ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS) CLEAN ENERGY PROGRAM

COOPERATIVE AGREEMENT NO. 114-A-13-00008

Project Proposal

The Project Proposal for the Full and Energy Efficient Restoration Programme of Municipal Buildings in Tbilisi City

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1. THE PROBLEM DEFINITION

It is a widely acknowledged fact that since 30th of March 2010, Tbilisi city has joined the EU initiated Covenant of Mayors and by doing so, took the responsibility of GHG emissions reduction at least by 20% by the year of 2020.
In accordance with the Covenant of Mayors, within the scope of the agreement, Tbilisi city municipality (council) prepared Sustainable Energy Action Plan/SEAP (http://www.covenantofmayors.eu/index_en.html). The crucial component of the sustainable energy development plan of the city is the building sector, including municipal buildings.

1.1 The general overview of municipal and private properties in Tbilisi

The total area of residential living space in Tbilisi is around 37 million sq. meters. Tbilisi is the city of a significant historic heritage and the vast majority of downtown buildings represent sights of cultural heritage, the reality that imposes a dilemma for conducting restoration works upon them. Such buildings account for 10-12% of an overall residential living area. Three storey red brick buildings, with timber single glazed windows is prevailing type of residential houses in the historical centre. Such buildings are characterized by relatively thick (0.7 -1.0 m) walls and high thermo-technical indicators. Restoration works require preservation of an authenticity and for this very specific reason, the budget for each building is an individual accounting unit.

60% of the remaining residential property mainly consists of block buildings, constructed in sixties or afterwards of the last XX century, so called “Khrushchev apartments”, with the operational cycle of 25-30 years.

Small share of residential buildings are concrete and block constructions, individual detached buildings for single households (operational cycle of these constructions is hard to determine).
For the purpose of analyses of municipal buildings, the database compiled by the “Sustainable Development Centre -Remisia”, within the framework of the EC-LEDS project had been deployed. The database contains 10 different groups of buildings: theatres, art schools, playgrounds and parks, kindergartens, sports academies, stadiums, medical establishments, libraries etc., 418 units in total.

As the existing information contained data solely on energy consumption and building area, while for the purposes of the assessment of costs involved in restoration, specific variable such as the dates of commence of exploitation became essential, within the process of preparation of this project proposal, for defining the pilot group, additional data gathering via different methods (interview, archive research etc.) became necessary. In vast majority of cases, current owners do not have any information about the building in their possession and the database in non-existent within municipalities.

Below is presented the general analysis of municipal buildings in Georgia, brief overview of the necessity for restoration and energy efficiency increasing activities. This particular analysis is based on the information provided in the SEAP (Sustainable Energy Action Plan) document, prepared by the Tbilisi Municipality with the support of Remissia. Throughout the process of preparation of the given project proposal, the research already had been carried out in 7 different municipal units (Tbilisi, Batumi, Kutaisi, Zugdidi, Gori, Telavi and Akhaltsikhe).

Buildings under the ownership of municipal units in Georgia have a certain degree of commonality based on their functional purposes, more specifically the buildings of administrative unit, sports academies, kindergartens, arts schools, libraries, playgrounds and recreational parks, stadiums, medical establishments etc.

Specific characteristic do emerge due to the peculiarities of geographical spread. Despite the functional similarities, based on climate variables and types of building materials the whole spectrum of buildings can be observed: steel and concrete constructions, timber, brick buildings hybrid type, steel only natural stone et cetera. Based on this, they differ from physical depreciation, thermo-technical and construction standpoints.

Most buildings are characterised with a high degree of heat wastage; Energy wastage most commonly is associated with the inappropriate design of the building envelope throughout the lifespan of the building, alongside with the building exploitation, their energy efficiency indicators usually deteriorate. As for new constructions, big volume of resources is directed into a development of municipal projects such as road infrastructure and tunnels. Significant portion of these works are funded by local authorities. In year 2015, in the process of preparation for the Youth Olympic Festival 2015, activities at a larger capacity were carried out Tbilisi Technological Development Fund.

Below, within the table 1 and drawing 1 indicators of numerous municipal buildings of differing purposes is outlined.

Table 1. Groups of municipal buildings according to their function

N	Building Type	N of Buildings	Area (m^2)
1	Buildings in parks	10	15 112
2	Art Schools	26	18 576
3	Museums	14	2 537
4	Theatres	3	5 100
5	Sport and health centres	12	38 342
6	Libraries	42	11 225
7	Health Service Centres	27	26 763
8	Kindergartens	158	222 090
9	Administration Buildings	14	11 203
10	Other buildings	66	102 704
	Total	**372**	**453 652**

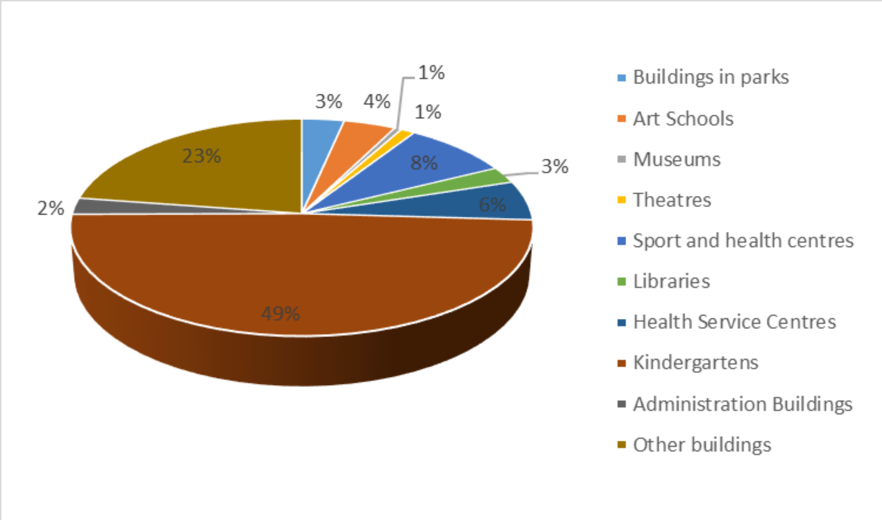

Fig. 1 Division of total areas of municipal buildings according to their function

The research has indicated that relatively comprehensive and reliable information at this stage is available solely on kindergartens; hence the decision was made to select kindergartners for the purpose of the pilot project. The methodology adjusted on the kindergarten buildings can be reapplied to other groups of buildings. Kindergartens are interesting use case for different reason as well: they have 49% share in the total area of municipal buildings. As for other groups of buildings, after identifying accurate dimensions and legal status of ownership, fitness and wellness centres become second priority target followed by medical establishments (accurate dates of their construction or renovation must be identified first). With regards to libraries and art centres, as they are located inside buildings built for different purposes (e.g. residential), they do not represent direct interest of this project.

According to the 2011 Sustainable Energy Development Action Plan for Tbilisi city, by the year 2020, total reduction of emissions from the building sector should have been 182 Gg annually. In 2015, the monitoring report on the SEAP implementation in Tbilisi city was prepared and as the result, the initial 2011 SEAP was updated. By 2014, the emission as estimated originally in 2011 should be reached to 830 Gg, however the monitoring process has exposed that in reality it is twofold higher (1624 Gg) as compared to the initially planned figure. In reality, the largest growth rate of 44% amongst analysed sectors came on building sector, more specifically on residential building subcategory. As the report of monitoring in 2014 has revealed, total savings did not exceed 16 Gg of CO_2; this is only 8.5% reduction of originally planned estimated numbers. In proportion with baseline scenario emissions, the reduction is only 1%. Based on above described, from the standpoint of GHG reduction, Tbilisi municipality needs to act in several directions, including both buildings under the administrative ownership, as well as private residential properties.

In 2012-2015, few pilot projects had been implemented in order to increase energy efficiency in buildings under Tbilisi municipality's ownership. These actions, even for specific buildings, are fragmented and sporadic and do not ensure full energy efficiency of the building. On another hand, separate public service bodies (Agency for Kindergartens of Georgia, Technological Development Fund etc.) implement renovation of existing municipal and construction of brand new buildings. Nevertheless, these processes do not accommodate for energy efficiency measures. The experience of other cities (Riga, Berlin) has disclosed increased economic and energy efficiency benefits of the systematic/programmatic approach to building renovation, as contrasted to executing solely pilot projects, even at a larger scale.

Besides, within the process of preparation of the Low Emissions Development Strategy (LEDS) and National Energy Efficiency Action Plan (NEEAP), as requested by the Government of Georgia and drafted with an assistance from GIZ, the NAMA project proposal on "Low Emission/Efficient Building Sector Development" favours systematic/programmatic approach to the building renovation process.

Based on processes and projects described above, the given project proposal has been drawn for Tbilisi city municipality that comprises from two parts: 1) The General Concept of Systematic/programmatic Renovation of Buildings and 2) Specific Project Proposal preparation for pilot buildings (kindergartens). The experience of other cities indicates that the comprehensive approach to renovation of municipal buildings, systemic planning is more cost saving and ensures both, high degree (quality) of renovation and the fulfilment of low emission, energy efficiency initiatives. Therefore, because of these reasons, long-term planning (20-25 years) of municipal building renovation process becomes essential.

Assessment undertaken in the last period (cost efficiency analysis) has exposed findings indicating that building based on conceptual framework of sustainable building is not only environmentally friendly option offering healthy living space, social wellbeing and comfort; moreover, it is considerably lucrative in financial terms.

An initial cost of the building does increase, nevertheless throughout the entire life cycle of the building, at the expense of total savings on maintenance and utilities, the overall cost of energy efficient building is 10-15% less.

The factor of energy efficiency is one of the cornerstones of sustainable design process. The increasing concerns over the climate change and other environmental measures vest an extra value in savings achieved via increase of number of buildings constructed based on principles of energy efficiency.

In considerable number of existing buildings in Georgia, by execution of modern approaches, the reduction of energy consumption by 40-50%, CO_2 emissions by 35%, water utilization by 40% and household waste by 70% are tangible outcomes. In the process of sustainable planning, it is utterly important to concentrate on natural light utilization, natural ventilation, ensure protection from the direct sunlight (greenery, shady, screens of different types), use triple glazing and energy efficient window profiles, sun beam reflecting surfaces, green roofs for maximum reduction of sun heat.

Landscape architecture must ensure the minimization of "heat islands" in urban areas. For these purposes, besides trees and summer-houses, the drought resistant vegetation needs to be planted, once that require less watering. As the part of this process, energy utilization from alternative sources (sun, wind, earth etc.) must be maximised.

2. THE AIM OF THE PROJECT

The aim of the project is to prepare a long term (20-25 years) plan for the full and energy-efficient restoration of buildings in the Tbilisi municipality and detailed outline of conceptual framework for the single pilot group. Municipal buildings covered in the project include kindergartens, arts and sports academies administrative and other buildings. From the listed building types, kindergarten buildings were selected as the pilot group. Within the scope of the project proposal, the renovation programme of around 400 municipal buildings inside the Tbilisi municipality must be written up. The project proposal determines the volume and typology of works, budget, the construction management methodology, possible sources of financing; will identify possible barriers and favourable conditions for the project realisation. The implementation of such long-term plan shall enable Tbilisi city municipality to comply successfully with responsibilities voluntarily committed after signing the Covenant of Mayors. It is worthwhile to note, that there is no dedicated department in the organisational structure of the Tbilisi city's Mayor Office, responsible for gathering statistical and other data on properties under the municipal ownership (or generally on all buildings throughout the city) or fulfilling restoration control and management duties. Building management and restoration works are carried out chaotically, as the rule by the demand of administrative or local authority units, occupying the space inside the building. Unlike to other entities, the Agency for Kindergarten Administration (the organization body responsible for administering kindergartens) manages kindergartens in Tbilisi city area organisationally.

The agency calculates energy consumption rates in kindergartens and oversees buildings refurbishment activities. Energy efficiency measures carried out in the time period of 2010-2014 in municipal property mainly cover kindergarten buildings. The second part of this project proposal (the systemic/programmatic renovation of the pilot group) is concerned with the full systemic renovation for the group of kindergartens, deploying energy efficiency measurements.

The implementation of the pilot project will fine-tune the methodology for the purpose of future reapplication on other groups of buildings.

3. TASKS FOR IMPLEMENTATION

3.1 Methodology

- The methodology section offers the general overview of buildings, attempts to identify their operational characteristics and create taxonomies based on functionalities;
- Rules of appraisal of the physical depreciation of buildings must be outlined. As buildings under the renovation were constructed predominantly in Soviet era, building codes and regulations of Soviet period take precedent http://www.ocenchik.ru/docs/3.html: http://www.avg.ru/pressa/pdf/019._belyh_a.v-1.pdf, whilst assessing physical conditions of constructions in Georgia;
- The revealing of homogenous groups of buildings and the selection of sample buildings within a group must be carried out in accordance with principles of "intervals division methodology". Characteristics of selected buildings under review must be passed down onto group/subgroup of buildings. Methodology is conservative and known as the principle of ascending interval that suggests identification of the centre of weighted average and analysis of neighbouring members, for reapplying the findings.
- The selection process of the group of buildings under renovation must be conducted in correlation with the predefined set of criteria. For instance, for the scope of this project proposal-phase II, kindergarten buildings were selected as the pilot group due to the availability of information and high volume of buildings. The full renovation package must be prepared for the target group, including project expenditure analysis documentation, covering energy efficiency activities as well;
- Factorization of buildings inside the pilot target group based on several indicators (age, degree of depreciation, functionality etc);
- By applying the methodology known in mathematical analysis under the name of score factorization method (division into factor groups in relation to a certain equivalence), scores must be divided/buildings grouped/ in factor groups (the whole score of buildings under the certain group must be further subdivided based on roof, heating system, wall insulation and other. For locating the common intersection point of scores (building under restoration) examination and further distribution on other variables (groups of buildings) is required;
- The comprehensive analysis of cost efficiency of municipal buildings' entire restoration process and the estimation of emission reduction.

3.2 Phases of implementation of the project proposal

The project proposal contains two directly inter-related components, however possibly executable independently. Herewith, only activities and stages involved in realisation of the first component are reviewed. With regards to actions under the second component, please refer to Appendix 1, where they have been outlined separately.

Phase I Activities

- **Collecting the statistical data on municipal buildings in Tbilisi city and their grouping according to various characteristics.** This activity involves information/statistical data collection of the following groups of buildings: buildings in parks, art schools, museums, libraries, medical centres, administrative buildings and buildings of different purposes. With assistance from the municipality the following statistical data shall be collected: detached building/occupies part of the building, year of construction, functional characteristics (occupancy/purpose), year of restoration and type of restoration undergone, type of the building (cultural heritage sight if it belongs to one), area, energy consumption by energy source (electricity, natural gas, oil produce, wood). Based on existing statistics, buildings must be categorized by various indicators, those that define their need for energy consumption, renovation needs and degree of such measures, forms of ownership and functions of municipalities in the process of caretaking of each individual building;.

  The main characteristic for grouping buildings inside the particular functional group is a degree of their sustainability (possibility and prerequisite for restoration). For realizing appropriate grouping, predefined assessment criterion shall be agreed upon. For instance, the determinant of renovation categories of constructions erected in Soviet era, must be congruent with norms and regulations on building depreciations of that particular period[1], something that is largely driven by the age of construction. The assessment of post-Soviet period buildings must be compliant with existing building regulations;

- **Selection of standard municipal building in each group for the purpose of further inspection and conducting energy efficiency audit**. Inspection and energy audit of selected standard buildings, for the purpose of identification the need for restoration and energy efficiency measures, the capacity and usefulness of such measures.

  The objective of this exercise is to select buildings fit for an inspection amongst the grouped buildings that can be realized by the methodology of "interval division"[2], which has been applied during the pilot project preparation stage. In order to establish the category of energy efficiency, the inspection and audit of selected buildings must be carried out, also the appraisal of potential for energy efficiency improvement is essential. Described works must be carried out at least on 5% sample from each individual group. Inspected buildings must be described in detailed manner and grouped based on various parameters;

- **Determining necessary action plan for energy efficiency renovation of inspected buildings, budgeting and cost/benefit analysis.** Within the scope of these actions, costs of renovation works and energy efficiency measurements must be evaluated. Detailed budget

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[1] As in case of pilot project (kindergarten buildings) majority of buildings under the restoration were constructed in the soviet period, physical condition of buildings are assessed based on norms and regulations of Soviet Socialist Republic of Georgia form that time.: //www.ocenchik.ru/docs/3.html: http://www.avg.ru/pressa/pdf/019._belyh_a.v-1.pdf

[2] The method of interval division (Bolzano method) or bisection method Г.М.Фихтенголц, Курс дифференсиального и интегрального исчисления,т.1, стр.87,168 explores the method of identification weighted average centre for value set and researching characteristics of neighbouring element for the purposes of spreading findings further to other members of interval.

grasping investment costs and post energy efficiency measures savings, investment payback period assessment must be produced;

- **Assessment of GHG reduction potential in inspected building**. The GHG potential shall be assessed for such a unit that will enable generalization of finding on group/subgroup of buildings;

- **Creation of factor groups/subgroups on the basis of technical finding per sample building**.
Results of findings of energy efficiency and restoration needs for each standard building must be generalised on similar buildings that may derive additional subgroups. This may occur deploying the method of factorization[3], as applied to the process of the pilot project preparation. On the grounds of results for each standard building, the volume and need for restoration in relative subgroup must be identified. Also, similar subgroups of the researched group of buildings must be revealed. Under the functionally similar subgroup, several factor groups can be outlined further, sharing similar technical parameters, need for restoration and energy efficiency measures with the sample building.
- **Generalisation of financial needs for each standard building on factor groups/subgrpoups.** Research findings on financial needs for selected standard buildings shall be generalised for groups. This can occur based on area unit assessment results distribution on overall area of buildings; cost-benefit analysis must be carried out for standard buildings.
- **Spread the assessed GHG reduction potential on relevant factor groups/subgroups for each standard building.** The analysis of GHG reduction potential must be prepared for each subgroup.
- **Preparation of the long term plan for the full energy efficient restoration of various groups of buildings**. The programme must comprise of two parts: building restoration schedule and cost-benefit analysis (for 20-25 years) and barrier analysis with supplementary recommendations on overcoming those barriers:

    1) Whilst **analyzing barriers**, at least barriers identified throughout the pilot project preparation must be outlined. These include: existing barriers in state procurement that hinder energy efficient measures implementation, as they are associated with additional expenses; other legal barriers, such as absence of energy efficiency standards etc. Absence of qualified organisations and certified products in the process of energy efficient project design and execution.

    2) In the process of **scheduling the restoration** the cost benefit analysis and various means of GHG emission reduction must be reviewed; final decision on the method of implementation must be made by the municipality congruent to existing financing schemes.

[3] Factorization of the value set (dividing into factor groups in relation with different equivalencies Лоран Шварц, Анализ 1, стр.19. This method offers division of the value set into factor groups (in this particular case division of entire number of buildings value into roof, heating system, wall insulation etc.) for the purpose of identification of their point of intersection and after the definition of this point (buildings under construction) analysis and further spreading this factors for other values (group of buildings).

- **Identification of project beneficiaries and project partners and definition of their role for each group**. All private, non-government, public or international organisations must be considered alongside with various social groups interested to participate in project implementation and form partnership or receive benefits from the project. Quite often interested stakeholders act as the project partner and be a project beneficiary at the same time.
- **Recommendations on means and schemes of finances for each separate group.** Within the scope of these measures, all existing sources of finances and schemes for each group shall be reviewed and most effective scheme selected.
- **Restoration and construction/design works monitoring methodology identification**. First of, the existing problems in design/construction monitoring processes in municipal building must be analyse. On the basis of conducted surveys and existing legal frameworks review detailed methodology for monitoring works must be written up, Methodology must include detailed instructions for implementation and training materials shall be prepared independently.
- Training of municipalities in existing nationally accepted or required for this project standard. Training material preparation and training programmes in local municipalities' procurement departments for the purpose of introducing energy efficient building norms and regulations to local municipality employees.
- Providing energy efficient materials and highly qualified labour force. This action is required for the successful implementation of this programme, however at this stage it is possible to realise on central government level, mainly nationwide and herewith the result will be applied. Actions require training of construction and design companies in energy efficient materials.
- Development of the labour market of highly qualified energy auditors and green civil engineers. Qualified at degree level energy auditors and green civil engineers must be available at the job market; appropriate higher educational establishments have crucial role in this. Further development of associations of architects and construction industry professional bodies is must, deploying their expertise in organising seminars and workshops, development of professional certification procedures.
- Introduction of green building concepts and elements in energy efficient technology restoration process, Green building guide must be prepared, printed and distributed. Preparing municipalities and cities population's awareness of green building concepts for future introduction

4. PROJECT PARTNERS AND BENEFICIARIES

In this chapter private, public or international organisation and the category of society willing to provide partnership to the project with various means of participations will be analysed. Also, project beneficiaries will be assessed, despite the fact that they frequently coincide with project partners, however in our case the circle of beneficiaries, as a rule is wider.

First and utmost, the partners in the process of energy efficient rehabilitation of general existing public buildings are examined, afterward, additionally stakeholders who have substantial interest and role in the kinder garden building rehabilitation.

Partners in energy efficient rehabilitation project of existing buildings in Tbilisi municipality are as follows:

Tbilisi Municipality and The Ministry of Economy and Sustainable Development are core partners of the discussed project. They have a significant role in project implementation, as caretaking and rehabilitation of state and municipality owned building is their direct responsibility, as the assets are under their direct ownership, they determine functional purposes and at the same time they act as decision makers when it comes to rehabilitation.

- **Tbilisi City Municipality**: In 2010 Tbilisi city voluntarily joined the EU led initiative onGHG reduction and took responsibility to reduce GHG emission into atmosphere by year 2020 throughout the administrative territory belonging to Tbilisi city municipality by 20%. Besides, those buildings under full rehabilitation within the scope of this project are under the ownership of Tbilisi city municipality. Tbilisi city municipality is the major implementer in this project and accordingly, is the partner of the project, hence after the fulfilment of rehabilitation of the pilot buildings (kindergartens) as intended as an outcome of this project, Tbilisi city will have an opportunity to reapply the same methodology to other building under its ownership, which will drastically reduce the expenditures of municipality in the sector of energy supply
- The Government of Georgia, more specifically the **Ministry of Environment and Natural Resources Protection of Georgia**, the responsible body for instigating requirements under the framework of convention on climate change, also implicating the reduction of GHG emissions on entire territory of Georgia. This is the core purposes of the project. Besides, the ministry is one of the co-coordinating bodies of the Covenant of Mayors in Georgia and the full support of undersigned municipalities in the process of the realization of duties is one of its key responsibilities. The ministry is ready to assist the project with necessary data input and provide methodological support, and simultaneously support the fundraising efforts from climate change related donor organisation for acquiring low APR financial grants.
- **The Ministry of Energy of Georgia**, one of the co-ordinators of the covenant of mayors in Georgia and at the same time has its vested interest in undertaking energy efficient measures in buildings and in supporting usage of renewable energy sources. The Ministry currently is preparing the National Energy Efficiency Action Plan (NEEAP), required by the EU association agreement and is fully dedicated to assist the project, as in case of successful outcome this project can make tangible contribution in the NEEAP. The ministry proactively collaborates with municipalities and cities, including Tbilisi municipality, in the process of preparation of action plans on sustainable development of energy sector and supplies them with parameters measured on national level (GDP, population growth, elasticity coefficient in various sector etc.)
- Management of property under state ownership is a prerogative of the **Ministry of Economic and Sustainable Development**, and despite the fact that that its role in the course of restoration is not clearly and unambiguously defined, nevertheless the ministry oversees the preparation of low emission program planning in the process of LEDS development. The ministry also co-ordinates EBRD initiated project on energy efficient actions planning in residential houses. The ministry is responsible for upgrading building standards from the stand point of energy efficiency.
- **LEPL "Tbilisi City Technology Development Fund"** is one of the key partners in kindergarten pilot project creation. Currently the fund is executing case study pilot project

on the basis of kindergarten #95, involving energy efficiency and general resources effective utilisation. Achievements and failures, as identified throughout the pilot project, will be thoroughly examined and considered in the kindergarten pilot project implementation process. Besides, the fund is ready to co-finance the pilot project to a certain degree.

Tbilisi City Technology Development Fund is also ready to support innovative building methodologies and technology introduction not only in projects on Tbilisi city municipal territory, but also throughout the entire country. More information and proactive trainings on modern efficient technologies throughout the country is essential.

- **The Ministry of Regional Development and Infrastructure**-this ministry is directly linked with the fulfilment of SEAPs. Municipal Development Fund (MDF), under the management of this particular ministry, finances restoration of municipal buildings, social housing of IDPs and eco migrants etc. In partnership with them, financing of houses with certain functionalities (social housing) is possible. They can supply equipment, set the infrastructure etc.
- **Non-Governmental (NGO) sector**: Energy Efficiency Centre-Georgia with long standing experience in energy efficient technologies; Sustainable Development and Policy (SDAP) centre, with co-funding of EU grant and Rustavi city mayor's office that implements energy efficient restoration of three kindergartens in Rustavi city. Named NGOs are ready to share their expertise and knowledge in energy efficient technologies.
- Georgia based **donor organisations** and programs working in the field of energy efficiency (USAID, EU and it's energy efficient programmes, GIZ etc), ones that proactively cooperate with Tbilisi city municipality in different directions and more specifically in construction sector. Projects supported and co-funded by them enhance green building development, increase ecological awareness, introduce energy efficient technologies, reduce poverty, also give recommendations to building industry. Above listed donor organisations closely cooperate with public and private sectors in innovative restoration programs, support municipalities in fulfilment of pilot projects.
- **Private sector**: the private sector mainly consists from construction, design and development companies. There are several types of development companies in Georgia: developers that manage construction projects and for further profit margin increase form construction companies; developers working on government contracts; organisations founded in connection with specific, investment bank funded projects, that enjoy reliable funding source; medium and small sized companies with relatively smaller revenues and ones that try to increase profit margins by growing efficiency indicators; companies supplying heating/ventilation, cooling and alternative energy generating systems. More detailed information about activities and barriers associated with their activities of each type of the company will be offered in project barriers section. Amongst listed types of companies, medium and small sized entities are considered as core group of partners of the project, as they wish to establish themselves on Georgian market and become competitive force by offering modern, energy efficient technologies.

In case of the pilot kindergarten buildings project, above itemized beneficiaries list will be extended by the Legal Entity of Public Law (LEPL) Tbilisi City Municipality Kindergarten Agency. The agency implements kindergarten buildings restoration long-term plan and is one of the co-financiers of the project.

Beneficiaries of energy efficient restoration of Tbilisi municipality buildings are:

- **Tbilisi City Municipality.** An implementation of just pilot project will enable Tbilisi city municipality to fulfil ?? % of its GHG reduction responsibilities from construction sector. More specifically, if the project is initiated in 2017 by the year 2020 using energy efficient technologies around 38 133 square meters kindergartens area must be restored and if per square meter average annual saving of 0.025 tonne CO2eq is achieved, it will be in total saving equivalent of 953tons which is 0.5% of total 180 262 tonnes of CO2 from Tbilisi building sector.
- Governmnet of Georgia and more specifically **the Ministry of Environment and Natural Resources Protection of Georgia**, which is responsible for ensuring the compliance with requirements of agreements within the Framework Convention on Climate Change, reducing GHG nationwide in Georgia. The document presented by the Government of Georgia in September 2015 (INDC-Intended Nationally Determined Contribution) considers building sector as one of the key sectors in the process of GHG reduction.
- **The Ministry of Energy of Georgia** that is preparing the NEEAP, required by the EU-Georgia association agreement. The Ministry's stance on energy efficiency increase in building sector states that the increase is crucial for energy independence and energy security process. This project is the part of NEEAP and will assist the ministry to meet its commitments.
- The Ministry of Economy and Sustainable Development is currently drafting a section of legislation on building and construction standards that introduce of energy efficient and renewable technologies. If the ministry manages to finalise standard adoption prior to project initiation, than project becomes ideal case study for demonstration the outcomes of newly adopted standard and if the situation is opposite, barriers and findings of the pilot project will be reflected in the statute. Herewith it must be mentioned that throughout the implementation of the pilot project, Tbilisi city council may allow temporary standards.
- **Tbilisi city Technology Development Fund**-this project will serve the goal of business portfolio extension for development fund, with consideration on modern energy efficient technologies.
- **The Ministry of Regional Development and Infrastructure of Georgia**-this ministry is directly linked with the implementation of SEAPs. Municipal Development Fund under the management of this particular ministry finances restoration of municipal buildings, social housing of IDPs and eco migrants etc. In partnership with them financing of houses with certain functionalities (social housing) is possible. They can supply with equipment, set the infrastructure etc.
- **NGO sector**: non government organisations working on projects of building restoration and energy efficiency can re-implement these results in different municipalities and avoid sporadic selection of buildings.
- **Private sector**: construction, design and developer companies can benefit from the expertise in new direction, new technologies, increase market share and voume, improve energy efficieny.

In case of pilot kindergarten buildings' restoration project, the list of beneficiaries will be extended by the following implementators:

- Kindergarten agency of Tbilisi city municipality is the main beneficiary of this process, as the cost saving is achieved not only via energy consumption measures, but from unplanned renovation measures as well.
- Kindergarten pupils, as after the full restornation of kindergarten buildings young children can benefit from increase comfort and healthier environment.

- Parents of kindergarten pupils, as their children will be studying/ staying in more comfortable and healthier environment.
- Ministry of education and science, as predefined by norms tempretature, illumination, ventilation and healthy environment standard requirements will be met
- Ministry of Labour, Health and Social Affairs of Georgia. First of all, the project enhances healthy environment for kindergarten pupils and at the same time creates additional vacancies.

5. FAVOURABLE CONDITIONS FOR PROJECT IMPLEMENTATION

- Tbilisi city municipality has responsibility to reduce GHG emission and the municipality is motivated to increase energy efficiency in its' buildings, as besides reduction of emissions it will bring considerable financial savings.
- This project and the pilot proposal are fully compliant with responsibilities acknowledged by the country within the framewok of climate change conventions, as well as EU association agreement and energy collaboration pacts;
- The Government of Georgia is drafting a low emissions development strategy and in this strategy building sector is one of the leading sectors, as herewith emission growth rates are fastest. More specifically, in Tbilisi city in the time period of 2009-2014 emission growth rates were 64%, nationwide the same indicator in the time period of 2007-2011 was approximately the same number-65%.
- The country is preparing national energy efficiency action plan, that must be grounded in the success of actually executable actions and in case of pilot project success, similar approaches and financial schemes will be used for action plan preparation.
- Few large scale projects are being carried out nationwide (for instance NAMA of low emission buildings, Batumi city buildings energy efficient restoration, energy efficiency increasing in domestic energy consumption etc.)

6. EXISTING BARRIERS FOR PROJECT IMPLEMENTATION

Barriers

- ***Existing legislature on state procurement***

Problems identified in the selection process of design/engineering or construction companies is mainly linked with the procedural issues, that are defined in the law on state procurement. According to the given piece of legislation, main defining factor for purchasing decision is a low price and not a high quality. Quality assessment is carried out after decision is being made based on lowest price offered. Elimination of this barrier is crucial in those procurements that are linked with new technologies (energy efficiency and renewable energy sources are good example) whereas lack of experience is apparent.

One of the recommendations for overcoming such barrier is emporing local human resource and introduction of potential increasing programmes, initiation certification programmes for design and construction companies and only after thorough examination procure good at the lowest rates.

- ***Absence of monitoring process on restoration works***

The monitoring and inspection process of implemented works is one of the most important issues. The assessment of implemented works is carried out by National Forensics Bureau. Frequently, the assessment work is done by invited consultant, increased time period of assessment report preparation and final cost.

One of the recommendations for municipalities, besides design and construction works, is purchasing monitoring rights from accredited private entities or forming its own monitoring department. In this case intermediate works monitoring becomes possible, ensuring high quality at the end.

- ***Absence of energy efficient construction standards and associated with this deficit of qualified design and construction companies.***

Big share of construction companies involved in the restoration business are mentally ready for fulfilling innovative projects, exploring new markets and increasing company revenues. However, in this process the problem of lack of technical standards is clearly observed, leading to low quality, low grade products.

More specifically, as the thermo-technical analysis of implemented projects has revealed, works/projects are executed chaotically and with the violation of integrated design principles, i.e. the emphasis is made on one direction (solely energy efficiency or renewable or any other direction) and the vision is not holistic acknowledging functionality and design vision in total. Frequently, this innovative component are promotional only and do not have real impact.

At this instance, the most important recommendation is adaption of certain standards (at the first stage for municipal building only), that will increase construction companies' qualification necessary for certification process.

Concerning the pilot project (kindergarten restoration) implementation, municipality may adopt temporary minimum standards, compliant to them will be mandatory in the scope of this specific project.

- ***Private construction companies' market***

Insufficient degree of development of private constrtctuon sector and lack joint ventures in the process of energye efficient technology spread is one of the most serious barriers faced by this project.

1. Developers, that manage construction projects, as the rule further to increase profit margins form construction companies. Companies ARCI, AXIS, KID Architecture, and Centre Point were founded following this pattern in the past. Many of them disappear from the marketplace after completing specific projects and do not develop. Very small of percentage of such companies become innovators, as the rule their range is very limited and narrow. Due to these factors, 70% of above listed entities are not vocal on marketplace as they used to be upon foundation or they moved to average sized construction market segment. Amongst these companies, just ARCI group managed to become innovator and was first to construct energy efficient house in 2007 on Kipshidze Street with heated external casing.
2. Second type of companies-to this particular group belong organisation working alongside state funded project, those that usually win government tenders, have large revenues and relatively smaller profit margins. Therefore, the innovative idea implementation lags behind, and as the rule after some time they lose spheres of influence and become disintegrated into smaller companies or are forced out of the industry. This was the case in Artes, Aword, ENS, NCC, Magistrale, Module, Iberia, Meridian, 7-SKY. Such companies copy building solutions. They will introduce innovative actions only in case of existing demand from the government.
3. Third type of companies are those established as the investment initiative of retail banks and enjoy reliable funding sources. Such companies include "New Building Company", m2. These companies in certain cases implement energy efficient project solely because they are dependent on energy credits and donor requirements are very strict (for example in case of m2). This type of constructing companies possesses great potential in implementing energy efficient solutions. They are ready to purchase consultancy projects, as often this is prerequisite.
4. From the perspective of innovation medium and small sized companies, with smaller revenues and the quest for profit margin increase by achieving high indicators of efficiency are more interesting. Such companies are in constant search and try to offer innovations to the market, achieving higher rates of return. Such companies pursue aggressive innovative tactics. Offer to the market not only building service, but building solutions too. To such group belong: ArtStudio, ARCI, and New Technology Centre. Companies from this group are active in smaller towns as well and achieve success. They represent interest group as their flexibility ensures innovative measures implementation.
5. With regards to heating/ventilation, cooling and alternative energy generation systems, there is a variety of companies on Georgian market supplying customer with the equipment. This direction develops rapidly due to high "promo" activities and softer energy credit terms and conditions. As the result government and donor grants, the market developed faster on account of projects in mountainous regions of Tusheti,

Adjara, Khevsuretietc,). These played a significant role in raising general public awareness and development of companies inside this sector.

On this energy efficient technology marker decision making whilst selecting solution is made not by independent consultants, but by the manufacturers themselves, representing biased side. Such market limits competition, hinders creative thinking and limits rapid development of technological market as the result.

- ***Lack of full energy services providing companies***

In the process of development of energy efficient buildings and energy efficient technoglogies the existence of the link such as full energy performance contract is essential. This type of contract is signed with an organisation that becomes fully responsible for both technology and reliability and for collecting saved sums of money from general population. Such service is a barrier on European and other markets. After overcoming this barrier, one opportunity is creation of the company, creation of joint venture and training local staff.

- ***Lack of public awareness***

Public awareness has a dominant role in selection of restoration methodologies and in formation innovative construction teams in the future. As an example, in the case of kindergarten building restoration process, hugely important is parents' attitude toward creation of comfortable environment for their children.

General public must be able to envision advantages of energy efficient activities on a global and local scale and the demand has to be derived from public. This direction has to become more prestigious gradually.

The role of municipality in this process is immensely important; municipality within the framework of the covenant of mayors must work alongside with general public, non-government and private sectors.

Low levels of coordination

If allocated donor funds and government transfers for energy efficiency restoration purposes will be coordinated congruously, the outcome will be much more effective. These processes currently are spread out, leading to layovers and reducing final outcomes.

If standards will be adopted this problem will be partially resolved, however even more effective will be municipal authorities' cooperation with NGOs working in the field of energy efficiency. In order to achieve this goal (high degree of cooperation) it is recommended to set sustainable development agencies in the organisational structure of municipalities, responsible for matters of coordination.

7. RESTORATION PROJECT PREPARATION STAGES AND COSTS FOR VARIOUS FUNCTIONAL GROUPS OF MUNICIPAL BUILDINGS

Action	Probabilistic Result	Estimated budget (US dollar)	Execution time frame (Month)	Executing unit	Comments
1. Gathering statistics on municipal buildings in Tbilisi city and their grouping by various characteristics.	Review of municipal buildings according to their functionalities, need for restoration and the role of municipality in the process of restoration.				
2. Selection of standard municipal buildings in each group for the purposes of further inspection and conducting energy audit.	Description of results of the inspection for each building and grouping of buildings based on these results				
3. Identification of necessary measures, budget definition and cost/benefit analysis of inspected buildings	Cost/benefit analysis on restoration/energy efficiency measures of inspected buildings				
4. Assessment of GHG reduction potential in inspected buildings and their breakdown by units suitable for the generalisation.	Analysis of GHG emissions reduction potential in inspected buildings (per area unit or another units)				
5. Outlining factor subgroups for each standard building according to technical findings	Deploying the method of factor analysis for each functional group, grouped by one specific indicator (volume of restoration, types of energy efficient measures etc.) and apportionment of building				

	subgroups.				
6. Generalisation of financial needs on subgroups found using factor-analysis method, derived on the basis of each standard building.	For each subgroup, cost-benefit analysis must be carried out				
7. Extending standard building factor-analysis findings on GHG reduction potential on subgroups.	GHG reduction potential analysis for each individual subgroup				
8. Preparing long term plan for the full energy efficient restoration of various groups of buildings.					
8.1 Analysis of barriers and appropriate recommendations on overcoming these barriers.	Analysis and recommendations on all barriers considered within the Chapter VI. Among them, at this stage the most important obstacle is existing barrier in state procurement legislation; other legal barriers and lack of qualified companies and certified materials in the process of implementation.				
8.2 Schedule of building restoration and cost benefit analysis (20-25 years).	Building restoration cost-benefit efficiency analysis and GHG emission reduction schemes for 20-25 year time perdio,				
9. Identification of project partners, beneficiaries for each functional group and role definition of the group on case-	List of partners and beneficiaries with indication of roles of each of them				

by-case basis.					
10. Recommendations on means of financing and schemes for each group	Reports and recommendation on existining, internationally available financianng, co-funding mechanisms. Recommendations for specific group on most appropriate scheme.				
11. Developing methodology of monitoring on restoration and design engineering works.	The methodology of monitoring on restoration and engineering/design works, with accompanying training materials and instrcutions.				
12. Training of municipalities within the frame of existing or adapted for this project norms and regulations.	Preparing training materials and delivering training programs for local municipalities procurement staff for the purpose of familirzing norms and regulations.				
13. Supplying the process with energy efficient materials and highly qualified labor force.	Programs, trainings and certification of energy efficient building material suppliers on national level.				This action must be carried out nationwaide by the state and herewith only findings will be used.
14. Development of the market of energy auditors and green structural engineers	Highly qualified energy audits and green structural engineer are available on the market				This action must be carried out nationwaide by the state and herewith only findings will be

					used.
15. In the process of energy efficient restoration, introduction of relevant green building concepts in-line with available financing sources.	Increasing awareness of municipalities on green buildings				

ANNEX 1

Low emission restoration programme of kindergarten buildings in Tbilisi city

(The second component of the project proposal)

1. THE GENERAL OVERVIEW OF MUNICIPAL BUILDINGS IN TBILISI

For the purpose of analyses of municipal buildings, the database compiled by the centre for the sustainable development “Remissia”, within the framework of the EC-LEDS project had been deployed. The database contains 10 different groups of buildings: theatres, art schools, playgrounds and parks, kindergartens, sports academies, stadiums, medical establishments, libraries etc., 418 units in total.

As the existing information contains data solely on energy consumption and building area, and for the purposes of the assessment of costs involved in restoration, the specific variable such as the dates of operational life cycle became essential, within the process of preparation of this project proposal, for determining pilot group, additional data gathering via different methods (interview, archive research etc.) became necessary. In vast majority of cases, current owners do not have any information about the building in their possession and the database in non-existent within municipalities.

The research has indicated that relatively comprehensive and reliable information at this stage is available on kindergartens; hence decision was made to select kindergartners for the purpose of the pilot project. The methodology adjusted on the kindergarten buildings can be reapplied to other groups of buildings. Kindergartens are interesting use case for different reasons as well; they have 49% share in the total area of municipal buildings, as for other groups of buildings, after obtaining precise information, sports and wellness centers become interesting target (after specifying the ownership rights).

1.1. CHARACTERISTICS OF KINDERGARTEN BUILDINGS IN TBILISI MUNICIPALITY

Out of existing 157 kindergarten buildings in Tbilisi, detailed information was acquired on 154 units, the overall area of all buildings under consideration equals to 223 652 m^2, average area of single building is 1 452 m^2.

Building Area

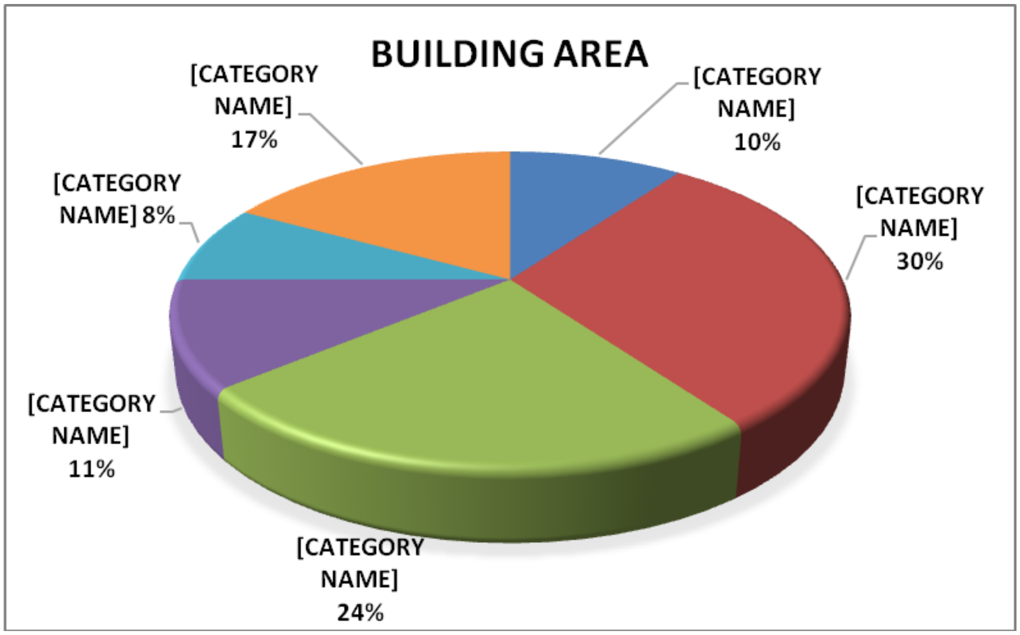


Figure 1.According to the area, majority of kindergarten buildings (55%) fall withing the range of 500-1500 m². Also, considerably large group (17%) comprises of buildings with an area of 2 500 m². The share 500 and 2 000-2 500 m² buildings is relatively insignificant.

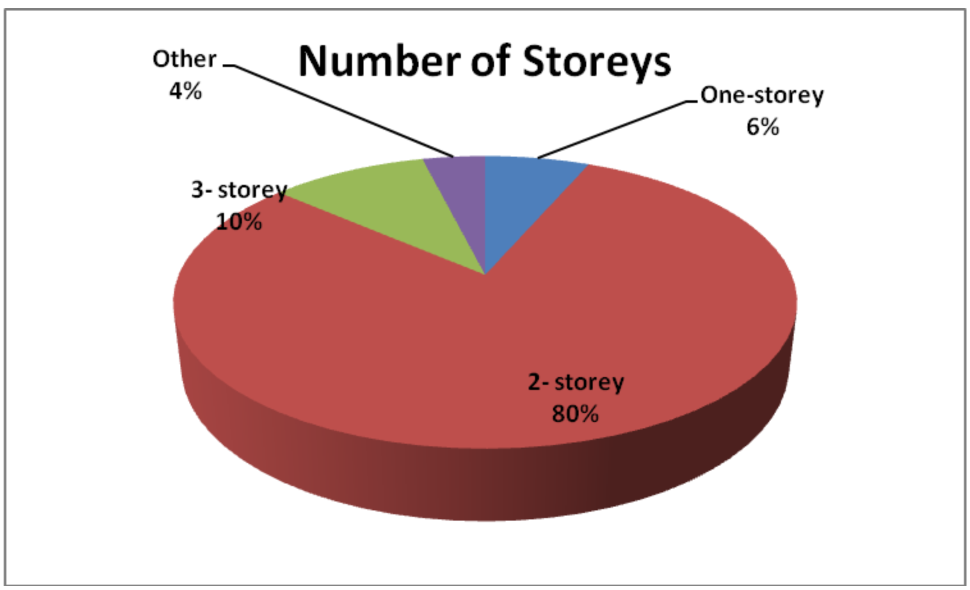


Figure 2. Number of storeys of kindergarten buildings (80% are two-storey and 6% are one-storey buildings)

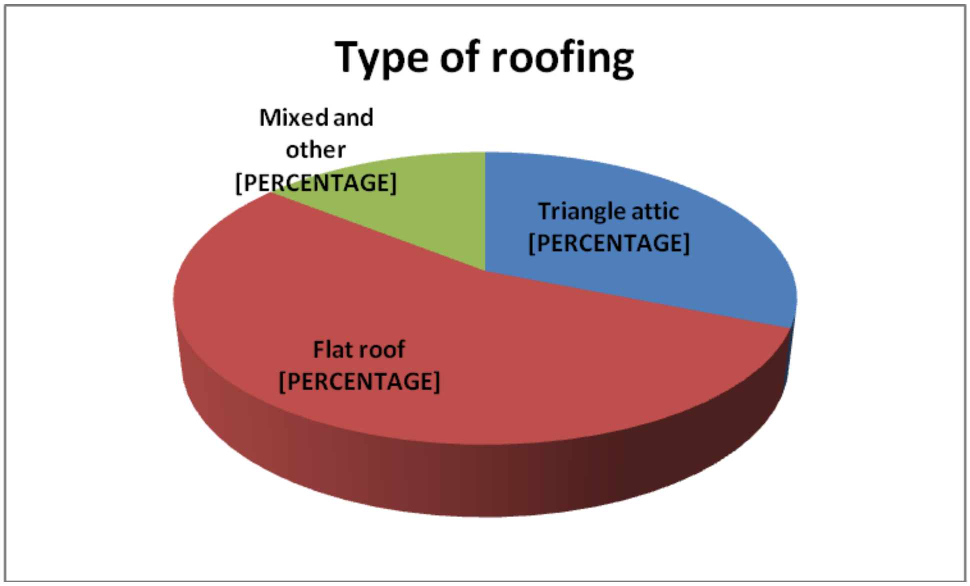


Figure 3. Majority of kindergarten buildings (55%) have flat roof, 31% triangle attic. Remaining roofs are of standard types (mixed, differing shapes)

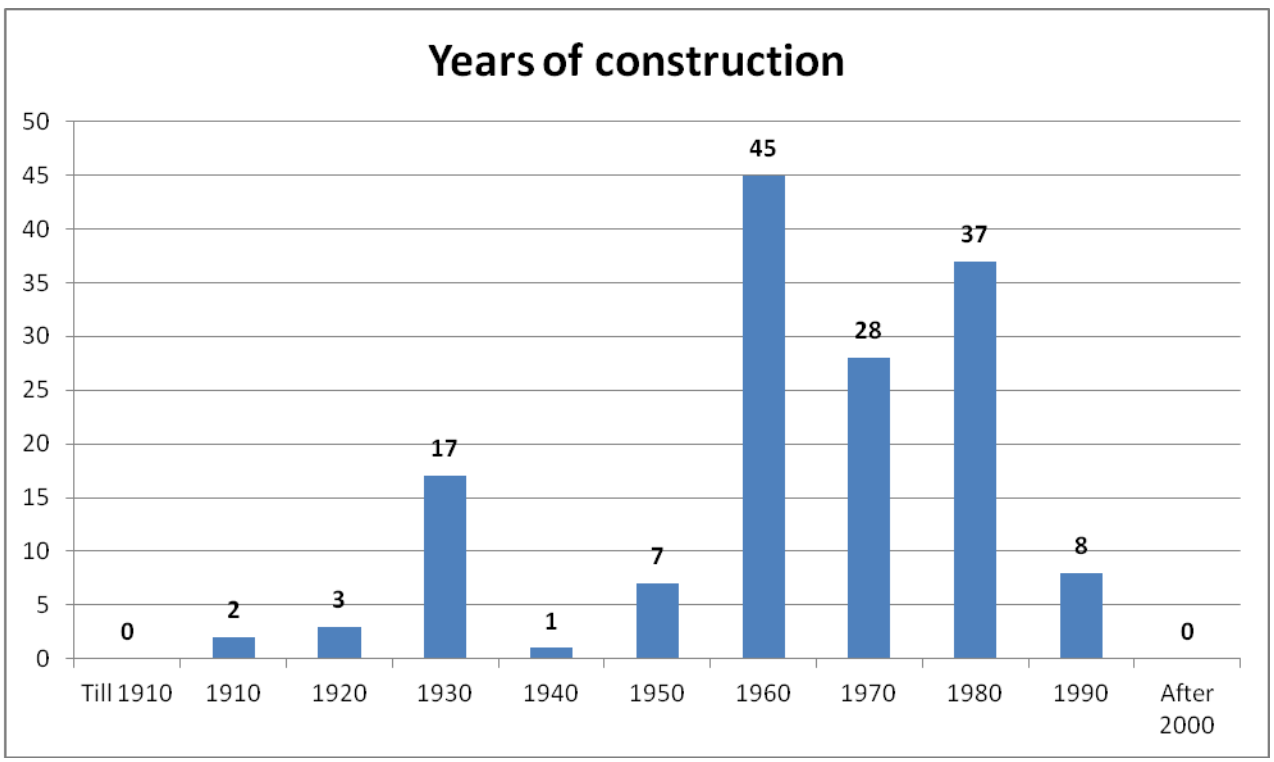


Figure 4. Vast majority of buildings (72%) is constructed in the time period of 1960-1980

Vast majority of kindergarten buildings were constructed in 60-es and 70-es of XIX century. One out of these buildings represents the sight of cultural heritage; in case of the second building general renovation was conducted (building casing). Due to this reason, building represents an outlier and does not enable generalization of research findings.

After thorough analysis, it has been revealed that an average kindergarten has the following parameters:
1. The building is two-storey
2. Was constructed in 1960-1980
3. The building area equals to 500-1500 m^2
4. The building has a flat roof

2 STANDARD BUILDING SELECTION AND ASSESSMENT OF THEIR NEED FOR RESTORATION

2.1 Methodology of selection of standard building

Selection of standard buildings for various periods was executed based on interval selection method, whereas intervals were divided based on time parameter i.e. building construction year. Taking into consideration the life span capability of the building, primary grouping of buildings was carried out based on the need for restoration degree. The assessment of the degree of need for restoration was determined in accordance with building depreciation appraisal method offered by the Soviet building standard (please refer to Annex A of Appendix 1). The use of Soviet building norms is motivated by the fact that buildings under restoration were constructed in Soviet period in accordance with these norms.

2.2. Selection of standard buildings amongst kindergarten buildings and determination of need, capacity and feasibility of renovation works

2.2.1. Selection of standard buildings

The building data processing with the method of time interval division was carried out for kindergarten buildings constructed from 10s to 90ies of XX century. This value set do not contain kindergarten buildings constructed after 2000, as their restoration period extends beyond the project period and they do not represent topic of interest for this particular research.

As mentioned above, sample kindergarten building selection was driven on the basis of time interval selection method, implying the following steps:

1. Selection of the first and last kindergarten buildings within the analysed time frame (since 1910 till 2000), on the basis of building construction date

1	Oldest building	Kindergarten #125	444 m^2	**Chughureti**	Kinkladze (former Shirshov) street	1915

					N 24	
2	Newest building	Kindergarten # 70	828 m²	**Saburtalo**	Vashlijvari, Godziashvili 2nd lane, N10	1998

2. Determining the median age of the building in between the oldest and newest buildings

3	The building of median age	Nasaguri Kindergarten	353 m²	**Samgori**	Nasaguri settlement	1956

3. Selection of the building of median age once again out of two intervals (1915-1956 and 1956-1998) for the interval with maximum set of values (1956-1998).

4	The building of median age for the interval	Kindergarten #107	2000 m²	**Gldani**	Gldani VI micro district	1977

4. Like the third phase, selection of the building of median age and inspection for the new interval (1956-1977 and 1977-1998) wih maximum set of values

5	The building of median age for the interval (1956-1977)	Kindergarten N24	1 176 m²	**Didube**	Tsereteli Avenue N 110	1966

5. Inspection of the building of median age in the new interval (1956-1966 and 1966-1977) for the interval with maximum set of values

6	The building of median age for the interval (1966-1977)	#71 kindergarten	1826 m²	**Krtsanisi**	Station lane #3	1971

Thereby, applying interval method, 6 model kindergarten buildings were selected and detailed expert research conducted; findings reapplied to subgroups accordingly.

For the final analysis, energy audit results of kindergarten No. 112 initiated by the "Centre for Sustainable Development-Remissia" within the scope of EC-LEDS project in 2015 and the pilot project data[4] prepared for the kindergarten 95 by the "Dagenbach Landscape" in August 2015 on behalf of Tbilisi Technological Development Fund were used additionally. Hence, for final inspection 8 buildings were selected.

[4] http://ntc.ge/Kindergarten95.rar "Measures to promote energy efficiency in the No. 95 Municipal Kindergarten building, Tbilisi D. Abashidze st. No. 4, for the further dissemination among other Kindergartens".

It is worthwhile to mention herewith that the selection of buildings constructed in the same year was carried out according to principles of lack of coincidence of geographical areas, accordingly, selected buildings were spread out on these districts of Tbilisi city:

- Mtatsminda-Krtsanisi
- Didube-Chughureti
- Gldani-Nadzaladevi
- Isani-Samgori
- Vake-Saburtalo

2.2.2. Result of the inspections

Degree of need for restoration

In order to determine the degree of need for restoration, in all selected 8 kindergarten buildings the primary inspection was carried out; details of an inspection are outlined within the Appendix B of this Annex 1.

After collation of the results of visual inspection, instrumental measurement procedures and current building codes/regulations in Georgia, inspected buildings were categorized and in the process of categorization the following indicators were considered: dates of operational capability, date of last restoration, energy consumption indicators, quality of works identified in the post-inspection process. As the result of categorization, three groups were identified on the basis of the need for restoration.

- **Severe need for restoration**: To these group belong older constructions that require structural reinforcements or demolition of certain wings, extensions of the building. The age of building within this group exceed 60 years. Their restoration activities include: full renovation of the roof, increasing energy efficiency indicators of windows, heat insulation of casing, making heating and ventilation systems energy efficient, replacing internal communications, installation of brand new water supply systems, interior renovation, garden infrastructure upgrades, demolishing certain wings/extensions of the building for the purpose of rebuilding, foundation and frame structural reinforcements. Out in inspected kindergartens in this category fall: kindergartens 71, 125, 79, 119 and 96.

- **Moderate need for restoration:** Buildings within this category are from 20 to 60 years old. They do not require structural reinforcements and the list of restoration works for them looks as follows: full renovation of the roof, increasing energy efficiency indicators of windows, heat insulation of casing, making heating and ventilation systems energy efficient, replacing internal communications, installation of brand new water supply systems, interior renovation, garden infrastructure upgrades. Out of inspected kindergartens in this category fall: kindergartens No. 24, 107, 95, 112 and 98.

- **Weak need for restoration:** To this category of relatively newer buildings belong construction that are newer than 20 years and they require only energy efficiency increasing works, that cost 113-146 USD per m2. Out of inspected kindergartens in this category fall: kindergarten 70.

Additional research was carried out in the "Severe need for restoration" group, to ensure the compliance of the building to predefined requirements of this group. For selection, time interval division method was used again. In this, case first interval represents oldest (constructed in 1915) and older than 60 years, (earliest constructed 1956) kindergarten buildings. Inspection of both kindergarten buildings has proven that both of them belong to the group "Severe need for restoration". Median building inside this interval was constructed in 1935. Out of these two intervals (1915-1935 and 1935-1956), the building of median age inside the interval with most buildings (1935-1956) was constructed in 1945. Due to the fact that in the time period of 1941-1949 kindergartens were not constructed, for reliability two kindergarten buildings constructed in 1940 and 1950 were selected. In maximum value set interval (1935-1940) the kindergarten building of median age was constructed in 1937. Finally, taking into consideration above highlighted aspects, based on time interval division method the following building were selected:

Kindergarten #96	**Chughureti**	Nino Chkheidze str. #13	1935
Kindergarten #98	**Chughureti**	Ts.Dadiani str. #39	1940
Kindergarten #119	**Chughureti**	Iv. Javakhishvili #59	1950
Kindergarten #79-	**Nadzaladevi**	Meeting st. #1	1937

For determining the need for restoration of given kindergarten buildings,the information provided by the administration of respective kindergartens to Tbilisi City Mayor's office in November 2014 was cross checked via telephone interview. On the basis of information provided:

1. Audited kindergarten #96, has two buildings: one out of these two (two-storey building) requires reinforcement works, Besides, one of the walls has to be demolished and rebuilt, timber staircase must be replaced, building façade renovated. According to the representative of kindergarten administrations (administrator) bases on the construction field experts' opinions, one of the wings of the building is not suitable for the restoration.

2. Kindergarten # 98 is situated on the first floor of an apartment block. Cracks are observed on building walls, however according to the administration (deputy director), significant damages and structural faults are absent.

3. In kindergarten #119, few years back reinforcement works were implemented in most problematic area, however due to the age of the building cracks still appear; Building façade is in difficult condition, occasionally water leaks; Kindergarten belongs to the "moderate need for restoration" group

4. Kindergarten building # 79 is lodged in school building for last 3 years, as kindergarten building, due to the degree of damage is not suitable for restoration. Currently the new building is being constructed.

As the result of research (12 buildings in total: 8 inspected and 4 interviewed), it can be assumed that majority of buildings over the 60 years fall under the category of "Severe need for restoration and their grouping within this category becomes highly reliable.

The potential for energy efficiency increase and GHG emission reduction

From the viewpoint of the energy efficiency only four kindergartens (71, 70, 95 and 112) had been inspected, All four inspected building had more or less similar problems, determining their low thermal-technical variables and is expressed in the following:

- Wall are not sufficiently insulated and require thermaltechnical analyses in order to meet Energy Code[5] requirements for the U indicator[6] (W/m^2 C) (please refer to the thermal measures calculations of pre-educational establishments in Tbilisi municipality for surrounding walls, attics and floor for selected kindergartens at this URL: http://www.ntc.ge/EnvelopeAnalysis.pdf)
- Floors and roofs for the implementation of specific measures, require thermal-technical analysis for attaining wt/m^2 U-indicator as outlined within the energy code.
- The execution of thermal brigdes is unsatisfactory, requiring thermaltechnical analysis for achiving U indicator as determined by the energy code.
- Windows are made of metal-base laminate, in certain placed they are out of order and thermal-technical analysis in accordance with energy code requirements is necessary for achieving U indicators.
- Entrance in the building do not have door portals and therefore, entrance doors require door-checks (hold open devices)
- Transparent components of the building (windows, skylights, stained glass windows, natural light areas) require thermal-technical analysis for achieving U indicator in accordance with energy code requirements.

  Post energy audit results and required standards on U variables of these building is given within the Table 2.

Table 2. Standart/Normative and Real U-indicators in 4 kindergarten buildings audited

Name of the building component	Required by the standard U=(W/m^2.^{0}C) value	U indicator for various elements of assessed buildings

[5] This Code is not approved yet in Georgia and is not used.

[6] U-factor or U-value describes the thermal transfer process. It is same to general heat transfer coefficient describing the thermal transfer ability of some element of the building, measured by heat (in watts) transfer rate through 1 m^2 structure divided on temperature difference between two sides of the structure, referred in the formula as C.

	Russia[7]	Italy[8]	Kindergarten #71	Kindergarten #70	Kindergarten #95	Kindergarten #125
Walls	0.46	0.46	1.40	1.39	1.38	2.5
Floors	0.48	0.43	1.35	1.20	1.18	1.0
Roofs	0.30	0.43	1.52	1.56	1.47	1.8
Windows	2.00	2.20	2.85	3.01	2.90	3.3

For audited four kindergarten buildings, thermal wastes were assessed and methodology for assessment is presented within the Appendix B of this Annex I, calculation in the Appendix C of the Annex I. The Table 3 show heat losses from all four buildings in total as well as from different component alongside with the potential for their reduction.

Table 3. Heat losses of assessed kindergarten buildings and potential for its reduction

Name of the building component	Audit results on heat losses (kW)			
	Kindergarten #71	kindergarten #70	kindergarten #95	kindergarten #112
Walls	42.4	20.2	37.6	94.6
Floors	27	10.9	19.5	35.5
Roofs	26.4	12	22.3	63.9
Windows	11	11.4	41.4	15.2
Staircase	low	low	31.5	low
Sum	106.8	53.6	152.3	209.3
Reduction	51.4 (48.1%)	28.7 (46.5%)	62.6 (58.9%)	163.1 (22.1%)

[7] Refers to 2600-2700 degree/day geographic zone. In Georgia this value equals to 2 627 degree/day. Source: http://window.edu.ru/catalog/pdf2txt/321/19321/2533

[8] Refers to 2 782 degree/day geographic zone (Bolsano, Italy). Source: http://www.academia.edu/9249568/Historical_trends_and_current_state_of_heating_and_cooling_degree_days_in_Italy, http://www.eurima.org/u-values-in-europe/, Cost C16, Improving the Quality of Existing Urban Building Envelopes - COST C16 Improving the Quality of Existing Urban Building Envelopes IV: Facades and Roofs (Research in Architectural Engineering) by L. Braganca, 2007).

After the enrgy audit of above analysed building,s it has been revealed that, in order to become compliant with international energy norsm, they require **external envelope thermal technical indicator upgrading measure (heat insulation of walls, roofs, floors, additional glazing on window glasses, stemming of certain apertures)**

- Heat insulation of external walls (façade) with a 50 mm thermal insulation material, with a coefficient of heat-conductibility of $\lambda = 0.032$ W/m/degree.;
- Heat insulation of attic floor, floor and the roof with heatfiber glass tiles of 55 mm thickness and heat-conductibility coefficient of $\lambda = 0.04$ W/m/degree., with the density of $\rho = 180$ kg/cubic meter;
- Reduction of the coefficient of glazing
- Increasing thermal protection and thermal accumulation characteristics if external walls

After an implementation of given activities (heat insulation of building binding component) the heat waste in the kindergarten of the "moderate need for restoration" will be reduced by 58%. In weak and severe groups, after an implementation of these activities, thermal waste will be reduced by 46.5% and 48.1% accordingly. One of the reasons for this is the fact that kindergartens constructed in 60-80-es of the past century, placed mainly in the mid-rehabilitation group, differ by architecture from kindergartens, built before 60-es and after 90-es. In this period (1960-1980) the constructions are marked by increased surfaces (e.g. Kindergarten is often placed in 2 separately standing buildings) and relatively enlarged natural illumination (with windows and stained-glass windows of wider area), resulting in higher heat losses and consequent increased expenses on heating. As a result of taking energy efficiency measures the heat losses are significantly decreased, providing for getting larger savings in mid-rehabilitation group compared to other groups. Obviously, this judgment is of general character to assess the whole group of this age and in different specific cases the outcomes may be quite different.

More detailed description of these activities as planned for the kindergarten N 95 and is recommended generally for al kindergartens, is reviewed in the Appendix E of this Annex 1.

Apart from the heat insulating of an external envelope of buidlings, renovation of lighting and heating system using sun light collector,s high efficieny boilers, thermal pumps and photo voltaics is necessary.

- Lighting systems

In the majority of kindergarten building, electricity consumption is related to two major expenditure factors: hot water supply and lighting systems. One of the recommendations is providing hot water supply systems entirely supported by the solar energy collector and heat pump systems. After executing these activities, electricity consumption will be driven solely by the lighting systems. For reducing electricity consumption and saving costs, it is recommended to use LED bulbin the lighting systems. These bulbs have longer operation life cycle. Besides, it is possible to utilise photovoltaic systems more effectively.

- Heating/ventilation and cooling systems

Heating/ventilation/cooling systems are of significant importance, as their efficiency defiens the higher indicators of an overall energy efficiency. After ensuring building envelope thermal technical characteristic matches required level U=0.57, it become possible to connect into heating system low emission energy generator such as: air/water thermal pump, gas condensing heating boiler, hot water supply entirely based on an energy generated from sun collector, surplus can be directed toward the generation of increased temperature in heating system network.

Providing heating network based on the collectors' system[9], offers possibility to manage individually administrative and public spaces. In dormitories, installation of individual air purification (recuperation) system is included. Such systems provide healthy environment in dormitories without altering the air temperature. Multiple air circulation without significant heat waste becomes possible using recuperation method. In mono classes, where students do not sleep, individual ventilation system must be installed and for this purposes additional inward opening windows (Tilt & turn) will be introduced.

After implementing these measures, mainly electricity is being saved.

Table 4. Potential for electricity saving in different types of kindergarten

Energy efficiency measure	Audit results on electricity savings			
	Kindergarten #71	Kindergarten #70	Kindergarten #95	Kindergarten #112
Area of the kindergarten	1 826	828	1 861	2 450
Kindergarten occupancy (children + personnel)	535	221	305	550
Annual reduction of electricity per m2 in systems of hot water supply and lighting (kW/hour %)	11.6 (18%)	12.75 (36%)	7.94 (51%)	2.23 (10%)
Annual reduction of electricity per person meter in systems of hot water supply and lighting (kW. hour %)	39.5(18%)	47.8 (36%)	48.8 (52%)	8.6 (10%)

[9] This system implies the existence of central collector getting the heat and distributing it afterwards in different directions.

After switching hot water supply system to solar energy and replacing lighting systems with energy efficient alternatives, the energy saving annually per m^2 can reach from 18 to 50% of previously consumed electricity per person as well as per m^2. In No. 112 kindergarten this percentage is low, as the source of hot water supply here is natural gas and measures to be taken are limited only by the increase of energy efficiency of lamps.

- ***Other activities***

In the case kindergarten N95, apart from energy efficient activities, various activities are being implemented, mainly in relation with organisation of water supply systems, erecting shady and energy consumption monitoring initiatives (introduction of automated building management system-"Building Management System-BMS). Apart from few activities (replacement of lightning systems and erection of shades), other measure besides the fact that they do not guarantee significant economy of GHG savings, at this stage, it is hard to appraise them due to absence of precise data (electricity consumption calculation based per user consumption is non-existent.

Due to these very specific reasons, it is essential to introduce monitoring and management system, that will supply kindergarten management with analysis of information in real time (at some point the project team too) with very accurate data, enabling to plan these "other activities" in various kindergartens, participating in this project.

Within the Appendix E of this Annex 1 these activities are analysed in greater detail.

Within the Table 5, the post-energy efficiency activities energy saving potential of inspected kindergartens in relation with the current energy consumption and GHG emission reduction is presented. The Table contains data for all three types of kindergarten buildings, out of which one fall into a "severe need for restoration category" (# 71), two (#95 and #112) under moderate need for restoration and one (#70) under the "low need for restoration" category.

Table 5. Energy saving and GHG emission reduction potential in inspected kindergartens

Building area 1826 m²	Type of energy resource	Annual Consumption per m²			Annual savings per m²			Annual emission reduction per m²		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial saving	Base coefficient	Base emission	Emission reduction
		m^3/KWh/m^3	KWh/a	GEL	m^3/KWh/m^3	KWh/a	GEL	kg/KWh	t/a	t/a
Kindergarten **#71** Severe need for restorations	Gas	9.55	89.73	7.16	6.78	63.69	5.08	0.202	0.018	0.013
	Electricity	64.59	64.59	12.79	11.57	11.57	2.29	0.136	0.009	0.002
	Water	1.45	n/a	9.94	0.58	n/a	3.98	n/a	n/a	n/a
	Sum		154.32	28.89		75.25	11.35		0.027	0.015
Site area **1826** sq. meters	Type of energy resource	Total annual consumption			Total Annual Saving			Total annual emission reduction		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial savings	Emission coefficient	Base year emission	Emission reduction

		m3/kWh/m3	kWh/s	GEL	m3/kWh/m3	kWh/s	GEL	kg/kWh	t/a	t/a
Kindergarten **#71**	Gas	17 433	163 841	13 074	12 374	116 295	9 280	0.202	33.10	23.49
	Electricity	117 949	117 949	23 354	21 120	21 120	4 181	0.136	16.04	2.87
	Water	2 649	n/a	18 158	1 060	n/a	7 263	n/a	n/a	n/a
	Sum		**281 790**	**54 586**		**137 415**	**20 725**		**49.14**	**26.36 (54%)**
Building area 828 sq. meter	Type of the resource	Annual Consumption per m^2			Annual savings per m^2			Annual emmision reduction per m^2		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial saving	Base coefficient	Base emission	Emission reduction
		m^3/KWh/m^3	KWh/a	GEL	m^3/KWh/m^3	KWh/a	GEL	kg/KWh	t/a	t/a
Kindergarten #70 low needs for restoration	Gas	8.74	82.11	6.55	5.38	50.60	4.04	0.202	0.017	0.010
	Electricity	35.79	35.79	7.09	12.75	12.75	2.53	0,136	0.005	0.002
	Water	1.35	n/a	9.24	0.54	n/a	3.70	n/a	n/a	n/a
	Sum		117.90	22.88		63.35	10.26	n/a	0.022	0.012

Site area 828 m²	Type of energy resource	Total annual consumption			Total Annual Saving			Total annual emission reduction		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial savings	Emission coefficient	Base year emission	Emission reduction
		m3/KWh/m3	KWh/s	GEL	m3/KWh/m3	KWh/s	GEL	kg/KWh	t/a	t/a
Kindergarten #70	Gas	7 234	67 987	5 425	4 458	41 898	3 343	0.202	13.73	8.46
	Electricity	29 637	29 637	5 868	10 560	10 560	2 091	0.136	4.03	1.44
	Water	1 116	n/a	7 650	446	n/a	3 060	n/a	n/a	n/a
	Sum		**97 624**	**18 943**		**52 458**	**8 494**		**17.76**	**9.90 (56%)**
Building area 1988 sq. meter	Type of energy resource	Annual Consumption per m²			Annual savings per m²			Annual emmision reduction per m²		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial saving	Base coefficient	Base emission	Emission reduction
		m^3/KWh/m^3	KWh/a	GEL	m^3/KWh/m^3	KWh/a	GEL	kg/KWh	t/a	t/a
Moderate needs for	Gas	28.89	271.57	21.67	13.57	127.55	10.18	0.202	0.051	0.024

restoration	Electricity	15.51	15.51	3.07	10.45	10.45	2.07	0.136	0.002	0.001
	Water	0.57	n/a	3.93	0.23	n/a	1.57	n/a	n/a	n/a
	Sum		287.03	28.67		138.00	**13.82**		0.053	0.025 (47%)
Building area 1988 m²	Type of the resource	Total annual consumption			Total Annual Saving			Total annual emission reduction		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial savings	Emission coefficient	Base year emission	Emission reduction
		m3/KWh/m3	KWh/s	GEL	m3/KWh/m3	KWh/s	GEL	kg/KWh	t/a	t/a
Kindergarten #95	Gas	53 764	505 290	40 323	25 257	237 372	18 943	0.202	102.07	47.95
	Electricity	28 864	28 864	5 715	19 453	19 453	3 852	0.136	3.93	2.65
	Water	1 067	n/a	7 317	427	n/a	2 927	n/a	n/a	n/a
	Sum		**534 154**	**53 355**		**252 156**	**25 721**		**105.99**	**50.60(47%)**
Building area	Type of energy	Annual Consumption per m²			Annual savings per m²			Annual emission reduction1 m²		
		Base year	Base year	Base year	Energy	Energy	Financ	Base	Base	Emission

2 450 m^2	resource	energy consumption	energy consumption	expenditure	savings	savings	ial saving	coefficient	emission	reduction
		m^3/KWh/m^3	KWh/a	GEL	m^3/KWh/m^3	KWh/a	GEL	kg/KWh	t/a	t/a
Kindergarten #112 Moderate need for restoration	Gas	14.61	137.3	9.39	3.43	32.23	2.20	0.202	0.028	0.0065
	Electricity	19.63	19.63	3.89	1.91	1.91	0.38	0.136	0.003	0.0003
	Water	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Sum		156.93	13.28		34.14	2.58		0.031	0.0068(22%)
2 450 m^2 2100[10] m^2 (heated)	Type of energy resource	Total annual consumption			Total Annual Saving			Total annual emission reduction		
		Base year energy consumption	Base year energy consumption	Base year expenditure	Energy savings	Energy savings	Financial savings	Emission coefficient	Base year emission	Emission reduction
		m3/KWh/m3	KWh/s	GEL	M^3/KWh/m^3	KWh/s	GEL	kg/KWh	t/a	t/a
Kindergarten	Gas	30 674	288 338	23 010	7 200	67 681	5 402	0.202	58.24	13.67
	Electricit	48 088	48 088	9 521	4 680	4 680	927	0.136	6.54	0.64

[10] The reduction per 1 m^2 is calculated only for natural gas consumed for heating.

#112	y									
	Water	0	0	0		0	0		0	0
	Total		336 426	32 531		72 361	6 327		64.78	14.31 (22%)

Table 6. Summary Table resulting from the Table 4

Kindergarten No.	Total energy consumption per 1 m^2 (kWh)	Energy Saving per 1 m^2 (kWh)	Energy Saving per 1 m2 (kWh)	Financial Saving per 1 m2 (kWh)	Emission Saving per 1 m2 (kWh)
71 (severe need for restoration)	154.32	75.25	49	7.37	0.015
70 (low need for restoration)	117.90	63.35	54	6.56	0.012
95[11] (moderate need for restoration)	287.03	138.00	48	12.25	0.025
112[12] (moderate need for restoration)	156.93	34.14	22	2.58	0.007
Average[13]	179.05				

GHG produced per m2 in the case of kindergarten buildings varies from 22 kg to 53 kg in CO2 equivalent, something that significantly depends on the type of building and number of children. GHG reduction per m^2 varies from 7 kg to 25 kg in CO2 equivalent, depending on the type of energy efficiency measures. In case of implementation of all energy efficiency measure, average annual saving per 1 m^2 varies from 12 to 15 kg.

From the Table 6, it becomes obvious that financial savings per 1 m^2 for three kindergarten buildings fluctuates within the range of 4.73-8.09 GEL (sole exception is the kindergarten N 112, for which only following three activities have been measure: building attic thermal insulation, installation of new lighting systems and solar energy usage for hot water supply, that yields in relatively smaller savings and requires relatively small investment), which is the small range and enables us to formulate the hypothesis that the savings as the result of such energy efficient activities per m2, is similar for all three categories of restoration complexity.

2.3. Cost of the restoration and energy efficiency increase activities for kindergarten buildings

For the assessment of the cost of energy efficient activities, the technical and economic findings revealed within the research process of kindergarten # 95 had been acknowledged.

[11] The No. 95 kindergarten is considered to be a non-typical one, as it has a lot of stained-glass windows and other elements, causing great energy losses and consequently the impact of energy efficiency measures here is sufficiently influential.

[12] In case of No. 112 kindergarten the planned measures are minimal: substitution of bulbs with energy efficient lamps and thermal insulation of roof, while in other kindergartens almost full portfolio of energy efficient measures is envisaged (see Appendix B of Annex 1).

[13] Energy consumption was averaged only per $1m^2$, as for other parameters No. 112 kindergarten sharply differs from others because of limited measures.

Based on the cost accounting produced by the Dagenbach Landscape for the kindergarten # 95 http://ntc.ge/Kindergarten95.rar, full restoration expenditure analysis with consideration of energy efficiency activities had been drafted. Below, within the Table 6, cost of full reconstruction of selected buildings including full energy efficiency activities is given. Based on these findings, the recommendation of long term (20 year) kindergarten programme had been prepared.

Within the Table 7, the detailed cost accounting for three different case scenatios of kindergarten restoration is given: A-severe need for restoration, B-moderate need for restoration; C-weak need for the restoration.

Table 7. Costs of energy efficiency activities and full restoration of different categories of kindergartens according to the need for restoration parameters.

#	Activity Description	Unit	Cost (US Dollars)			Comments
			Severe need for restoration (A)	Moderate need for restoration (B)	Weak need for restoration (C)	
1	Roof renovation with the introduction of rainwater collection and filtration systems	1 m²	75-105	75-105	0	The price encompasses both flat and pitched roofs
2	Heat insulation of walls. floors and attic	1 m²	25-32	25-32	25-32	
3	Restoration of windows and thermal bridges	1 m²	35-45	35-45	35-45	In certain cases, this measure may not be required for the C position.
4	Heating+solar collectors Internal heating network	1 m²	65-75	65-75	35-45	
5	Solar barriers	1 m²	5-6	5-6	5-6	
6	Wastewater management	1 m²	8-12	8-12	0	
7	Water supply and sewage systems	1 m²	9-12	9-12	0	
8	Photovoltaic systems	1 m²	11-13	11-13	6-8	
9	Ventilation (recuperation) and air conditioning systems	1 m²	11-13	10-13	5-7	
10	Micro energy management system	1 m²	2-3	2-3	2-3	
11	Construction reinforcement works	1 m²	120-145	0	0	
12	Interior, floor and internal doors renovation.	1 m²	35-50	35-50	0	
	Total		399-511	280-366	113-146	

For determining cost of individual activities, the cost estimate norms of 1984, alongside with current market prices had been used. The prices are calculated for 1 m² a building. Costs calculation includes[14] material transportation costs-3%, overheads-10%, planned accumulation /income-8%, reserves for unexpected works and 18% VAT[15].

2.4. Cost benefit analysis of restoration/energy efficiency programme of kindergarten buildings in Tbilisi city municipality

Based on above outlined assessments, the programme of full and energy efficinect restoration for kindergarten buildings in Tbilisi city was prepared.

Within the process of the programme preparation the following criteria were considered:

1. Building grouping and prioritization according to the degree and magnitude of the need for restoration.
2. The date of last renovation must be considered
3. Areas for restoration
4. Restoration and energy efficiency activities cost and payback period,
5. Environmental (CO2), health and social benefits.

Concerning energy efficiency activities and costs, at this stage, the allowance has been made that almost 90% of buildings require almost identical measure, as for differences, they must be defined precisely in the process of programme implementation. However, the approach is quite conservative and the initial increase of energy efficiency costs is not anticipated due to specifications of the building.

Areas for restoration according to groups (criterion 3)

On the basis of findings of first two criterions for the assessment of kindergarten buildings, the third criteria was appraised, more specifically, establishing number and area of building according to the need for restoration. Out of 8 inspected building 2 belong to the group of severe need for restoration, 4 to moderate group, one to the weak group. Therefore, proportional allocation of building according to the categories of the “need for restoration” is given in the Table 8.

Table 8. Percentage allocation of 8 audited kindergarten buildings across the categories for restoration.

The degree of need for restorations	Number of kindergarten buildings	Share in total area (%)
Severe need for restoration	3	37.5
Moderate need for restoration	4	50.0
Weak need for restoration	1	12.5
Sum:	8	100.0

[14] The cost of cooling system is not considered in the budget, as during the warm season kindergartens are on leave, especially as the air conditioning systems are increasing the energy consumption and related emissions.

[15] Profit norm defined for state purchases, which could not be exceeded by the service delivering private company.

With these predefined percentage indicator all 157 kindergarten buildings were grouped inside the restoration category.

Table 9. Quantitive allocation of kindergarten buildings in Tbilisi city across restoration categories

The degree of need for restorations	Number of kindergarten buildings	Share in total number (%)
Severe need for restoration	58	37.5
Moderate need for restoration	79	50.0
Weak need for restoration	20	12.5
Total:	157	100.0

On the next stage, the share of audited 8 kindergarten buildings was weighted against their respective category. The results are demonstrated in the Table 10.

Table 10. Area for restoration according to categories for 8 audited kindergarten buildings

The degree of need for restorations	Area (sq. meter)	Share in total area (%)
Severe need for restoration	3 622.96	31.5
Moderate need for restoration	7 034.10	61.2
Weak need for restoration	828.36	7.2
Total	11 485.42	100.0

Based on this percentage proportions the assessment of areas for each restoration categories had been carried out and the findings are given in the Table 11.

Table 11. Restoration areas according to categories for 157 different kindergartens

The degree of need for restorations	Area (sq. meter)	Share in total area (%)
Severe need for restoration	69 543	31.5
Moderate need for restoration	135 775	61.2
Weak need for restoration	15 455	7.2
Total	220 773	100.0

Charactrization of different categories according to the costs of restoration per 1 1 m^2 is given in the

Table 12.

Table 12. Required investment for the restoration of buildings of all three categories

The degree of need for restorations	Area (m^2)	Share in total area (%)	Cost of activities per m2 (upper and lower limits in USD)	Cost of activities on entire area (upper and lower limits) USD
Severe need for restoration	69 543	31.5	399-511	27 747 657 -35 536 473
Moderate need for restoration	135 775	61.2	280-366	38 017 000-49 693 650
Weak need for restoration	15 455	7.2	113-146	1 746 415 -2 256 430
Total (USD)	220 773	100.0		**67 511 072-87 486 553**
Total (GEL)				**162 701 684 – 210 842 593**

The restoration cost of kindergarten buildings in Tbilisi city amounts in between 67.5-87.5 million USD. This costing defines the approximate volume of works, is the result of an interpolation and requires further detailed investigation.

In Table 13, financial savings as a result of restoration per 1 m^2 and on overall area is given; Table 14 contains data on annual emission savings potential.

Table 13. Annual financial savings in case of simultaneous restoration of buildings

The degree of need for restorations	Area (m^2)	Total investment[16] (in GEL)	Annual savings per m^2[17] (GEL)	Total Annual Saving (GEL)	Payback period in years (rough estimates lower limit)

[16] In contrast to Tables 6, 7 and 12, here the 1 m^2 restoration cost does not include "The green roof" and water management, but refers only to rehabilitation and energy efficiency expenses..

[17] As it was explained earlier, kindergartens constructed in 60-80-es, which due to the age mainly fall into the moderate restoration group, differ with architecture from kindergartens built before 60-es and after 90-es.

Severe need for restoration	69 543	54 301 956	5.17	456 403	119
Moderate need for restoration	135 775	67 079 639	8.09	1 663 034	40
Weak need for restoration	15 455	4 208 860	4.73	113 938	36
Total (USD)	220 773	125 590 455		**2 233 375**	56

Table 13 demonstrates the case if all kindergartens would be entirely rehabilitated considering the energy efficiency measures simultaneously (during a certain period) and in this case the annual financial saving from the decrease of energy consumption would constitute 1.5 million GEL. Despite the pact that under the rough assessment the time of return actually in all cases exceeds the average lifetime of the building and refers to long-run period, so it could not efficiently cover all saving only by energy saving, nevertheless it is profitable for Municipality, as in any case it should maintain and rehabilitate the buildings and thus by this way it gets some privilege. In particular, it saves annually at least 1.5 million GEL. It ought to be mentioned as well that savings do not consider financial saving from the annual unplanned orders, being much smaller for the newly restored kindergartens.
In addition from the Table 13 it is obvious that from economic standpoint, financially most viable group is the category of buildingsunder the weak need for restoration subgroup. Concerning the group of severe need for restoration, it required relatively larger investment capital and does not ensure appropriate cost savings. Hence, in the process of program rehabilitation both these types are desirable to be grouped together. Besides, the overall area of the group of buildings with the weak need for restoration is relatively small (7.2%) and therefore coupling "weak" and "moderate" groups is realistic. to both, per area unit and overall area indicators.

Table 14. Annual emission reduction in case of simultaneous restoration of buildings

The degree of need for restorations	Area (m^2)	Share in total area (%)	Annual savings per m^2 CO_2t equivalent	Total Annual Saving CO_2t equivalent
Severe need for restoration	69 543	31.5	0.015	1 043
Moderate need for restoration	135 775	61.2	0.025	3 394
Weak need for restoration	15 455	7.2	0.012	185
Sum	220 773	100.0		**4 622**

It could be seen from Table 14 that in the long-range period the greatest potential for the GHG emissions reduction has moderate restoration group both for the unit of area and for the total area as well.
Table 15 the time of return by energy savings in case of one building restoration is given.

Table 15. Features of complete and energy efficient restoration of 2 000 m² kindergarten being in different state of rehabilitation

#	State of kindergarten to be restored	Cost of restoration, 50% covered by the grant (GEL)	Annual saving from energy efficiency (GEL)	Annual saving from reduced emission selling[18] (GEL)	Time of return with 50% grant (year)
1	Severe need for restoration	961 590	14 744	348	64
2	Moderate need for restoration	674 800	24 497	655	27
3	Weak need for restoration	272 330	13 126	288	20

Table 15 demonstrates economic parameters for different types of kindergartens to be restores, having the same area (2 000 m²). It could be seen from the Table that even in case of saving got from the energy saving and from the selling of reduced emissions, the 50% grant is necessary for moderately restored building to cover rehabilitation cost in 29 years. However, in case of taking only energy efficiency measures for moderately restored building with the same savings, the 50% grant, under the rough assessment, permits to return the expenses in (272 330/16 841) 16 years, but without the grant the return will be delayed till 32 years.

Financial report on all three groups of buildings restoration over the 25-year period

The aim of this pilot project proposal is to demonstrate generally the advantage of the concept of programme approach over the chaotic or short-term 2-3 years restoration process. The programme is mainly based on result outlined in previous sections.

Based on analysis of various factors, one of the scenarios of the restoration project can be an initiation with all buildings under the group "weak need for restoration" in parallel running restoration of most severely damaged buildings, as this version of scenario is the most profitable one. Also, at the early stage including buildings under the moderate need for restoration is possible, for balancing annual investments. Herewith, the subject of great interest represents buildings that bear significant risk of shifting to the group of severe need for restoration section in the foreseeable future due to the age of the building.

Findings and calculations within the table 15 is based on full restoration of all three groups throughout 25 year time period, in manner where annual investment expenditure (exluding savings achieved after energy efficiency measure) is evenly spread (within the range from 6.320 – 6.540 million GEL). Income generated from the energy efficient activities enables to increase the area of overall restoration.

[18] Selling price of 1tCO_2 eq is considered in calculations to be equal to 5 USD (12.05 GEL).

The calculation includes following assumptions:
1. USD to GEL currency exchange rate is 2.41 (exchange rate 2.38)
2. Minimum and maximum prices are indicated in GEL
3. The restoration period is 25 years
4.**Annuals savings from the restoration is used for co-financing upcoming year's restoration activities.**
5. Includes required investment volume annual growth around 0.15-0.21% excluding co-financing via savings from overall restoration works, given growth parameter was introduced for maintaining works implementation growth trend.
6. Sequence of works according to groups: During the year 1, full group of the kindergarten buildings with the weak need for restoration are subject to energy efficiency makeover with addition of moderate and sever need for restoration groups in equal quantities, in upcoming years allocated in equal numbers on severe or moderate group, until severe need for restoration group is not fully covered, and finally only the group with moderate need for restoration remains.

The required investment according to years excluding the saving is given in Table 16. This saving includes water savings resulting from restoration as well as energy savings from energy efficiency measures.

Table 16. Annually required investments and annual savings

Year	Investment required (GEL)	Savings (GEL)	Additional Investment to be mobilized (GEL)
2016	5 517 972	0	5 517 972
2017	5 678 273	178 683	5 499 591
2018	5 748 116	266 026	5 482 090
2019	5 818 818	354 444	5 464 374
2020	5 890 389	443 950	5 446 440
2021	5 962 841	534 556	5 428 285
2022	6 036 184	626 277	5 409 907
2023	6 110 429	719 126	5 391 303
2024	6 185 587	813 117	5 372 471
2025	6 261 670	908 264	5 353 406
2026	6 338 689	1 004 581	5 334 107
2027	6 416 655	1 102 084	5 314 571
2028	6 495 579	1 200 785	5 294 794
2029	6 575 475	1 300 700	5 274 775
2030	6 656 353	1 401 845	5 254 509
2031	6 738 227	1 504 233	5 233 993
2032	6 821 107	1 607 881	5 213 226
2033	6 905 006	1 712 804	5 192 202
2034	6 980 892	1 819 017	5 161 875
2035	7 024 668	1 932 160	5 092 508
2036	7 117 394	2 076 038	5 041 355
2037	7 211 343	2 221 816	4 989 527

2038	7 306 533	2 369 518	4 937 015
2039	7 402 979	2 519 169	4 883 810
2040	7 500 503	2 670 796	4 829 707
Total	162 701 684	31 287 869	131 413 814

***Required investment: the difference between costs and savings**

Calculations for the Table 16 are provided in Appendix F of this Annex I. Appendix F is attached in the format of an excel spreadsheet ("Results of the Audit.xlsx), which includes detailed financial calculations and enables user to recalculate results for different periods of the full restoration implementation process, by entering area of restoration (yellow cells) on yearly basis.

Drawings 1-4 demonstrate the total share of savings in overall annual investment and rate of changing of this share.

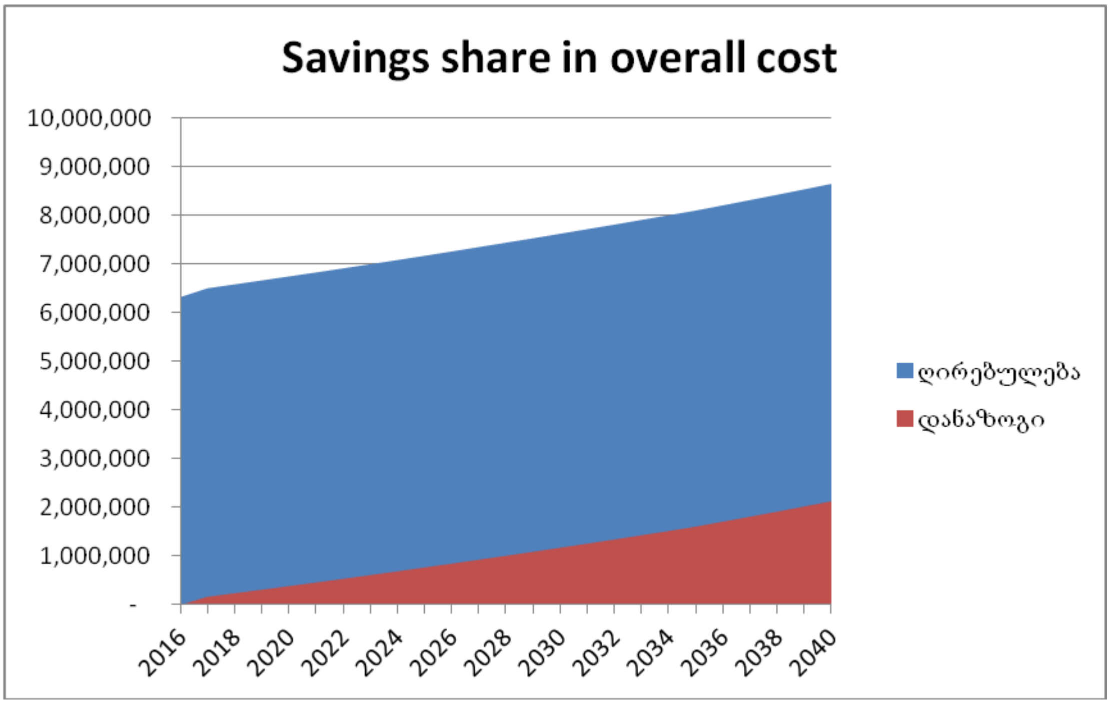


Figure 5. Savings share in overall annual investment (blue colour-investment, red colour - savings)

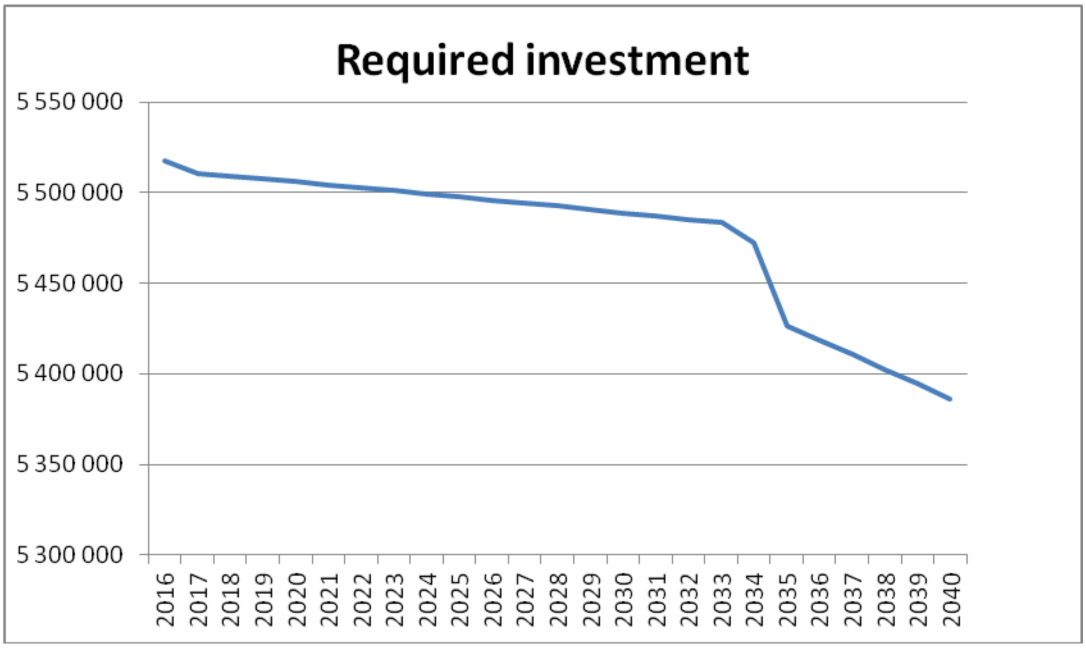


Figure 6. The growth rate of annually required investment

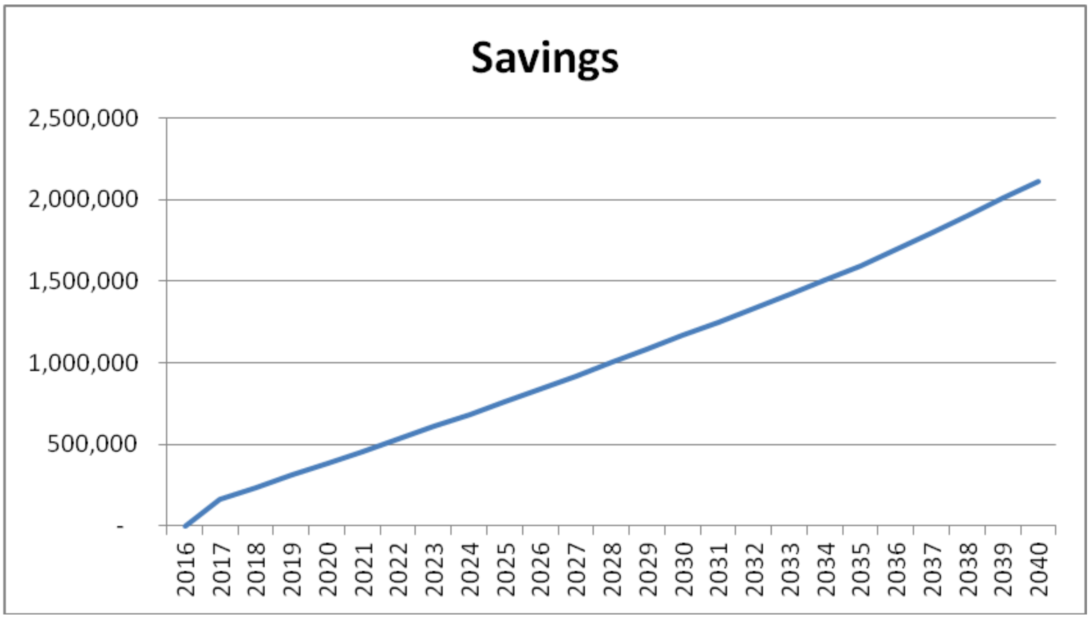


Figure 7. The annual growth of finanical savings

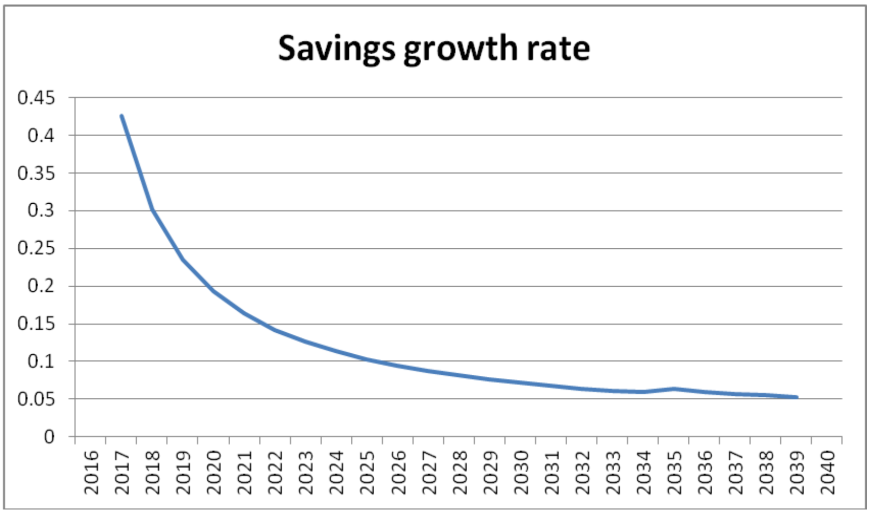


Figure 8. The growth rate of annual finanical savings

It should be mentioned herewith that annual financial savings caused by reduction of incidental expenditure as a result of full renovation of buildings are not considered in these calculations.

Additional source of financing can become the monetization of reduced emission. In case if a ton of reduced emission could be sold for 5$, then annually required investment will decrease. Relevant income and changes in required investment are given within the Table 17.

Table 17. Required investment in case of realization of Emission Reductions (ER)

Year	Accumulated emission reduction (t)	Income from accumulated emission (USD 5/t in GEL)	Required investment after deduction of ER income (GEL)
2016	0	0	5 517 972
2017	218	2 628	5 496 963
2018	363	4 368	5 477 722
2019	509	6 130	5 458 244
2020	657	7 914	5 438 526
2021	807	9 719	5 418 566
2022	958	11 547	5 398 360
2023	1 112	13 397	5 377 906
2024	1 267	15 270	5 357 200
2025	1 425	17 166	5 336 240
2026	1 584	19 085	5 315 022
2027	1 745	21 028	5 293 543
2028	1 908	22 995	5 271 799

2029	2 074	24 986	5 249 789
2030	2 241	27 002	5 227 507
2031	2 410	29 042	5 204 951
2032	2 582	31 107	5 182 118
2033	2 755	33 198	5 159 004
2034	2 931	35 315	5 126 560
2035	3 125	37 657	5 054 851
2036	3 408	41 067	5 000 288
2037	3 695	44 522	4 945 005
2038	3 985	48 023	4 888 992
2039	4 280	51 570	4 832 240
2040	4 578	55 164	4 774 543
Total	**50 614**	**609 901**	**130 803 913**

Hence, the required investment (136 887 520 GEL) will be reduced by 609 901 GEL down to 136277618 GEL.

The shares of different income sources in total budget are provided in Table 18.

Table 18. Different sources of co-financing (GEL)

(a)	Total budget (GEL)	162 701 684
(b)	Savings from the reduction of water consumption (GEL)	(7 181 671)
(c)	Income from energy savings (GEL)	(24 106 199)
(d)	Income from realization of ER (USD 5/ per ton) (GEL)	(609 901)
(e)	**Required additional finances (GEL)**	**130 803 913**

Details of calculation of financial savings from the reduction of water and energy consumption and reduced emission are provided in Appendix F of this Annex 1.

Shares of energy efficiency costs and restoration costs in total required investment are provided in Table 19.

Table 19. Shares of EE measures costs and restoration costs in total investment (in GEL).

(a)	Total required investments	162 701 684	100.00%
(b)	Costs of energy efficiency measures	60 123 111	36.95%
(c)	Cost of restoration	102 578 572	63.05%

Costs distribution between EE measures and rehabilitation measures after all income sources are taken into consideration is provided in Table 20. Water consumption saving is subtracted from the primary restoration cost, while energy economy saving and emission sale income- from the energy efficiency cost.

Table 20.

(a)	Required investment (after deduction of all incomes) (GEL)	130 803 913	100.00%
(b)	Investment for EE measures (GEL)	35 407 011	27.07%
(c)	Investment for rehabilitation of kindergartens (GEL)	95 396 902	72.93%

Table 20 demonstrates that still 30% grant support is necessary in addition to these incomes from energy savings and ER in order not to increase the planned expenses of Municipality because of implementation of EE measures in kindergartens.

3. RECOMMENDATIONS ON RESTORATION PROCESS MANAGEMENT AND OPERATIONS FOR KINDERGARTEN BUILDINGS' GROUP

It is important to define conditions for restoration works execution and further operation of buildungs. First of all, the degree of the need for the restoration must be identified for the group of kindergarten buildings. Afterwards, conceptual ideology shall be agreed upon, whereby the degree of the need for restoration shall be identified and, based on the functionality of the building, its operational and construction ideology determined. This process if followed by the detailed calculation and design identification phases. Further, the construction and monitoring organisations selected, followed by the actual construction stage. The entire cycle, depending on the degree of need for restoration shall take approximately 6-8 months. (Please refer to the diagram).
After the end of restoration phase, the stage of operation kicks off, ideology of which shall be defined in the process of designing.

1. Determining the grade of restoration
2. Formulational of conceptual ideology
3. Design works
   - Cost estimation
4. Selection of construction and monitoring organisation
5. Construction phase

In the process of defining building's functionality, it is recommended to define their multifunctional purposes for future effective development. For the group of kindergarten buildings, this might be delivering additional tutorial classes, Sunday schools or various business activities, something that shall enhance proper operation and management of buildings.

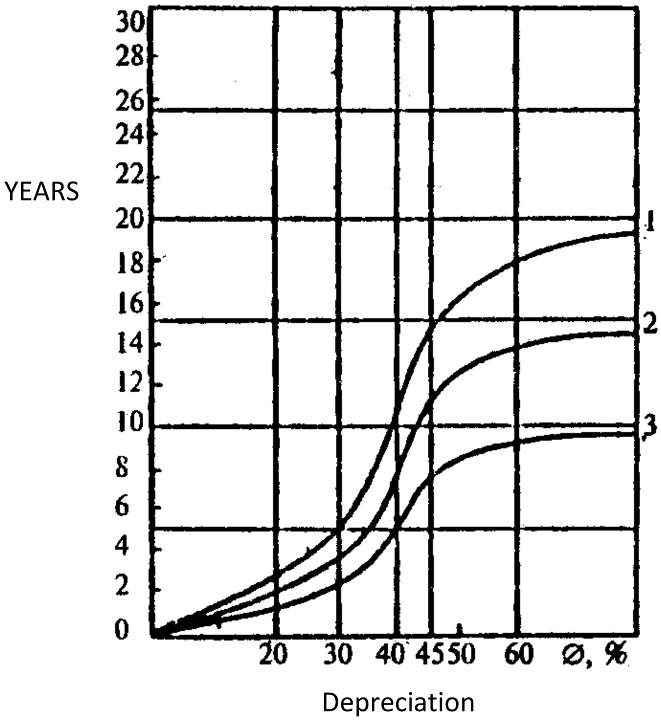
The support of parents for the successful "green kindergarten" is essential. Special educational programmes shall be prepared for parents (possible alongside with children). Within the scope of this programme educational seminars shall be delivered by teachers, explaining to parents the uniqueness of the given kindergarten. For these purposes, lecture theatre/seminar room shall be allocated for parents inside the infrastructure, or internal space can be used for the same goal.

For ensuring topicality of sustainability of kindergarten and its "green" indicators, it is necessary to come up with progressive principles for the development. In order to meet this goal, constant innovative development must be introduced: involving kindergarten management, parents' community, public and private sectors can be highly efficient.

Supporting same processes can become possible using mechanisms of so called PPP (public-private partnership). For private sector and the state joint execution of project that are less interesting for businesses due to various barriers is more attractive, without introduction of additional motivators from the government side aimed to private sector (example: one time grants, tax subsidies etc.)

APPENDIX A TO ANNEX I. EXTRACT FROM THE BUILDING CODE ON OPERATIONAL LIFE CYCLE OF VARIOUS CONSTRUCTION COMPONENTS

Diagrams presented below, clearly show the extract from building code (http://www.ocenchik.ru/docs/3.html), on operational life cycle of various construction component and determining dates of restoration becomes feasible.



Physical deprecation of internal water supply systems.

I - Stand-pipe from galvanised pipes

2 - Galvanised distributing pipes, all kinds of mixers,
locking devices

3 - Ferrous material and pressure pipes and
distributing pipes, cast iron locks.

Physical depreciation of central heating systems

I - Cast iron radiators;

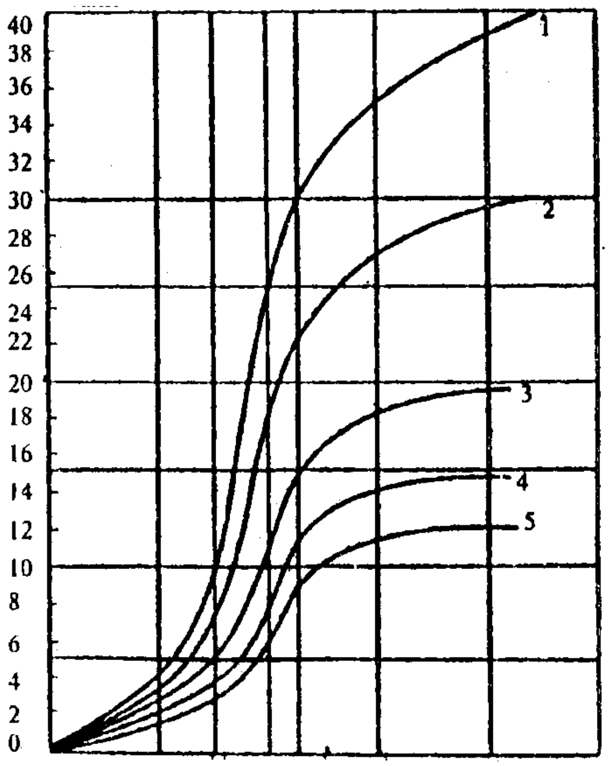
2 - Steel standing-pipe convectors

3 - Ferrous material distributing pipes

4 - Hot-air stove of every single type

5. Locking fittings of every type

Years



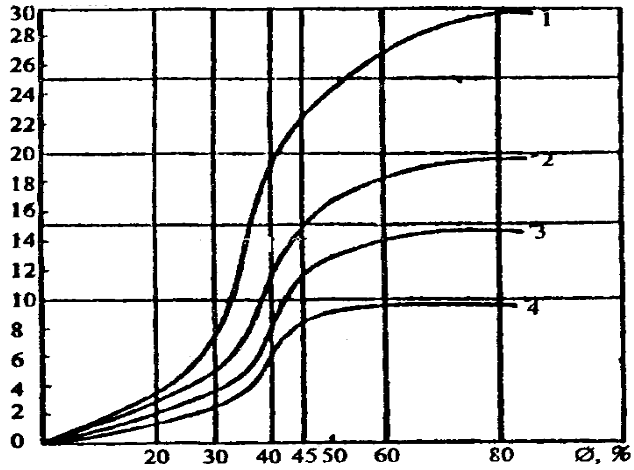
Internal water network physical depreciation

1 - Ungalvanised piping

2 - Ceramic and cats iron dipping tanks

3 - Ferrous metal pipes, PVC pipes, bronze taps and loc

4 - Cats iron taps and locking fittings



Physical depreciation of internal sewage systems

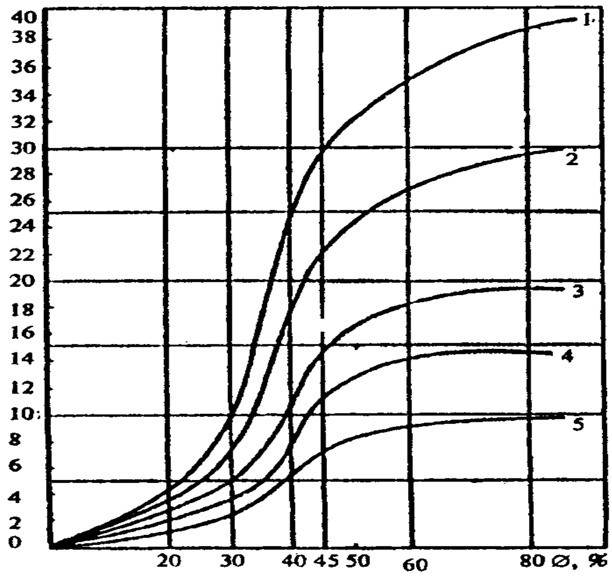
1 - Cast iron pipes, cast iron bath

2- Cast iron and stainless steel basins

3 - Steel pipes and baths, ceramic toilets and basins, asbestos cement pipes

4 - Enamelled steel washing basins

5 – PVC pipes



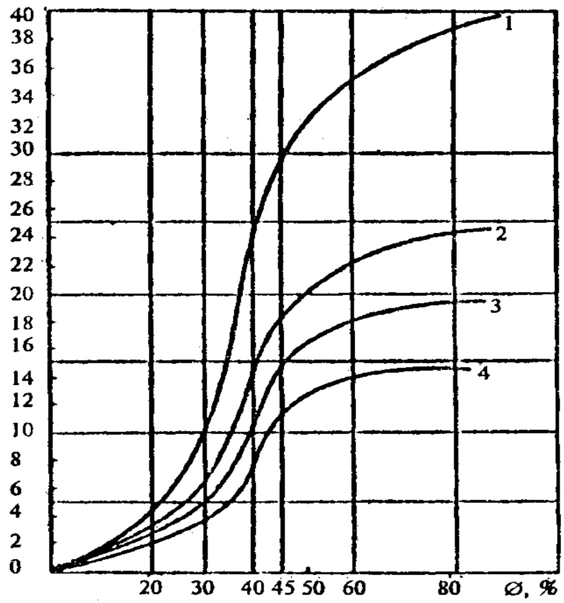
Physical depreciation of internal electricity network

1 - Hidden internal network;

2 - Open internal network;

3 - Distributing nods

4 - Electric tools



APPENDIX B TO ANNEX I. DETAILED RESULTS OF INSPECTION OF BUILDINGS SELECTED BY THE TIME INTERVAL DIVISION METHOD

Tbilisi city, Samgori district, kindergarten situated in Nasaguri settlement

The building has been erected since 1956 and its loadbearing construction has the following characteristics:

1.Foundation ribbon construction is made from continuous monolithic concrete, concrete is produced from rough river filling material, something that can be clearly observed on the façade of the building.

2. Loadbearing wall construction is made from sharp tufa rock on mortar of cement/sand, however some walls are done using red and silex bricks

3. Floor trusses are made from the timber and partiall monolithic steel and concrete tiles in swashroom areas. Timber beams are partially broken and need to be replaced, alongside with floors decks. Stairwell to the second floor is not designed for children usage and is outdated, the height adjustment of individual stairs is necessary.

4. The building is constructed reliably and fundamentally, in compliance with building norms and regulations of that time period.

5. The building has a utility space without designated entrance, underneath the floor on first storey.

6. Building has a hipped roof, partially made from tin and partially from corrugated asbestos board. The roof needs to be replaced alongside with rainwater harvesting systems. It must be noted that, according to current building regulations, use of asbestos is forbidden.

7. Out of dated electricity network has to be replaced

8. New central heating system that operates quite reliable is available in the building. However, due to frequent energy outages during the winter period, automated system disable mechanism and additional gas heaters become necessary

9. Windows and doors are made of steel-metal profiles; the state of heat bridges is unsatisfactory

10. Façade walls require plastering, especially socle block and silicate brick parts of the building, as nearly 70% of external walls are severely worn out due to the aggressive climate conditions, plastering must be done over the steel web.

11. Extension wing walls, alongside with the foundation are damaged, engineering-geological research of this component and construction reinforcement project preparation are necessary.

12. Sewege system of the next door neighbour must be replaced and moved away, as it often is blocked and causes serious problems to children's playground. Weeper system needs sorting out. It must be noted that sanitary sewer manholes do not have covers, something that is completely unacceptable.

Existing building does not display significant deformation and demage, apart from above outlined damages. For determining reinforcements work's volumes and types, engineering-geological research must be conducted and construction design project reviewed.

Based on all above mentioned we can conclude that:

- The building is contructed robustly and reliably in compliance with building norms and regulations of that time. Significant deformations or deviations are not visible apart from the damaged wing of the building that requires additional reinforcement works based on geological research findings. Reinforcement works must be consistent, in accordance with requirements of the technology of priority of works conducting.
- Roof timber rafters are mainly in satisfactory conditions. Cracks and damages are not observed, neither is termite caused damage; as for roof coating, it must be replaced completely.
- Internal electricity network must be replaced.
- The heating system of the building is brand new and functions in good order
- Windows and doors have recently been replaced and their current state is satisfactory. Thermal technical characteristics of heat bridges require improvement.

- Façade heat insulation and wall plastering with mortar of cement/send on fine-grained steel grid is required.

Based on the degree of need for restoration categories, the building belongs to the group of "severe need for restoration".

Tbilisi city, Krtsanisi district, Station lane street N23, Kindergarten # 71

The building has been erected since 1956 and its loadbearing construction has following characteristics:

1.Foundation ribbon construction is made from continuous monolithic concrete, concrete is produced from rough river filling material,.
2. Load bearing wall constructions of the building is mainly made of silex bricks on the mortar of cement/sand; however small sized holystone and construction block walls are present as well.

3. Floor trusses are done with set of hollow steel and concrete tiles and partially monolithic steel and concrete tiles in washroom facilities.

4. The building is constructed reliably and fundamentally, in compliance with building norms and regulations of that time period.

5. The building has a basement level, in relatively dry and acceptable condition, requiring cosmetic renovation and cleaning. Afterwards, it can be utilised as the supplementary storage space.

6. Building has a hipped roof, partially made from tin and partially from corrugated asbestos board. The roof needs to be replaced alongside with rainwater harvesting systems. It must be noted that, according to current building regulations, use of asbestos is forbidden.

7. Out of dated electricity network has to be replaced

8. Existing central heating system is brand new and functions properly. As the old boiler does not ensure full hot water supply of the building, additional boilers are being installed currently.

9.Building windows and doors are made of steel-plastic profiles; they are brand new, in good condition

10. Façade walls require plastering, especially silicate brick parts of the building, as nearly 55% of external wall is severely worn out due to the aggressive climate conditions, plastering must be done over the steel web.

11. Extension wing walls, alongside with the foundation are damaged, engineering-geological research of this component and construction reinforcement project preparation are necessary.

12. External sewage and rain water harvesting systems must be replaced inside the territory belonging to the kindergarten.

Based on all above mentioned we can conclude that:

- The building is contructed robustly and reliably in compliance with building norms and regulations of that time. Significant deformations or deviations are not visible apart from the damaged wing of the building that requires additional reinforcement works based on Geological research findings. Reinforcement works must be consistent, in accordance with requirements of the technology of priority of works conducting.
- Roof timber rafters are mainly in satisfactory conditions. Cracks and damages are not observed, neither is termite caused damage; as for roof coating, it must be replaced completely.
- Internal electricity network must be replaced.
- Heating system of the building is brand new and functions in good order
- Windows and doors have been recently replaced and are in satisfactory condition. The condition of heat bridges is unsatisfactory and requires detailed revision
- Façade heat insulation and wall plastering with mortar of cement/send on fine-grained steel grid is required.

Based on the degree of need for restoration categories, belongs to the group of "severe need for restoration".

Results of the energy audit of the building

Central heating system, on high temperature water heating gas boiler, functions within the building. Heating and water piping are brand new and has been operational since January of 2015. Utility bills are available including December 2014 and therefore, this audit covers the same period.
Utility bills for the year 2014 for the kindergarten look as follows: Gas-17 433 cubic meters (13 074 GEL); electricity expenditure-117 949 kw/h (18 872 GEL); Water-2 977 cubic meters (18 158 GEL).
Based on interviews of employees, it has been revealed that in the period of heating, appropriate micro climate, as defined by the health and safety regulations, was not provided for all storage units solely by using heating boiler, therefore they used oil based electric heaters, so called Karmas

Building hearing and cooling capacity caluclations were carried out taking into consideration the following climate parameters:
• The average temperature of coldest five day sequence (- 8 ^{0}C for Tbilisi)
• The length of heating season (151 days for Tbilisi)
• Cooling period (when temperature equals to or exceeds 29 ^{0}C in Tbilisi)
• Degree-day 26 50

Heat waste and its reduction calculations for the kindergarten No. 71

On the basis of energy audit in the kindergarten building, reasons for high heat waste in this building were identified. The measurement of external surrounding construction's dimensions was carried out. Accordingly, heat wastage was calculated only for study wings (glazed entrance space is excluded from the heated area) of the building. Heat waste from external surrounding components is following: external walls-42.4 kW, roof-26.4 kW, floor-27 kW, windows-11 kW; total waste equals to 106.8 kW.
Heat waste reduction calculation was carried out with consideration of all heat insulation activities for the main building (activities are listed in the pilot proposal-appendix 1).
After an implementation of described measure, heat waste of the building in power units can be reduced from 106.8 kW to 51.4 kW (by 51.8%).
By the reduction of heat waste of the building (from 106.8 kW to 51.4 kW) the additional 55.4 kW power required for the heating will be reduced. The saved power/heat over the heating season period will equal to 55.4*(22-(4.6))/(22-(-8))=32.1 kW.
The saved heat over the heating season (151 days), under the conditions of improved heat parameters will equal to 151days *24 hours *32.1 kW=11 6330 kWh. After burning one cubic meter of gas 9.4 kWh energy is being produced, hence the amount of saved natural gas on heating season will be equal of 17 433-11 6330/9.4= 5 058 m^3 (thermal capacity 35 600 kJ/cubic meter and the boiler coefficient of efficiency=0.92), that accounts for 30% of previously consumed gas. The economy in money terms solely on gas consumption will be 3 793 GEL per annum.

Utilising hot water supply and heating systems integrated with solar collectors and heating pump will also ensure significant savings of energy consumed.

Electricity consumption bill includes electrictity consumes by 10 units of water heating devices-Thermax, The energy consumed by the water heating Thermax is calculates as: E_T =10unit *1.2 kW*8 hours *22 days *10months = 21120 kWh.

Savings in money terms equal to 3 379 GEL. Based on economic arguments, in the case of absence of gas heating boiler, it is better to provide hot water supply management with standard boiler as opposed to the electric heater, as for energy saving standpoint, the hot water supply with solar collectors is more important.

In case if we equip heating system with the low temperature gas condensate heating boiler, in combination with the solar collector heat pump and photovoltaic, the further significant reduction of gas consumption is possible. If such systems operate in correlation with heat and water planned economic consumption networks, additional 50% savings can be attained and remaining gas expenditure half diminished, end consumption equalling to 6 187+5 058=12 374[19] cubic meters, that amounts 70% of current expenditure. In money terms this reduction equals **to 9 280 GEL**

It is possible to reduce utility bills by further 40-45% from water consumption perspective, in case if we redirect kitchen water to the sewage sand irrigation systems. Installation of such systems, in combination with water saving plumbing systems gives an opportunity for 40% reduction of water consumption, and in our case this can be expressed in money terms as-**18 158*0.4=7 263 GEL**
As throughout the year 2014, electricity was used for heating and hot water generation, the savings will be achieved in these components too. The assessment of the volume of savings at this point is impossible, as the differential data on electricity consumption is not known to the researcher. With high degree certainty, it can be argued that in case if Thermaxs are replaced with solar collector savings will equal to **3 379 GEL worth of 21 120 kWh electricity**.

Possible savings of gas and electricity in the kindergarten #71

Building	**Types of the energy sources**	**Consumption**						**Emission**		
		Base	**Base**	**Base**	**Savings**	**Savings**	**Savings**	**Emision Factors**	**Base**	**Reduction**
		m3/kWh/ m3	**kWh/a**	**GEL**	**m3/kWh/ m3**	**kWh/a**	**GEL**	**kg/kWh**	**t/a**	**t/a**
Kindergarten #71	Gas	17 433	163 841	13 074	12 374	116 295	9 280	0.202	33.10	23.49
	Electricity	117 949	117 949	23 354	21 120	21 120	4 181	0.136	16.04	2.87
	Water	2 649	n/a	18 158	1 060	n/a	7 263	n/a	n/a	n/a
	Sum		**281 790**	**54 586**		**137 415**	**20 725**		**49.14**	**26.36**

[19] The actual consumption of gas in this Kindergarten makes 17 433 m^3. The saving from energy efficiency will be 5 068 m^3, and the remaining 12 375 m^3 could be consumed. As this remaining amount may be cut by half, the actual consumption could be lowered to 6 187 m^3. Therefore the overall saving would be equal to 12 374 m^3.

Tbilisi city, Chughureti district, Kinkladze street N 24 (former Shirshov), Kindergarten N 125

The main part of the building is the construction built in 1915, with extensions throughout its operational life cycle. Its loadbearing construction is following:

1. Foundation ribbon construction is made from continuous monolithic concrete; concrete is produced from rough, river filling material.

2. Loadbearing wall constructions are made of red bricks on lime mortar mix and match.

3.Extension wing foundation is made from monolithic concrete on rough concrete river filling material.

4. Extension wing wall is made of sile brick on mortal of cement/sad, that leads us to the conclusion that extension was built in 70ies of the last century.

5. Floor trusses are made from timber and partially from monolithic steel and concrete tiles in sanitary points. Timber beams are partially broken and need to be replaced alongside with floors decks. Steel stairwell to the second floor is not designed of children and is outdated, installation of new stairwell with appropriate stair heights is necessary.

6. The building is contructed robustly and reliably in compliance with building norms and regulations of that time, however without any seismic resistance measures: the building does not have a common belt, that would have bond together main and extension parts of the building, as a monolithic spatial system.

7. Building has a hipped roof, partially made from tin and partially from corrugated asbestos board. The roof needs to be replaced alongside with rainwater harvesting systems. It must be noted that, according to current building regulations, use of asbestos is forbidden.

8. Out of dated electricity network has to be replaced

9. New central heating system has been installed and it is functioning properly.

10. Windows and doors are made from steel and plastic profiles, brand new, in a good condition.

11. Façade wall require plastering works, especially silex brick part of the building. Plastering must be done on a steel grid.

12. It must be noted, that on the first level of the building neighbour is intruded illegally and has set up storage space. Engineering-geological research of this component and construction reinforcement project preparation is necessary.

13. This part of the building is physically depreciated, upgraded modern requirements demand for more space and technologically advanced construction. For normal operation fundamental research, engineering-geological investigation, reinforcement project review and reinforcement are required.

Taking into a consideration all above mentioned, constructing brand new building equipped with modern technologies, suitable for emerging needs would have been beneficial.

Hence, we can conclude the following:

- The building is constructed robustly and reliably in compliance with building norms and regulations of that time. Significant deformations or deviations are visible. Preparation of construction reinforcement design following the Geological research is required.
- Reinforcement works must be consistent, in accordance with requirements of the technology of priority of works conducting.
- After a successful completion of construction works professionally, with high quality assurance, an usual operation of the building will be possible.
- Roof timber rafters are mainly in satisfactory conditions. Cracks and damages are not observed, neither is termite caused damage; as for roof coating, it must be replaced completely.
- Out of dated electricity network needs to be replaced.
- Central heating system is brand new, functioning properly.
- Windows and doors have been recently replaced and they are in satisfactory condition. Upgrading heat bridges and energy audit of their thermal technical characteristics is required
- Façade heat insulation and wall plastering with mortar of cement and sand on fine-grained steel grid is required
- Building extension is damaged and its demolition, construction of new building, equipped with modern technologies is recommended.

Based on the degree of need for restoration categories, the building belongs to the group of "severe need for restoration".

Tbilisi city, Didube district, Tsereteli avenue No. 110, kindergarten N 24

The building has been erected since 1956 and its loadbearing construction has the following characteristics:

1.Foundation ribbon construction is made from continuous monolithic concrete, concrete is produced from rough river filling material

2. Load bearing wall construction is made from red brick on mortar of cement/sand.

3. Floor trusses are assembled steel and concrete construction hollow tiles and partially monolithic steel concrete tiles in washroom facilities.

4. The building is contructed robustly and reliably in compliance with building norms and regulations of that time

5. Building has a hipped roof. Tin roof cover has been recently replaced and is in a good condition

6Central heating system is brand new, functioning properly.

7. External windows and doors are made of PVC material; brand new, in good condition

8.Building façade walls require plastering works

9. Asphalt surface, pavement and walking pathways around the building must be taken care of. Significant damages or deformations are not observed.

on all above mentioned we can conclude that:

- The building is contructed robustly and reliably in compliance with building norms and regulations of that time. Significant deformations or deviations are not visible
- Roof construction is in satisfactory condition
- Heating system in the building is brand new and is in working order
- Doors and windows have been recently replaced and their condition is satisfactory. Detailed research on their thermal technical characteristic is required though

- Heat insulation of the façade is required and plastering of back wall with the mortar of cement and sand is desired too.
- Asphalt surface, pavement and walking pathways must be taken care of.

Based on the degree of need for restoration categories, the building belongs to the group of "moderate need for restoration".

Tbilisi city, Saburtalo district, V. Godziashvili II lane N 10, kindergarten N 70

The building has been erected since 1998 and its loadbearing construction has the following characteristics:

1. Foundation ribbon construction is probably made from continuous monolithic concrete
2. Loadbearing construction of wall is monolithic steel and concrete frame, consisting from columns and rafters.
3. Floor trusses are made of monolithic steel and concrete tiles
4. The building is contructed robustly and reliably in compliance with building norms and regulations of that time
5. Building roof is of a soft construction. Roof cover has been recently replaced and its condition is satisfactory.
6. Central heating system is brand new, functioning properly.
7. External windows and doors are made of PVC material; brand new, in good condition. As for internal doors-they made of timber, in quite good condition.
8. Inner courtyard and whole territory is wellorganized.

It must be noted that any damages or defotmations are not observed onto existing building.

Based on all above mentioned we can conclude that:

- The building is contructed robustly and reliably in compliance with building norms and regulations of that time.
- Significant deformations or deviations are not visible
- It must be noted herewith that roof construction is in satisfactory conditions
- Heating system in the building is brand new and functions properly.
- Windows and doors have recently been replaced and their condition is satisfactory, apart from indetnal doors. Their replacement is recommended,
- Asphalt surface of inner courtyard, pavements and walking pathways must be taken care of.
- Operation of existing building in usual mode of operation is possible

Based on the degree of need for restoration categories, the building belongs to the group of "weak need for restoration".

Energy audit results

Central heating system operating on natural gas with high temperature water heating boiler is functional within the building. Heating and water piping are brand new and being in operation since January 2015. Utility bill expenditure is available up to December 2014, hence the audit encompasses the same period.

Utility bills for the kindergarten looks like this: gas-7 234 cubic meters (5 425 GEL); electricity consumption 29 637 kWh (4 724 GEL); Water 1116 tones (7 650 GEL).
By the method of interview (kindergarten director and members of staff among interviewees) it has been revealed, that in the period of heating, providing sufficient microclimate as defined within health and safety regulations, is not possible solely by heating boiler and additional oil based electric heaters are being used; hot water supply is supplemented with 5 Thermex water heaters.

In the calculation for the heating and cooling projects of the building the following climate parameters are being used: (similar to parameters used in case of other kindergartens).
• Averaged temperature of coldest five day period (for Tbilisi -8 degrees)
• Duration of heating season (for Tbilisi 151 days)
• Average cooling period (for Tbilisi 29 degrees)
• Degree-day 26 504

Calculation of heat waste and their reduction for the kindergarten #70

Based on the findings of energy audit conducted throughout the building the reasons from high heat waste indicators were revealed on-site. The measurement of dimensions external casing walls was carried out on-site. Accordingly, heat waste was calculated for an entire building. Heat waste from external casing building components are following: external walls-20.2 kW, roof-12.0 kW, floor-10.9 kW, windows-11.4 kW, aggregate heat losses is 53.6 kW.

The heat waste calculations in case of implementing every single energy efficiency measure, as reviewed in the main body of the pilot project proposal text, has indicated that in case of undertaking all these measures, potential reduction from 53.6 kW to 28.7 kW (by 46.5%) is realistic. Utilisation of hot water supply system integrated with heat pump and solar collector, also stipulated significant energy saving.

By the heat losses reduction from 53.6 kw to 28.7 kw, capacity utilised will be shrinked by 29.4 kW. The saved power over the heating season is adequate to reduced consumption. This reduction equals to 24.9kW.*(22-(4.6))/(22-(-8))=14.4 kW. Energy saved throughout the heating season (151 days) will be 151 days *24 hours *14.4 kW=52 185.6 kWh heat energy. By combustion of 1 m^3 of gas (with calorific power of 35 600 kj/cubic meter and boiler efficiency=0.92) 9.4 kWh energy is produced, therefore the amount of saved natural gas over the heating season will be 7234-52 185/9.4= **1 682** m^3, 23% of previously consumed gas resources and financial savings totalling **1 261 GEL** per annum.

Electricity consumption includes energy consumed by 5 units of water heating equipment Thermex: The energy consumed by a water heating equipments Thermex equals to E_T =5 unit*1.2 kW *8 hours *22 days *10 months =10 560 kWh, the amount that can be totally saved and accordingly savings expressed in monetary terms will be **1 690** GEL. Electricity can be saved in case of existence gas operated heating boiler (such system does exist in kindergarten #70) and using combined heating system. From the financial savings standpoint, it is better to organise hot water supply via gas heating boiler instead of electrical water heating equipment's, and from the energy saving standpoint using hot water supply system based on solar collectors is more important.

In case if we equip heating system with low temperature gas condensing heating boiler in combination with solar collector and photo voltaic systems, significant reduction of gas consumption becomes possible. If operation of such system is executed in correlation with planned thrifty consumption of heating and water, additional 50% saving and reducing by half remaining gas consumption becomes real. Afterwards, final saving will be 1682+2776=**4 458** m^3, 61% of current expenditure. Where, 2 776 m^3= 7 234 m^3 (present day consumption)-1 682 m^3 (saving through the energy efficiency increase of the building) = 5 552 m^3 (remaining consumption). It could be decreased still by 50%, i.e. by 2 776 m^3.
The amount on total savings in the gas component expressed in money terms is **3 343 GEL.**

It realistic to save utilities expenditures by 40-45% from the viewpoint of water consumption, if we direct kitchen water to fat absorber and use the same water for irrigation and sewage purposes. Installation of such systems in combination with water saving plumbing systems gives an opportunity for overall water consumption reduction by 40%, in our case expressed in money terms as **7 650 * 0.4=3 060** GEL.

As throughout the year 2014, in kindergarten # 70 electricity was used for heating and hot water generation, the saving will be achieved in this component too. The assessment of volume of savings at this point is impossible, as differentiated data on energy consumption could not be obtained. Something that can be stated affirmaltively is the fact that if thermex water heaters are replaced by solar collacotrs, **10 560 kW** electricty worth **1 690** GELs will be saved.

Building	**Types of the energy sources**	**Consumption**						**Emission**		
		Base	**Base**	**Base**	**Savings**	**Savings**	**Savings**	**Emission Factors**	**Base**	**Reduction**
		m3/kWh/m3	**kWh/a**	**GEL**	**m3/kWh/m3**	**kWh/a**	**GEL**	**kg/kWh**	**t/a**	**t/a**
Kinderga	Gas	7 234	67 987	5 425	4 458	41 898	3 343	0.202	13.73	8.46

rten #70	Electricity	29 637	29 637	5 868	10 560	10 560	2 091	0.136	4.03	1.44
	Water	1 116	n/a	7 650	446	n/a	3 060	n/a	n/a	n/a
	Sum		**97 624**	**18 943**		**52 458**	**8 494**		**17.76**	**9.90**

Tbilisi city, Gldani district, VI micro district, kindergarten N 107

The building has been erected since 1956 and its loadbearing construction has the following characteristics:
1. Foundation ribbon construction is made from continuous monolithic concrete; concrete is produced from rough river filling material
2. Loadbearing construction of the building is mostly made from assembly of wall blocks and bridge walls (mid walls) done using silicate brick.

3. Floor trusses are assembled steel and concrete construction hollow tiles and partially monolithic steel concrete tiles in washroom facilities.
4. The building is constructed reliably and fundamentally, in compliance with building norms and regulations of that time period
5. East wing rooms of the building require heat insulation, wall thickness is not sufficient from the viewpoint of heat resistance.

6. Building roof is of a soft construction. Roof requires refurbishment, together with the rain collecting system. Roof cover is damaged and leaks the water.
7. Out of dated electricity network needs to be replaced.
8.Central heating system is brand new, functioning properly.
9. Building windows and doors are brand new, made of PVC materials, however the quality is unsatisfactory, they are not sufficiently thermally stable.

10. Façade wall require plastering works. Plastering must be done on steel grid.
11. It must be noted that basement is in a satisfactory condition, requiring just a minor

refurbishment work.
12.The asphalt surface needs to be replaced completely. The rain water harvesting system needs sorting out. Significant damages and deformations are not observed

Based on all above mentioned we can conclude that:

- The building is contructed robustly and reliably in compliance with building norms and regulations of that time. Significant deformations or deviations are not visible
- It must be noted herewith that roof cover must be replaced.
- Internal electricity network must be replaced.
- The heating system of the building is brand new and functions in good order
- Windows and doors have been replaced recently, but they are of a very low quality.
- Façade heat insulation and wall plastering with mortar of cement and sand on fine-grained steel grid is required
- The asphalt surface needs to be replaced completely. The rain water harvesting system needs sorting out.

Based on the degree of need for restoration categories, the building belongs to the group of "moderate need for restoration".

Tbilisi city, Chughureti district, D. Abashidze street N 4, Kindergarten # 95

The building has been erected since 1988 and its loadbearing construction has following characteristics:

1. Foundation ribbon construction is made from continuous monolithic concrete; concrete is produced from rough river filling material,
2. Basement walls are mostly constructed using monolithic concrete components, however occasional assemblies from socle bricks are present
3. The loadbearing construction of the building is steel and concrete frame, consisting of columns and rafters. Surrounding wall construction is done with a silicate brink on mortar of cement/sand.
4. Floor trusses are partially done using hollow steel and concrete tiles and partially by monolithic steel and concrete tiles, assembled on monolithic steel and concrete beams.
5. The building roof construction is of two type, most part of the building roof is of soft construction, made of pitched holystone fill and concrete screed. The roof of the main entrance in the building is done by tin construction of multilevel geometry, with steel loadbearing construction. Damages and deformation in the given building are not observed, requiring minor renovation, restoration and cosmetic works.
6 Building windows and doors are made of PVC, brand new, however the quality is unsatisfactory and not sufficiently heat resistant,
7. Building walls and floor require heat insulation
8. Building has properly ventilated facade

Based on all above mentioned we can conclude that:

- The building is contructed robustly and reliably in compliance with building norms and regulations of that time

- The thermal envelope of the building requires improvement and thermal technical characteristics systematization

- Significant damages and deformations of the building are not observed; all minor damages are due to deterioration of hydro insulation layer

Based on the degree of need for restoration categories, the building belongs to the group of "moderate need for restoration".

Results of energy audit of kindergarten No. 95

Central heating system functioning on 100 kW capacity water heating gas boiler (1 unit) exists within the building. Second boiler is out of order and does not function. Heating and water supply piping is made of steel. Hot water supply is provided by 7 units of water heating, Thermex equipment.
Utility bills for the time period of 11.06.2014 till 16.06.2015 for the kindergarten # 95 include: gas utility bill-24 731 GEL, electricity utility bill 5 106 GEL, water utility bill- 7 317 GEL. Based on these numbers, gas consumption was 53 764 m^3, i.e. 505 292 kWh energy; consumed electricity was 28 864 kWh.

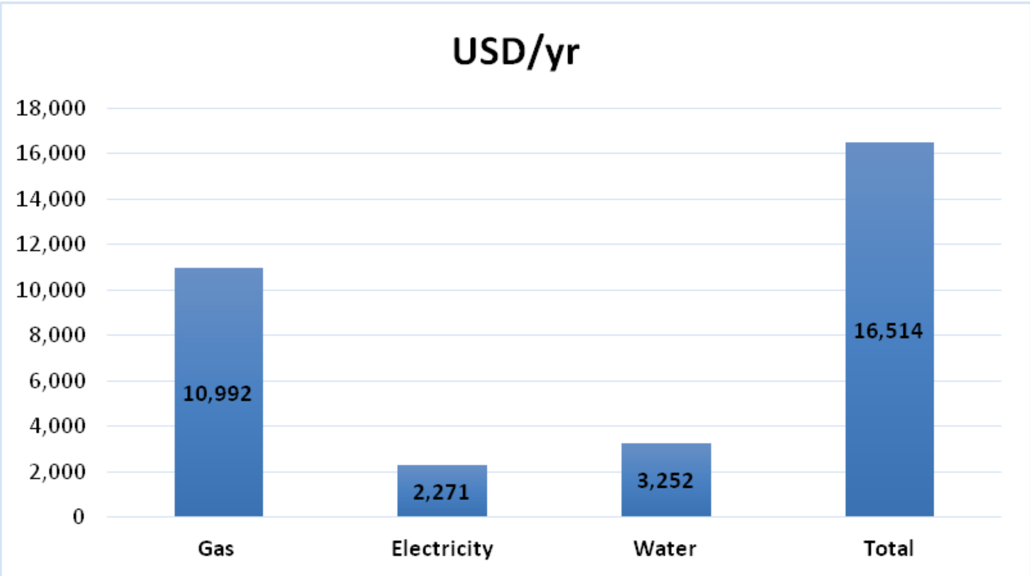


Figure 9. Annual spending for NG, electricity and water consumption in the kindergarten # 95 (For the period 11.06.2014-16.06.2015)

Electricity expenditure includes energy consumed by an artificial lightning and 7 units of water heating equipment Thermex: energy consumed by water heating Thermex equipment is evaluated as E_T =7units *1.2kWh *8 hours*22 days *10 months =14 784 kWh. In the scenario of gas heating boiler existence, it is advantageous to provide hot water supply via a boiler instead of electric heaters based on economic motivation, from energy saving standpoint, it is more beneficial to provide hot water supply using solar collectors.

By the method of interview (kindergarten director and members of staff among interviewees) it has been revealed, that in the period of heating, providing sufficient microclimate as defined within health and safety regulations, is not possible solely by heating boiler and additional oil based electric heaters are being used. Establishing current picture of thermal protection (photographing), analyses of separate storage spaces, marking of main defining sections and for determining other thermal technical indicators it is necessary to research external casing walls' heat insulation layer thickness, heat insulation qualities of building materials. Different types of material vary based on their thermal physical characteristics. Acquiring knowledge on thermal physical qualities is necessary for calculating thermal processes. In manuals and guidebooks available thermal physical information on dry materials prevails. Applied materials throughout the operational life cycle can acquire humidity and its thermal protection degree can significantly deteriorate, hence for practical energy audit of the building, it is recommended to measure thermal resistance of external casing walls.
The purpose of the energy audit is to calculate heat waste volumes in atmosphere during the heating season and prepare recommendations for reduction. Required actions for achieving this objective are:
On-site energy audit was conducted in summer period and because of this whilst selecting thermal physical characteristics of the construction, corrected guide data, based on operational experiences, was applied.

Based on the conducted energy audit in the kindergarten, reasons for high heat waste of the building were revealed. Measurement of dimensions of external casing construction and individual rooms that have thermal links with outside environment was carried out on-site; the capacity of heat wastes in environment was calculated.
Amount of aggregate capacity of heat waste calculated by adding up heat wastes of individual storages is 152.3 kW. High heat waste is related to insufficient indicators of heat protection of building components (walls, leaded panes, windows, ceiling, floor, and roof) and with high percentage of leaded panes (please refer to the Appendix C to the Annex I).
Stairwell is characterized with highest rate of heat losses (31.5 kW) due to the high percentage of glazing and non-insulated roof construction
Amongst energy efficiency measures to be implemented, it is worthwhile to note following activities:
□□Heat insulation of external casing wall with 50 mm thickness XPS material with heat conductivity coefficient of □□□□0.032 W/m/degree
□□Attic floor, ground floor and roof insulation with solid 50 mm mineral fiber glass (basalt fiber) and of □□□□0.04 W/m/degree heat conductivity heat insulation material
□□The reduction of a glazing coefficient by reducing the area of leaded panes.
□□Solar radiation heat protection in summer and using solar radiation for heating the building in summer; solar radiation heat accumulation in building foundation
□□External casing walls' thermal protection and heat accumulation qualities improvement
□□Use of ventilated windows
□□High degree of imperviousness of the building, low share of external air in the ventilation system and automated climate control
□□Automated control of effective lightning systems
□□Reduction of glazing area by applying natural lightning at maximum capacity

Detailed analyses of heat waste scenarios were carried out for an implementation of all energy efficient activities.

After implementing above described activities, the capacity of heat waste of the building can be reduced from 152 305 W to 62 601 W (by 58.9%). Including stairwell heat waste reduction from 31.5 to 11.24 kW. Calculations of heat waste for existing and post energy efficiency activities implementation can be found in Appendix C.

Use of hot water supply system integrated with solar collectros and heat pump will ensure significant savings of consumed energy.

Heat waste reduction from 152.3 kW to 62.6 kW will save 89.7 kw of heat power consumed by the heating system. The saving of consumed heat power over the heating season will equal to 89.7*(22-(4.6))/(22-(-8))=52 kW. Saved energy for the heating season (151 days) will equal to 151 days *24 hours *52 kW=188 448 kWh heat energy. As the result of burning one cubic meter of a natural gas (with calorific value of 35 600 kJ/cubic meter and boiler efficiency of 0.92) 9.4 kWh energy is produced, therefore the volume of saved gas on heating season will be 188 448/9.4= 20 047 m^3, 37% of previously consumed natural gas. Savings expressed in money terms are 9 222 GELs per annum.

In case if 13.5 kW capacity heat pump with a transformation coefficient of 3.5 (COP+3.5) will be used in the heating system, gas consumption will be 52-13.5=38.5 kW thermal capacity; whereas if heat pump's electric capacity equals to 13.5/3.5=3.9 kW electric (together with 13.5 kW thermal power). Therefore, additional saving will be 151days *24 hours *13.5 kW=48 924 kWh. As increased electricity demand will be satisfied by the photo voltaic system.

Ennergy Audit Results of Kindergarten No. 95

Building	Types of the energy sources	Consumption						Emission		
		Base	Base	Base	Savings	Savings	Savings	Emission Factors	Base	Reduction
		m3/kWh/ m3	kWh/a	GEL	m3/kWh/ m3	kWh/a	GEL	kg/kWh	t/a	t/a
Kindergarten #95	Gas	53 764	505 290	40 323	25 257	237 372	1 9438	0.202	102	47.95
	Electricity	28 864	28 864	5 715	19 453	19 453	3 852	0.136	4	2.65
	Water	1 067	n/a	7 317	427	n/a	2 927	n/a	n/a	n/a
	Sum		**534 154**	**53 355**		**252 156**	**25 721**		106	50.59

Tbilisi city, Saburtalo district, Panaskerteli-Tsitsishvili street No. 14, kindergarten N 122

Kindergarten N 112 is located in two-storey building constructed by steel-concrete tiles. The building has been operational since 1978. Overall heated area is 2 450 sq. meters; whereas both ceiling and floor area equals to 1 225 sq. meters. Total area of walls in contact with external environment is 1 305 sq. meters (out of this north wall 525 sq. meter, east wall-127 sq, meters, south wall-526 sq. meters and west wall 127 sq. meters), total area of double glazed PVC windows is

159 sq. meters (out of this on north wall 75 sq. meters, east wall 5 sq. meters, south wall-74 sq. meters and west wall 5 sq. meters). Overall volume of the building equals to 9 800 cubic meters. Analyses of obtained information enables us to plan for possible energy saving activities and define savings realisation as identified in the initial research conducted on kindergarten N 112 in Tbilisi.

These activities are:

- Building attic heat insulation
- Installation of new systems of lightning
- Solar energy utilization for the purpose of hot water supply

Based on the degree of need for restoration categories, belongs to the group of "severe need for restoration".

Result of the energy audit

The factual energy saving potential for the kindergarten #112 as assessed by the energy audit is presented within the table below.

Energy Audit Results for Kindergarten #112

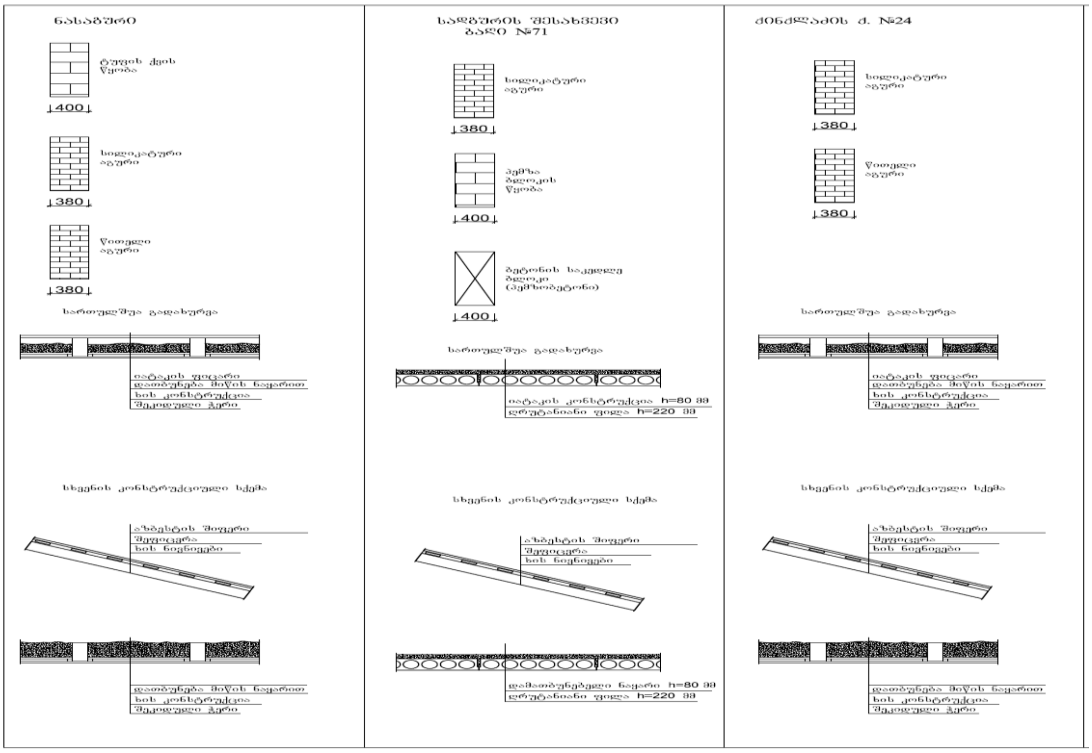
Building	Types of the energy sources	Consumption						Emission		
		Base	Base	Base	Savings	Savings	Savings	Emission Factors	Base	Reduction
		m3/kWh/ m3	kWh/a	GEL	m3/kWh/ m3	kWh/a	GEL	kg/kWh	t/a	t/a
Kindergarten #95	Gas	30 674	288 338	23 010	7 200	67 681	5 402	0.202	58.24	13.67
	Electricity	48 088	48 088	9 521	4 680	4 680	927	0.136	6.54	0.64
	Water	0	0	0	0	0	0	n/a	0	0
	Sum		336 426	32 531		72 361	6 327		64.78	14.31

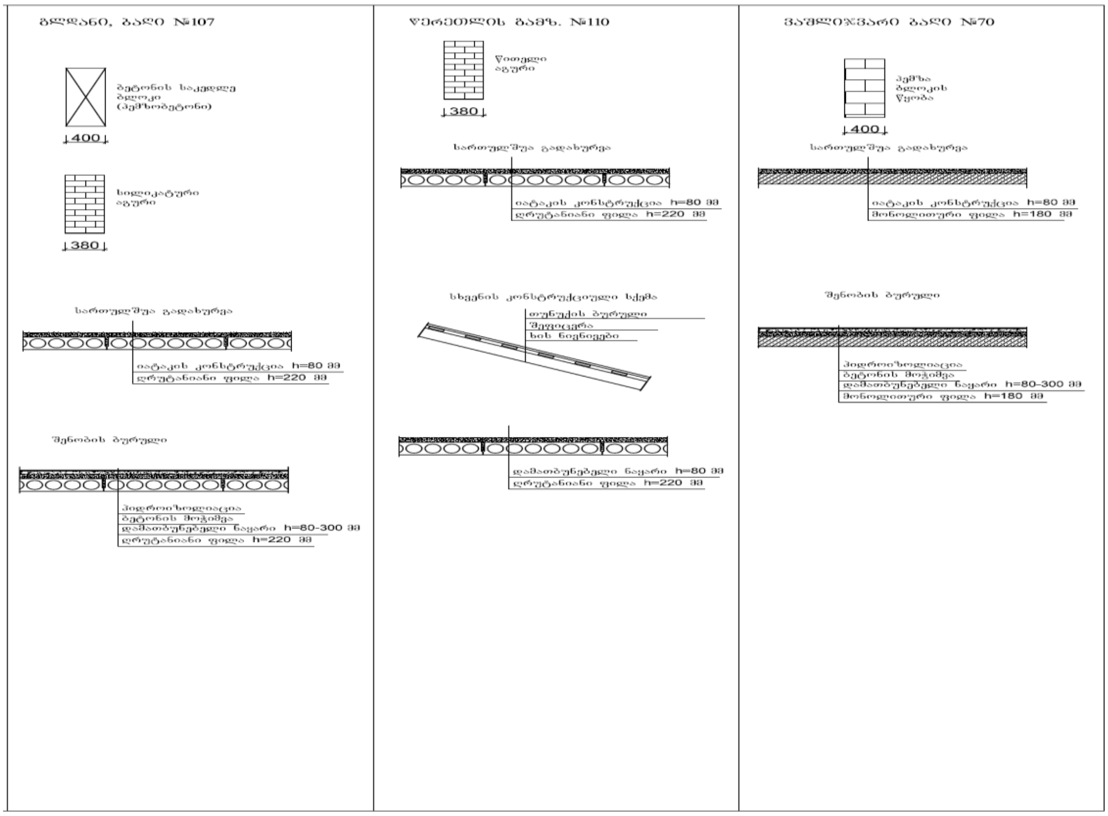
As the table demonstrates, kindergarten #112 in Tbilisi city can save annually 77 361 kWh electricity, that amount for 21.5% of base consumption (336 426 kW/h). Accordingly, the amount of CO_2 emission can be reduced by 14.31 tonnes annually that amounts for 22.09% of total base emission 64.78 t/a).

Based on analysis of results of the energy audit and relevant calculations, it has been revealed reference rate of energy saving for kindergartens in Tbilisi city equals to 29.6 kWh/a per sq. meter, 26.0 kWh/a/m^2 out of this comes on heating, whereas just 3.6 kWh/a/m^2 on electrical tools. These low savings are the results of limited measures planned and assessed for this #122 kindergarten building. Much more savings are anticipated per sq. meter in case of implementation of measures considered above for other kindergarten buildings.

APPENDIX C. CALCULATIONS OF MEASURES REQUIRED FOR THERMAL PROTECTION OF SURROUNDING WALLS, ATTICS AND INTERNAL WALLS IN PRE-SCHOOL EDUCATIONAL ESTABLISHMENTS UNDER THE OWNERSHIP OF TBILISI CITY MUNICIPALITY.

General notes: External loadbearing casing walls in kindergartens selected for an inspection (Nasaguri kindergarten and kindergartens N 71, 24, 107, 110 and 70) are constructed from materials with various coefficients of thermal conductivity: tufa rock ($\lambda = 0.3 - 0.64$ W/m/k), silicate brick ($\lambda = 0.5 - 1.3$ W/m/k); whole red brick ($\lambda = 0.67$ W/m/k), red hollow brick ($\lambda = 0.44$ W/m/k); holystone block ($\lambda = 0.11 - 0.16$ W/m/k), holystone-concrete ($\lambda = 0.19 - 0.52$ W/m/k); concrete wall block ($\lambda = 1.51$ W/m/k). Thickness of load bearing wall varies depending on conditions from 380 to 400 mm. External plastering is done with mortar of sand/cement and internal walls with lime mortar.




გლდანი, ბაღი №107
ბეტონის საკედლე ბლოკი (პემზობეტონი)
400
სილიკატური აგური
380
სართულშუა გადახურვა
იატაკის კონსტრუქცია h=80 მმ
ღრუტანიანი ფილა h=220 მმ
შენობის ბურული
ჰიდროიზოლიაცია
ბეტონის მოჭიმვა
დამათბუნებელი ნაყარი h=80-300 მმ
ღრუტანიანი ფილა h=220 მმ
წერეთლის გამზ. №110
წითელი აგური
380
სართულშუა გადახურვა
იატაკის კონსტრუქცია h=80 მმ
ღრუტანიანი ფილა h=220 მმ
სხვენის კონსტრუქციული სქემა
თუნუქის ბურული
შეფიცვრა
ხის ნივნივები
დამათბუნებელი ნაყარი h=80 მმ
ღრუტანიანი ფილა h=220 მმ
ვაშლიჯვარი ბაღი №70
პემზა ბლოკის წყობა
400
სართულშუა გადახურვა
იატაკის კონსტრუქცია h=80 მმ
მონოლითური ფილა h=180 მმ
შენობის ბურული
ჰიდროიზოლიაცია
ბეტონის მოჭიმვა
დამათბუნებელი ნაყარი h=80-300 მმ
მონოლითური ფილა h=180 მმ

As for floor trusses, constructions consisting from listed components are being used: floor beam (4 cm, $\lambda = 0.15$ wt/m/k), earthfill ($\lambda = 0.2$ wt/m/k) for the purpose of sound and heat insulation, timber construction (80 mm) and dropped ceiling; timber construction (80mm.), hollow tile (220 mm), timber construction (80 mm), monolithic tile (180 mm).

Attic roof construction components are: asbestos sheets, timber raftets, tin-plate, timber cladding.

Attic roofing construction components include: heat insulating earthfill, timber construction, dropped ceiling, hollow tile.

Building roof cover construction elements are: hydro insulation materials, concrete braces, insulating earth fill, hollow tile, bracing, monolithic tile.

The building is constructed robustly, however external casing walls, floor trusses, roof construction and roof covering, from the stand point of thermal protections do not comply with modern requirements-thermal resistance indicators of walls are in accordance with out-of-dated standard. As the result, heat waste in atmosphere is high and in order to ensure compatibility with modern standard, heat insulation of wall with appropriate insulation materials is necessary.

Hence, it is necessary to come up with required norms for heat resistance thermal conductivity and selecting thermal insulation materials, defining their thickness, for increasing thermal resistance indicators of existing constructions.

Calculation of heat protection activities: In pre-school educational establishments (kindergartens) in Tbilisi city, the number of temperature-days equals to 2650 degree/days. Requirement for heat resistance's thermal conductivity for an external casing wall equals to 2.16 m^2/K/W; for roof 3.34 m^2/K/W; attic roof and basement ceiling (unheated) 2.9 m^2/K/W. If we take into an account heat resistance of thermal conductivity of internal and external walls that equal to 0.115 m^2/k/W and 0.44 m^2/K/W (or aggregate 0.158 m^2/K/W) then for required heat resistance of thermal conductivity we shall have the following indicators:

For external casing wal-2.31 m^2/W. for roof 3.5 m^2/W.; for attic roof and unheated basement ceiling -3.07 m^2/W.

Under conditions where the difference between the internal air temperature (22 Celsius) and external air temperature (-8 Celsius) equals to 30 degrees, heat waste into environment from one m^2 of the external casing wall equals to 13 W/ m^2. Identical indicator for the roof construction equals to 8.6 W/ m^2 and for the attic and basement ceiling to 9.8 W/ m^2.

External casing walls of the building, roof, floor trusses, roof cover represent construction consisting from several elements of different thermal conductivity coefficient linked together in parallel or consecutive (in relation to the heat stream) manner. These elements include: several whole materials (skeleton), air layer, heat insulation materials, conductor metal insertions etc.
Calculation of aggregate heat resistance of a heterogeneous wall construction, when non uniformity is created by the heat stream distribution elements, is relatively easy: for calculating aggregate heat resistance of the construction, the method of aggregation method of non-uniform construction elements (composite materials) is applied.

Whereby the wall consists of combinations of heat steams of consecutive and parallel directions, the separation of elementary regular cell and further subdivision according to certain flatness characteristics become necessary (please refer to appendix 1). For this specific case, within the appendix 1, the specific case study and methodology of calculation of reduced heat resistance for heterogeneous hollow tile is being used, with special emphasis on calculation of effectiveness of thermal conductivity of existing air layers inside the hollow tile. Quite frequently, the hear resistance of air layers ($\delta_{ჰაერ} / \lambda_{ჰაერ}$) is calculated incorrectly, when the process of convection is not taken into an account. Proportionately with an increase of the thickness of an air layer, the heat conductivity coefficient grows (due to the origination of convection inside the layer) and heat resistance remains practically unchanged (please see table 1). For instance, an increase of air layer thickness from 0.01 m to 0.2-0.3 heat resistance coefficient increases up to 0.077 W/m/K, whereas heat resistance fluctuation is 0.13 to 0.15. The data from the table is used for calculating heat resistance of hollow tile.

Conclusions:

On the basis of detailed analyses of measures for heat protection of walls, attics and floors in pre-school educational establishements in Tbilisi city (methodology can be found in the annex) the following conlusions can be formulated (Please refer to appendix 1):

Recommendations:

1. **Due to the fact that external casing walls of the analysed building are non-isotropic and mixed materials are present and wall of few types of materials can be observed, 5 cm XPS heat insulation layer shall be used.**
2. **Corrugated asbestos tiles shall not be used as a construction material**
3. **For improving attic roof, roof construction and basement ceiling heat indicators it is necessary to undergo heat insulation activities (on average five layers of basalt felt, each 8 mm thick).**

APPENDIX I TO APPENDIX C. CALCULATIONS OF HEAT RESISTANCE OF HOLLOW TILE

Two case scenarios are analysed:

1. The tile is used in the attic roof as a load bearing construction
2. The tile is used in basement (unheated space) ceiling as a load bearing construction.

The tile is made of steel and concrete, with thermal-conductivity coefficient of $\lambda_A = 1.92 ვტ/(მ \cdot ^{O} C)$. Tile layout with dimensions and thermal resistance calculating scheme is presented on the figure 1.

For simplicity sake of calculations round holes were replaced by their equivalent (equal areas) square holes. The value of the side of the square is:

$$a = \sqrt{\frac{\pi d^2}{4}} = \sqrt{\frac{3.14 \cdot 0.16^2}{4}} = 0.14მ$$

Let us consider two case scenarios for calculation:

1. Regular component is divided by parallel to heat stream flatness (adiabatic flatness). Drawing 1 a.

2. Regular component is divided into flatnesses rectangular to heat stream (isothermal flatness).

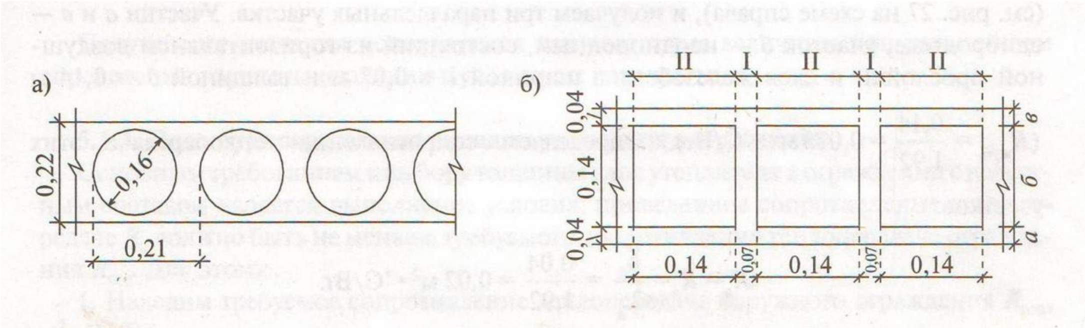


Figure 10.

a) Let us isolate regular component and divide in parallel to the heat stream (adiabatic flatness), we shall come up with two sections. Section I is homogenous and section II is heterogeneous, consisting from two air layers a and b, with equal thickness. Thermal resistance of given layers R_I და R_{II} accordingly, equal to:

$$R_I = \frac{\delta_1}{\lambda_1} = \frac{0.22}{1.92} = 0.115 \text{ m}^2{*}^{o}\text{C/W}$$

$$R_{II} = R_a + R_{\text{ჰაერ}} + R_b = \frac{2\delta_A}{\lambda_A} + R_{\text{ჰაერ}} = \frac{2 \cdot 0.04}{1.92} + R_{\text{ჰაერ}}$$

Table 21. Thermal resistance of heat-conductibility of air layer

Layer thickness, δ, m	Thermal resistance, $R_{\text{ჰაერ}}$, $(\text{მ}^2 \cdot {}^{o}C)/\text{ვტ}$			
	Horizontal heat supply from bottom to top and vertical		Horizontal heat supply from top to bottom	
	Under the conditions of layer temperature:			
	Positive	Negative	Positive	Negative
0.01	0.13	0.15	0.14	0.15
0.02	0.14	0.15	0.15	0.19
0.03	0.14	0.16	0.16	0.21
0.05	0.14	0.17	0.17	0.22
0.1	0.15	0.18	0.18	0.23
0.15	0.15	0.18	0.19	0.24
0.2-0.3	0.15	0.19	0.19	0.24

Air layer thermal resistance $R_{\text{ჰაერ}}$ was identified in the table 1:

- For panels of attic roofs, horizontal air layer, whereby thermal stream flows from bottom to top, is separated by the heat insulation layer, therefore air in this layer will be under the conditions of temperature above zero degree, hence from the table I, for layer thickness $\delta_{\text{ჰაერ}} = 0.14$ m under this conditions $R_{\text{ჰაერ}} = 0.15$ m²K/W, hence:

$$R_{II} = 0.04 + 0.15 = 0.19 \text{ m}^2\text{/W}$$

- Unheated basement, under condition of insulated ceiling panel on top of the steel-concrete tile, air above zero degree conditions for the layer $\delta_{\text{ჰაერ}} = 0.14$ m, hence $R_{\text{ჰაერ}} = 0.19$ m²K/W

$$R_{II} = 0.04 + 0.19 = 0.23 \text{ m}^2\text{K/W}$$

Thermal conducitivit's heat resistance for casing construction is calculated by this formula:

$$R_{\text{შემომზ.კ}} = \frac{\sum_{i=1}^{m} A_i}{\sum_{i=1}^{m} \frac{A_i}{R_i}}$$

Where as A_i-is construction characteristic, section area in m2s

R_i- section heat conductivity reduced heat resistance sq. meter/K/wt

m-varying number of thermal conductivity heat resistance for various sections of the casing construction.

- For attic ceiling

$$R_{\text{ალიაბ,}} = \frac{0.07 + 0.14}{\frac{0.07}{0.115} + \frac{0.14}{0.19}} = 0.155(\text{მ}^{2^0}C)/\text{ვტ}$$

- For basement ceiling

$$R_{\text{ალიაბ,}} = \frac{0.07 + 0.14}{\frac{0.07}{0.115} + \frac{0.14}{0.23}} = 0.173(\text{მ}^{2^0}C)/\text{ვტ}$$

b) Separate regular element and divide heat stream with rectangular flatnesses (isothermic flatness). We shall come up with three parallel sections.

a and в sections are homogenous, whereas section b is heterogenous, consisting of air laeyere and concrete screen layer with the width of 0.07 m and thichkness b=0.14m

$$R_{\text{რკ.ბეტ,}} = \frac{0.14}{1.92} = 0.073(\text{მ}^{2^0}C)/\text{ვტ}$$

We shall define hear resistance of thermal conductivity of these sections:

$$R_a = R_b = \frac{\delta_a}{\lambda_b} = \frac{0.04}{1.92} = 0.02(\text{მ}^{2^0}C)/\text{ვტ}$$

- For attic ceiling

$$R_{\text{ალიაბ,}} = \frac{0.07 + 0.14}{\frac{0.07}{0.073} + \frac{0.14}{0.15}} = 0.109(\text{მ}^{2^0}C)/\text{ვტ}$$

- For basement ceiling

$$R_{\text{ალიაბ,}} = \frac{0.07 + 0.14}{\frac{0.07}{0.073} + \frac{0.14}{0.19}} = 0.122(\text{მ}^{2^0}C)/\text{ვტ}$$

Wholly regular component's heat resistance thermal conductivity equals to:

$$R_{\text{იზოთ.}} = 2R_{\text{ადიაბ.}} + R_{\text{იზოთ..}} = 2\cdot 0.02 + R_b$$

- For attic ceiling:

$$R_{\text{იზოთ.}} = 2\cdot 0.02 + 0.109 = 0.149(m^{2\,0}C)/W$$

- For basement ceiling:

$$R_{\text{იზოთ.}} = 2\cdot 0.02 + 0.122 = 0.162(\text{მ}^{2\,0}C)/\text{ვტ}$$

Average meaning of regular cell's abiatic and isothermic flatness division (thermal conductivity of full heat resistance) returns results that are calculated using the following formula:

For attic ceiling:

$$R = \frac{0.155 + 2\cdot 0.149}{3} = 0.151\text{მ}^{2\,0}C)/\text{ვტ}$$

- For basement ceiling

$$R_{\text{ადიაბ,}} = \frac{0.173 + 2\cdot 0.162}{3} = 0.166(\text{მ}^{2\,0}C)/\text{ვტ}$$

Found results of attic and roof heat resistance can be applied as known variables in the further heat insulation calculation process for roof constructions.

Algorithm for the calculation of heat insulation thickness of the construction

The main pre-condition for selecting thermal insulation thicknkess for the construction with known physical compsoition is the following: reduced heat resistance of heat conductivity $R_0, \text{მ}^{2\,0}C)/\text{ვტ}$ shall be no less that heat resistance of thermal conductivity of the casing construction.

1. We defined heat resistance of thermal conductivity of the casing construction $R_{\text{მოთხ}}, \text{მ}^{2\,0}C)/\text{ვტ}$
2. We shall find out coefficient of thermal technical uniformity r.

In case of homogenous wall the heat transmission occurred from hot environment to cold with all mechanism of thermal conductivity: on surfaces heat is exchanged via heat convection and eradiation; in physical layers heat exchange via thermal conductivity. At the end, thermal conductivity occurs from how environment to cold. Sum of heat resistance of thermal conductivity for the complex wall equals to R_0.

$$R_0 = \mathrm{R}_{\text{შიგა}} + \sum \mathrm{R}_i + \mathrm{R}_{\text{გარე}}, \text{მ}^{2\,0}C)/\text{ვტ}$$

Where $\mathrm{R}_{\text{შიგა}}$ and $\mathrm{R}_{\text{გარე}}$ are heat resistance of thermal conductivity for internal and external surfaces, as for $\sum \mathrm{R}_i$ it stands for the sum of heat resistance of different layers.

In analysed case scenario, temperature field is considered as one dimensional. For analysed task this allowance is not viable and due to aerodynamic heating inside the wall, the temperature field can be two or even three dimensional. Besides, thermal resistance depends on internal links of inner layers of the construction that serve as heat conductive insertions.

By the influence of these factors thermal resistance will be reduced and will be conditional thermal resistance- $R_0^{\text{პირ}}$. The coefficient $r = R_0^{\text{პირ}} / R_0$ is the thermal technical homogeneity characteristic that varies within the range of 0.65-0.98. In considered cases the result r=0.88 is accepted.

APPENDIX D. SANITARY AND EPIDEMIOLOGICAL STANDARDIZATION IN GENERAL EDUCATIONAL ESTABLISHMENTS

For ensuring optimum study process for pre-school and school age pupils, protecting their bodies from harmful physical factors, Ministry of Labour, Health and Social Affairs has issued order N 308/N on 16th of August 2001 on sanitary-hygienic and epidemiological standardization norms called "Sanitary norms and rules in pre-school and general educational establishment equipment on their equipment, management and working order". Norms are required in every pre-school or general education establishment in every city, village or settlement regardless to their ownership type or subordination.

According to normative documents, every single kindergarten must fulfil the standard requirements, more specifically: requirements for land plot, building, natural and artificial lightning, sanitary-technical equipment, storages, containers and allotment sanitary conditions, thermal and air regime, eating outlet equipment, product storage and food preparation, personnel hygiene, rules of admissions, day schedule and study activities organisation, catering management, physical education management and children hygiene education and upbringing.

For inventerozation of kindergarten energy consumption, from above listed requirements special attention shall be dedicated to building sanitary requirements, natural and artificial lightning, thermal-air regimes, catering outlet equipment, product storage and food preparation sanitary norms.
Based on norms and regulations, kindergartens must be situated on separated land plots of the micro district 300 m radiuses away from the high street, communal or industrial plant. The distance from the kindergarten building till the red line should not be less than 25 m, as for boundaries between land borders and residential quarters and windows, no less than 10 m.
Pre-school educational establishment main building must have natural lightning. On another hand, during the lightning the depth of the group room can be 6m, for deeper building two-sided parallel or angle alignment of windows is necessary.

The source of artificial lightning must ensure sufficient and even lightning of an entire building. Luminous lightbulbs as used for light source at groups, music and gymnastics halls shall be of 200 lux at 0.5 m above the floor level, in the entrance hall at 0.8m., dressing rooms-at the floor level; in those room were children under 6 are taught, lightning on the tables shall be 30 lux; in bedrooms, isolation chambers and ill children's room 75 lux at 0.5 m above the floor level.
When lightbulbs are used, the level of lightning shall equal to 100 lux. In those rooms where children are constantly present, switches must be installed at 1.8m above the floor. Artificial lights must come on in accordance with so called light calendar.
Pre school educational establishements for children must have central heating and ventilation. In village type settlement with no more than 50 people, wood stoves are allowed, but stove must be locked hermetically. The building must be heated up 1.5-2 hours before the commencement of the study process.

Room temperature depends on the purpose of the room and age of pupils. Playroom and group rooms, situated on the first floor, the floor temperature in the winter shall not be below 22 degree. Relative moisture content during the occupancy periods shall be 40-55% in kitchen and laundry room 60-70%. Throughout warm periods of year non-stop aeration is recommended, in cold period brief reduction of air temperature to 18 degree for senior preschool children and to 19 degrees for junior preschool children is allowed.

APPENDIX E. COSTS OF ENERGY SAVING AND LOW EMISSION RENOVATION ACTIVITIES BASED ON EXAMPLE OF KINDERGARTEN # 95[20]

In the process of designing energy efficiency measures for buildings, it is crucial to pay particular attention to the key parameters of building physics, such as: construction thermal technique (degree-days, thermal conductivity, modes of humidity, air penetration); building lightning technique (artificial and natural lightning; sun and earth radiations); building acoustics and sound insulations. These factors serve as basis for energy efficiency planning and implementation.
Major activities within the scope of this project for improving thermal technical characteristic of external casing:

Heat bridges and heat envelope of an external casing

Based on energy audit analysis, for reducing energy wastes for the kindergarten buildings, it is important to improve construction casing heat envelope. External heat insulation of all 4 façade wall, roof construction, 00 and floors on other levels (parts in touch with exterior) must be heated from beneath, by increasing heat bridge's thermal technical indicators' and renovating windows.

- **Improving thermal characteristics of the roof**

One of the schemes of roof's heat insulation implies organization of green roofs. By the means of green roof, gravity filtration of the rain water is done. Green roof ideology reduced area of heat islands.
At the same time the second, sufficiently original heat insulation system is planned, which considers the integration of solar photovoltaic and collector systems within the roofing. The mounting of solar pipes is envisaged, providing the transformation of solar rays without change of temperature in the building.

- **Actitvities for improving thermal and hydro insulation characteristics of walls**

Thermal technical characteristcis of the project building is calculated for U=0.057 indicator (time of heat stream conductivity per one area unit). Wall panel improvement is implemented not only for wall, but for the floor truss tile areas in contact with environment and influenced by the temperature, From the basement side, on 00 level, fully heat-insulated concrete tile and =3.6 level floor tile section that has a direct interaction with an exterior. Such envelope of heat insulation ensures high indicator of heat momentum and provides opportunity for utilising low temperature,

[20] Accounting for the program of measures to be carried out at 1 m^2 of kindergarten was performed at the model case of No. 95 kindergarten.

energy efficient energy generators. Wall heat insulation envelope implies existence of steam barriers, leading to significant improvements of hydro insulation indicators.

Improving of thermal characteristics and hydro insulation qualities of window openings; Dew-point temperature location corrections

In all eight inspected kindergartens 40% is wasted through transparent components of constructions (windows, heat bridges, gable windows) inefficiency, hence construction solutions are expressed in several types of actions:

1. Reduction of excess amount of windows to reasonable number. In the place of freed openings, installation of energy efficient wall block. Each layer of the wall element (air in touch with surfaces, heat insulation, frames and transparent surface) must ensure standard weighted heat resistance indicator, no less than R+13+5/. The standard defines transparent material sun heat flaw coefficient, as 0.4(please refer to illustrated building code, 4^{th} edition, Francis D.K. 2012).
2. Heat bridges renovation and correction of dewpoint temperature.
3. Replacing individual knots of window openings with more energy efficient ones
4. On certain terraces (pergolas) and sun blinds installation, for the purposes of heat stain areas reduction and sun beam streams seasonal management.

<u>Activities for minimization heat stains</u>

As the result of solar irradiation of the larger areas (concrete and asphalt surfaces), they heat up and produced heat stains, containing the heat for the long periods of time. Such surfaces require proper management. Project building roof and terraces represent typical heat islands (total area approximately 1200 sq. meters) requiring special handling.

On the roof surface, this problem can be solved by organising green surface. From this stand point, problematic are balconies and terraced situated on the south façade of the building. For managing heat streams onto them, we consider appropriate setting up shady areas using deciduous plants. Such shades will provide on larger areas of south façade cool microclimate alongside windows and leaded panes. In winter periods, after the leaf drop, sun beams will increase temperature of the tile and provide relatively warm microclimate alongside the windows.

After implementing activities described herewith (total cost of 335 000 GEL), in case of kindergarten # 95, heat waste will be reduced by approximately 58.9%, leading to 9 222 GEL reduction of overall cost (24 731 GEL).

Renovation of heat systems (solar collectors, high efficiency boiler, heat pump and photo voltaics)

Hydraulic switching mechanism of the heating system is represented by one heat pump, with the capacity of 13.5 kWh, hot water storage reservoir-1 500 litres, gas condensing boiler-100 kW (due to the fact that efficiency of an old boiler is very low, the risk of malfunctioning and additional costs for connecting to network exist; it is advisable to connect to the network high efficiency gas condensing boiler) and solar concentrator-20 sq. meters; also the network includes 5 kWh photo voltaic shingle and accumulators with the capacity of 1.14 kW. Energy saving indicators of such system reach up to 62% (13.5 kWh thermal energy will be saved in this way).

Annual gas savings will be 151 days*12 h*13.5 kWh/9.4=2 602 m^3, volume expressed in money terms as 1223 GEL per annum.

As for saved emission it equals to 24 462 kWh*0.202 $kgCO_2$ /kWh= 4.9 tonnes per annum.

It is worthwhile to considered that nameplate capacity of a photovoltaic shingle is 5 kWh, heat pump consumption is 13.5/3.5[21]=3.86 kWh, remaining 5kWh-3.86 kWh=1.14 kWh is used for pumps (operating water all year around) and emergency lightning.

Therefore, energy generated annually by a photo voltaic, excluding heat pump consumption equals to 366 days*1.14 kWh *12 h+ (366-151) days *3.86 kWh *12 h=5 836 kWh. If we assume that 80% of this energy is consumed by the of effective energy management system, hence the overall electricity saving per annum is 5 836*0.8=4 669 kWh, expressed in monetary values as 4669 kWh *0.177 GEL =826.41 GEL. The given saving of electricity also reduces emissions by 4 669kWh*0.136 kgCO2/kWh=0.63 tonnes.

Besides, the given system enables to replace so called Thermex electrical devices used for hot water generation. Given activity shall provide 14 784 kWh savings per annum corresponding to 2620 GEL. Reduced emission 14 784 kWh*0.136 kgCO2/kWh=2.0 t.

Therefore, combination of heating and hot water generation activities guarantee 4.9+0.63+2.0=7.53 tonnes of emission reduction annually.

New system of heating and hot water supply ensures annual savings of 4 669 GEL. Emission
Total cost of installation of the given heat and hot water generation system is 110 247 GEL:

1. Photo voltaic shingle-**22 000** GEL;
2. Electricity accumulator 1.15 kw-**5 500** GEL;
3. Solar collector, bivalent boiler, 3 units, 500 litres, hot water boiler 400 litres, installation package, pump controller 1 unit, pump collection 1 unit, pointers 2 packs, surge tank, liquid for the system-100 litres, installation works-**46 625** GEL;
4. Gas condensing boilers 100 kw, automated; 3 collectors profiled; pump group with mixing system-**15 822** GEL;
5. Heat pump 2 units, automated-**20 300** GEL.

   Therefore, payback periods equals to 23.5 years. Based on above mentioned, the given activity does not necessarily have a direct economic impact, however plays significant role in emission reduction plan.

Micro energy management system

The restoration project of the kindergarten N95 in Tbilisi foresees an organisation of micro energy management system. This a system of energy resource management based on specific algorithm, integrated with smart systems of management.

By means of this device financial monitoring of various networks, management of supplied and generated energies is possible. Information is presented in visualised manner, consumers would be able to select profitable supplier for profitable time slot22.

[21] 3.5 is the value of Coefficient of Performance of the Heat Pump, being the ratio between the work performed and obtained heat/cold.

Kindergarten employees will have an opportunity to observe energy consumption and generation processes on specifically installed informational screens or special devices (smartphone, computer, tablet)
This stand serves as a tool for increasing awareness on energy management and implementation of energy efficiency measures (climate change battle) amongst children. Animated modules of green lessons will be displayed on stand, enhancing visualisation of the information. For example, such modules can be:

- Scan of energy consumption and identification of opportunities for energy savings in building lightning, heating, cooling, ventilation
- Identification of smart counters
- System of energy monitoring, reflecting loopback about energy consumptions and give advices for ensuring energy saving.

Precipitation water collection and management

As the audit of kindergarten building N95 has revealed, substantial resources are spent on water consumption. Therefore, the decision has been made to carry out renovation works in this direction, guaranteeing reductions of operational expenditures and simplifying the process of operation itself;
Kindergarten buildings, as the rules, consume two types of water;
1.Technical water, used for irrigation, cleaning and washroom facilities;
Drinking and catering water, used for dish washing and other catering related activities.
Water supply is realised via centralised piping network, and during the study period, monthly supply volumes equal to 200-250 tonnes. Out of this volum, 40% comes on technical needs, 60%-catering;
Existing project for kindergarten restoration implies rain water harvesting for its further utilisation. An expected volume of such water, based on average annual precipitation indicators (500-600 mm) is approximately 60-80 tonnes. This does not exceed 2-3% of total water consumption of pre-educational establishments. Therefore, inclusion of secondary waters in overall utilisation is utterly important.
Water management principle implies hybrid utilisation of the resource. For culinary need the water shall be purchased from municipal water Distribution Company and technical water requirements will be fully satisfied by the secondary water. These measures shall reduce water expenditure for kindergarten by 50%.

APPENDIX F. WATER MANAGEMENT AND WASTE WATER HANDLING SYSTEMS

The process of restoration of the kindergarten N 95 in Tbilisi covers organisation of secondary water management systems. Given system implies both rain water harvesting and waste water secondary utilisation for technical purposes. However, it must be noted that implemented measures ensure attaining other goals, such as: savings during the operation (obviation of occasional maintenance) and improving building heat casing.

[22] This refers to different supplyers and consumers of energy within the system of one building.

For the purposes of the rain water harvesting green roof and complex of water collecting components will be introduced, with the total cost of 91 175 GEL.

Operational life cycle of green roof is about 50-60 years. Cheap alternative of such roof (that does not provide effective means for water collection) is a bitum polymeric membrane roof (present condition of the roof). Initial investment of such roof is 12 000-16 000 (on average 14 000) GEL, however its operational cycle does not exceed 4-5 years. Bitum is dark coloured material and surface temperature in summer reaches 60-65 degrees of Celsius, creating substantial heat waves.

Temperature increase on green roofs is minimised due to the existence of green surface and it acts as a water filter simultaneously.

Based on this, if we assume that throughout 50 year life cycle, roof renovation or replacement will be necessary every 5 years, for this time period roof operation on average shall cost 126 000 GEL. Therefore, the cost of the green roof 91 175 GEL is significantly cheaper alternative.

Additional saving is attained by using water collecting system. Annual expenditure on water supply of the building currently amounts for 7 300 GELs. The green roof with functionalities of secondary water recycling, will ensure supply of 50% consumed water independently from the network, reducing annual expenditure by 3 650 GEL.

Table 22. Accumulated expenditure year-by-year basis looks as following:

Year	Green Roof	Bitumen Polymer Membrane
1	94 825	21 300
2	98 475	28 600
3	102 125	35 900
4	105 775	43 200
5	109 425	64 500
6	113 075	71 800
7	116 725	79 100
8	120 375	86 400
9	124 025	93 700
10	127 675	115 000
11	131 325	122 300
12	134 975	129 600
13	138 625	136 900
14	142 275	144 200

From the given table, it becomes obvious that proposed system guarantees full investment pay back in 14 years.

Besides, given measures, ensure CO_2 emissions reduction. However, due to the fact that water origin and accordingly emission source is out of Tbilisi city boundaries, this activity is considered solely by economic parameters.