MULTI-CRITERIA OPTIMIZATION OF CONSTRUCTION TECHNOLOGY OF RESIDENTIAL BUILDING UPON THE PRINCIPLES OF SUSTAINABLE DEVELOPMENT

by

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Between various building materials and technology solutions for structural and architectural realization of residential building as well as various effects in use period we do not know which of variants gives the best performance from sustainable development point of view.
This paper aims to give a model for optimization of housing construction technology based on some aspects of sustainable development as a set of multi-criteria:
- *energy consumption of building,*
- *renewable resource use, and*
- *air pollution by CO_2 emission.*

The model uses the multi-criteria compromise ranking technique. As a result we take he rank-list of variants and then we can select the best ones or several better variants. This diversity of acceptable solutions gives opportunity to meet future housing demand, depending to different possibilities and interests of user, but by environmentally sustainable manner. This paper gives case study of some typical single-family houses in Bosnia and Herzegovina.

Key words: *rezidential buildings, sustainable development, optimal construction technologies*

Introduction

Housing is one of basic human needs and we should take efforts to find the best way to meet the demand, according to individual possibilities of users and external limitations. Each society has specific economic and social framework, but we must take in considerations some other criteria that become nowadays worldwide important. Protection of natural environment, unavoidable, represents the general criterion for all human activities, also for construction industry and housing. There are many aspects of impact of the built environment on nature like disturbing of eco-balance, land degradation, air pollution, but the most important is energy consumption [1]. Between 25 to 40 percent of total energy consumption belong to residential sector what is too large especially for undeveloped countries, because they need, by priority, energy for their economic development.

Contemporary understanding of human practice based on the principles of a sustainable development, requests that all human products have to be considered within the frame of their whole life cycle in order to analyze their environmental impact. Conceptual framework of life cycle analysis includes all life phases of one product: extraction of raw materials from nature, transportation, materials preparation, product processing, product operating, and, finally, giving the residuals back to nature. In each phase of the life cycle all relevant aspect that influence the environment have to be considered, like land possession and degradation, resource use, energy consumption, air, water and soil pollution, and waste disposal. Residential buildings, as specific and complex products appear in various material and space realization and because of that, emerges the question which of them have more advantages compared to other similar products, regarding to their impact on the environment.

Aim and objectives

This paper is aimed to develop the appropriate MCDM (Multi Criteria Decision Making) model [2-5] for selection of some environmental friendly solutions for structure and envelope as well as the construction technology of residential building according to local (country's physical, social and economic) and global limitations.

Identification

In order to identify main influence factors, it is necessary to examine the residential building from construction point of view by items: the bearing structure and its materials, the architectural envelope and various materials for it, the finishes and work force for the construction. Further, it is necessary to determine the needs of the building in order to meet main requirements of dwelling function, especially heating as the more important factor. Finally it is necessary to identify relationships between human dwelling function as a part of built environment and natural environment by main items: energy consumption, mineral and renewable resource use, as well as impact on nature [6].

Quantification

In order to determine construction technology influence factors (materials, work, machinery) it is necessary, as the first step, to make the life cycle inventory of building. It means, the building have to be analyzed in detail (up to each specific construction element, *i. e.* material, in time perspective of its own life cycle) and all relevant parameters have to be derived (primarily material and energy related values). Because is it too large research effort, in this work was used an approximate (simplified) model based on local standard construction specifications and norms that overcomes main construction materials and techniques. In case of lack of these data, it can be made by indirect (correlative) methods. The inventory data is used as a basis for determining relevant impact aspects of building, for each phase of its life cycle, especially for pre-production, production and post-use phases. On that way environmentally related parameters like total energy consumption and total CO_2 emission are determined by using of specific standardized values from worldwide known databases*. For determining the energy consumption in use phase of building, the *Energy Plus* software is used [8].

Model development

Proposed model solves the discrete problem: optimizing system contains a set of variants – various single-family residential buildings that should be analyzed (inventoried), "measured", evaluated and finally compared in order to select the optimal variant according to given set of criteria, what means the multi criteria optimization should be applied to the model.

Research methodology

Research variables

Main research variables are:

– total mass of building, (by various construction materials),
– embodied energy of building (by parts: production of materials, transportation, construction human work and mechanized work),
– renewable resource (materials as well as energy sources),
– energy use of building (heating), and
– CO_2 emission (pre-construction, construction and use period).

Data collection

Necessary construction technology data for residential buildings (types of main construction materials, its mass, construction methods, technique and machinery used) are derived from technical specifications of houses – plans and bills of quantities. Some of (older) building types have not this documentation and we have had to re-construct them on basis of historical data.

Total masses of used construction materials have combined with standardized values of embodied energy by unit of mass, in order to determine total embodied energy for each residential building. In tab. 1 are given such data from some various sources.

* BUWAL250; Idemat 2001; ETH-ESU 96

Table 1. Embodied energy by unit of mass for main construction materials

Construction materials	Embodied energy [MJ/kg]			
	Source (a)	Source (b)	Source (c)	Source (d)
Steel	30-70	64.6	30-60	24-59
Aluminum	54-75 (final. pr.)	227.2	200-250	241-270
Glass	12-40	13.9	12.25	13-31
Clay-ceramics materials	3-5		2-7	1-9.4
Gypsum		2.3	1-4	
Lime		7.7	3-5	
Cement	3.6-4.7	4.4	5.8	4.3-7.8
Concrete "in situ"			0.8-1.5	
Concrete "in blocks"			0.8-3.5	
Concrete prefabricated			1.5-8.0	
Gravel and Sand [m^3]	0.03-0.444		>0.5	0.03-0.12
Timber - Wood [m^3]		0.7	0.1-5	0.52-7.1
Plastics		61	50-100	
Copper		71	100	
Lead, Zinc			25	

(a) Udovičić, B., Energy, Society and Environment (Vol. I – Energy recoursces, Vol. II – Energy transformation, utilization of different forms of energy, energy balance, Vol. III – Energy and Society, Vol. IV – Energy and environment), IRP "Građevinska knjiga", Belgrade, 1988, 1989

(b) Building LCA Project Consultative Workshops. Greening the Building Life Cycle – Life Cycle Assessment Tools in Building and Construction
http: www.cfd.rmit.edu.au/lca/buildlca/casestud/ee/

(c) Atkinson, C., Sue, H., John, W., Suzy, E. Life Cycle Embodied Energy and Carbon Dioxide Emissions in Buildings. Industry and Environment, a publication of the UNEP, Vol. 19, No. 2 (April-June 1996): 29-31

(d) University of New South Wales, Sydney, Australia, Faculty of the Built Environment, BENV1171 Architectural Technologies 1
http: www.fbe.unsw.edu.au/Learning/Material-notes/sus1.htm

In order to compute total life cycle CO_2 emission of residential buildings, appropriate standardized data of CO_2 emissions of building materials, as well as energy carriers, are used from some sources, as is given in tab. 2.

Table 2. Specific CO_2 emission of main construction materials and energy carriers

Construction materials / Energy carriers	CO_2 emission [kg/kg]			
	Source (a)	Source (b)	Source (c)	Other sources
Steel	2.95	2.25		
Aluminum	7.64-8.22	9.964		
Cooper		5.2106		
Glass	0.58-0.77	0.748		
Plastics - PE	2.2			
Plastics - HDPE	2.06	2.2974		
Plastics - PVC	1.94	2.6904		
Lime	0.88	1.0237	1.352	1.18
Gypsum		0.11694		
Bitumen				0.42
Reinforcing steel				2.50
Wire mesh				2.60
Ceramics		0.255		0.349
Brick		0.112		0.189
Cement		0.9638		0.96
Mineral wool		1.3785		
Poly-urethan		1.3547		
Glass wool		0.4232		
Solid concrete		0.1311		
Gravel / sand		0.0018		
Timber - Wood		0.0024		0.003
Paints		1.6427		
Natural gas [m^3]	2.29		1.8717	
Gasoline	3.98		3.104	
Heating oil	3.76		3.115	
Diesel	3.59		3.171	
Braon coal	2.84		2.735	
Lignite			1.137	
Fire wood	1.50		1.606	

(a) Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Schweiz, Ökoinventare für Verpackungen BUWAL 250, Band I, II

(b) SimaPro - software, Pre Consultants, The Netherlands

(c) International Institute for Applied Systems Analysis, CO_2 Database, CD-ROM; www.iiasa.com

Profile of the sample

Some single-family buildings as the most frequent local housing models were examined:

Type 1: Traditional Bosnian (dinaric village) house, constructed before 1940 by use local materials (stone, wood, clay, lime) as well as human and animal (!) work force,

Type 2: House constructed around 1960 as typical bricklayer's building (with enough wood and some concrete) by low use of mechanization,

Type 3: "Prefabricated" house, constructed around 1980 by use of prefabricated concrete blocks, semi-assembled plates, more mechanized construction,

Type 4: Contemporary house with reinforced concrete structure, thermal-insulated clay blocks, modern façade, windows and finishes, built by mainly mechanized works,

Type 5: Modern house of prefabricated wood, well-insulated, lights; with bearing structure of steel, with modular wall elements, assembled, and

Type 5a: The same as Type 5, but with bearing structure made of laminated wood.

Tehnical data for the most frequent local housing models are given in tab. 3.

Table 3. Technical data for selected houses

Name / type	Number of stories	Story height [m]	Volume [m^3] Area [m^2]	Materials and structures			Art of windows	Type of construction technology
				Façade walls	Bearing walls	Ceiling structure		
Type 1	Basem+ Ground	2.70	228 84	stone + combined wood and clay	stone + combined wood and clay	wood beams	one-sided, size up to 0,7 m by 1,1 m, handmade	primitive construction technique with natural materials (dinaric house type)
Type 2	Gr.f+1	2.80	309 110	thick brick 25 cm	thick brick 25 cm	wood beams	two-sided, size up to 2,2 m by 1,4 m, handmade	classic construction technique with brick and wood
Type 3	Gr.f+1	2.70	392 145	prefabricated concrete block 25 cm	prefabricated concrete block 25 cm	semi-assembled "SIGMA" ceiling plate	"wing-on-wing", size 1,4 by 1,4 m industry product	semi-assembled, prefabricated concrete elements
Type 4	Bas.+ G+1	3.05	831 237	brick blocks + RC structure	brick blocks 20 cm	*in situ* made monolithic RC plate 12 cm	"wing-on-wing", size 3,6 by 1,4 m industry product	contemporary monolithic RC + "sandwich" walls
Type 5	Gr.f+1	2.80	340 121	assembled panels 17 cm + steel str.	assembled wood panels 17 cm	assembled RC plate 10 cm + steel bearing structure	contemporary "thermo", size up to 1,2 1,4 m, industry product	assembled "sandwich" panels + RC plate + steel bearing structure
Type 5a	Gr.f+1	2.80	340 121	assembled panels 17 cm + wood str.	assembled wood panels 17 cm	laminated and glued wood beams + wood panels	contemporary "thermo", size up to 1,2 1,4 m, industry product	assembled "sandwich" panels + laminated wood bearing structure

Note: Although house type 5 and 5a is used very rare, we have examined it because we believe that these types have good performance. House type 1, namely, belongs to the past, but we would check if the local construction tradition brings somewhat positive in sustainable manner

Method of analysis – mathematical background

In order to compare these variants we have used the Multi Criteria Compromise Ranking (MCCR) method 7 as appropriate tool for discrete technical problems of which variables can be measured. The optimizing system contains:

- set of variants X_j, $j = 1, 2, \dots, J$, and
- set of criteria (vector F of functions f_i, $i = 1, 2, \dots, n$) with criteria values (of our variables) for all variants in matrix form $i \quad j$.

Each criterion-function has to gravitate toward the extreme (max or min) in positive meaning of criterion. These extreme values f_i^* give the ideal solution (ideal point in multidimensional area of criteria functions) F* $(f_1^*, f_2^*, \dots f_n^*)$ and we try to met it, under given limits. But such solution really exists rare, and we looking for non-inferior solutions of the optimizing system.

The solution x^+ X is non-inferior if there is not other x' X, such that:

$$F(x') \quad F(x^+) \text{ and } f_i(x') > f_i(x^*), \text{ at least for one } i.$$

The solution nearest to ideal ones, measured by chosen distance gauge, is the compromise solution. As distance gauge often is used next metrics:

$$L_p(F^*,F) = \{ \ _{1,n}[f_i^* - f_i(x)]^p\}^{1/p}, \ 1 \quad p \quad \infty$$

It represents the distance between ideal point F* and point F(x) in space of criteria functions. In order to emphasize importance of parameter p, metrics $L_p(F^*, F)$ can be noted as R(F(x), p), actually it is function of compromise programming.

If we have non-homogenous criteria functions, it is necessary to introduce one transformation, which denominate all criteria functions with its own value interval length. The interval length of criteria function i is $D_i = f_i^* - f_{i,\min}$, where is $f_{i,\min}$ minimal eligible value. In order to get dimensionless criteria functions with values in interval [0,1], next transformation is used:

$$T(f_i^* - f_i(x)) = [f_i^* - f_i(x)]/D_i, \ i = 1, \dots, n$$

The function of compromise programming now has the form:

$$R'(F,p) = \{ \ _{1,n}[(f_i^* - f_i(x))/D_i]^p\}^{1/p}$$

A decision maker can give weights for all criteria function, and then the function of compromise programming has form:

$$R(F(x),p,w) = \{ \ _{1,n} w_i [(f_i^* - f_i(x))/D_i]^p\}^{1/p}$$

where is w_i weighting coefficient of criterion function $f_i(x)$ or *weight of criterion i*.

In engineers practice often is used "discrete models" approach, where instead of mathematic model of continual functions are given variants – alternate solutions. Than we made rankig of variant upon the given measures of benefits, or criteria $f_1, f_2, \ldots, f_n$.

Value of criterium function i for variant a_j is f_{ij}. Variant a_j is better than variant a_k according to criterion i only if $f_{ij} > f_{ik}$.

For such problems practicaly we use "new" distance gauges or "border" forms of L_p metrics:

$$S_j = \Sigma_{1,n}\, w_i\, (f_i^* - f_{ij})/(f_i^* - f_i^-), \quad \text{for } p = 1$$

(summ of all deviations of the variant j from ideal point is minimal) and

$$R_j = \max_i\{w_i(f_i^* - f_{ij})/(f_i^* - f_i^-)\}, \quad \text{for } p = 8$$

(variant j has minimal among all maximal deviations), for variant a_j, $j = 1, \ldots, J$; where n is the number of criteria, w – weight of criterion ($\Sigma_{1,n}\, w_i = 1$, $w_i \quad 0$), f_{ij} – value of criterion function i for variant j, and $f_i^* = \max_j f_{ij}$; $f_i^- = \min_j f_{ij}$; $i = 1, \ldots, n$.

Variant a_j is better than variant a_k according to gauge S if: $S_j < S_k$, or **:**

$$\Sigma_{1,n}\, w_i\, (f_i^* - f_{ij})/D_i < \Sigma_{1,n}\, w_i\, (f_i^* - f_{ik})/D_i \quad \text{or}$$
$$\Sigma_{1,n}\, w_i f_{ij}/D_i > \Sigma_{1,n}\, w_i f_{ik}/D_i \text{ ,where } D_i = f_i^* - f_i^-$$

Variant a_j is better than variant a_k according to gauge R if: $Rj < R_k$, or:

$$\max_i w_i\, (f_i^* \quad f_{ij})/D_i < \max_i w_i (f_i^* - f_{ik})/D_i, \text{ where is } D_i = f_i^* - f_i^-$$

Ranking by use of gauges S_j and R_j gives positions $s(a_j)$ and $r(a_j)$ on the rank-lists for variants a_j, $j = 1, \ldots, J$. These rank-list are different and it is necessary to obtain unique rank-list. It is possible by forming of new partial gauges for ranking

$$QS_j = (Sj - S^*)/(S^- - S^*) \quad (\textit{i. e.} \text{ satisfying of mayority of criteria) and}$$

$$QR_j = (R_j - R^*)/(R^- - R^*), \; (\textit{i. e.}\text{"minimax" strategy of decision making}),$$

where: $S^* = \min_j S_j$, $S^- = \max_j S_j$; $R^* = \min_j R_j$, $R^- = \max_j R_j$.

Integral gauge for ranking is linear combination of gauges QS_j and QR_j, according to relation:

$$Q_j = vQS_j + (1 - v)\, QR_j,$$

where: v is the weight of strategy of decision making by mayority of criteria.

Variant a_j is better than variant a_k by multi criteria if $Q_j < Q_k$ and take higher position on the rank-list. By rankig upon the gauge Q we get the compromise rank-list for given v.

Method VIKOR [7] (MCCR– Multi Criteria Compromise Ranking) sugests that the best multi-criteria variant is ones that has the first position on the compromise rank-list for v = 0,5 and satisfies two conditions:

– “sufficient advantage” regarding the near variant following on the list, and
– “sufficient stable” the first position by changing of v.

Formal procedure – algorithms of multi criteria compromise ranking performs in the *decision making matrix form*, is as follows.

Criterion	Extr.	w_i	a_1	a_2	a_3	…	a_J	f_i^*	f_i^-	D_i
f_1	min/max	w_1	f_{11}	f_{12}	f_{13}	…	f_{1J}	f_1^*	f_1^-	$D_1 = f_1^* - f_1^-$
f_2	“	w_2	f_{21}	f_{22}	f_{23}	…	f_{2J}			
f_3	“	w_3	f_{31}	f_{32}	f_{33}	…	f_{3J}			
…	…	…	…	…	…	…	…			
f_n	…	w_n	f_{n1}	f_{n2}	f_{n3}	…	f_{nJ}			

Next step is represented by the transforming – *normalizing* of criteria functions, by use of operation: $T(f_{ij}) = (f_i^* - f_{ij})/D_i$. Than have to be determined gauges S_j and R_j , and finally integral gauge for ranking Q, with chosen weight of strategy v, as is shown in following matrix-form.

Parameters of optimizing	a_1	a_2	a_3	...	a_J	
$d_{1j}w_1 = (f_1^* - f_{1j})^* w_1/D_1$	$d_{11}w_1$	$d_{12}w_1$	$d_{13}w_1$	...	$d_{1J}w_1$	
$d_{2j}w_2 = (f_2^* - f_{2j})^* w_2/D_2$	$d_{21}w_2$	$d_{22}w_2$	$d_{23}w_2$		$d_{2J}w_2$	
$d_{3j}w_3 = (f_3^* - f_{3j})^* w_3/D_3$	$d_{31}w_3$	$d_{32}w_3$	$d_{33}w_3$		$d_{3J}w_3$	
...	...	...	...	...	...	
$d_{nj}w_n = (f_n^* - f_{nj})^* w_n/D_n$	$d_{n1}w_n$	$d_{n2}w_n$	$d_{n3}w_n$		$d_{nJ}w_n$	
$S_j = \ _{i=1,n}(d_{ij}w_i)$	S_1	S_2	S_3	...	S_J	$S^* = \min_{j=1,j}(Sj)$ $S^* = \max_{j=1,J}(S_j)$
$R_J = \max_{i=1,n}(d_{ij}w_i)$	R_1	R_2	R_3	...	R_J	$R^* = \min_{j=1,J}(R_j)$ $R^- = \max_{j=1,J}(Rj)$
$QS_j = (S_j - S^*)/(S^- - S^*)$	QS_1	QS_2	QS_3		QS_J	
$QR_j = (R_j - R^*)/(R^- - R^*)$	QR_1	QR_2	AR_3		QR_J	
$Q_j = vQS_j + (1 - v)QR_j$	Q_1	Q_2	Q_3	...	Q_J	
Ranking of variants	r_{j1} r_{j2} r_{j2} ... Q_{j1} Q_{j2} Q_{j2} ...					According to Q_j

Now we give appropriate values of criteria functions (derived, calculated and simulated) for our analysis examples. It is important to say that all of them are expressed as total values in life cycle perspective ant then divided by size of used area of residential space in analyzed houses, tab. 4.

Table 4. The matrix-form for multi criteria compromise ranking of sample variants

Criteria function f_i	Aim	Variants					
	min max	Type 1 Tradit. dinaric house	Type 2 Brick house	Type 3 Concrete block house	Type 4 Contempor. house	Type 5 Prefabricated house steel c.	Type 5a Prefabricated house wood construction
Total mass [t/m^2]	min	1.54	3.07	1.37	1.19	0.93	0.913
Bldg. mat. renewable resources [t/m^2]	max	0.333	0.219	0.136	0.110	0.111	0.120
Total embodied energy [GJ/m^2]	min	0.882	9.017	6.166	5.016	3.777	2.752
Renewable energy source [MJ/m^2]	max	173	91	46	53	116	75
Emission CO_2 from bldg. materials [kg/m^2]	min	0.122	0.610	0.222	0.290	0.203	0.129
Heating energy, during 50 years of use [GJ/m^2]	min	111	81	66	73	51	51
Total CO_2 emission, during 50 years (construction & heating) [t/m^2]	min	9.952	7.840	6.072	6.780	4.713	4.639

1 MJ = 0,27777 kWh; 1 GJ = 277,77 kWh

The MCCR method use as the first the partial metrics (QS_j, QR_j) and than compromise (Q_j) metrics for minimization of difference between ideal (optimal) F* and current (procedural) F vector of criteria functions, what gives the final rank-list of proposed solutions (tab. 5). Weight of all criteria function was the same (1/*n*).

Table 5. The results of optimization

Results of optimization	Aim	Variants					
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 5a
Compromise metrics Q_j	min	0.548	1	0.728	0.762	0.453	0
Rank	–	3	6	4	5	2	1

This output can be discussed by varying the strategy of decision-making, depending of preference (weight factor) for partial metrics QS_j and QR_j. In this case the strategy weight was 0.5 for both metrics, what is almost satisfactory.

Now we have to test the first-ranked variant if it has "sufficient advance" compared to the second-ranked variant and also if it has "stable position". If is it true, the first-ranked variant becomes *compromise* (the nearest to optimal) solution. Of course, we can choose several of better variants as acceptable solution for our purpose.

Results of study

The MCCR procedure gives clear result: the best performance has the house type 5a as the first-ranked (modern prefabricated wood-based house with bearing structure of laminated wood); near to it is house type 5 (the same type, with steel bearing structure); than comes the traditional (!) Bosnian house. It means, the future housing practice in Bosnia and Herzegovina (B&H) has to be based on principles: use of local (preferably renewable) resources, with more attention to thermal insulation of houses, as well as energy efficiency of heating systems, what can reduce existed energy and material intensity of local dominate housing (single-family houses).

Implications and practical application

It is important to underline: in B&H over 75 percent of single-family houses (where live over 70 percent of people) are type 2 and 3; about 20 percent are type 4, and similar. The MCCR model showed that these types are not satisfactory sustainable.

During the analysis we have discovered some problems. The first and the most important is absence of interest for such analysis in our construction industry. Our architects, engineers as well as contractors have very low knowledge about sustainable building practice. As a consequence, we still always have material and energy very intensive housing in both: construction as well as dwelling sectors. The fig. 1. shows the historical perspective of embodied energy of tested buildings. The material consumption seems like it.

Concerning to heating energy consumption, the picture seems much grayer. Because the thermal insulation of buildings is insufficient, they consume very large quantity of heating energy. On the fig. 2 is showed historical perspective of the consumption (on basis of 50 years of use).

The first consequence of such large energy consumption in housing sector is proportional great part of CO_2 emission. It especially applies to house type 2, 3, and 4 as dominant forms of housing. Average energy consumption for heating of these houses is 1.47 GJ/m^{2}a*. In other hand, house type 5 requires 1.02 GJ/m^{2}a, what give possibility to save amount of 0.45 GJ/m^{2}a. Embodied energy of tested buildings is no so large – it makes about 9 percent of heating energy during 50 years period, for house types 2, 3, and

* In the same time, average heating energy consumption in Germany is deep under 1 GJ/ m^{2}a (ca. 0.4 GJ/ m^{2}a).

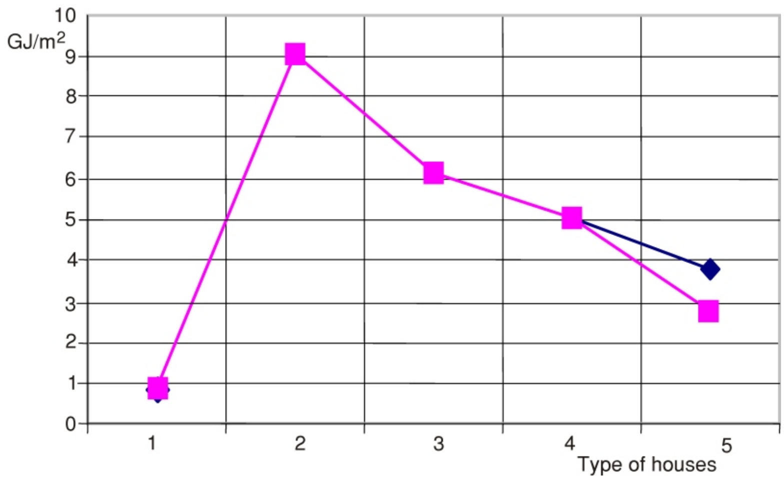

Figure 1. Embodied energy of tested building

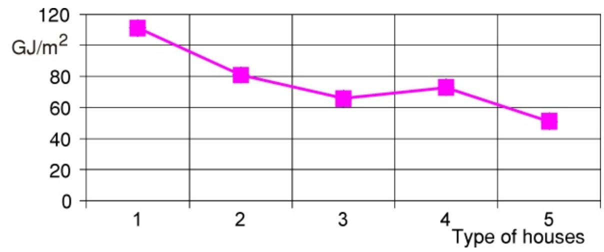

Figure 2. Heating energy consumption, 50 years

4. Embodied energy of house type 5 (5a) makes 7 percent of appropriate heating energy, and it shows that house type 5 (5a) is the most energy efficient.

If we analyze the current energy balance of B&H, we can find that the biggest parts of primary energy consumption (fast 90 percent) take fossil fuels. Between them a major role has domestic brown coal (over 50%) as a fuel for thermal electric plants. If we know that efficiency factor of this coal use is only 24%, it become clear that our energy industry gives a great part of total CO_2 emission in B&H, what currently amounts 10 t/citizen by year. It means that we must take all efforts to reduce so great harmful impact in order to participate to worldwide action for reduction of "greenhouse" gases emission.

In our housing industry nowadays are mainly used liquid fossil fuels (over 70%); other is electricity. If we promote sustainable building practice, we can reduce both: the material and energy consumption. It has to be obligation of civil engineers and architects, but also obligation of government.

Conclusion

Our experience regarding the local building practice (in residential building area) shows that sustainable development principles do not play anyone role! If someone have to make decision which construction technology should be applied to new building, he takes narrow technical criteria (stability, bearing capacity, durability) as dominant and, eventually, construction costs per unit of measure. For sake, he does not use anyone optimization technique for these multi criteria. The consequences are very bad: construction, as well as use of buildings consumes very large amounts of materials and energy but also produce harmful impact on environment. Bosnia and Herzegovina is poor, developing country in transition process and there is none reason to squander its modest resource.

On the contrary, we have to optimize all our activities, using the multi criteria technique. In housing area we have good opportunity to develop new access upon the principles of sustainable development that guarantee lower material and energy intensity of whole dwelling function (in both construction and housing sectors). Based on our natural renewable resources like wood and hydropower the new "green building" practice can be affirmed and tested house type 5a is possible paradigm.

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