# Project Design Document

# The thermo-technical rehabilitation of public and apartment buildings in Ulaanbaatar / Mongolia

**Ulaanbaatar / Mongolia, November 2013**

## Contents

## Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| BMZ | Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung |
| CDM | Clean Development Mechanism |
| EUR | EURO |
| ERA | Energy Regulatory Authority |
| GASI | General Agency for Specialized Inspection |
| GIZ | Gesellschaft für Internationale Zusammenarbeit<br>*German International Cooperation* |
| ICLEI SEA | International Council for Local Environmental Initiatives South East Asia |
| JICA | Japanese International Cooperation Agency |
| KfW | Kreditanstalt für Wiederaufbau<br>*German Bank for Reconstruction* |
| KOICA | Korean International Cooperation Agency |
| MES | Ministry of Education & Science |
| MEGD | Ministry of Environment and Green Development |
| MNT | Mongolian National Tugrik |
| MCUD | Ministry of Construction & Urban Development |
| ME | Ministry of Energy |
| UB | Ulaanbaatar |
| UN-Habitat | United Nations – Habitat |
| UN ESCAP | United Nations Economic and Social Commission for Asia and the Pacific |
| HPUA | Housing and Public Utility Authority |
| TTR | Thermo-Technical Rehabilitation |
| PIU | Project Implementation Unit |

Exchange rate: 1 USD = 1750 MNT

# 1. Executive Summery

The Regional GIZ Project "The Integrated Resource Management in Asian Cities: the urban Nexus", financed by the German Federal Ministry of Economic Cooperation & Development (BMZ) promotes the practical implementation of planning and management approaches for an integrated urban resource management for the sectors of energy, water and food security in 10 selected Asian cities of 6 countries in Asia and Pacific region. The Political partner of the Project is UN ESCAP located in Bangkok. ICLEI SEA is the implementation partner.

In the frame work of this project Ulaanbaatar city (as one of the ten selected cities participating in the Project) has submitted 2 project proposals for cooperation with the Regional GIZ Project. One of the project proposals deals with “The thermo-technical retrofitting of existing apartment and public buildings in Ulaanbaatar”. The GIZ Project accepted these proposals and requested Ulaanbaatar city to set up a Nexus Task Force which subsequently has been established via Resolution of Mayor of UB No.A/884 from Sep.18, 2013 installing also a Project Steering Committee. The Project Steering committee is chaired by Mr.B.Badral, General Manager of Ulaanbaatar City and Head of the Governor’s Office.

In order to start with the Nexus Project study one project location in Ulaanbaatar for the implementation of “The thermo-technical rehabilitation of existing apartment and public buildings” project has been identified using certain criteria. This location has been presented to the Task Force to get their comments and suggestions. The Task Force has agreed to the selection of this location for the project implementation.

Ulaanbaatar City intends to implement here a project dealing with both; heat energy savings through additional insulation of panel buildings and introduction and testing of consumption based tariffs for heating as demonstration, training and learning show case and by doing so it will demonstrate an integrated resource management approach by solving the pressing problems of the city especially with regard to heating energy shortage. In the same time it will contribute to reduction of greenhouse gas emissions and creation of an environmentally friendly City.

Target groups of the Project are residents of apartment buildings, school, kindergarten and orphanage children, teachers, architects, engineers, contractors as well as decision-makers and the population of Ulaanbaatar.

According to the preliminary cost estimation the Project costs for TTR measures of **apartment buildings** amounts to MNT **17’327’495’000.0** (**USD 9’902’000** )**.** It includes the cost for main TTR relevant measures (such as external wall insulation, roof insulation, basement ceiling insulation, replacement of windows and entrance doors, complete renovation of the heating system). The cost for TTR measures and renovation of the heating system and sanitation of **non-apartment buildings** (schools, kindergarten, orphanage) amounts to MNT **3’665’090’000.0** (**USD 2’095’000**).

All phases of the project starting with the elaboration and approval of the project design document until completion and handing over be will be led by the Project Steering Committee established via Resolution of Mayor of UB No.A/884 from Sep.18, 2013. The Task Force under the Steering Committee will provide necessary technical support through elaboration of the project design document and support the PIU during the project implementation.

The regional GIZ Project will provide support to the Task Force for the elaboration of the project design document, and will provide support to the Ulaanbaatar city by seeking for project finance. The GIZ Project will provide also advisory service to the Project implementation unit (PIU) for the selection, introduction and adaption of new technologies; will provide support through site supervision and training.

The Ulaanbaatar city will be responsible (through installing of PIU) for the project implementation, especially for project financing. Other key stakeholders are the condominium organizations and their Supreme Council, Housing Company, District Heating Company, MCUD, MEGD and the Energy Regulatory Authority (ERA).

The project design document comprises apart from Executive Summary the following Chapters:

- Problem analysis (Rationale),
- Project design
- Technical Feasibility
- Partner organizations
- GIZ experience in Mongolia
- Costs
- Partner contributions
- Schedule.

All other aspects of the project for instance, Institutional and Legal Framework, Socio-Economic Feasibility, Training and Capacity Building, Financial Analysis and Programme Implementation Concept have been studied thoroughly in CDIA Pre-feasibility study[1] and GITEC Feasibility Study Report[2].

It is intended that other Mongolian Partner organizations such as MCUD, ME, MEGD, MES and GASI will contribute in kind through supporting the issuing of relevant documents for example building permits and facilitating relevant administrative procedures.

The duration of the project implementation is planned for two years from 2014 to 2016.

## 2. Problem Analysis (Rationale)

Ulaanbaatar, the Capital of Mongolia has 1, 2 million inhabitants. Nearly half of the population of 2,7 million lives in the Capital City with additional 30.000-50.000 migrants moving to UB every year. The migrants settle down mostly in the Ger districts encompassing 65% of the population of UB. The public urban services cannot comply with the ever growing demand for physical infrastructural provisions.

Ulaanbaatar's housing stock is still dominated by pre-cast concrete panel buildings from the 1970s, 80s and the early 90s. More than 20% of the over 1 million city's population lives in these buildings. Total over 500 five to twelve story pre-cast-panel buildings accommodate some 50,000 apartments. The buildings are in an inadequate state due to their age, poor or non-existent maintenance and lack of insulation. Rehabilitation of the buildings is required for social,

[1] CDIA Thermo-Technical Rehabilitation of Pre-Cast Panel Buildings in Ulaanbaatar, Pre-Feasibility Study Final Report, May 2009
[2] GITEC TTR Feasibility Study - Phase 1 Report, VOLUME 1 – MAIN REPORT, June 2011

environmental and economic reasons. It will not only improve the residents' well-being but also prevent an important part of Ulaanbaatar's housing stock from decaying and turning into slums.

In Ulaanbaatar, there are 200.000 pupils in more than 206 primary and secondary schools out of which 110 are governmental and 96 are private.

According to an internal study of UB City Government, there is a deficit of 20-30 schools, i.e. there is a deficit of 20.000-30.000 schooling places for children and adolescents. A majority of the schools are connected to heat only boilers fueled by coal contaminating the environment.

The problem of missing schooling facilities has been aggravated through the transition to a 12-year primary and secondary education cycle by MES in 2008.

A majority of schools in UB and other locations like Baganuur have up to three shifts of teaching per day to cope with the ever increasing number of children in demand of schooling.
This problem will grow because of the baby boom in Mongolia starting recently because of incentive fiscal policies of the Mongolian Government for more child birth to have more Mongolian citizens in this scarcely populated Country.

More than 70% of the 110 governmental schools have been constructed before 1970.

Earthquake safety considerations had not been taken into consideration at that time.

Schools built after 1970 are of better quality as the drawings have been checked from 1970 onwards.

At least 10 % of all schools in UB have to be demolished because of not corresponding to safety requirements. Because of missing schooling capacities demolitions have not taken place.

The hygienic conditions in the schools and kindergartens in particular in the Ger districts are a great problem.

Often there are only pit latrines. Moreover, there is no flowing water to wash one's hands or to shower.

The children hence are not taught the most basic hygiene rules and regulations and are increasingly exposed to infectious diseases.

The Government of Mongolia gives high priority to the education of the Mongolian youth.

6 % of the GDP is currently spent on education. However, that is not sufficient taking into consideration the growing needs for education in a growing population with 1.9% population growth in 2009.

An Education Master Plan for 2009 to 2015 elaborated by the MES and shared with the donors determines the orientation of educational policies.

It focuses on a solid primary and secondary education, reducing drop-out rates, the construction of more schools and kindergartens throughout the Country and a concentration on Technical and Vocational Training (TVET) instead of university education as only means for a career.

Considering the transition to a 12 year primary and secondary education system there is a strongly felt need for more adequate schooling facilities. It is well-known that favorable schooling environment strongly enhances the mental and physical capabilities of adolescents.

With the growing number of migrants from other Aimags settling down in UB the situation of missing adequate schooling facilities is critical in the Capital.

Moreover, budget running costs for heating are a heavy financial burden for the state budget.

With improved thermal insulation the heating costs could be reduced by more than half while the children could learn in an environmentally and child-friendly environment. Savings in CO2 emissions would also be reached.

The MES is determined to improve the learning situation especially for children of young age.

It is envisaged to introduce international standards to the construction and retrofit of schools in order to compete and catch up with more advanced Countries.

As there is not sufficient money available for new construction, retrofitting of schools is becoming more and more popular. However, there is a lack of experience with regard to retrofitting technologies in particular considering energy-efficiency and improved sanitation.

Respective awareness raising campaigns with regard to environment and hygiene rank high on the Agenda in the MECS and UB City Administration. However, without facilities for hand washing and showering only using pit latrines this is rather difficult. Best practices in particular in the Ger districts are needed, to raise the consciousness in sanitation and improve the health situation.

This is also to be seen in the context of the Millennium Development Goals Mongolia has committed herself to.

The promotion of sports facilities (sports halls) is a top priority for the Mongolian Authorities of MECS, GASI, the Specialized Inspection Agency of UB and UB Superintendent Education Department.

Costs for heat energy supply in public buildings such as government buildings, schools and hospitals are a burden for the public budget although the heat energy is subsidized. Heating costs and hence CO2 emissions could be strongly reduced through improved thermo-technical insulation of public buildings.

The demand for potable water will also surpass the existing reserves in UB by 2014.

New techniques considering waste water recycling are urgently required to ease the situation.

A similar situation is occurring with regard to electricity provision. Again the current demand is already now surpassing the installed capacity.

In order to raise children in a healthy manner it is considered vital to complement mental training by physical training. The retrofitting of sports' halls, closed down by the GASI because of health

risks, is therefore essential to achieve internationally acceptable educational standards. This is one of the national priority needs of the Mongolian Education Sector in the framework of a modernizing Mongolian Economy and Society due to increasing wealth perspectives.

UB Master Plan covers systematically the needs for a sustainable city development and embraces the objectives of the 'Thermo-Technical Rehabilitation of Pre-Cast-Panel Buildings and public buildings (in particular schools & kindergartens) and recommends:

- Rehabilitation of built up areas and in-fill developments;
- Heat efficiency measures and introduction of consumption based tariff systems;
- Extension of existing building stock life span to reduce pressure on the housing market and demand / supply gap.

Moreover, the demand for heating energy provision in UB will exceed the installed capacity latest by 2014.[3] Shortages with regard to heating supply already occur nowadays in apartments and public buildings at the far end of heating supply substations. Recently the city Government of UB announced a list of around 80 newly constructed buildings which will be not connected to district heating system due to facing capacity shortage.

Costs for heat energy supply in public buildings such as government buildings, schools and hospitals are a burden for the public budget although the heat energy is subsidized. With improved thermal insulation the heating costs could be reduced by more than half while living and working environment could be improved.

Mongolian contractors, engineers & architects lack knowledge on thermo-technical rehabilitation and energy efficient, energy saving and renewable technologies.

# 3. Project design

Goal, outcomes, indicators.

## 3.1 Project Goal

The objective of the project design document is to provide necessary initial information required for the appraisal and approval of the "Thermo-technical rehabilitation of existing apartment and public buildings in Ulaanbaatar (Khoroo 16) / Mongolia" project by the Project Steering Committee (PSC), especially with regard to project location, technical feasibility, cost and financing.

After the formal decision and approval by the PSC it is intended to provide further recommendations and suggestions on the Improvement of Legal Framework, Socio-Economic Feasibility, Training and Capacity Building, Financial Analysis and Program Implementation Concept and other aspects if required.

After approval of the project design document by UB city Government the project document will be submitted to the Mongolian Partner Ministries like MCUD, MEGD, MED and international donor organizations for financial support and credits.

The project goal is formulated as follows:

[3] Respective data and calculations have been elaborated by JICA within the Master Plan for UB of 2008.

Demonstration of heat energy savings through additional insulation of public and apartment buildings improving the living and working conditions in the buildings and introduction of consumption based heating tariffs contributing to a resource efficient and environmentally friendly City as replicable model.

### 3.2 Indicators:

- Heating energy consumption in the thermo-technically retrofitted buildings of Khoroo 16 has been reduced by up to 50% (baseline 2013).
- CO2 emissions in the thermo-technically retrofitted buildings of Khoroo 16 have been reduced by 50% (baseline 2013).
- The consumption based tariffs for heating have been tested and introduced in the project area.

### 3.3 Project‘s results:

1. Additional insulation and rehabilitation of public and apartments buildings is improving the thermal comfort in apartments and public buildings.

   **Indicator:** the residents and public servants are satisfied with the building rehabilitation improving the living and working condition.
   Source: Satisfactory/examination Survey.

2. The residents and public organizations are paying for heating energy according to their consumption.

   **Indicator:** The consumption based tariffs for heating energy have been tested and introduced in the project area.

# 4 Technical feasibility

### 4.1 Project area and findings

The identified location (eastern part of the 16th *Khoroo* or Micro district in Bayanzurkh district, in the eastern part of the city) represents a typical apartment neighborhood/quarter dominated by pre-cast panel buildings (see Figure 1). The selection criteria for this location are given in Annex 1. The Google picture of the area is given in Annex 2 and the layout plan in Annex 3 respectively.

This part of the 16th Khoroo, which is characterized by predominance of 5 (altogether 19 buildings) and few 9 (altogether 3 buildings) story panel buildings disposes of currently 1465 households or 4972 residents. Also public two secondary schools, one public kindergarten, one public orphanage (the only one in Ulaanbaatar), one private hospital and several one family houses are located here. “Ulaankhuaran Urguu” Housing Company, one the 20 city owned housing companies is serving this area with regard to district heating, power, water and sewage.

**Public buildings:**

The schools comprise:

School No. 53 (built in 1973) with an installed capacity for 920 children serving 1602 children from grade 1-12 with three shifts and 85 teachers at the moment.

School No. 44 (built in 1970) with an installed capacity for 960 children serving 2378 children in three shifts with 112 teachers at the moment.

Kindergarten No. 82 (built in 1980) with an installed capacity for 250 children serving 563 children with 15 teachers at the moment.

**Pre-cast-panel buildings:**

This panel buildings are 17-32 years old and besides some “cosmetic” repair work and roof renovations no significant overhauls have been undertaken in the past leading to gradual dilapidation of the panel buildings in general. Huge heat loss through the concrete panels, especially through panel joints is very common for this type of buildings.

One of the features in this Khoroo is the heating undersupply in general also due to the remote location from the power plants which are located in the western part of the city. According to the Housing company information the apartments are receiving only about 60% of the required heat load worsening additionally the living conditions in apartments and causing moisture damages like condensation and mould growth in the winter time.

Some of the 5 story buildings have been upgraded with so called “Mansard” stories. All buildings in the area are connected to the centralized power, heating, water supply and sewage system. Few multi-story buildings built here in the last years have been connected directly to main heating supply grids, having a heat exchanger of their own. The heating, hot and cold water are supplied by two substations in the area. The substations are in good condition, have been rehabilitated recently by a project financed by KOICA. Also about 70% of the main heating pipes have been replaced in the past. Hence only secondary distribution pipes have to be replaced during the Thermo-Technical Rehabilitation (TTR) measures if required.

The panel-buildings in the area have in general no structural deficits. Nevertheless it is recommended to conduct detailed structural assessment of the panel buildings before the TTR measures start.

***Figure 1.*** *The picture of 16th Khoroo dominated by 5 story pre-cast panel buildings*

### 4.2 General issues related to the implementation of TTR measures

Thermo-Technical Rehabilitation measures have to be implemented in compliance with the respective building codes. The Mongolian Building Norm and Code 23-02-09 for Thermal Performance of Buildings (MRTCUD, 2009) specifies the thermal resistance for building elements with the R value (W/m².C).

The rehabilitation works will be divided into thermo-technical relevant measures and non-thermo-technical relevant measures as shown below:

The TTR relevant works include:

- insulation of external walls;
- replacement of all windows;
- renewal of main entrance area;
- rehabilitation and insulation of roofs;
- insulation of basement ceiling;
- renovation of heating system and metering.

The Non-TTR relevant works include:

- rehabilitation of stairs;
- rehabilitation of power distribution network;
- rehabilitation of sewage, cold and hot water pipes in basement floor;
- rehabilitation of elevators (only in 9 story buildings);
- rehabilitation of basement floor (creation of additional storage rooms);
- external works which are essential for the functionality of the building.

All construction works will be carried out with the apartments remaining occupied by the dwellers. The working methods and work organization are to be planned accordingly in order to minimize the nuisance for the dwellers.

As indicated in the GITEC Feasibility study report "The construction of a mansard roof has been considered as the only promising alternative which would lead to a substantial reduction of the investment cost. This alternative would reduce the investment costs of the minimum work package by some 25%."

A computer based calculation on energy saving potential and initial cost estimations for TTR measures on panel apartment and non- apartment buildings (two schools, one orphanage, one kindergarten) are attached in **Annex 4** and **5**. The cost for the renovation of the heating system in apartment buildings is given in two versions in **Annex 10**. The first version has been included into total cost estimation of TTR measures. The cost for renovation of the heating system and sanitation in public buildings is given in **Annex 11**.

The similar calculation and estimation for other buildings in the 16$^{th}$ Khoroo could be done later in due course if required.

Other related calculations with regard to the total floor area, energy savings for particular building parts, investment cost for insulation and renovation of building assemblies are elaborated in **Annex 6**, **7, 8** (apartment buildings) and **Annex 9** (non-apartment buildings).

### 4.3 Energy savings and CO2 reductions

The potential heating energy, financial savings are given in **Annex 4** and **5** based on the calculated heat demand before and after the TTR measures.

The actual heat energy consumption for apartment buildings is around 300 kWh/a/m². The calculated heat consumption after TTR measures would be around 145 kWh/a/m².

A comparison of the energy saving scenarios of GTZ/UDCP, PFS and CDM Report with the calculations based on actual assumptions shows that the GTZ/UDCP and PFS analysis comes up with higher results (around 350 kWh/a/m²).

The actual heat energy consumption for non- apartment buildings is around 395 kWh/a/m². The calculated heat consumption after TTR measures would be around 170 kWh/a/m².

The annual heat energy saving for apartment buildings after TTR measures would be **8,240,017.7** kWh/a and **1,415,706.**6 kWh/a for non-apartment buildings respectively (see **Annex 4** and **5**).

The potential annual $CO_2$ savings both for apartment and non-apartment buildings have been calculated separately and amount to **3131.2 t** and **538 t** respectively. (see **Annex 12,13**).

### 4.4 Cost estimation of TTR measures

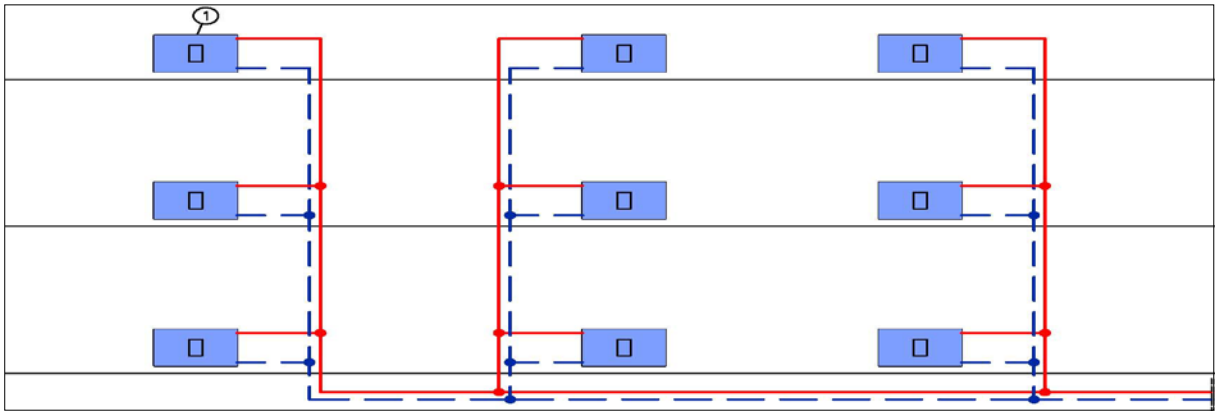
For cost estimation purposes the comprehensive Bill of Quantity (BOQ) which has been elaborated in 2012 in framework of GIZ/USAID project “Thermo-technical retrofitting of school buildings in Ulaanbaatar” and the current inflation rate have been used as reference.

The cost estimation has been done separately for apartment (includes 5 and 9 story panel buildings) and non-apartment buildings (two schools and one kindergarten) and includes only essential TTR works such as:

- rehabilitation of external walls
- replacement of all windows;
- renewal of main entrance area;
- rehabilitation and insulation of roofs;
- insulation of basement ceiling;

In frame work of TTR measures the two versions of renovation of the heating system have been considered. The first version has been included into total cost calculation. Within this version the one-pipe heating system in 5 storey panel buildings will be converted into two-pipe system (see Picture 2). Also heating radiators in each apartment will be equipped with heat cost allocators.

The total Project costs for TTR measures in the project area amounts to MNT **20’992’585’000**. This amount represents the minimum investment which is required for TTR measures on apartment and public buildings in the area (it doesn’t include cost for VAT, unforeseen works, technical supervision cost of the client, design cost, official charges, levy for standard fund etc.).



***Picture 2.*** *Two-pipe heating system.*

The unit prices of main construction materials to be used by TTR measures are based on current market prices considering those materials meeting the relevant standard requirements. The respective building layout plans have been used as a calculation base of the quantities for each sub-item. The item “Additional costs” includes costs like transport, labour, scaffolding etc.

A total number of 1172 apartments comprising a total gross area of 84549 m² and 13991 $m^2$ of two schools and one kindergarten and one orphanage building area are to be re-habilitated in the area. The cost for TTR measures for 1 square meter apartment building is MNT **205’000 (USD 117.0**). The cost for TTR measures for 1 square meter non- apartment building is MNT **262,000 (USD 150.0)**.

## 4.5 Instruments to recover the costs of rehabilitation investments

In order to recover the costs for TTR measures following changes should be introduced:

The Energy Law needs modification so that the direct reductions in energy production costs (primarily **savings in unburned coal**) which are the direct result of the Thermo-Technical Rehabilitation efforts will be assigned to the TTR project for repayment of investment.

The energy cost savings created by the TTR Project are essential to its financial feasibility, and need to be made available for servicing the incurred debt financing.

Introduction of the **betterment charge/fee** by the City Council should be seen as a cost recovery instrument for public investment in private property. It will allow the local governments and utilities to recover the investments necessary for TTR measures and to charge those owners who receive a direct benefit through the investment. The typical payment periods are 10 – 30 years. Which period is suitable for this particular case has to be studied further. The betterment charge is even more justified in the case of rehabilitation of privately owned buildings where the benefits go directly to the apartment owners.

As indicated in the CDIA Pre-feasibility study, the betterment charge is suggested as the ***main instrument*** to recover the costs of rehabilitation. It is compulsory and should be added to the monthly utility bill and collected by the housing companies together with the other service fees and charges; the housing companies would transfer the collected amounts to the executing agency of the Project which would use it for financing further rehabilitation and for servicing debts. The betterment charge for the individual apartment is calculated taking into consideration the total costs of building rehabilitation to be recovered, the period of recovery and the size of the apartment.

Also the introduction of a **connection fee** for developers and owners who want to connect their buildings to the district heat distribution system has been suggested in the CDIA Pre-feasibility study. Connection fees will allow individual owners the connection to the public service network; as the network capacity is limited and the extension is expensive, the connection fees compensate for consuming a part of the capacity which will be saved and made available through rehabilitation measures. Connection fees would represent an additional source of income which should be used also for energy efficiency and capacity expansion investments of the district heating system, incl. the rehabilitation of the existing secondary distribution networks.

The Non-TTR work items (external works and elevator rehabilitation / replacement) are foreseen to be financed by UB City counterpart funding. UB City has set up programs which target both work items and allocate the respective budgets on annual basis.

The optional Non-TTR items include the rehabilitation of the stair case and the improvement of the apartment double door system. Both items are important for the general impression of the joint property, ease maintenance requirements and increase security. They are, however, rather nice to have and not essential for the successful of TTR project.

The construction of a mansard roof has been considered as the only promising alternative which would lead to a substantial reduction of the investment cost for the minimum work package. The construction of mansard roofs is a common praxis in Mongolia.

As described in GITEC report the TTR tender document for this alternative would introduce a clause that the tenderer is obliged to construct a mansard roof on top of the existing flat roof according to specified professional standards. The construction company is to compensate the gratis availability of 'building ground' by taking over some minimum work package rehabilitation cost such as new main entrance, refuse room, fire escape rehabilitation, external TTR works, water / sanitation, electrical and safety measures. The roof rehabilitation can be omitted as the mansard floor serves as new roof. The optional staircase rehabilitation is commonly included in such contractual agreement.

As indicated in the GITEC report this alternative would reduce the investment costs of the minimum work package by some 25%. It supports in addition the city municipalities' efforts in developing a compact city with infill development and increasing the efficiency of existing infrastructure systems. In return, more apartment owners could benefit from the rehabilitation program.

There may be many other instruments to be explored as potential financial sources of the TTR Project. Also certain regulations and incentives have to be introduced to support the poor households who cannot pay for TTR measures and heat and energy bills. These and other options will have to be further investigated.

### 4.6 Introduction of consumption based tariffs

This TTR project should be used as a demonstration project for the introduction of consumption based tariffs based on heating system metering, control of heat flow at the substation and individual control of heat flow in each apartment, at each radiator. The bottleneck for the introduction of consumption based billing systems in the housing sector remains mainly in the need for refurbishment and rehabilitation of the heating systems which is based on the converting of one-pipe heating system into two-pipe system.

Substantial heating cost reductions up to 50% and more can be achieved by introducing consumption based billing after a refurbishment of the heating system and a thermo-technical rehabilitation of the entire building.

As per Law Energy Regulatory Authority (ERA) is the responsible body for the heating pricing system. Fixed lump-sum tariffs which are based on the heated floor space or heated volume are used in the housing sector. Despite some tariff increases in last years the financial sustainability of the heat transmission and distribution companies continues to be weak. Therefore their ability to cover maintenance requirements and access to commercial financing for modernization and expansion investments is limited.

The heating tariffs for housing are set by ERA currently at 341 MNT/m² (flat rate) and at 7'879 MNT/Gcal (consumption based rate). Metered tariffs for residential households are already in place since 2008. According to the preliminary calculation the charge for meter heating will be lower by up to 30% after retrofitting in comparison to fixed/flat rate.

The tariff structure provides significant financial incentives for efficient use of energy as long as consumption based tariffs are introduced. Most households, however, still pay flat rates due to technical difficulties of metering the consumption. Housing Companies of some new apartment

building blocks which have their own heat exchanger and heat meters bill the apartment owners based on consumption.

Most of the Housing Companies which manage the utility provision of the existing housing stock are rather reluctant in introducing consumption based tariffs as it would be accompanied by higher transparency of the whole billing system and might result in lower management profits.

The consumption based tariff does not provide an incentive to invest in the refurbishment of the heating system without thermo-technical retrofitting of the buildings. This explains the outcry by the end consumers when consumption based tariffs were introduced by an ADB pilot project without adding TTR measures. As indicated in the GITEC study the substantial heating cost reductions of 31% up to 62%, however, can be achieved only by introducing consumption based billing after refurbishment of the heating system and a thermo-technical rehabilitation of the entire building.

This documents that there is a need for political will and commitment to provide financial incentives for physical investments in TTR related energy conservation measures (the endorsement of the Energy conservation Law for example). The long term viability of this policy is to be assessed in order to promote energy conservation measures as well as affordable heating for residential households and a thriving energy& industrial sector.

According to the GITEC study the road map for the introduction of a city wide consumption based heating billing system would be:

- Memorandum of Understanding between ERA, UB City, District Heating Company, HPUA and Housing Companies to implement the existing ERA regulation for consumption based billing in the housing sector.
- Definition of the roles, responsibilities and requirements for each stakeholder in terms of investment needs, operation and maintenance requirements, recuperation of the investment costs and capacity development.
- Acquisition of funds for investment and capacity development.
- Simulation of consumption based heating tariffs for residential consumers and analysis of the results regarding heat company revenues, heating bills and impacts on consumers.
- Review of heating tariff levels and structure.
- Implementation of the respective physical works in designated clusters.
- Capacity building for Housing Companies.
- Introduction of comprehensive computer based billing systems by the Housing Companies.
- Information campaigns to educate consumers about impending changes and use of metering and control equipment and the impact on consumption based heating bills.

# 5 Partner organizations, networking & responsibilities

The following institutions are considered the main partners in this Project:

**Ulaanbaatar City Government (meso & micro level)**

- Mayor’s Office of Ulaanbaatar City
- Office of the Capital City Governor
- Housing and Public Utility Authority
- Housing Company

- District Heating Company
- Selected apartment and public buildings in the 16th Khoroo.

**National level (macro level)**

- Ministry of Construction and Urban Development (MCUD)
- Ministry of Environment and Green Development (MEGD)
- Energy Regulatory Authority
- General Agency for Specialized Inspection (GASI)

The Project Steering Committee installed in Ulaanbaatar City Government will in general be responsible for project steering and coordination. The PIU which will be responsible for the implementation will be reporting to the steering committee.

The Mongolian Partner Ministries and organizations such as MCUD, MEGD, MES, MED and GASI will contribute in kind through supporting the issuing of relevant documents for example building permits and facilitating relevant administrative procedures.

The Project will contribute to adjustments in three areas of the legal and institutional framework: in the tariff system, particularly in the part of heating tariffs for which ERA is in charge; in the Mongolian Building Code and Norms (BCN) for which both the Ministry of Construction and Urban Development and its Agency "Construction Development Center" are responsible; and in the financial instruments to recover the costs of rehabilitation investments, for which the responsibility lies within the City Government.

The GASI is responsible for building permits and acceptance of buildings before being handed over to the client. The GASI in particular checks the safety of the buildings in collaboration with specialized Technical Committees under the umbrella of the Construction Development Center. UB city Inspection Agency will be participating in the process.

The designs and the technical specifications will be elaborated in collaboration with Mongolian architects/engineers. It will be paid attention to elaborate the designs and specifications on the basis of Mongolian and international standards.

The tendering for TTR measures for selection of the contractors for retrofitting will be done by the PIU according to Mongolian Procurement Law and guidelines.

GIZ project will provide technical guidance, advisory service and advisory site supervision service to the PIU during the designing and implementation of TTR measures.

GIZ will also promote the Project and advice on the coordination of the different stakeholders involved in the Project.

# 6 GIZ experience in Mongolia

The GIZ is an international cooperation enterprise for technical assistance, owned by the Federal Republic of Germany. It is a public benefit organization not aimed at making profits. Profits (if any –e.g., reserves which were not required to cover liability risks) may not be

distributed to GIZ' shareholder (the German Government), but must be spent for development projects.
GIZ in Mongolia has implemented the following activities in the area of urban development, TVET (Technical Vocational Education & Training) and construction sector promotion:

GIZ has implemented the first thermo-technical rehabilitation of a pre-cast panel building in Mongolia. In order to scale up this demonstration project, a prefeasibility study financed by CDIA (Cities Development Initiative for Asia/ financed by the German, the Spanish Government and ADB) was implemented. The objective was to analyze the possibilities and costs for the thermo-technical rehabilitation of all pre-cast panel buildings in UB including a respective project proposal.

GIZ has implemented the thermo-technical rehabilitation of 3 secondary school buildings in Ulaanbaatar through financial cooperation with USAID improving the learning conditions of school children and reducing the running cost of heat only boilers. Heat energy consumption was reduced by 50% as well as CO2 emissions.

ADB financed a CDM Baseline study with regard to the thermo-technical rehabilitation of pre-cast panel buildings in UB.

KFW has completed a feasibility study on the thermo-technical rehabilitation of pre-cast panel buildings.

GIZ has designed a Mongolian-German ECO CITY on 72, 5 ha approved by the MRTCUD and UB CITY Government. The first two demonstration houses have been erected showing heat energy savings of up to 65%. It has also been demonstrated that solar energy functions for heating and warm water provision in the harsh Mongolian winter in combination with thoroughly insulated and well-designed houses.

GIZ has designed a child-friendly and an energy-efficient secondary school for Baganuur (District of UB) on behalf of the MECS. The school is be financed by the EFA-FTI (Education for All - Fast Track Initiative) Catalytic Fund administered through World Bank (2 Million USD). Construction has started in July 2011. GIZ plays an advisory supervision role and will conduct training to contractors during construction.

GIZ has implemented non-formal skills upgrading training in construction sector such as composite thermal insulation, dry construction, heating and sanitary installation, metal roof construction and road maker. Moreover, skills upgrading training courses for architects and engineers have been conducted in collaboration with the Construction Development Center of the MCUD with regard to energy savings and energy audits for buildings. Altogether some 150 engineers & architects have been further qualified.

## Costs

The total Project costs amount to MNT **20'992'585'000 (USD 11'995'760).** The Ulaanbaatar city will be responsible for project financing.

## Partner contributions

The Mongolian Partner organizations such as the MCUD, MEGD, UB City and GASI will also contribute in kind through making available the plots, the buildings for rehabilitation, supporting the issuing of relevant documents for example building permits and facilitating other administrative procedures.

## Schedule

The Project is envisaged to start in second half of 2014 ending in 2016.

# Annex 1

**Selection criteria for the implementation of TTR measures in 16th Khoroo in Bayanzurkh district:**

The following selection criteria for this location have been applied:

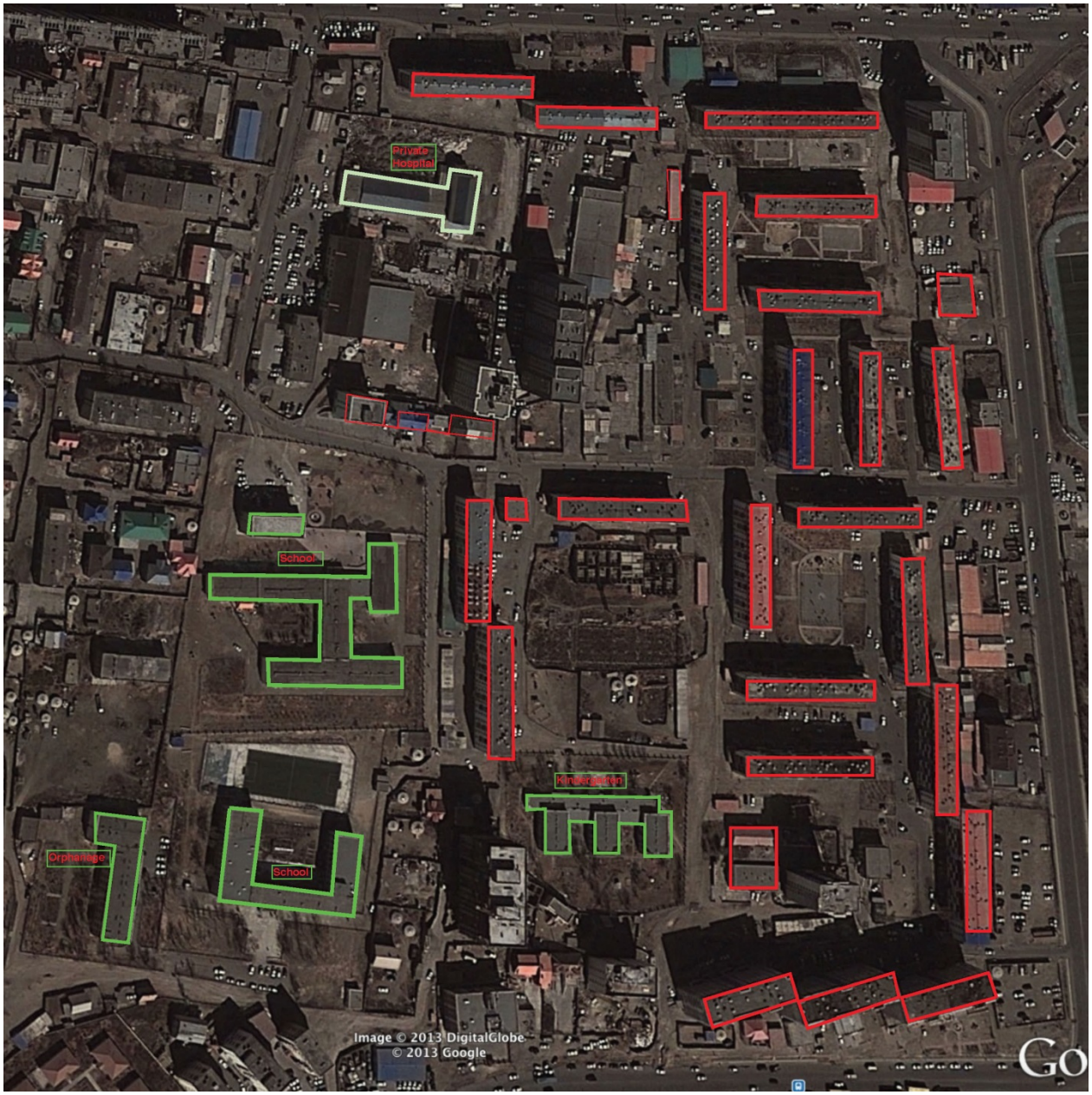
- The cluster comprises buildings which allow for flexibility in the number of apartments to be rehabilitated based on budget availability.
- The cluster is located at a prominent spot to attract interest in thermo-technical rehabilitation measures of apartment owners and the Ulaanbaatar community.
- The cluster is representative and includes one or more of the main panel building types and if possible, all panel buildings of a cluster should be rehabilitated; whereas the non-panel buildings should consume less than half of the cluster heating and should be easily equipped with heat meters.
- The cluster should not comprise 12-storey panel buildings and buildings which are in a bad physical condition as they might require too many repair works in addition to thermo-technical rehabilitation.
- The cluster should comprise panel buildings which have a good ratio of gross floor to total wrap area and minor numbers of extensions in the first floor.
- The apartment management cooperatives are supportive and the apartment owners are receptive for the TTR measures.
- Structural stability of the buildings
- Urgent need for thermo-technical rehabilitation.
- Unhealthy living and working condition due to excessive thermal loss und undersupply of heating energy

**Selection process:**

The location for the TTR project was presented to the Task Force which has been installed via Resolution of Mayor of UB in September 2013. The Members of the Task Force have agreed to this location, because among others the substation and about 70% of the main line have been renovated in the past, so that the project could concentrate more on TTR measures and improvement of the secondary distribution lines which belong to Condominium Associations and apartment owners.

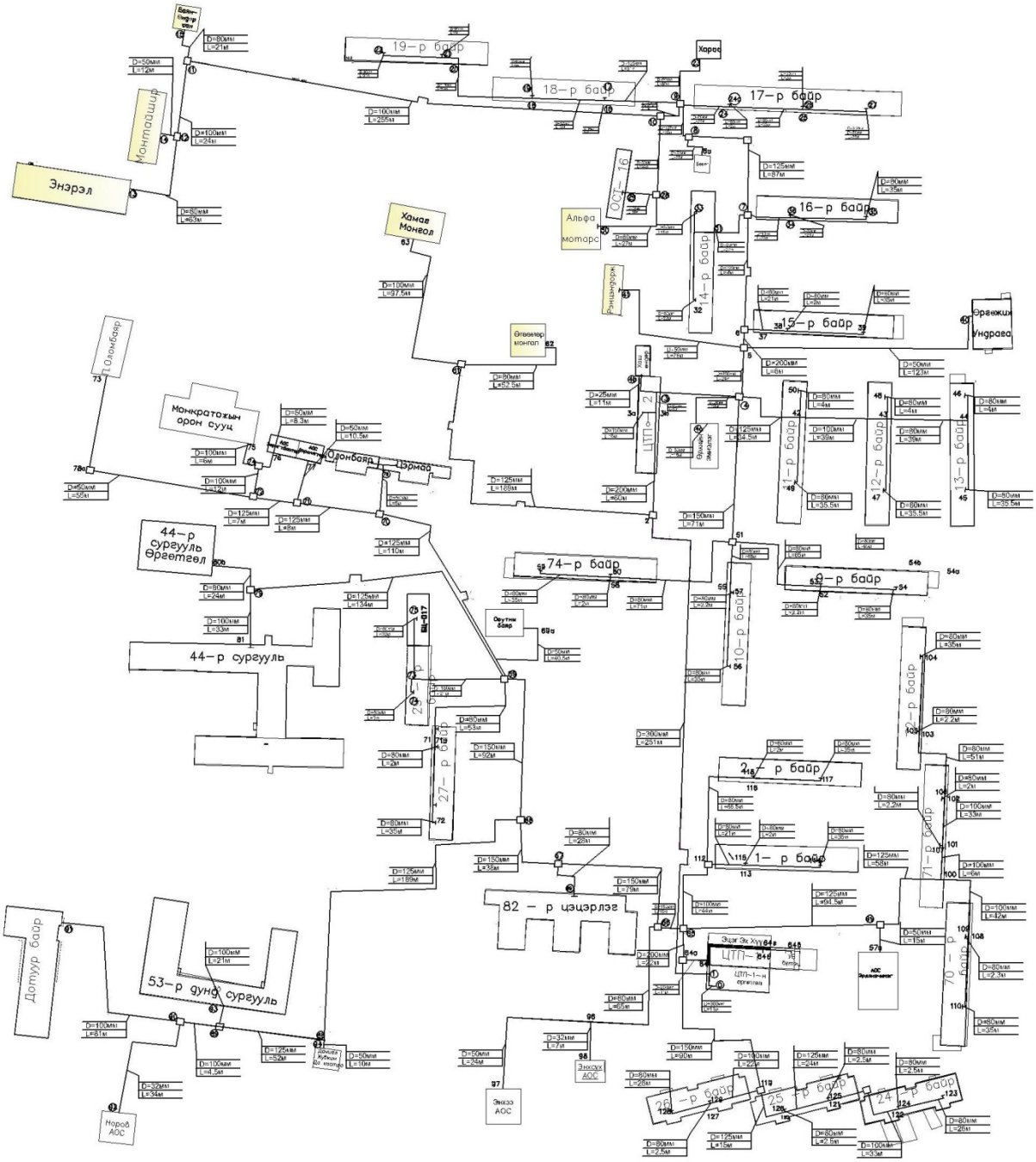
## Annex 2

***Google picture of 16th Khoroo***



# Annex 3
## Design of heat distribution net

16-р хорооллын УДДТ-1,2-ын гидравлик тооцоо




*Layout of the 16th Khoroo / Ulaanbaatar*

# Annex 4

## Cost estimation and heat energy savings for thermo-technical rehabilitation of apartment buildings

| | | | |
|---|---|---|---|
| | Interest rate | % | 12% |
| | Useful live | a | 30 |
| Price index | Annuity factor | | 0.124 |
| 1 | Heat energy price | MNT/kWh | 17.9 |

| | | Unit | Exterior walls | Basement ceiling (0,35) | Roof | Windows | Entrance doors |
|---|---|---|---|---|---|---|---|
| 1 | Number of calorific value | кКh/a | 142.2 | 49.77 | 142.2 | 142.2 | 142.2 |
| 2 | Surface area | $m^2$ | 38872.19 | 15456.72 | 15456.72 | 12784.32 | 240.43 |
| 3 | Investment costs per unit | MNT/$m^2$ | 87,860.00 | 62,510.00 | 120,110.00 | 230,000.00 | 230,000.00 |
| 4 | Investment costs for heat energy efficiency | MNT | 3,415,310,490.40 | 966,199,567.20 | 1,856,506,639.20 | 2,940,393,600.00 | 55,297,980.00 |
| 5 | Cost of capital per year | MNT | 423,989,135.95 | 119,947,548.20 | 230,473,524.46 | 365,031,216.15 | 6,864,893.49 |
| 6 | Total capital cost | MNT | 12,719,674,078.60 | 3,598,426,445.92 | 6,914,205,733.79 | 10,950,936,484.39 | 205,946,804.77 |
| 7 | Old U-factor | W/$m^2$*K | 1.05 | 0.88 | 0.44 | 3.1 | 3.1 |
| 8 | New U-factor | W/$m^2$*K | 0.212 | 0.275 | 0.19 | 1.7 | 1.7 |
| 9 | Heat energy savings | W/$m^2$*K | 0.838 | 0.605 | 0.25 | 1.4 | 1.4 |
| 10 | Heat energy savings per unit | Вт/К | 32574.9 | 9351.3 | 3864.2 | 17898.0 | 336.6 |
| 11 | Heat energy savings per year | кВт*цаг/a | 4632149.9 | 465415.0 | 549486.4 | 2545102.4 | 47864.0 |
| 12 | Saved energy cost per year | MNT/a | 82,915,483.81 | 8,330,928.10 | 9,835,806.49 | 45,557,333.42 | 856,765.74 |
| 13 | Benefit / loss per year | MNT/a | (341,073,652.14) | (111,616,620.10) | (220,637,717.97) | (319,473,882.73) | (6,008,127.75) |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total heat energy saving potential per year in kWh/a** | | | | | | **8,240,017.70** |
| **Total investment cost for energy efficient rehabilitation** | **9,233,708,277.00** | **MNT** | **5,535,796.33** | **US$** | **4,112,039.60** | **EUR** |
| **Investment cost to save 1kWh of heat energy** | **1,120.60** | **MNT** | **0,669** | **US$** | **0.497** | **EUR** |
| **Saved heat energy costs per year** | **147,496,317.60** | **MNT/a** | **88,162.80** | **US$/a** | **65,482.30** | **EUR/a** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total useful floor space area** | **$m^2$** | **84,548.90** | | | | | |
| **Investment cost per $m^2$** | **109,211.48** | **MNT/$m^2$** | **65.47** | ***US $/$m^2$** | **48.63** | ***Euro/$m^2$** |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

# Annex 5

## Cost estimation and heat energy savings for thermo-technical rehabilitation of non-apartment buildings

| | | | |
|---|---|---|---|
| Interest rate | % | | 12% |
| Useful live | a | | 30 |
| Annuity factor | | Price index | |
| Heat energy price | MNT/kWh | 1 | |

| | | Unit | Exterior walls | Basement ceiling (0,35) | Roof | Windows | Entrance doors |
|---|---|---|---|---|---|---|---|
| 1 | Number of calorific value | кКh/a | 142.2 | 49.77 | 142.2 | 142.2 | 142.2 |
| 2 | Surface area | m2 | 4947.26 | 5387.96 | 5387.96 | 1790.05 | 53.74 |
| 3 | Investment costs per unit | MNT/m2 | 87,860.00 | 128,250.00 | 120,110.00 | 230,000.00 | 230,000.00 |
| 4 | Investment costs for heat energy efficiency | MNT | 434,666,615.04 | 691,005,870.00 | 647,147,875.60 | 411,710,580.00 | 12,360,660.00 |
| 5 | Cost of capital per year | MNT | 53,961,103.41 | 85,783,996.09 | 80,339,304.25 | 51,111,257.25 | 1,534,497.54 |
| 6 | Total capital cost | MNT | 1,618,833,102.20 | 2,573,519,882.75 | 2,410,179,127.62 | 1,533,337,717.62 | 46,034,926.26 |
| 7 | Old U-factor | W/m2*K | 0.87 | 1.5 | 0.53 | 3.1 | 3.5 |
| 8 | New U-factor | W/m2*K | 0.2 | 0.33 | 0.19 | 1.7 | 1.7 |
| 9 | Heat energy savings | W/m2*K | 0.67 | 1.17 | 0.34 | 1.4 | 1.8 |
| 10 | Heat energy savings per unit | Вт/К | 3314.7 | 6303.9 | 1831.9 | 2506.1 | 96.7 |
| 11 | Heat energy savings per year | кВт*цаг/а | 471345.6 | 313745.8 | 260497.1 | 356362.4 | 13755.8 |
| 12 | Saved heat energy cost per year | MNT/a | 8,437,086.78 | 5,616,049.10 | 4,662,897.91 | 6,378,886.20 | 246,228.86 |
| 13 | Benefit / loss per year | MNT/a | (45,524,016.62) | (80,167,946.99) | (75,676,406.34) | (44,732,371.05) | (1,288,268.68) |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Total heat energy saving potential per year in kWh/a** | | | | | | **1,415,706.60** |
| **Total investment costs for heat energy efficient rehabilitation** | **2,196,891,601.00** | **MNT** | | **US$** | | **EUR** |
| **Investment cost to save 1kWh of heat energy** | **1,551.80** | **MNT** | | **US$** | | **EUR** |
| **Saved energy cost per year** | **25,341,148.90** | **MNT/a** | | **US$/a** | | **EUR/a** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total useful floor space area** | **m2** | **10631.70** | | | | | |
| **Investment cost per $m^2$** | **206,635.77** | **MNT/$m^2$** | **121.55** | **US $/$m^2$** | **88.95** | **EUR/$m^2$** |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

## Annex 6

### Calculation of areas in $m^2$ (apartment buildings)

| | Type of apartment | Amount | One building | | | | | | | All Buildings | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Living area | Total area of envelop | Exterior walls | Roof | Floor | Windows | Doors | Living area | Total area of envelop | Exterior walls | Roof | Floor | Windows | Doors |
| | | | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ | $m^2$ |
| 1 | 5 story pre-cast panel building with 4 entrances | 18 | 3499.20 | 3524.04 | 1575.00 | 699.80 | 699.80 | 538.30 | 11.10 | 62985.60 | 63432.72 | 28349.88 | 12597.12 | 12597.12 | 9688.80 | 199.80 |
| 2 | 5 story pre-cast panel building with 6 entrances | 1 | 5216.40 | 5104.50 | 2223.20 | 1043,00 | 1043,00 | 778.10 | 16.70 | 5216.40 | 5104.50 | 2223.15 | 1043.28 | 1043.28 | 778.14 | 16.65 |
| 3 | 9 story pre-cast panel building with 2 entrances Left and right side | 2 | 5358.96 | 4669.33 | 2698.60 | 595.40 | 595.40 | 768.20 | 7.99 | 10717.92 | 9338.65 | 5397.25 | 1190.88 | 1190.88 | 1536.46 | 15.98 |
| 4 | 9 story pre-cat panel building with2 entrances Middle part | 1 | 5628.96 | 4960.90 | 2901.90 | 625.40 | 625.40 | 780.90 | 7.99 | 5628.96 | 4960.90 | 2901.90 | 625.44 | 625.44 | 780.93 | 7.99 |
| 5 | **Total amount** | | | | | | | | | **84548.90** | **82836.77** | **38872.19** | **15456.72** | **15456.72** | **12784.32** | **240.43** |

# Annex 7

## Calculation of areas m2 (school buildings & kindergarten)

| | Type of building | Labeling | Areas with heating | Areas | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Total envelop area | Exterior walls | Roof | Floor | Windows | Doors |
| | | | m2 | | | | | | |
| 1 | **School No. 44** | | **4658.32** | **8186.54** | **1959.26** | **2748.56** | **2748.56** | **697.75** | **32.41** |
| | Entrance-part | T3 | 1116.16 | 1629.94 | 347.49 | 558.08 | 558.08 | 159.408 | 6.88 |
| | South-part | T4 | 1812.48 | 2831.52 | 741.174 | 906.24 | 906.24 | 264.546 | 13.32 |
| | West-part | T5 | 890.88 | 1276.32 | 229.896 | 445.44 | 445.44 | 150.66 | 4.88 |
| | Sports hall | T6 | 288 | 892.80 | 260.79 | 288 | 288 | 53.568 | 2.44 |
| | Connection to hall of culture | T2 | 118.8 | 297.28 | 36.99 | 118.8 | 118.8 | 22.692 | 0.00 |
| | Hall of culture | T1 | 432 | 1258.68 | 342.924 | 432 | 432 | 46.872 | 4.88 |
| 2 | **School No. 53** | | **4563** | **5596.20** | **1759.70** | **1521.00** | **1521.00** | **779.50** | **15.34** |
| | Entrance-part | T3 | 1458 | 1922.40 | 610.1 | 486 | 486 | 337.2 | 3.13 |
| | East-part | T4 | 1080 | 1314.00 | 388.2 | 360 | 360 | 200.9 | 4.88 |
| | West-part | T5 | 2025 | 2359.80 | 761.4 | 675 | 675 | 241.4 | 7.33 |
| 3 | **Kindergarten** | | **1410.39** | **3783.84** | **1228.30** | **1118.40** | **1118.40** | **312.80** | **5.99** |
| | Entrance-part | GF | 275.7 | 1175.64 | 291.9 | 398.4 | 398.4 | 81.00 | 5.99 |
| | Classroom 1 | K1 | 378.23 | 862.80 | 303.8 | 240 | 240 | 79.0 | 0.00 |
| | Classroom 2 | K2 | 378.23 | 862.80 | 306.4 | 240 | 240 | 76.4 | 0.00 |
| | Classroom 3 | K3 | 378.23 | 882.60 | 326.2 | 240 | 240 | 76.4 | 0.00 |
| 4 | **Orphanage** | | 3360.0 | | | | | | |
| | **Total amount** | | **13991.71** | **17566.58** | **4947.26** | **5387.96** | **5387.96** | **1790.05** | **53.74** |

# Annex 8

**(Apartment buildings)**

## 8.1 Energy saving measures: Thermal insulation composite system of exterior walls

| **Thermal insulation of façade** | | | **Reference area:** | | | 38872.19 $m^2$ |
|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total price** |
| 1 | Primer | litre | 0.25 | 3,600 | 900 | 34,984,969.74 |
| 2 | Adhesive application | kg | 4.5 | 880 | 3,960 | 153,933,866.86 |
| 3 | EPS-Rigid foam | $m^3$ | 0.15 | 1E+05 | 18,750 | 728,853,536.25 |
| 4 | Anchor fittings (dowels) | piece | 8 | 900 | 7,200 | 279,879,757.92 |
| 5 | Reinforced plaster | kg | 3.5 | 1,000 | 3,500 | 136,052,660.10 |
| 6 | Reinforcement sheet | $m^2$ | 1.1 | 1,500 | 1,650 | 64,139,111.19 |
| 7 | Color finishing coat | kg | 4 | 3,600 | 14,400 | 559,759,515.84 |
| **Cost of material** | | | | | **53,110** | **1,957,603,417.90** |

| | | | | | |
|---|---|---|---|---|---|
| Additional cost | $m^2$ | 1 | 37,500 | 37,500 | 1,457,707,072.50 |
| Overall cost | | | | | **3,415,310,490.40** |
| Unit cost | | | | MNT | 87,860.00 |
| | | | | Euro | 39.13 |

| **Thermal insulation of exterior walls: EPS - rigid foam 15 cm with l= 040 W/m*K** | | | | | | |
|---|---|---|---|---|---|---|
| Heating degree days /HDD/ | | | | 142.2 | kKh/a | |
| Average useful life | | | | 30 | a | |
| Interest on capital | | | | 12% | | |
| Annuity factor | | | | 0.124 | | |

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 96 | MNT/kWh | 0.041 | Euro/kWh |
| Community heating | 341 | MNT/$m^2$ | 0.147 | Euro/$m^2$ |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

| Thermal Insolation of exterior walls: EPS - rigid foam 15 cm with l= 040 W/m*K | | | | | | |
|---|---|---|---|---|---|---|
| | Reference area | Thermal transmittance value | HDD | Loss | Cost | |
| Comparison | $m^2$ | $W/(m^2*K)$ | kKh/a | kWh/a | Euro/a | MNT/a |
| Actual condition | 38872.19 | 1.05 | 142.2 | 5,804,006.50 | 44,869.81 | 104,232,570.00 |
| After thermo rehabilitation | 38872.19 | 0.212 | 142.2 | 1,171,856.50 | 9,059.43 | 21,045,052.00 |
| Savings | | | | 4,632,149.90 | 35,810.38 | 83,187,518.00 |
| Savings in % | | | | 80% | | |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| Cost effectiveness | | |
|---|---|---|
| Average useful live | 30 years | |
| Interest loan | 12% | |
| Annuity factor | 0.124 | |
| | EURO | MNT |
| Unit cost of Rehabilitation | 37.82 | 87,860.00 |
| Investment cost due to energetic rehabilitation | **1,470,215.45** | 3,415,310,49.00 |
| Yearly capital cost | 182,517.92 | 423,989,14.00 |
| Savings | 35,810.38 | 83,187,52.00 |
| Loss/Savings | (146,707.54) | (340,801,62.00) |

## 8.2 Energy saving measures: Basement ceiling

| Basement ceiling | | Reference area | | | | 15,456.72 | $m^2$ |
|---|---|---|---|---|---|---|---|
| No | Material | Unit | Consumption | Unit price | Price | Total price | |
| 1 | Primer | litre | 0.25 | 3,600 | 900 | 13,911,048.00 | |
| 2 | Adhesive application | kg | 4.5 | 880 | 3,960 | 61,208,611.20 | |
| 3 | Fiber insulation material | $m^3$ | 0.1 | 125,000 | 12,500 | 193,209,000.00 | |
| 4 | Anchor fittings (dowel) | piece | 8 | 900 | 7,200 | 111,288,384.00 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | Reinforced plaster | kg | 3.5 | 1,000 | 3,500 | 54,098,520.00 |
| 6 | Reinforcement sheet | $m^2$ | 1.1 | 1,500 | 1,650 | 25,503,588.00 |
| 7 | Color finishing coat | kg | 4 | 1,200 | 4,800 | 74,192,256.00 |
| | **Cost of material** | | | | **53,110** | **533,411,407.20** |

| | | | | | |
|---|---|---|---|---|---|
| Additional cost | $m^2$ | 1 | 28,000 | 28,000 | 432,788,160.00 |
| Overall cost | | | | | 966,199,567.20 |
| Unit cost | | | | MNT | 62,510.00 |
| | | | | Euro | 26.91 |

| **Insulation of basement ceiling – rigid foam 10 cm l= 040 W/m*K** | | |
|---|---|---|
| Correction of temperature | 0.35 | |
| Heating degree days /HDD | 142.2 | kKh/a |
| Average useful live | 30 | a |
| Interest on capital | 12% | |
| Annuity factor | 0.124 | |

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 96 | MNT/kWh | 0.041 | Euro/kWh |
| Community heating | 341 | MNT/$m^2$ | 0.147 | Euro/$m^2$ |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| **Insulation of basement ceiling - rigid foam 10 cm l= 040 W/m*K** | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **$m^2$** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 15,457 | 0.88 | 49.8 | 676,967.20 | 5,233.52 | 12,157,470.00 |
| After thermal rehabilitation | 15,457 | 0.275 | 49.8 | 211,552.30 | 1,635.48 | 3,799,209.00 |
| Savings | | | | 465,415.00 | 3,598.05 | 8,358,261.00 |

| | |
|---|---|
| Savings in % | 69% |

| Cost effectiveness | | |
|---|---|---|
| **Average useful live** | 30 years | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 26.91 | 62,510.00 |
| **Investment cost due to energetic rehabilitation** | **415,927.50** | **966,199,567.00** |
| **Yearly capital cost** | 51634.80 | 119,947,548.00 |
| **Savings** | 3598.00 | 8,358,261.00 |
| **Loss / Savings** | (48,036.71) | (111,589,287.00) |

## 8.3 Energy saving measures: Thermal roof insulation (apartment buildings)

| **Thermal insulation of flat roof** | **Reference area:** | | | | 15,456.72 | $m^2$ |
|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total price** |
| 1 | Moisture barrier | $m^2$ | 1.1 | 2,000,00 | 2,200 | 34,004,784.00 |
| 2 | Rigid foam EPS | $m^3$ | 0.2 | 125,000.00 | 25,000 | 386,418,000.00 |
| 3 | PE - sheet | $m^2$ | 1.1 | 500,00 | 550 | 8,501,196.00 |
| 4 | Cement floor | $m^3$ | 0.15 | 95,000.00 | 14,250 | 220,258,260.00 |
| 5 | Bituminous sheeting | $m^2$ | 1.1 | 4,400,00 | 4,840 | 74,810,524.80 |
| 6 | Sanded bituminous sheet | $m^3$ | 1.1 | 5,70000 | 6,270 | 96,913,634.40 |
| | **Cost of material** | | | | **53,110** | **820,906,399.20** |

| | | | | | |
|---|---|---|---|---|---|
| Additional cost | $m^2$ | 1 | 67000 | 67000 | 1,035,600,240.00 |
| Overall cost | | | | | 1,856,506,639.20 |
| | | | | MNT | 120,110.00 |
| Unit cost | | | | Euro | 51.70 |

| **Thermal insulation of flat roof - rigid foam 20 cm l= 040 W/m*K** | | | |
|---|---|---|---|
| Heating degree days /HDD | 142.2 | kKh/a | |

| | | | |
|---|---|---|---|
| Average useful live | 30 | a | |
| Interest on capital | 12% | | |
| Annuity factor | 0.124 | | |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 96 | MNT/kWh | 0.041 | Euro/kWh |
| Community heating | 341 | MNT/$m^2$ | 0.147 | Euro/$m^2$ |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

| **Insulation of flat roof 20 cm, EPS- rigid foam l= 040 W/m*K** | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **m2** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 15,456.72 | 0.44 | 142.2 | 967,096.10 | 7,476.46 | 17,367,814.00 |
| After thermal rehabilitation | 15,456.72 | 0.19 | 142.2 | 417,609.70 | 3,228.47 | 7,499,738.00 |
| Savings | | | | 549,486.4o | 4,247.99 | 9,868,076.00 |
| Savings in % | | | | 57% | | |

| **Cost effectiveness** | | |
|---|---|---|
| **Average of useful live** | 30 years | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 51.70 | 120,110.00 |
| **Investment cost due to energetic rehabilitation** | **799,185.00** | **1,856,506,639.00** |
| **Yearly capital cost** | 99,213.74 | 230,473,524.00 |
| **Savings** | 4,247.99 | 9,868,076.00 |
| **Loss / Savings** | (94,965.75) | (220,605,448.00) |

## 8.4 Energy saving measures: New, energetic improved windows (apartment buildings)

| New, energetic improved windows | | | Reference area | | | 12,784.32 m2 |
|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total price** |
| 1 | New windows | m2 | | 230,000.00 | | 2,940,393,600.00 |

| New, energetic improved windows Thermal transmittance value 1,7 W/(m2*K) | | |
|---|---|---|
| Correction of temperature | 1.0 | |
| Heating degree days /HDD | 142.2 | kKh/a |
| Average useful live | 30 | a |
| Interest on capital | 12% | |
| Annuity factor | 0.124 | |

| Energy prices | | | | |
|---|---|---|---|---|
| Electrical energy | 96 | MNT/kWh | 0.041 | Euro/kWh |
| Community heating | 341 | MNT/m2 | 0.147 | Euro/m2 |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

Exchange: 1,00 EUR = 2,323 MNT (10.30.2013)

| Replacement of old wooden windows through new, energetically improved windows | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **m2** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 12,784.32 | 3.1 | 142.2 | 5,635,583.90 | 43,567.76 | 101,207,915.90 |
| After thermal rehabilitation | 12,784.32 | 1.7 | 142.2 | 3,090,481.5 | 23,892.00 | 55,501,115.20 |
| Savings | | | | 2,545,102.4 | 19,675.76 | 45,706,800.70 |

| Cost effectiveness | | |
|---|---|---|
| **Average useful live** | 30 | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 99.01 | 230,000.00 |
| **Investment cost due to energetic rehabilitation** | **1,265,774.26** | **2,940,393,600.00** |

| | | |
|---|---|---|
| **Yearly capital cost** | 157,137.85 | 365,031,216.10 |
| **Savings** | 19,675.76 | 45,706,800.70 |
| **Loss / savings** | (137,462.08) | (319,324,415.40) |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

## 8.5 Energy saving measures: Improvement of outside doors

| **Improvement outside doors** | Reference area | | | | 240.43 | $m^2$ |
|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total Price** |
| 1 | New doors | m2 | | 230,000.00 | | **55,297,980.00** |

| **New, energetic improved outside doors** | | |
|---|---|---|
| Correction of temperature | 1.0 | |
| Heating degree days /HDD | 142.2 | kKh/a |
| Average useful live | 30 | a |
| Interest on capital | 12% | |
| Annuity factor | 0.124 | |

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 96 | MNT/kWh | 0.041 | Euro/kWh |
| Community heating | 341 | MNT/m2 | 0.147 | Euro/m2 |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

| **Replacement of old doors against new, energetic improved doors** | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **m2** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 240.43 | 3.1 | 142.2 | 105,984.6 | 819.35 | 1,903,348.40 |
| After thermal rehabilitation | 240.43 | 1.7 | 142.2 | 58,120.6 | 449.32 | 1,043,771.70 |
| Savings | | | | 47,864.0 | 370.03 | 859,576.70 |
| **Cost effectiveness** | | | | | | |
| **Average useful live** | | | | 30 | | |
| **Interest loan** | | | | 12% | | |

| | | |
|---|---|---|
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 99.01 | 230,000.00 |
| **Investment cost due to energetic rehabilitation** | **23,804.55** | **55,297,980.00** |
| **Yearly capital cost** | 2,955.18 | 6,864,893.50 |
| **Savings** | 370.03 | 859,576.70 |
| **Loss / savings** | (2,585.16) | (6,005,316.80) |

### 8.6 Summary: Energy saving measures in apartment buildings

| **Summery: Cost of energy saving measures in apartment buildings** | **MNT** | **EURO** |
|---|---|---|
| **Thermal insulation of façade** | 3,415,310,490,00 | **1,470,215.45** |
| **Basement ceiling** | 966,199,567,00 | **415,927.50** |
| **Thermal insulation of flat roof** | 1,856,506,639,00 | **799,185.00** |
| **New, energetically improved windows** | 2,940,393,600,00 | **1,265,774.26** |
| **Improvement outside doors** | 55,297,980,00 | **23,804.55** |
| **Total** | **9,233,708,277,00** | **3,974,906.76** |

| **Summary: Energy saving measures in apartment buildings** | | | | |
|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **Cost** | |
| **Comparison** | **m2** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 84,548.9 | 2,451,137.00 | 60,592.50 | 103,007,250.00 |
| After thermal rehabilitation | 84,548.9 | 1,337,966.80 | 24,272.70 | 41,263,590.00 |
| Savings | | 1,113,170.20 | 36,319.80 | 61,743,660.00 |
| Savings | | 45% | | |

| **Cost effectiveness** | |
|---|---|
| **Average useful live** | 30 |
| **Interest loan** | 12% |
| **Annuity factor** | 0.124 |

| | EURO | MNT |
|---|---|---|
| **Unit cost of rehabilitation** | 47.01 | 109,211.50 |
| **Investment cost due to energetic rehabilitation** | **3,974,906.70** | 9,233,708,277.00 |
| **Yearly capital cost** | 493,459.50 | 838,881,077.00 |
| **Savings** | 36,319.80 | 61,743,660.00 |
| **Loss / savings** | (457,139.70) | (777,137,417.00) |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

# Annex 9
**(Non- apartment buildings)**

## 9.1 Energy saving measures: Thermal insulation composite system of exterior walls

| **Thermal insulation of façade** | | | **Reference area:** | | | 4,947.26 | $m^2$ |
|---|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total price** | |
| 1 | Primer | litre | 0.25 | 3,600 | 900 | 4,452,537.60 | |
| 2 | Adhesive application | kg | 4.5 | 880 | 3,960 | 19,591,165.44 | |
| 3 | EPS-Rigid foam | $m^3$ | 0.15 | 125,000 | 18,750 | 92,761,200.00 | |
| 4 | Anchor fittings (dowels) | piece | 8 | 900 | 7,200 | 35,620,300.80 | |
| 5 | Reinforced plaster | kg | 3.5 | 1,000 | 3,500 | 17,315,424.00 | |
| 6 | Reinforcement sheet | $m^2$ | 1.1 | 1,500 | 1,650 | 8,162,985.60 | |
| 7 | Color finishing coat | kg | 4 | 3,600 | 14,400 | 71,240,601.60 | |
| **Cost of material** | | | | | **53,110** | **249,144,215.04** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Additional cost | $m^2$ | 1 | 37,500 | 37,500 | 185,522,400.00 | |
| Overall cost | | | | | **434,666,615.04** | |
| Unit cost | | | | MNT | 87,860.00 | |
| | | | | Euro | 37,82 | |

| **Thermal Insolation of exterior walls 640mm: EPS - rigid foam 15 cm with l= 040 W/m*K** | | | | | | |
|---|---|---|---|---|---|---|
| Heating degree days /HDD/ | | | | 142.2 | kKh/a | |
| Average useful life | | | | 30 | a | |
| Interest on capital | | | | 12% | | |
| Annuity factor | | | | 0.124 | | |

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 88 | MNT/kWh | 0.038 | Euro/kWh |
| Community heating | 341 | MNT/$m^2$ | 0.147 | Euro/$m^2$ |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

| **Thermal Insolation of exterior walls 640mm: EPS - rigid foam 15 cm with l= 040 W/m*K** |
|---|

| Comparison | Reference area | Thermal transmittance value | HDD | Loss | Cost | |
|---|---|---|---|---|---|---|
| | $m^2$ | $W/(m^2*K)$ | kKh/a | kWh/a | Euro/a | MNT/a |
| Actual condition | 4,947.26 | 1.05 | 142.2 | 612,045.80 | 44,869.81 | 10,991,564.00 |
| After thermo rehabilitation | 4,947.26 | 0.212 | 142.2 | 140,700.20 | 9,059.43 | 2,526,796.00 |
| Savings | | | | 471,345.60 | 35,810.38 | 8,464,768.00 |
| Savings in % | | | | 77% | | |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| Cost effectiveness | | |
|---|---|---|
| **Average useful live** | 30 years | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of Rehabilitation** | 37.82 | 87,860.00 |
| **Investment cost due to energetic rehabilitation** | **187,114.34** | 434,666,615.00 |
| **Yearly capital cost** | 23,229. | 53,961,103.00 |
| **Savings** | 3,643.89 | 8,464,768.00 |
| **Loss/Savings** | (19,585.16) | (45,496,336.00) |

## 9.2 Energy saving measures: Basement ceiling

| Basement ceiling | | Reference area | | | | 15,456.72 | $m^2$ |
|---|---|---|---|---|---|---|---|
| No | Material | Unit | Consumption | Unit price | Price | Total price | |
| 1 | Floor covering | $m^2$ | 1 | 2,000 | 2,000 | 10,775,920.00 | |
| 2 | Cement floor | $m^3$ | 0.03 | 95,000 | 2,850 | 15,355,686.00 | |
| 3 | Reinforced concrete | $m^3$ | 0.12 | 95,000 | 12,500 | 61,422,744.00 | |
| 4 | Moisture barrier | $m^2$ | 1.1 | 500 | 550 | 2,963,378.00 | |
| 5 | Rigid foam EPS | $m^3$ | 0.1 | 125,000 | 12,500 | 67,349,500.00 | |
| 6 | Moistness insulation | $m^3$ | 1.1 | 4,500 | 4,950 | 26,670,402.00 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | Blinding concrete | $m^3$ | 0.6 | 95,000 | 57,000 | 307,113,720.00 |
| **Cost of material** | | | | | **53,110** | **491,651,350.00** |

| | | | | | |
|---|---|---|---|---|---|
| Additional cost | $m^2$ | 1 | 37,000 | 37,000 | 199,354,520.00 |
| Overall cost | | | | | 691,005,870.00 |
| Unit cost | | | | MNT | 128,250.00 |
| | | | | Euro | 55.21 |

| **Insulation of basement ceiling - rigid foam 10 cm l= 040 W/m*K** | | |
|---|---|---|
| Correction of temperature | 0.35 | |
| Heating degree days /HDD | 142.2 | kKh/a |
| Average useful live | 30 | a |
| Interest on capital | 12% | |
| Annuity factor | 0.124 | |

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 88 | MNT/kWh | 0.041 | Euro/kWh |
| Community heating | 341 | MNT/$m^2$ | 0.147 | Euro/$m^2$ |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| **Insulation of basement ceiling - rigid foam 10 cm l= 040 W/m*K** | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **$m^2$** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 5,387,96 | 1.5 | 49.8 | 402,238.20 | 3,109.64 | 7,223,685.00 |
| After thermal rehabilitation | 5,387,96 | 0.33 | 49.8 | 88,492.40 | 684.12 | 1,589,211.00 |
| Savings | | | | 313,745.80 | 2,425.52 | 5,634,475.00 |
| Savings in % | | | | 78% | | |

| Cost effectiveness | | |
|---|---|---|
| **Average useful live** | 30 years | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 55.21 | 128,250.00 |
| **Investment cost due to energetic rehabilitation** | **297,462.70** | **691,005,870.00** |
| **Yearly capital cost** | 36,928.10 | 85,783,996.00 |
| **Savings** | 2,425.50 | 5,634,475.00 |
| **Loss / Savings** | (34,502.60) | (80,149,522.00) |

## 9.3 Energy saving measures: Thermal roof insulation

| **Thermal insulation of flat roof** | | **Reference area:** | | | | 5,387.96 | $m^2$ |
|---|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total price** | |
| 1 | Moisture barrier | $m^2$ | 1.1 | 2,000,00 | 2,200 | 11,853,512.00 | |
| 2 | Rigid foam EPS | $m^3$ | 0.2 | 125,000.00 | 25,000 | 134,699,000.00 | |
| 3 | PE - sheet | $m^2$ | 1.1 | 500,00 | 550 | 2,963,378.00 | |
| 4 | Cement floor | $m^3$ | 0.15 | 95,000.00 | 14,250 | 76,778,430.00 | |
| 5 | Bituminous sheeting | $m^2$ | 1.1 | 4,400,00 | 4,840 | 26,077,726.40 | |
| 6 | Sanded bituminous sheet | $m^3$ | 1.1 | 5,70000 | 6,270 | 33,782,509.20 | |
| **Cost of material** | | | | | **53,110** | **286,154,555.60** | |

| | | | | | |
|---|---|---|---|---|---|
| Additional cost | $m^2$ | 1 | 67,000 | 67,000 | 360,993,320.00 |
| Overall cost | | | | | 647,147,875.60 |
| | | | | MNT | 120,110.00 |
| Unit cost | | | | Euro | 51.70 |

| **Thermal insulation of flat roof – rigid foam 20 cm l= 040 W/m*K** | | | |
|---|---|---|---|
| Heating degree days /HDD | 142.2 | kKh/a | |
| Average useful live | 30 | a | |
| Interest on capital | 12% | | |

| | | | |
|---|---|---|---|
| Annuity factor | 0.124 | | |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 88 | MNT/kWh | 0.038 | Euro/kWh |
| Community heating | 341 | MNT/$m^2$ | 0.147 | Euro/$m^2$ |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

| **Insulation of flat roof 20 cm, EPS- rigid foam l= 040 W/m*K** | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **m2** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 5,387.96 | 0.53 | 142.2 | 406,069.00 | 3,139.25 | 7,292,482.00 |
| After thermal rehabilitation | 5,387.96 | 0.19 | 142.2 | 145,571.90 | 1,125.39 | 2,614,286.00 |
| Savings | | | | 260,497.10 | 2,013.86 | 4,678,196.00 |
| Savings in % | | | | 64% | | |

| **Cost effectiveness** | | |
|---|---|---|
| **Average of useful live** | 30 years | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 51.70 | 120,110.00 |
| **Investment cost due to energetic rehabilitation** | **278,582.80** | **647,147,876,00** |
| **Yearly capital cost** | 34,584.29 | 80,339,304.00 |
| **Savings** | 2,013.86 | 4,678,196,00 |
| **Loss / Savings** | 32,570.43) | (75,661,108.00) |

## 9.4 Energy saving measures: New, energetic improved windows (apartment buildings)

| New, energetic improved windows | | | Reference area | | 1,790.05 | m2 |
|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total price** |
| 1 | New windows | m2 | | 230,000.00 | | 411,711,500.00 |

| New, energetic improved windows Thermal transmittance value 1,7 W/(m2*K) | | |
|---|---|---|
| Correction of temperature | 1.0 | |
| Heating degree days /HDD | 142.2 | kKh/a |
| Average useful live | 30 | a |
| Interest on capital | 12% | |
| Annuity factor | 0.124 | |

| Energy prices | | | | |
|---|---|---|---|---|
| Electrical energy | 88 | MNT/kWh | 0.038 | Euro/kWh |
| Community heating | 341 | MNT/m2 | 0.147 | Euro/m2 |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

| Replacement of old wooden windows against new, energetic improved windows | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **m2** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 1,709.05 | 3.1 | 142.2 | 789,088.10 | 6,100.31 | 14,171,017.70 |
| After thermal rehabilitation | 1,709.05 | 1.7 | 142.2 | 432,725.70 | 3,345.33 | 7,771,203.30 |
| Savings | | | | 356,362.40 | 2,754.98 | 6,399,814.40 |

| Cost effectiveness | | |
|---|---|---|
| **Average useful live** | 30 | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 99.01 | 230,000.00 |

| | | |
|---|---|---|
| **Investment cost due to energetic rehabilitation** | **177,232.28** | **411,710,580.00** |
| **Yearly capital cost** | 22,002.26 | 51,111,257.30 |
| **Savings** | 2,754.98 | 6,399,814.40 |
| **Loss / savings** | -(19,247.28) | (44,711,442.80) |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

## 9.5 Energy saving measures: Improvement of outside doors

| **Improvement outside doors** | Reference area | | | | 53.74 | $m^2$ |
|---|---|---|---|---|---|---|
| **No** | **Material** | **Unit** | **Consumption** | **Unit price** | **Price** | **Total Price** |
| 1 | New doors | m2 | | 230,000.00 | | **12,360,200.00** |

| **New, energetic improved outside doors** | | |
|---|---|---|
| Correction of temperature | 1.0 | |
| Heating degree days /HDD | 142.2 | kKh/a |
| Average useful live | 30 | a |
| Interest on capital | 12% | |
| Annuity factor | 0.124 | |

| **Energy prices** | | | | |
|---|---|---|---|---|
| Electrical energy | 88 | MNT/kWh | 0.038 | Euro/kWh |
| Community heating | 341 | MNT/m2 | 0.147 | Euro/m2 |
| | 20,886 | MNT/Gkal | 0.008 | Euro/kWh |

| **Replacement of old doors through new, energetic improved doors** | | | | | | |
|---|---|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **HDD** | **Loss** | **Cost** | |
| **Comparison** | **m2** | **W/(m2*K)** | **kKh/a** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 53.74 | 3.1 | 142.2 | 23,690.50 | 183.15 | 425,452.10 |
| After thermal rehabilitation | 53.74 | 1.7 | 142.2 | 12,991.10 | 100.43 | 233,303.80 |
| Savings | | | | 10,699.40 | 82.72 | 192,148.30 |
| **Cost effectiveness** | | | | | | |

| | | |
|---|---|---|
| **Average useful live** | 30 | |
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 99.01 | 230,000.00 |
| **Investment cost due to energetic rehabilitation** | **5,320.99** | **12,360,660.00** |
| **Yearly capital cost** | 660.57 | 1,534,497.50 |
| **Savings** | 82.72 | 192,148.30 |
| **Loss / savings** | (577.85) | (1,342,349.20) |

## 9.6 Summary: Energy saving measures in non-apartment buildings

| **Summery: Cost of energy saving measures in apartment buildings** | **MNT** | **EURO** |
|---|---|---|
| **Thermal insulation of façade** | 434,666,615.00 | **187,114,34** |
| **Basement ceiling** | 691,005,870.00 | **297,462.71** |
| **Thermal insulation of flat roof** | 647,147,876.00 | **278,582.81** |
| **New, energetic improved windows** | 411,710,580.00 | **177.232.28** |
| **Improvement outside doors** | 12,360,660.00 | **5,320,99** |
| **Total** | **2,196,891,601.00** | **945.713.13** |

| **Summary: Energy saving measures in non- apartment buildings** | | | | |
|---|---|---|---|---|
| | **Reference area** | **Thermal transmittance value** | **Cost** | |
| **Comparison** | **m2** | **kWh/a** | **Euro/a** | MNT/a |
| Actual condition | 10,631.71 | 2,236,188.40 | 17,287.60 | 40,159,099.00 |
| After thermal rehabilitation | 10,631.71 | 820,481.80 | 6,343.01 | 14,734,809.00 |
| Savings | | 1,415,706.60 | 10,944.59 | 25,424,290.00 |
| Savings | | 45% | | |

| **Cost effectiveness** | |
|---|---|
| **Average useful live** | 30 |

| | | |
|---|---|---|
| **Interest loan** | 12% | |
| **Annuity factor** | 0.124 | |
| | EURO | MNT |
| **Unit cost of rehabilitation** | 85.52 | 206,636.00 |
| **Investment cost due to energetic rehabilitation** | **909,222.80** | 2,196,891,601.00 |
| **Yearly capital cost** | 112,874.20 | 191,886,210.00 |
| **Savings** | 10,944.60 | 18,605,808.00 |
| **Loss / savings** | (101,929.65) | (173,280,401.00) |

Exchange rate: 1,00 EUR = 2,323 MNT (10.30.2013)

# Annex 10

## Cost estimation for renovation of the Heating installation (apartment buildings)

**Objective**: Adjustments for the introduction of of consumption based tariffs

### Version - 1:

The whole Heating installation of each apartment building should have to be renovated. The main heat meter will be installed in the substation of each building. After heat meter the heating risers to the apartments will be installed and radiators equipped with thermostatic valves and lock shield will be connected apartment wise through horizontal two-pipe system. The pipes installed along the external walls behind the plinths could be made out of plastic pipes. Each apartment will be equipped with one heat meter.

**Compilation of the Costs for 5 storey panel building for 58 families with 4 entrances**

| | | |
|---|---|---|
| Reference floor area /5 story panel building with 4 entrances/ | 3,499.20 | m2 |
| Material cost for the new Heating installation of a building with the above area | 186,097,358.6 | MNT |
| Estimated total cost including the additional cost of 80% | 334,975,245.5 | MNT |
| Apartment unit area cost | 95,729 | MNT/m2 |
| Average cost per apartment | 6,413,849 | MNT |

**Cost estimation for the entire Heating renovation**

| | | |
|---|---|---|
| Reference total floor area /16-th khoroo in Ulaankhuaran/ | 84,548.88 | m2 |
| Apartment unit area cost | 95,729 | MNT/m2 |
| **TOTAL COST** | **8,093,787,675.2** | **MNT** |

Exchange rate: MNT to Euro 2325

## Version 2:

In this case there is no need to change the whole existing heating system. A main heat meter will be installed in the substation of the building and heat cost allocators will be fixed on each radiator. There is a need for a Cost allocation ordinance to warranty the consumption dependency, fairness and objectivity.

| | | |
|---|---|---|
| Reference floor area /5 story panel building with 4 entrances/ | 3,499.20 | m2 |
| Material cost for the new Heating installation of a building with the above area | 28,809,396.0 | MNT |
| Estimated total cost including the additional cost of 80% | 51,856,912.8 | MNT |
| Apartment unit area cost | 14,820 | MNT/m2 |
| Average cost per Apartment | 992,916 | MNT |

| | | |
|---|---|---|
| Reference total floor area /16-th khoroo in Ulaankhuaran/ | 84,548.88 | m2 |
| Apartment unit area cost | 14,820 | MNT/m2 |
| **TOTAL COST** | **1,252,984,653** | **MNT** |

| | | |
|---|---|---|
| Exchange rate: | MNT to Euro | 2325 |

## Annex 11

**Cost estimation for renovation of the heating system in public buildings (school, kindergarten and orphanage)**

Exchange rate: 1 USD = 1750 MNT

| No | Building name | Heated area | Unit cost for for Heating and Sanitation | Total cost for for Heating and Sanitation | Number of WC and Shower | Solar system for Warm Water | Total cost (MNT/USD) |
|---|---|---|---|---|---|---|---|
| 1 | **School number 53** | 4563m2 | 91'322.00 | 416,702,286.00 | 8 | 54'400'000.00 | 471,102,286.00 |
| 2 | **School number 44** | 4658m2 | 91'322.00 | 425,407,099.04 | 8 | 54'400'000.00 | 479,807,099.04 |
| 3 | **Kindergarten 82** | 1410m2 | 91'322.00 | 128,799,635.58 | 4 | 27'200'000 | 155,999,635.58 |
| 4 | **Orphanage** | 3360m2 | 91'322.00 | 306,890,357.19 | 8 | 54'400'000.00 | 361,290,357.19 |
| | | | | | | | |
| | **In Total** | **13992.24m2** | | **1,277,799,377.81** | | **190,400,000.00** | **1,468,199,377.81 (838'971.00)** |

giz

# Annex 12

## CO2 –Emission calculation for TRR of apartment buildings

**Hard coal, with calorific value of 8,14 kWh/kg**

| Energy demand | Type of Fuel | CO2-Emission total | CO2-Emission from Combustion | CO2-Emission from Extraction and Transport | CO2-Emission from renewable sources | CO2-Emission from fossil sources |
|---|---|---|---|---|---|---|
| kWh/a | | tons | tons | tons | tons | tons |
| **Before Thermo- technical Retro fitting** | | | | | | |
| 13189638 | Hard coal | 4880.17 | 4484.48 | 395.69 | 0.00 | 4880.17 |
| **After Thermo- technical Retro fitting** | | | | | | |
| 4949621 | Hard coal | 1831.36 | 1682.87 | 148.49 | 0.00 | 1831.36 |
| **Saving on CO2 Emission** | | | | | | |
| 8,240,018 | Hard coal | 3048.8 | 2801.6 | 247.2 | 0.0 | 3048.8 |
| **Hard coal** | | | | | **62.47** | **%** |

**Brown coal, with calorific value of 5,5 kWh/kg**

| Energy demand | Type of Fuel | CO2-Emission total | CO2-Emission from Combustion | CO2-Emission from Extraction and Transport | CO2-Emission from renewable sources | CO2-Emission from fossil sources |
|---|---|---|---|---|---|---|
| kWh/a | | tons | tons | tons | tons | tons |
| | | **Before Thermo- technical Retro fitting** | | | | |
| 13,189,638 | Brown coal | 5012.06 | 4616.37 | 395.69 | 0.00 | 5012.06 |
| | | **After Thermo- technical Retro fitting** | | | | |
| 4,949,621 | Brown coal | 1880.86 | 1732.37 | 148.49 | 0.00 | 1880.86 |
| | | **Saving on CO2 Emission** | | | | |
| 8,240,018 | Brown coal | 3131.2 | 2884.0 | 247.2 | 0.0 | 3131.2 |
| | | **Brown coal** | | | **62.47** | **%** |

## Annex 13

**CO2 –Emission calculation for TRR of non-apartment buildings** (doesn't include the orphanage building)

**Hard coal, with calorific value of 8,14 kWh/kg**

| Energy demand | Type of Fuel | CO2-Emission total | CO2-Emission from Combustion | CO2-Emission from Extraction and Transport | CO2-Emission from renewable sources | CO2-Emission from fossil sources |
|---|---|---|---|---|---|---|
| kWh/a | | tons | tons | tons | tons | tons |
| **Before Thermo- technical Retro fitting** | | | | | | |
| 2,236,188.40 | Hard coal | 827.4 | 760.3 | 67.1 | 0.0 | 827.4 |
| **After Thermo- technical Retro fitting** | | | | | | |
| 820,481.80 | Hard coal | 303.6 | 279.0 | 24.6 | 0.0 | 303.6 |
| **Saving on CO2 Emission** | | | | | | |
| 1,415,707 | Hard coal | 523.8 | 481.3 | 42.5 | 0.0 | 523.8 |
| | **Hard coal** | | | | **63.31** | **%** |

**Brown coal, with calorific value of 5,5 kWh/kg**

| Energy demand | Type of Fuel | CO2-Emission total | CO2-Emission from Combustion | CO2-Emission from Extraction and Transport | CO2-Emission from renewable sources | CO2-Emission from fossil sources |
|---|---|---|---|---|---|---|
| kWh/a | | tons | tons | tons | tons | tons |
| | | **Before Thermo- technical Retro fitting** | | | | |
| 2,236,188.40 | Brown coal | 849.8 | 782.7 | 67.1 | 0.0 | 849.8 |
| | | **After Thermo- technical Retro fitting** | | | | |
| 820,481.80 | Brown coal | 311.8 | 287.2 | 24.6 | 0.0 | 311.8 |
| | | **Saving on CO2 Emission** | | | | |
| 1,415,707 | Brown coal | 538.0 | 495.5 | 42.5 | 0.0 | 538.0 |
| | | **Brown coal** | | | **63.31** | **%** |

## Annex 14
**REFERENCES**


(1) GITEC TTR Feasibility Study - Phase 1 Report, VOLUME 1 – MAIN REPORT, financed through KfW, June 2011
(2) CDIA Thermo-Technical Rehabilitation of Pre-Cast Panel Buildings in Ulaanbaatar, Pre-Feasibility Study Final Report, May 2009
(3) ADB, Mongolia: 'CDM Baseline Study for Thermo Technical Rehabilitation of Pre-Cast Panel Buildings in Ulaanbaatar', December 2010
(4) Fraunhofer Institut Bauphysik, Scientific Monitoring of Building Restorations in Ulan Bator and Assessment of the Energy Savings Potential as well as Derivation of General Measures for Quality Assurance, Carried out by order of GTZ, Holzkirchen, September 2008
(5) GTZ/USAID, Project Design Document, Thermo-technical retrofitting of school buildings in Ulaanbaatar / Mongolia, October 2011
(6) GTZ-UDCP, Thermo- and technical rehabilitation of a pre-cast panel building in Ulaanbaatar, Survey on the perception and satisfaction among the inhabitants of Bayanburd, House No. 8, Chingeltei District, Ulaanbaatar, March 2008
(7) JICA, The Study on City Master Plan and Urban Development Programs of Ulaanbaatar City, prepared by Japan International Cooperation Agency in cooperation with Ministry of Roads, Transportation, Construction and Urban Development and Ulaanbaatar City, March 2009
(8) Mongolian Norm for Building thermal performance, БНбД 23-02-09, 2009
(9) Resolution of Mayor of Ulaanbaatar for installing of Nexus Project steering committee, No.A/884 from Sep.18, 2013
Google Earth: Ulaanbaatar, URL: http://earth.google.com