SUMMARY ANALYSIS

of the Findings of Energy Audit of Project Pilot Buildings

(prepared based on the data of the Final Report of the Institute for Energy and Automation under the Academy of Sciences of Uzbekistan in 2014)

Tashkent -2014

Introduction

In the framework of implementation of joint project of the United Nations Development Programme (UNDP), the Global Environmental Facility (GEF), and the State Committee for Architecture and Construction of Uzbekistan (SCAC), energy audits were conducted at pilot sites – schools and rural health clinics (SVPs) to identify the rate of energy use, energy losses, and emissions of greenhouse gases and to prepare detailed analysis and the list of recommendations to address those problems in the period between 2010 and 2014. The energy audit was conducted in two stages – before and after rehabilitation of demonstration buildings. The audit was conducted by the Institute of Energy and Automation (IEA) of the Academy of Sciences of Uzbekistan.

It is notable that only the institutions with government's license for this kind of activities were permitted to undertake energy audits in this period (2010-2013). There were in total 20 organizations in possession of licenses in Uzbekistan at that moment. Also it is notable that no organization has ever conducted energy audits of the social sector buildings in Uzbekistan until then. Thus, to ensure quality and comprehensive performance of these works, IEA of the Academy of Sciences of Uzbekistan, with the involvement of the project's international expert, designed the energy audit programme and produced the *Standard Methodology of Energy Audits of Social Sector Buildings*, which was subsequently approved by the State Architecture and Construction Committee of Uzbekistan on September 9, 2011.

Jointly with the representatives of the Ministry of Public Education and Ministry of Health, with the support of the State Committee for Architecture and Construction, 6 demonstration sites located in various regions/climate zones of Uzbekistan were selected:

1. Oqtepa SVP, Pskent rayon , Tashkent oblast;
2. Dehibaland SVP, Nuratau rayon, Navoi oblast;
3. School №5, Beshkupir village, Kanlikul rayon, Karakalpakstan;
4. School №35, Yangirobad town, Khatirchi rayon, Navoi oblast;
5. School №20, Mirmiron village, Karshi rayon, Kashkadarya oblast;
6. School №2, Chek-Jaloer, Rishtan rayon, Ferghana oblast.

Clearly, the geographic location of the sites covers all climate zones of Uzbekistan in order to obtain the findings of the surveys for all climate zones and have the ability to broadly disseminate recommendations nationwide.

Energy audit of buildings was conducted throughout the annual cycle covering both heating and non-heating seasons. The data on energy use were received from all pilot sites, and data related to characteristics of buildings, their dimensions, and other data related to construction and engineering aspects were collected.

The materials collected enabled to draft the list of recommendation for implementation in the subsequent major renovation of pilot buildings to enhance their energy efficiency. The results obtained enabled to give recommendations to design two new pilot schools to be built:

1. School №39, Toshkurgan village, Qo'rg'ontepa rayon , Andijan oblast;
2. School №54, Nuratau rayon, Navoi oblast.

After completion works for rehabilitation and construction of the pilot sites of the project, repeated (Stage 2) of annual energy audit was conducted and results were obtained describing the issues of enhancing energy efficiency of the project buildings.

**Basic Results of the Data of Pilot Sites before Major Renovation obtained after
Energy Audits (energy audits were conducted from 2010 to 2011)**

Energy audit was conducted in 6 selected buildings of rural schools and SVPs. In the selection of buildings, one of the key criteria was typical repetition (types of buildings) in different regions of Uzbekistan, for the purpose of broad dissemination of the experience, technical solutions, and recommendations to enhance energy efficiency of buildings.

The tables below present the data on energy use of the pilot buildings in the heating period.

Quantitative Assessment of the Energy Use for Heating of Demonstration Sites Before the Activities

Indicators	Unit of Measurement	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon	Oqtepa SVP Pskent rayon	Dehibaland SVP Nuratau rayon
					Building A		
Use of heat for the building in heating period, W_o before the activities Use of heat for the building in the heating period , before the activities	kW·ч	267712,6	405086,8	315286,2	319360,6	109327,7	179103,6

Per 1 square meter of heated space in terms of kWh per annum:

Indicators	Unit of Measurement.	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon	Oqtepa SVP Pskent rayon	Dehibaland SVP Nuratau rayon
					Building A		

Use of heat in the building for heating period, W_o before implementation of EE activities	kW·ч/sq. m.	326,88	204,38	256,96	380,64	349,29	451,14

As it is visible from the data presented, energy use for heating in the pilot buildings of the project varied in the interval from 204.38 kWh/sq.m. up to 451.14kWh/sq.m. per annum, which significantly exceeds the data reflected in the project document on the baseline of energy use in the existing old social sector buildings: from 185 kWh/sq.m. per annum up to 200 kWh/sq.m. per annum , i.e. from 1.1 to 2.25 fold!

As a result of energy audits, a number of inefficient technical solutions related to heating systems were identified along with outdated energy efficiency methods, which have proven to be ineffective. Recommendations were formulated to enhance energy efficiency of the buildings, which formed the platform to update a number of relevant building codes and regulations. These building codes and regulations (BCR) were subsequently reviewed by incorporating new requirements to enhance energy efficiency of the buildings, which were then approved by the State Committee for Architecture and Construction. Subsequently the recommendations formulated based on the results of energy audits were used in preparing the design and cost estimates (based on updated building codes and regulations) for major rehabilitation of pilot buildings and construction of two new pilot schools.

In the framework of the project the Guidelines for Application of Updated BCRs were produced, which provides detailed information on the implementation and use of new energy-efficient solutions depending on the region where buildings are located, to prepare design and cost estimates for the major renovation and construction. Use of integrated approach to design is an important prerequisite in preparing design documentation and cost estimates.

The *Catalogue of Energy Efficient Engineering Solutions* was prepared in the framework of the project in order to ease the work of design institutions in their design activities. Also, the project formulated *State Educational Standards*, training programmes and modules, approved and implemented in the academic process of technical universities and colleges, which facilitate training of new highly-skilled workers for the construction sector of Uzbekistan.

Notably human factor is also important in energy use. (1) The system of energy managers; (2) 4-tier information system for collection, storage, and processing of the data on energy use on the levels of pilot site, rayon, oblast and the country were developed under the project. These systems were distributed and tested at pilot sites

and in conducting energy audits of the project buildings after major rehabilitation and construction. Following results in the tables below were obtained in 2013 – 2014.

This table presents the data on energy use and energy efficiency at pilot sites of the project

Quantitative Assessment of Energy Efficiency of Demonstration Sites before and after Implementation of Energy Efficiency Activities

Indicators	Unit of Measurement	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon Building A	Oqtepa SVP Pskent rayon	Dehibaland SVP Nuratau rayon
Use of heat in the building for heating period, W_o **before the activities**	kW·h	**267712,6**	**405086,8**	**315286,2**	**319360,6**	**109327,7**	**179103,6**
Annual use of electricty by the lighting system, W_{oc} **before the activities**	kW·h	11680	25960	4608	13200	3443	2904,6
Use of heat in the building for heating period, W_o **after implementation of the activities**	kW·h	**97434**	**138567**	**112331**	**89809**	**28345**	**44541**
Annual use of electricty by the lighting system, W_{oc} **after implementation of the activities**	kW·h	4560	1264	4452	2992	3443	2704,3
Reduction in the use of heat and electricity **before the activities**	kW·h	279392,6	431046,8	319894,2	332560,6	112770,7	182008,2
Reduction in the use of heat and electricity **after implementation of the activities**	kW·h	101994	139831	116783	92801	31788	47245,3
Total reduction of heat and energy use	kW·h	**177398,6**	**291216**	**203111**	**239760**	**80982,7**	**134763**
	%	**63**	**68**	**63**	**72**	**72**	**74**
Total reduction of heat and energy use in 6 sites	kW·h	**1127231**					

Comparative Data of the Energy Use for Heating at Pilot Sites in the Heating Period (based on measurements/reports) before and after implementation of the activities to enhance energy efficiency

Indicators	Unit of Measurement	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon	Oqtepa SVP Pskent rayon	Dehibaland SVP Nuratau rayon
					Building A		
Use of heat in the building for heating period, **before the activities**	kW·h	267712,6	405086,8	315286,2	319360,6	109327,7	179103,6
Use of heat in the building for heating period, **after implementation of the activities**	kW·h	135325	192453	156016	124734	39368	61862
% reduction	%	**49,45**	**52,49**	**50,51**	**60,94**	**63,99**	**65,46**

The same in terms per 1 square meter per annum (heating season)

Indicators	Unit of Measurement	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon	Oqtepa SVP Pskent rayon	Dehibaland SVP Nuratau rayon
					Building A		
Use of heat in the building for heating period, **before the activities**	kW·h/sq. m per annum	**289.62**	**231.11**	**281.1**	**365.87**	**349.07**	**451.65**
Use of heat in the building for heating period, **after implementation of the activities**	kW·h/sq. m. per annum	**146.4**	**109.8**	**139.1**	**142.9**	**125.7**	**156.0**

Findings of the Estimates of Annual Energy Use Data of Demonstration Buildings*

Indicators	Unit of Measurement	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qo'rg'ontepa rayon	Oqtepa SVP Pskent rayon	Dehibaland SVP Nuratau rayon
					Building A	Building B				
Use of heat in the building for heating period, W_o	МДж	350763	498839	404392	323312	142509	639089	764311	102042	160347
	kW·h	**97434**	**138567**	**112331**	**89809**	**39586**	**177525**	**212309**	**28345**	**44541**
Efficiency factor of heat emission, $k_{то}$		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Efficiency factor of heat generation, $k_{ген}$		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Amount of energy required for the building in the heating period, $W_{нот}$*	**kW·h**	**135325**	**192453**	**156016**	**124734**	**54980**	**246562**	**294873**	**39368**	**61862**
Annual use of electricty by the lighting system, $W_{ос}$	kW·h	2720	592	3220	2384	984	3312	5540	1803	1715
Use of electricity for air conditioning in the hot period of the year, $W_{к}$	kW·h	326	-	354	348	742	1099	1172	-	-
Annual use of electricity for hot water, $W_{гвс}$	kW·h	300	-	-	300	-	600	300	-	469,5
Annual use of electricity by other electric equipment , $W_{об}$	kW·h	1388	1532	880	1520	760	2738	2542	4097	1972
Annual use of electricity by the building, $W_{ээ}$	**kW·h**	**4734**	**2124**	**4454**	**4552**	**2486**	**7749**	**9554**	**5900**	**4157**
Total annual use of energy by the building зданием ($W_{нот}+W_{ээ}$)	**kW·h**	**140060**	**194577**	**160469**	**129286**	**57467**	**254311**	**304427**	**45268**	**66019**

* Explanatory Notes to the Table – Findings of the Estimates of Annual Energy Use Date at Demonstration Sites

It is visible that the table presents the data on *Heat Use for the building in the heating period*, Wo and *Required Amount of Energy for the Building in the Heating Period,* Wнот*. The difference is explained by the efficiency factor of the heating systems and heat generation equipment (boilers).

As the project input in the construction and rehabilitation of the pilot building did not cover electric equipment, the final result of the project did not consider reduction in electricity use of pilot buildings. Total reduction of energy use in the pilot buildings was facilitated by the heat insulation materials and other technical solutions for energy efficiency according to the updated building codes and regulations. Main contribution of the project was significant reduction of energy use for heating in the pilot buildings.

Summary Data on Direct Reduction of CO2 Emissions

Indicators	Unit of Measure ment.	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School №2 Rishtan rayon	School №35 Khatirchi rayon	Oqtepa SVP, Pskent rayon	Dehibaland SVP, Nuratau rayon
					Building A		
Total emissionsCO_2 before the activities	tCO_2/per	60.77	96.70	110.15	72.07	24.06	62.74
Total emissionsCO_2 after implementation of the activities	tCO_2/per annum	22.29	28.71	40.86	19.86	7.70	16.74
Direct reduction of emissions CO_2 across sites	**tCO_2/per annum**	**38.48**	**67.99**	**69.30**	**52.22**	**16.36**	**46.00**
Total reduction of emissions CO_2	**tCO_2/per**	**290.3**					

The table demonstrates CO_2 emissions compared to the baseline **before and after the activities** to enhance energy efficiency of the buildings

Findings of the Estimates of CO2 Emissions of all Buildings of Demonstration Sites

Indicators	Unit of Measurement.	School № 5 Kanlikul rayon	School № 20 Karshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qorgontepa rayon	Oqtepa SVP Pskent rayon	Dehibaland SVP, Nuratau rayon
					Building A	Building B				
Use of energy for the building in the heating period	kW·h	135325	192454,2	156015.3	124734.7	54980.56	246562.5	294873.6	39368.1	61862.5
Annual use of electricity by the building	kW·h	4734	2124	4454	4552	2486	7749	9554	5900	4157
Type of fuel used		natural gas	natural gas	coal	natural gas	natural gas	natural gas	coal	natural gas	coal
Ratio of CO_2 emissions in the use of fuel	$kg(CO_2)/kW{\cdot}h$	0.202	0.202	0.341	0.202	0.202	0.202	0.341	0.202	0.341
Ratio of CO_2 emissions in electricity generation	$kg(CO_2)/kW{\cdot}h$	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573
Emissions of CO_2, generated in the use of heat	tCO_2/per annum	27.3	38.9	53.2	25.2	11.1	49.8	100.6	8.0	21.1
Emissions of CO_2, generated in the use of electricity	tCO_2/per annum	2.7	1.2	2.6	2.6	1.4	4.4	5.5	3.4	2.4
Total CO_2 emissions	tCO_2/per annum	**30.0**	**40.1**	**55.8**	**27.8**	**12.5**	**54.2**	**106.0**	**11.3**	**23.5**
Total CO_2 emissions at all sites	tCO_2/per annum	**361.3**								

The table is presented to demonstrate the estimates of all CO_2 emissions at pilot buildings of the project.

Sites BEFORE and AFTER Renovation

Dehibaland SVP, Navoi oblast

	Before	After
Energy use for heating, kWh per sq.m. per annum	451.14	156.00
Emissions of tons of, CO_2 per annum	62.74	16.74

Oqtepa SVP, Tashkent oblast

	Before	After
Energy use for heating, kWh per sq.m. per annum	349.07	125.70
Emissions of tons of, CO_2 per annum	24.06	7.70

School №2, Ferghana oblast

	Before	After
Energy use for heating, kWh per sq.m. per annum	281.10	139.10
Emissions of, tons of CO_2 per annum	110.15	40.86

School №5, Karakalpakstan

	Before	After
Energy use for heating, kW*h per sq.m. per annum	289.62	146.40
Emissions of tons of CO_2 per annum	60.77	22.29

School №20, Kashkadarya
oblast

	Before	After
Energy use for heating, kWh per sq.m. per annum	231.11	109.80
Emissions of tons of CO_2 per annum	96.70	28.71

School №35, Navoi oblast

	Before	After
Energy use for heating, kW*h per sq.m. per annum	365.87	142.90
Emissions of tons of CO_2 per annum	72.07	19.86

Total direct reduction of emissions in 6 pilot sites is **290.3 TCO_2/per annum.**

Recommendations to enhance energy efficiency of Social sector Buildings based on the experience of Construction and Rehabilitation of Pilot Project Sites

Energy efficiency of buildings consists of two components:

- Construction aspects including modern engineering solutions to improve heat insulation properties of the building's structures, use of modern window frames, doors, tambour, and other structures and materials, and use of highly effective systems of heating and energy efficient boilers;
- Organizational aspects, including proper optimal management of energy use in the building, so called energy management, designed to flexibly regulate the process of maintaining comfortable environment in the buildings according to the norms and regulations.

Based on the findings of the energy audits of pilot sites of the buildings of schools and rural health clinics (SVPs), the Institute of Energy and Automation of the Academy of Sciences Uzbekistan drafted a number of recommendations to enhance the energy efficiency of buildings, conducting feasibility studies of the energy efficiency activities proposed for implementation along with their classification of cost recovery periods. They were divided into:

- Long-term, high-cost activities, which required significant capital expenditures with the cost recovery period over 5 years;
- Medium-cost activities with the cost recovery period from 2 to 5 years;
- Low-cost activities with the cost recovery period from 1 to 2 years;
- Priority no-cost activities.

These recommendations were formulated for each pilot project building and outlined in detail in six-volume report (produced in 2011) under Phase 9 of the works in the first stage of the energy audit conducted by the IEA. These materials of the report were used in combination in drafting design documentation and cost estimates for major renovation of pilot school buildings as well as in designing new pilot schools with higher energy efficiency.

Conclusion

According to the estimates of the IEA, aggregate indicators of all 6 sites totaled:

Annual indicators before implementation of energy efficiency projects:
Total energy use — **1 657 673.1 kWh**
Total CO_2 emissions — **426.5 tons CO_2/per annum**
Financial costs (at current tariffs*) — **50 752.84 thousand soums**

Annual indicators after implementation of energy efficiency projects:
Total energy use — **530 442.3 kWh**
Total CO_2 emissions — **136.2 tons CO_2/per annum**
Financial costs (at current tariffs) — **16 242.93 thousand soums**

Total
Total reduction of energy use per annum — **1 127 230.8 kWh**
Total direct reduction of CO_2 emissions
per annum at 6 pilot sites — **290.3 tons of CO_2/per annum**
Total reduction of financial costs per annum (at current tariffs *)
— **34 509,91 thousand soums.**
* Cost $1m^3$ of natural gas — 122.85 soums (tariff at the time of audit and estimates)