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THE ENERGY EFFICIENCY PERSPECTIVE OF THE GEORGIAN RESIDENTIAL SECTOR

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THE ENERGY EFFICIENCY PERSPECTIVE OF THE GEORGIAN RESIDENTIAL SECTOR

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Abstract

In 2008 Winrock International, an American-based organization in Georgia, initiated a study to assess current construction practices in Georgia [1]. The study sought to characterize construction practices affecting energy consumption during the heating season and to demonstrate how various building methods could cost-effectively reduce energy consumption by up to 40% for new buildings in Georgia.

Key questions the study addressed are:

Why do new buildings continue to be built with cold indoor spaces, and why are minimally-acceptable thermal comfort standards not being met in winter and in summer?
Why are there high heating expenses in the buildings?
How can buildings be constructed to reduce heating expenses?
How do Georgia's construction practices compare to technologically developed countries, particularly Europe?
What is the payback period for innovative technical solutions that deliver high energy efficiency performance?
Which innovative construction technologies should be implemented in Georgia to improve energy efficiency?
What are the recommendations given to investors, construction sector developers and owners of the apartments in new buildings?
How can Georgia reduce energy dependence on imported fuel and how can energy security be improved for the country?

The answers to these and other questions can be found in the present paper. This paper shows that there are very good opportunities to improve energy efficiency of buildings in Georgia by using new advanced technologies.

This paper is intended for investors, producers of construction materials and products, builders, and customers, as well as for decision makers of the appropriate ministries.

1. The current situation of the Georgian residential sector from the standpoint of energy efficiency

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During the recent construction boom, more than two million square meters of real estate were constructed each year in Tbilisi alone. However Georgia, like many other countries, has been impacted by the global economic downturn. Thus construction activities have been reduced. With a pause in the construction frenzy, now is a great time to revisit how cost-effective, energy-efficient buildings can easily be constructed in Georgia.

Georgia's construction sector uses heavy weight concrete blocks for the external walls as well as decentralized heat supply systems. Lately there has been a trend towards the use of double glazed sealed units in either PVC or aluminum frames. However, this is a very recent occurrence and not widespread. In most existing properties, windows are single glazed in either wooden (usually residential) or metal (usually commercial) frames. Occasionally secondary single glazing has been placed inside, but is generally poorly fitted and therefore prone to leaking drafts.

With the collapse of the Soviet Union, the centralized heating systems were destroyed in the country. Since then, new national construction standardization documents (codes) in the thermal engineering field have not been developed and adopted. Primary importance is given to the structural stability of the buildings, as the country is located in a seismic zone. The old Soviet codes, in this regard, are used for structural stability engineering calculations. As detailed below, Soviet codes are also used as voluntary guidance in evaluating the thermal performance of buildings, but this is problematic.

Thermal performance level is defined in engineering codes as the value of the thermal resistance of the exterior envelope (that is, the ability of the construction to resist heat flow); this is called the "R-value." Currently, Soviet building codes are being used for evaluating the performance of Georgia's exterior building envelopes; however these specified R-values were formulated to address sanitary-hygienic requirements, *not* thermal performance. The Soviet-era R-values were established to prevent condensation on the inner surfaces of the envelope. They do not provide for the thermal comfort conditions necessary for rooms during winter and summer times. This means that most new buildings in Georgia are not built with energy efficiency considerations; at best, new buildings in Georgia are characterized by the minimally-acceptable R-value, designed to prevent condensation.

As noted above, construction companies in Tbilisi are primarily using the concrete frame / concrete block method of building. Low-quality blocks of heavy weight concrete or bricks are used as building materials for the exterior walls. The thickness of the exterior walls in new buildings in Tbilisi is: 250-300 mm or at best 400 mm. The thermal conductivity 'λ' of the above mentioned materials widely used in Tbilisi is $\lambda = 0.6 - 0.7$ W/m·°C. We can easily calculate from these figures that the R-value of Georgian new buildings is no more than $R_{wall} = 0.57$ m^2·°C/W, which corresponds only to aforementioned anti-condensation performance standards. For energy efficiency performance, the R-value of Tbilisi buildings are 3 - 4 times less than the values required for the city's climate zone. In essence, Tbilisi buildings waste limited energy resources and money, and in doing so needlessly pollute the environment. While this discussion focuses on new building construction it should be mentioned that Georgia's older buildings also are inefficient.

Recently, builders began to install double glazed window units with improved thermal resistance that is approximately $R_{win} = 0.35$ m^2·°C/W. This can be compared with single pane windows with a thermal resistance $R_{win} = 0.18$ m^2·°C/W found in the existing old buildings. Such window technologies can increase a building's energy efficiency by up to 20%. Since Georgia uses 400 – 500 percent more energy for heating per square meter of floor space than the EU countries with the same climate, installing more efficient windows is simply not enough to bring Georgia's new buildings to the appropriate level of energy efficiency. The thin walls made with low quality material, proportionally waste much more energy.

A fundamental transformation needs to take place in the production, sale, and use of energy-efficient construction materials and products, as well as in building design methods.

Such adjusted policy in the residential construction sector can deliver substantial benefits that are very much needed given the current political situation. From the standpoint of energy consumption, the residential sub-sector accounts for about 50% of energy in Georgia's energy balance. At a time when Georgia is pursuing improvements in the country's energy security, reducing consumption in this sector will help to fill the gap between energy supply and demand. Energy conservation is the quickest, cheapest and cleanest solution to problems stemming from rapidly growing global energy demands and climate change.

Energy conservation in the building sector will result in improved national energy security, financial capital, environmental value and human comfort. Energy conservation reduces energy consumption and demand per capita. This can reduce the rise of energy cost and the need for new power generation as well as dependence on imported energy.

Energy consumption is the most wasteful component of Georgia's economy (see Figure 1 graph). The amount of energy needed to produce goods and services in Georgia is 4 -5 times higher than in EU countries. This is a heavy burden on Georgia's energy sector and has direct negative impacts on the local, regional and global environment.

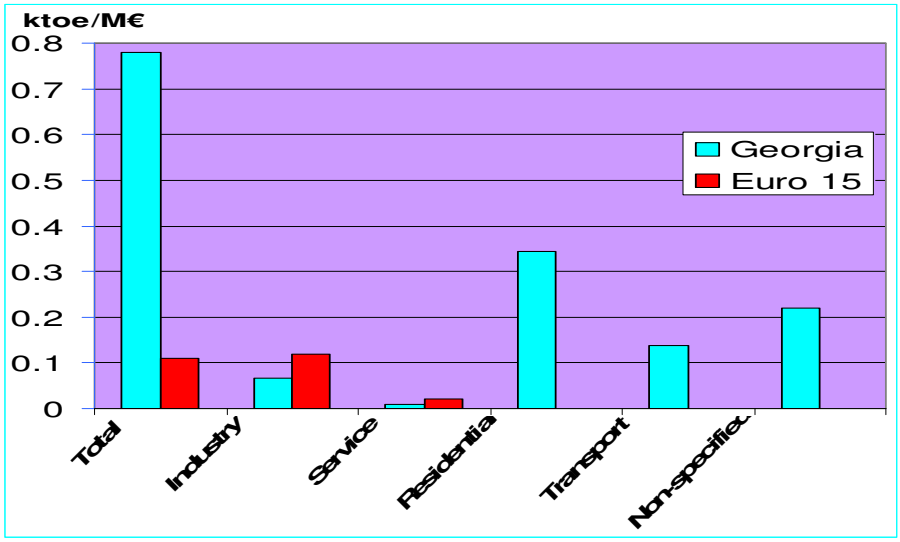

Figure 1. The energy intensity of Georgia's economy compared to the European countries

Reduced energy consumption in the residential sector can also contribute to the country's development in a sustainable manner, which is important within the framework of a number of international, multilateral and bilateral agreements that require concrete energy efficiency and conservation action in Georgia.

The EU has developed the European Union - Georgian Action Plan [2]. The Action Plan sets out a number of priorities. Among them are recommendations:

- to support development of legislation including financial and technical assistance to ensure compliance of Georgian norms and standards to the European Union legislation;
- to elaborate and implement a coherent long–term energy policy, converging gradually with EU energy policies.

The above mentioned Document can help Georgia achieve success in developing new codes, norms and standards, according to the requirements of EU legislation.

2. Fundamentals of new building codes mandating enhanced energy efficiency levels

Over the past decade a new generation of building energy codes with enhanced energy efficiency has been adopted in EU, Russia and other CIS countries. These codes mandate reductions of at least 40 percent in energy consumption through enhanced energy efficiency for heating in winter, compared to the old Soviet codes. Consequently, a fundamental transformation has taken place in the production, sale, and use of energy-efficient construction materials and products, as well as changes in building design methods.

The new European Directive (Law) 2002/91/EC [3] concerning energy efficiency in buildings has been in force since 2006. Through the general framework of member states at the national or regional level, the Directive requires a certain level of energy performance, which varies depending on the country's climate. Rather than prescribing the method or standards for each building component, the Directive allows for builders to choose designs and technologies that will deliver an energy-efficient final product. Details of how the performance is set for buildings and how EU developers and builders meet this target are discussed below.

The levels of energy efficiency required by the Directive are based on the value of the specific energy consumption for heating the building combined with optimal thermal comfort for the occupants. To calculate this value, the thermal performance properties of the building envelope must be determined. The specific heating energy consumption (for building heating and ventilation) is defined as the quantity of heat for space heating in the heating period per square meter of the total heated floor area or per cubic meter of the volume of a building, per degree-day, $W \cdot h/(m^2 \cdot {}^oC \cdot day)$ or $W \cdot h/(m^3 \cdot {}^oC \cdot day)$. The degree-days are taken into account for the climatic zones; in Georgia these vary from 900 to 5600 ${}^oC \cdot day$ with 2321 ${}^oC \cdot day$ in Tbilisi.

As previously mentioned, requirements are not set for the separate components that affect the heat balance of the building (walls, floors, ceilings, windows, etc.), but for the energy performance of the building as a whole. Energy performance is calculated as a function of the envelope performance, building geometry, design and selection of heating and ventilation systems and additional heat and solar gains, taking into account the efficiency of the heat supply system and climate parameters.

Assessment of energy efficiency is calculated by the use of an "Energy Passport". The Energy Passport of the building is a document that intends to verify energy performance in design, construction and operation. To help ensure quality of building design regarding energy-related aspects, the new Russian, CIS and other EU country codes also require the preparation of a special section of the building design entitled "Energy Efficiency." This section must include a summary of parameters for energy performance for various parts of the building design. These

parameters are presented side-by-side with code-required values. To facilitate and standardize calculations, a PC version of the Energy Passport has been developed. This version enables quick calculations, iterative assessment of design variants, and comparison with code values at all stages of design, construction, and operation.

One of the most positive aspects of the Energy Passport is that it includes a special section (see Figure 2) that can also provide energy performance information to potential buyers and residents. Consumers can then evaluate the building's energy efficiency and real costs, helping to stimulate market preferences for high-performance buildings.

Classes of energy efficiency building's ranges, kW·h/m^2 Climatic condition of Tbilisi
For new and reconstructed buildings
Very high **<30**
High **30.5-54**
Normal **55-63**
For the existing buildings
Low **64-106**
Very low **>107**

Figure 2. Energy Passport Section specifying classes of the energy efficiency rating

3. Assessment of energy efficiency for new buildings

Below is an assessment of the performance of seven "prototype" buildings for Georgia; the variants range from buildings presently constructed in Georgia (energy inefficient) to ones that could be constructed here using various energy efficient designs, materials and technologies. In this analysis, the variants have decentralized heating systems.

As a benchmark, the assessment uses the heavy weight concrete blocks and the single pane windows that are typically used in building construction. The results of these calculations are presented in the Table 1.

Table 1 –The energy efficiency levels and savings for 7 different buildings

Vari-ants	R-Wall	R-Win-dows	10 storeys 3 sections	8 st., 1 sec.,	7-8-9 st., 3 sec.,	9 st., 3 sec.,	10 st., 1 sec., ZNII EP	10 st., 1 sec., ARCI	15 st., 2 sec., Muza Venice	Average/ classes	Savings related to variant 1
	$m^{-}\cdot{}^{o}C/W$		Specific Energy Consumption, $kW\cdot h/m^2$							$kW\cdot h/m^2$	%
1	0.57	0.18	103	92.3	124	123	139	140	153	125/very low	0
2	0.57	0.35	82	78.0	100	101	115	114	120	102/low	19
3	0.57	0.56	74	72.4	92	92	106	103	107	92/low	26
4	1.0	0.35	60	57.1	72	72	81	79	81	72/low	42
5	1.0	0.56	54	53.0	63	63	72	68	68	63/nor-mal	50
6	1.61	0.56	43	42.4	51	51	54	51	49	49/high	61
7	1.95	0,35	46	44	57	56	61	57	56	54/high	57

Variant 1 primarily characterizes the thermal properties of Tbilisi's existing building stock, with single glazed windows, exterior walls from "simple blocks," and an R-value that meets the old mandatory level R = 0.57 $m^2\cdot{}^{o}C/W$. Such buildings were built during the Soviet period. The average specific energy consumption during the heating season of seven buildings is 125 $kW\cdot h/m^2$. The class of energy efficiency in this variant is very low, according to the EU Energy Passport system.

Variant 2 primarily characterizes the current building designs employed by Georgia's construction sector. As with the old Soviet-built stock, the thermal properties of the new buildings use "simple blocks" with R value at best R = 0.57 $m^{2-}\cdot{}^{o}C/W$; however the buildings have double glazed windows R = 0.35 $m^2\cdot{}^{o}C/W$. The average savings over variant 1 constitute 19%. The class of energy efficiency in this variant is low.

Variant 3 incorporates enhanced R-values for modern windows, including low-E coating (selective) glass. The average specific energy consumption of 7 buildings in this case will be 92 $kW\cdot h/m^2$ and 26 % savings related to variant 1. The class of energy efficiency in this variant is low, too.

Variant 4 has improved energy efficiency of the walls up to R = 1.0 $m^2\cdot{}^{o}C/W$; this can be achieved through the use of lightweight thermal blocks or multi-layer walls from "simple" blocks (with low R-value) and outside insulation. At this R-value, more than 40% of energy can be saved for each building. The windows are the same as in variant 2. The specific energy consumption for the heating period in this case is identified as 72 $kW\cdot h/m^2$ and 42 % savings are reached compared to variant 1. The class of energy efficiency in this variant is still low.

Variant 5 is developed with the same R-value for the walls R=1.0 $m\cdot{}^{o}C/W$ but an enhanced R-value for the modern windows including low-E coating glass. The average specific energy

consumption of 7 buildings in this case will be 63 kW·h/m^2 and 50 % savings over variant 1. In this variant, building thermal properties are characterized by a normal energy efficiency class.

Variant 6 has high R-values both for walls and for modern windows. The average specific energy consumption of 7 buildings in this case is identified as 49 kW·h/m^2 and 61 % savings related to variant 1. Such results can be achieved by the use of lightweight concrete blocks characterized by good thermal properties. A class of energy efficiency of the buildings in this variant is high.

Variant 7 includes buildings with increased R-value of the walls up to R = 1.95 m^2·^{o}C/W and the windows' properties as presented in variant 2. The average specific energy consumption in this variant is 54 kW·h/m^2 and 57 % savings related to variant 1. A class of energy efficiency of the buildings in this variant is also high. After making substantial improvements in the building envelope, there comes a point when using modern windows yields more savings than increasing the R value of the wall; Comparing variant 6 and 7 illustrates this.

It should be noted for comparison that Germany's normative document EnEV-2002 requires 40 kW·h/m^2 for 10 story buildings for the specific energy consumption or 32 kW·h/m^2 calculated to the climatic condition of Tbilisi. Such levels of energy consumption can be achieved in Tbilisi by using 200 millimeters of modified polystyrene-concrete blocks and modern windows with glass units and low-E coating in a single plastic frame.

From a thermal-engineering point of view, to reach high R-values for exterior walls as shown in Variant 6, it is necessary to make a decision between two approaches to wall design: 1) single-skin walls built from lightweight concrete blocks and 2) multi-skin (usually double) walls built from materials such as concrete blocks or bricks with an insulation layer. The basic advantage of single-skin walls made of light-weight aggregate concrete is the high thermal homogeneity, as well as an expected service life not less than 100 years. Light concrete blocks such as perlite-concrete, foamed-concrete and airocrete are being manufactured in small amounts in Georgia.

4. Assessment of energy performance using different types of walls and windows

Due to Georgia's position within an active seismic zone, the frame method of construction is required for stability. These frames are in-filled by blocks or bricks to complete the envelope. To verify the type of wall that will be the most cost-effective for the climatic conditions of Tbilisi, an assessment was conducted for the whole cycle of energy analysis of the buildings built in the case of:

- single-skin walls from lightweight perlite and aerated concrete (airocrete) blocks,
- double-skin walls from pumice blocks with foam plastic insulation.

These options were selected on the basis of technical solutions defined from current advanced construction practices in Tbilisi.

a. Lightweight perlite and aerated concrete in the single layer walls

The coefficient of the thermal conductivity of perlite blocks and their dimensions were obtained from the mining company Paravanperlite.

The size of a single perlite block is 400x200x200 millimeters (mm); thus the thickness of the walls will be 200 mm. Thermal conductivity is λ = 0.148 W/(m·°C). The thermal resistance of the exterior walls built from the *perlite blocks* is R=1.35 m^2·°C/ W.

Porobeton Ltd provided thermal conductivity and background information. For thermal conductivity performance, λ = 0.154 W/(m·°C), and the size of each block is 600x300x200 mm, with 300 mm taken as a thickness of the exterior wall. Thermal resistance of the exterior walls built from the *light airocrete blocks* is R=1.95 m^2·°C/ W.

The thermal resistance of the exterior walls built from the *simple blocks* (variant 1) is R=0.57 m^2·°C/ W. Approximate figures of annual natural gas consumption for heating purposes for a 10-story residential building in Tbilisi (denoted in the Table 1 as "ARCI"), with thermal properties of the abovementioned building exterior walls (variant 1) constitute: 52,018 m^3/year and can be expressed in monetary terms as: 26,529 GEL/year.

The main results of Energy Passport calculations for the walls built from lightweight perlite and airocrete blocks were done for the ARCI building's specifications (see Table 2). The geometry of the ARCI building is included in all further calculations to allow for comparison with walls from simple concrete block.

Table 2. The energy savings for the walls built from lightweight perlite and airocrete blocks

Variants of the walls, m^2·°C/W	Specific energy consumption for heating, kW·h/m^2	Savings related to var.1, kW·h/m^2	Savings related to simple block var.1, (%)
Simple block (var.1) R_{wall}=0.57 R_{win}=0.18	144	0	0
Perlite block R_{wall}=1.35 R_{win}=0.35	71	73	51
Airocrete block R_{wall}=1.95 R_{win}=0.35	60	84	58

The figures in Table 2 confirm that there is high energy saving potential (about 51%-58%) for buildings with exterior lightweight concrete single-layer walls.

b. Pumice blocks with foam plastic insulation in multi-layer walls

The Company Eurobuilding constructs high-quality dwelling in the center of Tbilisi with walls made from pumice blocks and insulated with 4 centimeters of foam plastic outside. The size of pumice block available on Georgian market is 400x300x200 mm with weight by volume (γ) ranging from 1000-1200 kg/m^3. The coefficient of its thermal conductivity can be defined approximately as: λ = 0.47 W/(m·°C). Thermal conductivity of the foam plastic is taken as: λ = 0.052 W/(m·°C). Thermal resistance of the exterior walls built from the *double layer wall* (the pumice blocks with foam plastic layer outside) is R=1.41 m^2·°C/ W.

The main results of Energy Passport calculations for pumice blocks with foam plastic layer and its comparison with the simple block are presented in the Table 3. Multi-layer energy efficient exterior walls also provide high energy savings potential.

Table 3. Energy savings for double layer walls built from pumice blocks with a foam plastic outside layer

Variants of the walls $m^2 \cdot {}^oC/W$	Specific energy consumption for heating, $kW \cdot h/m^2$	Savings related to var.1, $kW \cdot h/m^2$	Savings related to simple block var.1, (%)
Simple block (var.1) R_{wall}=0.57 R_{win}=0.18	144	0	0
Pumice blocks with foam plastic layer R_{wall}=1.41 R_{win}=0.35	70	74	51

5. Results of cost benefit analysis

The economic evaluation of gas-energy savings potential from lightweight exterior wall construction materials is summarised in Table 4. The analysis estimated cost savings for the 10-story residential building "ARCI," which has a total exterior wall area of 2,057 m^2.

Table 4. Results of cost benefit analysis for single layer walls from perlite and airocreate blocks and multi layer pumice block walls with foam plastic insulation

Type of exterior wall	Investments, GEL	Gas savings related to the simple block (var. 1), m^3	Gas savings in monetary terms, GEL/year	Payback period (PB), year
single layer wall of perlite block	84851	19680	10037	5.5
single layer airocrete block wall	85777	22487	11468	5
multi layer pumice block wall with foam plastic insulation	159418	20068	10235	13

As Table 4 indicates, both the perlite and airocrete variants for single layer exterior walls have almost the same payback period: 5-5.5 years. This short payback period proves that these basic energy-efficient lightweight blocks can save a lot of energy during the winter and can significantly reduce consumers' bills.

The analysis also revealed that the multi layer pumice blocks coupled with foam insulation have comparable energy performance, but are significantly more expensive than the perlite or airocrete.

Table 5 gives figures of monetary savings per square meter of floor area, resulting from reduced energy consumption during operation of the heating system in winter.

Table 5. Monetary savings for single layer walls constructed of various lightweight blocks.

Type of exterior wall	Number of wall blocks per m^2	Gas savings in monetary terms, GEL	Cost of exterior wall blocks per m^2	Annual savings regarding enhanced energy efficiency of the walls per m^2, GEL
single layer perlite block wall	12.5	10037	41.3	4.88
single layer airocrete block wall	8.3	11468	41.7	5.58
multi layer pumice block wall with foam plastic insulation	12.5	10235	77.5	4.97

6. Types of fenestration

Double-glazed, single-sash windows are used in new buildings in Tbilisi. These are produced by domestic companies like Interplast. Metal-plastic frames for such windows are also produced in Georgia. The thermal resistance of such window units in wooden or plastic frames is R_{win}=0.35 $m^2 \cdot {}^oC/W$ on average.

There are no window units with low-E coating glass available in the Georgian construction market. The Rural Energy Program contacted a number of construction companies as well as companies importing window glass. None of the companies surveyed purchase glass with low-E coating and hardly anyone was aware of the existence of these energy efficient window panes.

The thermal resistance of double glazed windows with low-E coating units in wooden and/or plastic frame is R_{win}=0.56 $m^2 \cdot {}^oC/W$ on average and their cost is up to 5-8% higher compared with windows without low-E coating. There are additional advantages of using low-solar-heat-gain low-E coating windows and overhangs through providing shade in summer.

7. Standardization of building's energy efficiency

As an independent state Georgia needs its own national system of standardization. No national construction standardization documents have been developed so far. The primary consideration during development and construction of buildings is given to structural stability because the country is located in a seismic zone. Designers use the old Soviet codes concerning structural stability calculations on a voluntary basis. The old Soviet code in thermal engineering set no requirements for energy efficiency because the price of fuel 20 years ago was so low. Consequently designers were not concerned about appropriate thermal performance of exterior walls. The price of fuel has become much higher now and we are more aware of the environmental damages that can result from wasting these resources. One of the primary

modern-day requirements for code development in construction thermal engineering is reducing consumption of heat and energy resources and curtailment of heat losses. Such an approach is demonstrated by European Directive [3] and improves buildings' energy efficiency.

It was revealed that Georgian advanced construction and development companies mostly understand the need for energy efficiency. However, due to the absence of appropriate requirements or legal framework to regulate the industry, they aren't ready to make such offers to customers, although some have already started to implement single projects with enhanced levels of energy efficiency. At the same time customers' preferences also started to change accordingly and are oriented towards a demand for a high-quality final product. This suggests that customers are becoming more informed about energy efficiency. Thus it is already time for construction companies to react to these preferences and offer customers buildings with enhanced energy efficiency levels.

The Construction industry in Georgia should be educated on how to design and construct modern buildings with good thermal comfort and relatively low energy consumption for heating. The best way to reach this target is to develop a national standard. The standard - "Energy Efficiency in Residential Buildings" can provide business with the major technical information on how to design comfortable buildings and sustain the business in a competitive market economy. This national standard can be adopted by professional societies or the corresponding Ministry and implemented on a voluntary basis. It would open the way for new energy-efficient technologies and stimulate market transformation in the production of these technologies.

This standard (see part 2 of this paper) is based on a fundamentally new approach for building energy efficiency codes, in which the thermal performance of the buildings as a whole (in terms of specific energy consumption over the heating season) are evaluated, as opposed to a piecemeal approach where separate building envelope elements are regulated. Insofar as this measure is set per degree-days of the heating season, it doesn't depend on the climatic region and is identical for similar types of buildings throughout Georgia. Such an approach was tested in Russia, the Ukraine, Kazakhstan and Moldova and demonstrated excellent results [4]. This approach also meets modern international requirements for performance-based codes, as developed by the CIB.[1] This standard also makes it possible to employ a flexible approach in the thermal-engineering design of buildings, in which the final result is achieved by improving the quality of design, based on creative potential, qualification, and technical abilities of designers.

8. Recommendations to Industry

The results of the assessment identified relatively simple ways to improve energy efficiency in Georgia's buildings through implementation of the most cost effective measures using light-weight concrete blocks and modern energy efficient windows with low-E coating. Such construction types will provide the opportunity to meet at least 40 % energy saved for heating

[1] CIB - International Council for Research and Innovation in Building and Construction - is the international association providing a global network for international exchange and cooperation in research and innovation in building and construction

purposes and would also provide thermal comfort. The key, economically-viable measures employed in the building envelope for energy performance improvement are identified as follows:

- Design the single skin exterior walls of buildings from light-weight concrete blocks with low thermal conductivity instead of the more usual heavy concrete blocks with high thermal conductivity;
- Use modern, energy efficient windows (sealed units with low-E coating) instead of basic double glazed windows;
- It is recommended that industry organize an energy efficiency certification process for building materials and products, as well as building performance as a whole, and to only use construction practices, materials and products that have received the certificate of compliance with these Georgian standards.

Light-weight concrete blocks are an excellent construction material for use in a climatic zone such as the ones found in Georgia. The use of lightweight concrete blocks for exterior walls, as single skin insulation material (with energy efficient windows) has the potential to satisfy enhanced energy efficiency requirements and these blocks provide an economically viable method to achieve market success in Georgia. Light-weight concrete blocks are environmentally friendly materials, as soon as materials used in light weight blocks are inorganic as usual. There are also many raw materials to produce such blocks.

Additional measures to reduce energy consumption for the heating of buildings are:

- Selection of a geometric form for the building that reduces heat losses;
- Optimal orientation of buildings with the goal of passive use of solar energy;
- Organization of controlled air exchange; and reduction of air permeability of the building envelope including windows;
- Use of energy-efficient heating systems;
- Use of renewable energy sources.

The construction industry is strongly recommended to develop a national building standard for thermal performance and energy efficiency. This standard, used on a voluntary basis, can regulate energy consumption for heating of buildings. The standard could also include the energy passport (certificate), which would show investors and clients the best or worst practices and help business overcome market economy hurdles. Such standards can recommend optimal performance levels as presented in variant 4 or higher (Table 3). The standard can be adopted by professional societies or the corresponding Ministry.

Local manufacturing of high-quality light concrete blocks will have a very positive impact on improving the energy performance of new buildings. Furthermore, this production will create new businesses and new jobs in the construction industry.

It is very important to underline that opportunities for future development of two basic measures for building energy performance improvement already exist in the Georgian construction market. This market is represented by small enterprises that are manufacturing different types of light concrete blocks and two types of windows. There is a need to support the development of such advanced technologies.

Besides energy savings, the use of light concrete blocks has the potential to reduce the cost of construction works in Georgia in a number of ways such as:

- by using light weight concrete blocks the weight of the walls will be reduced. This, in turn, will significantly reduce construction costs for ground and foundation works of construction;
- with a higher dimensional accuracy than the current heavy concrete blocks, it is easy to install the blocks without thick mortar beds; the thickness and thus the cost of plaster finishes will also be significantly reduced;
- size /weight ratio of light concrete blocks is characterized by high workability and therefore a much faster construction process
- use of light concrete blocks reduces transportation expenditures of the materials as well as labor costs
- reduces the risk of injury associated with the lifting of heavy blocks.

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It can be seen from this analysis that improvement of a buildings' energy efficiency is the most cost–effective way to change the situation in the Georgian construction market—turning buildings from energy wasters into climate and money savers. There are many tangible benefits to be achieved by the development of energy efficiency in the construction sector:

- reduced dependence on energy imports by improved national and energy security;
- improved quality of living standards in the country;
- improved air quality, particularly in urban areas;
- ongoing financial savings for the customers and potentially to the builders;
- job creation and market stimulation with the potential to export these new materials to Georgia's neighbors.

Georgia should seize this opportunity!

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