SUSTAINABILITY EVALUATION OF RESIDENT BUILDING IN BOSNIA AND HERZEGOVINA

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ABSTRACT

The energy system of resident building requires to be seen as the complex system with defined respective indicators including: economic, environmental and social indicators with respective sub-indicators.

In our analysis, we will assumed that the energy system is a complex system which may interact with its surrounding by utilizing resources, exchange conversion system products, utilize economic benefits from conversion process and absorb the social consequences of conversion process.

This evaluation will be based on the selection of a number of resident buildings as the potential options appropriate for the geographic, climate and cultural region. With multi-criteria method based on the selected number of indicators the sustainability index will be determined. In this evaluation attention is focused on the following resident buildings: Bosnian family house, Modern architecture dwelling, Traditional family house, Best choice of local family house.

The finale result of this study will be presented in Sustainability Index rating for the options under consideration. It can be noticed that the quality of the selected objects is defined in relation to the Sustainability Index.

INTRODUCTION

Through the history of human society there have been different patterns of social structure, which have lead from the pre neolith to the industrial society. Each of the successive social structure has been different with the complexity of its internal organization. The industrial revolution has triggered a new pattern of complexity determined by the need to generate more and more power to be used in everyday life. Invention of the steam generators, steam engines, steam turbine and many other energy conversion systems have promoted the increased commodity in human life and also initiated dramatic changes in the social structure of human society. It has become obvious that the welfare harvested by increasing the energy resources use has brought additional complexity to the organization of human society. New scientific achievements and technological progress have opened a new venue in the development of our society. In this respect, it is our need to look ahead in order to see if we can forecast our future in the near term and long term scale. This is a reason that a number of scholars have devoted substantial attention to the future of our society. It is obvious that there are need to dwell into the complexity of this issue in order to be able to understand the processes, which are going to affect our future [Complexity].

Following the development of human society the need for respective dwelling development was required. In early days of our society the human dwellings have been placed in natural cavities. Due to the limited number of cavities it was recognized the need to built primitive housing. Social structure Following the increased need for human commodities and adapting to its need the specific requirement has been development.

With the increase of human population a new dwelling have been needed. This has stimulated development of new architecture with specific aims to meet. Modern architecture is a term given to a number of building styles with similar characteristics; primarily the simplification of form and the elimination of ornaments that first arose around 1900. By the 1940s these styles had been consolidated and identified as the International Style and became the dominant architectural style, particularly for institutional and corporate building, for several decades in the twentieth century [New dwelling].

The exact characteristics and origins of modern architecture are still open to interpretation and debate. Functionalism, in architecture, is the principle that architects should design a building based on the purpose of that building. This statement is less self-evident than it first appears, and is a matter of confusion and controversy within the profession, particularly in regard to modern architecture [Modern architecture].

The evaluation of the resident building comprises necessity for the sustainability assessment of the design. This implies analysis of the building structure and operation characteristic. Every building is a complex system which requires specific methodology for the validation and assessment of the building design. It includes the multi-criteria evaluation of economic, environmental and social quality assessment.

RESIDENT BUILDING SYSTEM

Building is a complex system. It requires system approach for its evaluation and assessment. As every

complex system it is characterized by the number of indicators describing it quality. The evaluation of the building as the complex system requires specific methodology which comprises potential possibility to define appropriate index for the quality assessment As regards building as complex system it is necessary to define the complexity as the set of respective indicators. The number of indicators reflects specific characteristic of the system. In this respect it is of great importance to use the procedure which implies possibility to define specific quality of the building.

The sustainability in building means that the building design has to meet complexity of the modern human dwelling [Afgan, 2010]. It comprises a dwelling functionality and the need for new technologies. In particular the design of modern housing implies the introduction of new architecture with the respecting technological innovation. This has lead to the enormous variety of the house design which has become a new culture.

The technological a new dwelling have introduced a need for heating, cooling, cooking, electricity and ventilation system. Heating was based on the heat supply depending on the selected house design. It is usually designed with a central heating or individual heat supply. The heating system capacity depends on the geographical position, outside climate temperature and indoor commodity.

Cooling is a modern invention with the same pattern as heating by individual or centralized system. Usually, summer cooling requires major part of energy consumption in modern building. Every dwelling is characterized by the cooling system capacity design. It is usually defined by the electricity consumption per unit cooling space.

Cooking requires specific space in every building. It is an essential element of modern building. The energy consumption is defined by the number of inhabitants in the building. It requires specific ventilation system aimed to keep indoor atmosphere under control.

Every building is equipped with a number of electricity consumers, including: wash machine, refrigerator, dish washing machine, television and computer. Every element required for the commodity service requires respective electricity consumption.

Building System Selection

The Adriatic coast geographical Mediterranean climate with average insulation $q = 86$ W/m^2. The average air temperature $t = 24.5^0$ C. The resident building in this environment requires specific criteria for the design and architecture. It is of interest to perform an evaluation of the criteria parameters which are appropriate for the resident building in this environment. This type of exercise implies the need for the sustainability assessment with multi-criteria method.

In this analysis we will focus our attention on the selected number of dwelling having different specific feature characterized with its purpose. It is anticipated that all building are devoted to the living as the main purpose.

In this analysis a following building are taken into a consideration:

Bosnian family house. The essential characteristic of Bosnian house is based on the Turkish architecture from the period of Ottoman Empire. On Fig. 1 is shown the old time dwelling from eighteen century.

Figure 1.   Bosnian family house [photo by N. Afgan]

Modern architecture dwelling. The modern architecture building is defined as the high functionality dwelling. It is primary build in the Adriatic region as the summer house. Fig. 2 shows typical summer house at the Adriatic Coast.

Figure 2.   Typical house at the Adriatic Coast [photo by N. Afgan]

Traditional family house. In the period after the First World War it was very common to build resident building in private organization. A number of friends with different specialty use to merge in the local community enterprise.

Figure 3.   Traditional family house [photo by E. Zlomusica]

Best choice of local family house. This type of the dwelling is a market available selling house. It is a modern family house designed as the family house reflecting new stile in contemporary architecture. The essential characteristic of this building is modern design and the use of new material.

Figure 4.   Modern family house [photo by E. Zlomusica]

SUSTAINABILITY ASSESSMENT OF RESIDENT BUILDING

The assessment of resident building is based on the specific methodology designed for the sustainability evaluation in order obtains multi-criteria quality validation of the selected dwelling [Afgan and Carvalho 2000 and Afgan and Carvalho 2009].

The selected indicators for the sustainability assessment will include: Economic indicators with sub-indicators, Environmental indicator with sub-indicators, Social indicator with sub-indicators.

The first step in this evaluation is the criteria definition to be used in the assessment procedure. In this respect a following criteria with the respective indicators are used. Among those indicators are:

Economic indicator include three sub-indicators, namely: heat consumption per unit area, energy efficiency, investment cost per unit area,

The environmental indicator comprise following sub-indicators: CO_2 emission [kg/m^2], NOx emission [kg/m2], SO_2 emission [kg/m^2].

Among *the social indicators* are several sub-indicators, namely: income [€family], unemployment/family, rent cost.

SUSTAINABILITY EVALUATION OF RESIDENT BUILDING

The first step in the multi-criteria evaluation is focused on the calculation of the Economic, Environment and Social Indicators. In accordance with definition of the sub-indicators a following procedure for their agglomeration is adapted. Following three tables presents original data for the respective sub-indicators.

Table 1. Economic sub-indicators

Objects	Energy consumption	Efficiency	Investment cost
	kWh/m^2	%	€m^2
Bosnian family house	190	40	310
Modern architecture dwelling	90	70	410
Traditional family house	140	60	470
Best choice of local family house	70	90	510

Data presented in Table 1 correspond to Mostar region.

The average energy consumption for the building is based on the measurement obtained for the Sarajevo city [Hadzialic and Muhovic 2008]. The efficiency sub-indicators are published in [Vucicevic et al. 2010]. The investment cost is obtained from the data of Mostar city community [City of Mostar].

The environment indicator consists of three sub-indicators, respectively emitted amounts of CO_2,

NOx and SO_2 in the environment during production of an energy unit [Vucicevic et al. 2010].

Table 2. Environment sub-indicators

Objects	CO_2 emission	NO_x emission	SO_2 emission
	kg/kWh	kg/kWh	kg/kWh
Bosnian family house	0.357	$5.83 \ 10^{-3}$	$3.60 \ 10^{-4}$
Modern architecture dwelling	0.201	0	$1.66 \ 10^{-4}$
Traditional family house	0.357	$5.83 \ 10^{-3}$	$3.60 \ 10^{-4}$
Best choice of local family house	0.201	0	$1.66 \ 10^{-4}$

The average number of family members in Bosnia and Herzegovina is varying between 2.7 in urban centers and 3.84 in rural regions. In Bosnia and Herzegovina is dominant the four member family participating with 25%, while three members family 20% and one and five members family is participating with around 13%, [Study of Energetic sector in B&H]

Table 3. Social sub-indicators

Objects	Income	Unemployment	Rent cost
	€family	No of unemp/family	€m²
Bosnian family house	450	0.65	0
Modern architecture dwelling	610	0.54	0
Traditional family house	404	0.76	0
Best choice of local family house	700	0.62	0

The official unemployment in Bosnia and Herzegovina was 42,4% in January 2010 [Agency for Statistics of Bosnia and Herzegovina].

GDP/Cap is 3 287 € The average net salary is around 404 €, [Agency for Statistics of Bosnia and Herzegovina].

93% of population is living private houses and only 7% rented house. [Study of Energetic sector in B&H]

Using these data the economy, environment and social indicators are determined. In order to obtain agglomerated indicators the respective constraints have to be introduced. Usually the definition of indicators is designed with appropriate selection of constraints among the individual sub-indicators. It means to pose the priority among the sub-indicators. In this exercise a following constraints are utilized:

Constraint 1: Energy consumption > efficiency > Investment cost

Constraint 2: CO_2 emission > NOx emission > SO_2 emission

Constraint 3: Income > Unemployment > Rent cost

SUSTAINABILITY INDEX DETERMINATION

The sustainability of resident building can be measured with the Sustainability Index defined as the Synthesis Function [Hovanov 1996 and Hovanov 1998]. It represents as agglomeration function of the specific indicator and weighting coefficient product. APIS program [Afgan et al. 1998] is used to make agglomeration of sub-indicators with respective constraints.

The specific sub-indicators are obtained by the respective normalization of sub-indicators absolute values. This will lead to the formation fuzzy set of the sub-indicators. Once definition of the specific set of indicators is formed the Sustainability Index can be defined as

$$Q = \sum_{i-1}^{i-k} \bar{w} \, q_i$$

Where are

Q – Sustainability index

q_i - Specific indicator

$\bar{w}$ – Average weighting coefficients

k – Number of objects

Weighting coefficients are normalized and their sum is equal to 1. ASPID (analysis and synthesis of parameters under information deficiency) method includes calculation of weighting coefficients in agreement with constrain defined for the specific cases.

With these definition of the constraints the economic, environment and social indicators are

obtained. Table 4 presents data obtained for the indicators to be used in the determination of Sustainable index for the particular cases. In this exercise a following constraints for the Sustainability Index [Afgan et al. 1998] are used:

Table 4. Economic, Environmental and Social Indicators

	Economic Indicator (Energy Consumption > Efficiency = Investment)	Environment Indicator (CO_2 >) = SO_2)	Social Indicator (Income > Unemployment = Rent)
Bosnian family house	0.67	0.877	0.133
Modern architecture dwelling	0.27	0.163	0.660
Traditional family house	0.0217	0.877	0.349
Best choice of local family house	0.20	0.02	0.904

Case 1. Economic Indicator (with Energy consumption > efficiency > Investment cost) > CO_2 emission > NOx emission > SO_2 emission) > Social Indicator (with Income per capita > Unemployment > Rent cost).
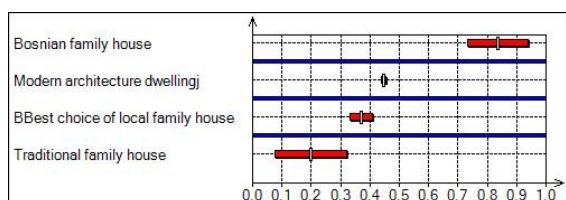

Figure 5.   Graphic presentation for the Case 1

The Case 1 demonstrates priority among options under constraint that the economic indicator has priority in comparison with environment and social indicators as defined for this case. It can be noticed that under this condition the Bosnian family house has higher Sustainability Index in comparison with other options under consideration. This proves that from the sustainability point of view the Bosnian family house reflects complexity of the multi-criteria assessment.

Case 2. CO_2 emission > NOx emission > SO_2 emission) > Economic Indicator (with Energy consumption > efficiency > Investment cost) >) >Social Indicator (with Income per capita > Unemployment > Rent cost)
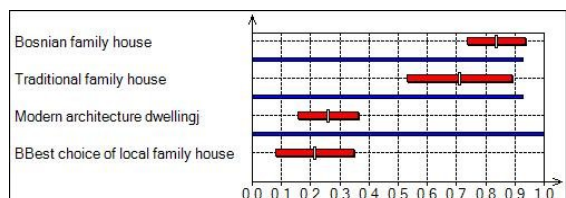

Figure 6.   Graphic presentation for the Case 2

The Case 2 implies priority of the Environment Indicator as defined. It shows that the Bosnian family house and Traditional family house are having priority in comparison with other options. It is of

interest to notice that the difference among options is result of effect of individual indicators.

Case 3. Social Indicator (with Income per capita > Unemployment > Rent cost) CO_2 emission > NOx emission > SO_2 emission) > Economic Indicator (with Energy consumption > efficiency > Investment cost).
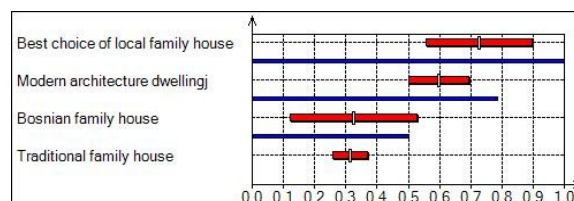

Figure 7.   Graphic presentation for the Case 3

The Case 3 represents the effect of Social Indicator on the priority among option under consideration. It shows that the Social Indicator has very high influence on the priority list.

CONCLUSIONS

Sustainability is a complex system property. Sustainability index represents the quality of the system. The Sustainability Index is obtained when a balance is found between the issues of reflecting imposed constrains. With its multi dimension scope it requires a new method for evaluation of complex system. Building is typical example of complex system with multi-criteria assesment.

The sustainability assessment of human dwelling is a procedure adapted for the evaluation of specific options. The procedure is defined as the tool for the quantitative measurement of the Sustainability Index as the measuring parameter for the evaluation of human dwelling.

The essential characteristic of the adapted method is based for the sustainability assessment of energy systems. ASPID is an abbreviation for the phrase, "analysis and synthesis of parameters under information deficiency". Validation of different

alternatives in the assessment of an energy system in building is used as the decision-making technique that is based on the fuzzy set theory with an appropriate method for weight coefficient determination. The main advantage of ASPID-3W, being enclosed in its ability to work accurately with nonnumerical, inexact, and incomplete information, is that the DSSS has a broad field of applications in various scientific domains, industrial and financial businesses, and so on.

The selected number of alternative for human dwelling is used to show application of the decision-making technique in the evaluation of the specific alternatives of building. It is shown that that the adapted procedure can be used for ranking alternative options under consideration in order to obtain quantitative validation of the options.

REFERENCES

Complexity, Wikipedia, Free Encyclopedia

New dwelling, Wikipedia, Free Encyclopedia

Modern architecture, Wikipedia, Free Encyclopedia

Afgan, N.H. 2010. Sustainability Paradigm: Intelligent Energy System, *Sustainability Journal*, ISSN 2071-1050.

Bosnian family house –photo by N. Afgan

Typical house at Adriatic coast- photo by N. Afgan

Traditional family house – photo by E. Zlomusica.

Modern family house – photo by E. Zlomusica.

Afgan, N.H., and Carvalho, M.G. 2000. Sustainability Assessment Method for Energy Systems, Kluwer Academic Publisher.

Afgan N.H., and Carvalho M.G. 2009. Quality, Sustainability and Indicators of Energy Systems, Begell House.

Hadzialic, M., Muhovic, S. 2008. Pilot project of saving energetic consumption. Consultation of public energetics in Bosnia and Herzgovina, *Proceedings of Consultation*, Sarajevo, May 60-67 (in Bosnian)

Vucicevic, B., Jovanovic, M., Turanjanin V. and Bakic V. 2010. Sustainability assessment of residential building energy system in Belgrade, 10th International Conference Sustainability Development of Building, Kuwait.

City of Mostar (www.mostar.ba) (in Bosnian).

Study of Energetic sector in B&H. 2006. Energetski institut Hrvoje Pozar - Croatia, Soluziona - Spain, Ekonomski institut Banjaluka, - BH, Rudarski institut Tuzla – BH.

Agency for Statistics of Bosnia and Herzegovina (www.bhas.ba), July 2010

Hovanov N. 1996. Analysis and Synthesis of Parameters under Information Deficiency, (in Russian), St. Petersburg University Press, St. Petersburg.

Hovanov N.V. 1998. Mathematical Models of Risk and Uncertainty, (in Russian), St. Petersburg University Press, St. Petersburg.

Afgan N., Carvalho M.G., and Hovanov N. 1998. Multi-criteria Assessment of New and Renewable Energy Power Plant, *Energy*, 27(8), pp. 759–775.