate balance between internal and external energy management [5].

Chabauda have been studied in zero energy in Iran. Their main aim was Investigating zero energy provide in buildings by solar energy. Study method was the descriptive. Results showed that considering the high rate of initial costs of solar air conditioner in the current economic situation it is not cost effective and for popular people fossil energy and electricity is cheaper than solar energy [6].

Shelley studied on thermal energy modeling of Green energy. The goal of the study was global warming systems with emphasis on thermal energy storage in the ground. Study method was the quasi-experimental and

for designing "transys" and "trnbuid" software was used. The result showed 26.1% reduction in power consumption and saving heat because pump operation time is shorter than other thermal methods [7].

Purmokhtar studied on the evaluation of photovoltaic systems of thermal air to create a zero energy home in Sydney. The main objective was study on the concept of achieving zero houses in Sydney through efficient energy. Study method was the quasi-experimental and a photovoltaic system was designed with solar energy [8].

Rahmaniet al. studied on solar energy in zero energy homes in South America. The main objective of these studies was investigating feasibility of using zero solar energy of NZEB building for a house. Study method was the quasi-experimental and the results showed that the subsidy system NZEB was most efficient method with long-term financial support [9].

National commission of Sustainable Development studied on maximizes residential energy and technology path of zero energy house. Their main objective was review of the key opportunities for energy efficient technology in the United States. Study method was descriptive. The result showed 40% reduction in energy consumption until 2020 [10].

Rahnavard, et al. studied on Nano composites based on an efficient combination energy of thermal storage of cold air conditioning systems for buildings that are friendly with environment. Their goal is efficient energy HiTESilveretitia (based on cold hybrid Nano composites of thermal energy storage) system with the building A / C (air conditioning), an experimental system designed for summer and winter conditions. Study method was the quasi-experimental and experimental that was studied on the system HiTES A / C. Results showed using Nano composites help to achieve effective redistribution of energy needs without compromising energy savings and improved energy efficiency in buildings. It is expected to save HiTES energy costs of A / C system in comparison with conventional systems A / C for more operating conditions [11,12].

Given the importance of the use of solar energy in buildings, the aim of this study was to investigate the zero energy of buildings in Tehran city with the approach of sustainable development and providing energy with lowest cost and long-term return based on climate and energy provided by natural resources.

In this study, investigating factors affecting on optimum design of residential buildings in Tehran that is one of the big cities and pollution of Iran with the approach of sustainable development that has the long-term return, lowest cost, high safety, reduce the harmful effects on environmental and the climatic conditions, will be discussed. To achieve these goals the following assumptions will be answered:

It seems if condition of interior space is preserved in the comfort level so for heating and cooling buildings do not need to use any renewable energy.

It seems using zero energy in architecture causes saving energy and reducing costs.

It seems using renewable energy sources is a method for optimizing interaction between humans and the environment.

It seems that zero energy buildings in terms of security, have high safety.

## METHODS AND MATERIALS

This survey is a combination study (qualitative and quantitative). From objective aspect it is practical and from method aspect is descriptive-analytical.

Library studies were used to collect theoretical information. After obtaining the theoretical basis, viewpoints of engineering and architecture organization experts in Tehran using field survey and a questionnaire are collected.

The proposal by experts in this scientific field with a questionnaire and AHP analytical method was evaluated. To analyze the data and hypotheses, SPSS 22 software was used.

The sample in this study are 386 members of the engineering and architecture organization. The sample size was calculated with Cochran formula.

Table 1- The Statistical population (N = 386)

Total	Ph.D.	Master of Science	Bachelor of Science	Title
386	12	156	218	number

The cognitive questions to determine the characteristics of the respondents using anticipate two question was that by these questions, level of education and grade engineering system have been questioned.

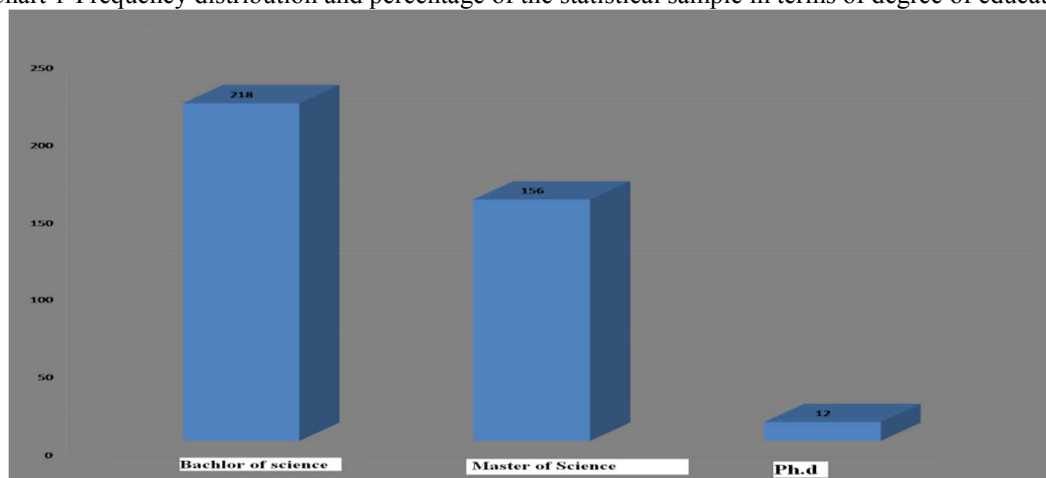
The research questions, 20 questions were used to evaluate the hypotheses is that the spectrum Likert scale was used. Validity of questionnaire by consultation with experts was confirmed. Reliability of questionnaire was estimated with Cronbach's alpha that 0.98 was obtained, which was approved.

## RESULTS

### The results of descriptive statistics

In order to better understand the nature of the group that has been studied and learn more about the research variables, before the data are statistically analyzed, this data should be described. The results show that the 56% of experts are Bachelor of Science, 41% are Master of Science and 3% are Ph.D. (Chart 1).

Chart 1-Frequency distribution and percentage of the statistical sample in terms of degree of education



In order to summarize the contents, the descriptive statistics (minimum, maximum, mean, standard deviation, skewness and kurtosis) were used (Table 2).

Table 2- Descriptive indicators of variables

kurtosis	skewness	standard deviation	Mean	maximum	minimum	variables
11.455	-3.345	.47045	4.8327	5.00	1.80	Economical
12.643	-3.500	.44579	4.8587	5.00	1.80	Environmental
10.120	-3.291	.43529	4.8577	5.00	2.60	Security

According to Table 2, the distribution of scores on all variables have a negative skewness. In other words, the cube of the mean scores, is a negative number and greater than the average scores for most people at this scale. Environmental distribution of scores has the highest skewness and security distribution of scores has lowest skewness. The distribution of scores on all variables have positive kurtosis. This means that the majority of people on this scale are close to the Mean.

### The analytical Results

In order to verify the data description and generalization of the results to the community that it is extracted sample, univariate t-test was used. The results have been presented in the following tables.

#### The first question

Is sustainable development indicators for Tehran economically appropriate or not? To answer this question univariate t-test was used (Table 3).

Table 3- Results of univariate t-test

Test Value = 3				Economic variable
Mean Difference	Sig.	df	T	
1.83273	.000	384	76.439	

As seen in the table 3, since the value of t-test at 0.001 is significant, it can be said that in view of Tehran's architects member of engineering, sustainable development indicators to be economically appropriate in Tehran. To investigate

each question in terms of economic development indicators, the chi-square test was used. Results in the following table is provided (Table 4).

Table 4- The results of the chi-square test

chi-square	Sig.	degree of freedom (df)	residuals	The expected case	observed	spectrum
055.4551	0.001	4	-76.0	77.0	1	1
			-76.0	77.0	1	2
			-51.0	77.0	26	3
			-51.0	77.0	26	4
			254.0	77.0	331	5
					385	Total
806.491	0.001	3				1
			-94.3	96.3	2	2
			-78.3	96.3	18	3
			-68.3	96.3	28	4
			240.8	96.3	337	5
					385	Total
873.255	0.001	3	1	96.3	1	1
						2
			16	96.3	16	3
			21	96.3	21	4
			347	96.3	347	5
			1	96.3	1	Total
825.732	0.001	3				1
			-94.3	96.3	2	2
			-73.3	96.3	23	3
			-76.3	96.3	20	4
			243.8	96.3	340	5
					385	Total
365.688	0.001	4	-76.0	77.0	1	1
			-73.0	77.0	4	2
			-68.0	77.0	9	3
			-73.0	77.0	4	4
			290.0	77.0	367	5
					385	Total

As can be seen from the chi-square test, results indicate that component of the development economically are appropriate in Tehran. To prioritize component of economic development indicators from aspect of the importance and relevance Friedman test was used. The results of test has been shown in the following table (Table 5).

Table 5- Friedman test to prioritize components of economic development indicators

priority	Ordinal Mean	
5	2.88	q1: prefer to pay the initial installation cost of zero energy system for cost savings
3	2.98	q2: If possible, I will zero energy system in residential building because high efficiency of system causes to reduce system maintenance costs.
2	3.05	q3: with increasing the price of fossil energy, property value of zero energy buildings will be increased than the buildings use fossil fuel.
4	2.97	q4: prefer use the zero energy building for reducing the monthly cost of my life.
1	3.12	q5: prefer to reduce the cost of upgrading building to the new generation of technology use a zero-energy building.
chi-square test: 45.510		
df: 4		
Sig: 0.001		

As the table 5 shows the statistic amount of chi-square test is 45.510 and significance level is equal to 0.001. Therefore, with 95% confidence can say that the components are presented in different categories. The highest indicator is zero energy use to reduce costs and lowest indicator is paying the initial installation cost of zero energy system for cost savings.

**The second question**

Do sustainable development indicators ecologically appropriate for Tehran or not? To answer this question univariate t-test was used (Table 6).

Table 6- Results of univariate t-test

Test Value = 3				Ecological variable
Mean Difference	Sig.	df	T	
1.85870	.000	384	81.810	

As seen in the table 6, since the value of t-test at 0.001 level is significant, it can be said that in view of architects engineering member, environmentally sustainable development indicators are appropriate in Tehran.

Continue to check each of the questions of development indicators environmentally chi-square test was used which results are presented in the table 7.

Table 7. Results of chi-square

chi-square	Sig.	degree of freedom (df)	residuals	The expected case	observed	spectrum
86.57111	0.001	4	-76.0	77.0	1	1
			-73.0	77.0	4	2
			-65.0	77.0	12	3
			-56.0	77.0	21	4
			270.0	77.0	347	5
					385	<b>Total</b>
921.171	0.001	3	-93.3	96.3	3	2
			-83.3	96.3	13	3
			-81.3	96.3	15	4
			257.8	96.3	354	5
					385	<b>Total</b>
						<b>1</b>
96.85711	0.001	4	-76.0	77.0	1	1
			-74.0	77.0	3	2
			-69.0	77.0	8	3
			-52.0	77.0	25	4
			271.0	77.0	348	5
					385	<b>Total</b>
921.358	0.001	3	-92.3	96.3	4	2
			-87.3	96.3	9	3
			-78.3	96.3	18	4
			257.8	96.3	354	5
					385	<b>Total</b>
						<b>1</b>
866.397	0.001	3	-95.3	96.3	1	1
						2
			-79.3	96.3	17	3
			-75.3	96.3	21	4
			249.8	96.3	346	5
					385	<b>Total</b>

As can be seen from the chi-square test, results indicate that component of the development ecologically are appropriate in Tehran. To prioritize component of ecological development indicators from aspect of the importance and relevance Friedman test was used. The results of test has been shown in the following table (Table 8).

Table 8-Results of Friedman test for prioritization of development indicators in terms of environmental factors

priority	Ordinal Mean	
4	2.97	q6: I use zero energy residential building to reduce air pollution in Tehran.
2	3.03	q7: It is better we use zero energy buildings to reduce surface water pollution (acid rain).
3	3.01	q8: if possible, I use zero-energy building to reduce the pollution caused to the soil I.
1	3.04	q9: I use zero energy building in Tehranto reduce the harmful effects of fossil fuel pollution on vegetation.
5	2.95	q10: I use zero energy building to avoid or mitigate climate changes in Tehran.
chi-square test: 11.67		
df: 4		
Sig: 0.02		

As the table 8 shows the chi-square test amount is 11.67 and significance level is equal to 0.005. Therefore, with 95% confidence can say that the components are presented in different categories. The highest indicator is using zero energy building to reduce air pollution in Tehran and lowest indicator is using zero energy building to reduce the harmful effects of fossil fuel pollution on vegetation (Table 9).

**The third question**

Do sustainable development indicators is safety for the city of Tehran or not? To answer this question univariate t-test was used (Table 9).

Table 9- Results of univariate t-test.

Test Value = 3				
Mean Difference	Sig.	df	t	
1.85766	.000	384	83.737	safe variable

As seen in the table 9, since the value of t-test at 0.001 is significant, it can be said that in view of Tehran's architects member of engineering, sustainable development indicators to be safety appropriate in Tehran. To investigate each question in terms of safe development indicators, the chi-square test was used. Results in the following table is provided (Table 10).

Table 10- Results of chi-square test

chi-square	Sig.	degree of freedom (df)	residuals	The expected case	observed	spectrum
543.839	0.001	2				1
						2
			-104.3	128.3	24	3
			-111.3	128.3	17	4
			215.7	128.3	344	5
				385	Total	
1213.065	0.001	4	-76.0	77.0	1	1
			-76.0	77.0	1	2
			-59.0	77.0	18	3
			-62.0	77.0	15	4
			273.0	77.0	350	5
				385	Total	
559.875	0.001	2				1
						2
			-117.3	128.3	11	3
			-101.3	128.3	27	4
			218.7	128.3	347	5
					Total	
841.899	0.001	3				1
			-95.3	96.3	1	2
			-86.3	96.3	10	3
			-64.3	96.3	32	4

			245.8	96.3	342	<b>5</b>
					385	<b>Total</b>
914.771	0.001	3				<b>1</b>
			-95.3	96.3	1	<b>2</b>
			-83.3	96.3	13	<b>3</b>
			-78.3	96.3	18	<b>4</b>
			256.8	96.3	353	<b>5</b>
					385	<b>Total</b>

As can be seen from the chi-square test, results indicate that components of the development from aspect of safety indicators are appropriate in Tehran. To prioritize safety indicators from aspect of the importance and relevance Friedman test was used. The results of test has been shown in the following table (Table 11).

Table 11- Friedman test for prioritization of development indicators in terms of safety components

priority	Ordinal Mean	
5	2.94	q 11: to reduce illness and death caused by fossil fuel pollution would use a zero-energy building.
4	2.99	q 12: using zero energy residential building creates the least risk and damaged for people living in and around it.
2	3.03	q13: if natural events (hurricanes, earthquakes ...) be occurred, zero energy building will be created lowest damage for the system and its environment.
3	3.00	q14: use of zero energy buildings in crisis (lack of energy, etc.) remove needs of the residential building.
1	3.04	q15: If military strikes (bombing) be occurred, zero energy building will be created lowest damage for the system and its environment
Chi-square test: 16.15		
df: 4		
Sig.: 0.003		

As the table 8 shows the chi-square test amount is 16.15 and significance level is equal to 0.01. Therefore, with 95% confidence can say that the components are presented in different categories. The highest indicator is if military strikes (bombing) be occurred, zero energy building will be created lowest damage for the system and its environment and lowest indicator is to reduce illness and death caused by fossil fuel pollution would use a zero-energy building.

## DISCUSSION

This study examines aspects of sustainable development in the use of zero energy residential complex in Tehran that in the form of three components: economic factors, environmental factors and safety factors were classified.

In economic component, the index "initial installation fee of zero energy system because of reducing the cost of upgrading the building to a new generation of technology" was in the first priority.

Point of view of sustainability, economic sustainability issues is confronting wide with two levels of local and global factors. Using the main economic factors leading to improve economic performance and it caused decreasing costs of repair and maintenance for the duration of the life cycle. Providing sustainable principles can be implemented in high level. Economic stability increase profitability through effective use of resources (human, material and financial). In other hand, in terms of the economic stability of the construction industry, house construction must be considered which it is included depreciation cycle cost, cost modernization and development, increase business, compliance of rules, profitability and risk management [13].

In the safety component, index of using zero energy buildings to reduce air pollution in Tehran was the first priority. Today, most of the basic rules emphasizes on the concept of personal safety physically, while it seems that Article 22 of the constitution of the Islamic Republic of Iran has presented theoretical basis for human security as a general model. A model that is involved factors as ensuring personal security, privacy, security, legal and judicial security. So, to explain the concept of "human security" and its indicators that can be considered as an effective step towards strengthening the protection of fundamental rights and freedoms.

In the environmental component, index of "using zero energy building in Tehran in order to reduce the harmful effects of fossil fuel pollution on vegetation" was the first priority. If the use of natural resources, including forests, pastures, water and land resources, energy and fuel resources, mineral resources, etc., with careful planning and proper management was performed, achieving the desired objectives with the optimal use of these resources

would be better and the indiscriminate use is also prevented. Therefore, resource management, help to achieve sustainable development. Resource management means comprehensive approach, systematic and consistent for goal-setting in the field of sustainable use of resources that are presented by resource planners and stakeholders [14].

## Conclusion

The data of this study, as mentioned earlier by a self-designed questionnaire were obtained. Validity of questionnaire by consultation with experts was confirmed. Reliability of questionnaire was estimated with Cronbach's alpha that 0.98 was obtained, which was approved. In this study, the dimensions of sustainable development in the use of zero energy residential complexes in Tehran in three economic factors, environmental factors and safety parameters were investigated. The results of the economic component as the first hypothesis and whether zero energy residential complexes in Tehran would be effective in terms of economic development? Results showed that respondents prefer to reduce the cost of upgrading building to the new generation of technology use a zero-energy building. The results of the safety component as the second hypothesis with zero energy residential complex in Tehran as the field of safety is high? Results showed that respondents tend to reduce air pollution in Tehran use from zero energy residential building. The results of the environmental component as third hypothesis as to whether designed residential complexes with zero energy in the city could be reduced the harmful environmental impacts? Results showed that respondents believe that the use of zero energy buildings in crisis conditions (lack of energy, etc.) to meet the energy needs of the residential building. According to the data and findings, it can be seen that the design of the residential complex in Tehran, helping to reduce air pollution caused by fossil fuels, reduction of surface water pollution, soil pollution reduction and thereby reducing disease and mortality causing of these pollution in Tehran. Cost savings and high safety of this type residential complex, force architects and users to use these buildings. Based on the outcome of the study, it can be suggested that a systematic relationship between organizations and research institutions, higher education, construction companies and contractors to promote the design and construction procedures established in Tehran to utilize the experiences and the science of each to the optimal design and implementation of appropriate residential energy in Tehran.

## REFERENCES

- [1] Saghafy, A. and Elyaszadeh, N. (2011). Recognizing components and plans of environmental sustainable design in architecture spaces and cities, *Journal of Abadi*, Vol. 72 and 73. Pp. 1-8. (In Persian).
- [2] Purdayhimy, Sh., zarghami, S. and Sajad, P. (2010). Social stability of Residential complex, No. 51, page 58.
- [3] Nasiri, H. (2000). Sustainable development vision of the Third World, First edition, publishing culture and thought, Tehran. Page 225.
- [4] SoltaniArabshahi, S. (2002). Sustainable Development; priority and challenges, *Journal of Environment*, No. 39, pp18-26.
- [5] Sakkas, A. (2006). Aspects and perspectives for the Zero Energy Buildings, International Workshop on Energy Performance and Environmental, Quality of Buildings, July 2006, Milos island, Greece
- [6] Chabauda, A. (2013). OPTIMAL DESIGN OF ENERGY PRODUCTION AND STORAGE SYSTEMS, 2013 4th Inverse Problems, Design and Optimization Symposium (IPDO-2013) Albi, France, June 26-28, 201.
- [7] Shelley, B. (2011). School of Photovoltaic and Renewable Energy Engineering University of New South Wales Sydney, p2.
- [8] Purmokhtar, A (2011). Recognition of the concept of sustainable development and sustainable in Iranian Architecture and urban planning, *Journal of Abadi*, Vol. 72 and 73. Pp. 17-24. (inpersian).
- [9] Rahmani, F. (2001). Sustainable development, challenges and solutions, *Political and Economic journal*, No. 168-167, pp. 111-102.
- [10] National commission of Sustainable Development. (2003). Reports the World Summit on Sustainable Development (Johannesburg, 4-13 September), First edition, Publishing Department of the Environment, Tehran.
- [11] Rahnavard, Z. and Rahbarnia, Z. (2006). Facing spiritual arts with technology. *Journal of Fine Arts*, Vol. 26, Pp. 108-101.
- [12] Saduq, M.B. (2000). Development and sustainable development, *environmental Journal*, No. 36, pp: 9-14.
- [13] Roufechaei, Kamand M. , Abu Hassan Abu Bakar, Amin Akhavan Tabassi. (2013). Energy-efficient design for sustainable housing development. *Journal of Cleaner Production xxx*,1-9. *Journal of Cleaner Production xxx*.
- [14] Baroo, C.G. and Badri, A. (2003). Sustainable development, concept, value and act. *Journal of geographical researches*, No. 44, Pp: 43-67.