Enhancing Energy Efficiency of Social Sector Buildings in Uzbekistan

Joint Project of the United Nations Development Programme (UNDP), the Global Environmental Facility (GEF), and the State Committee for Architecture and Construction of Uzbekistan

ANALYSIS
of the Results of Utilization of Energy Efficient Solutions at 8 Pilot Sites of the Project as a Result of Energy Audit conducted by the Institute of Energy and Automation under the Academy of Sciences of Uzbekistan in the heating season of 2013 - 2014

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1. Pilot sites of the project, utilized energy efficient engineering and technical solutions and technologies

In the framework of implementation of joint project of UNDP, GEF, and the State Committee for Architecture and Construction (UNDP-GEF project), 2 new rural schools were built, and 4 rural schools and 2 rural health clinics (SVPs) located in different climate zones of Uzbekistan were rehabilitated in 2012. The purpose of this effort was to obtain practical experience and analyze the results of application of new provisions of regulatory documents reviewed in the UNDP/GEF project on specific sites, use local energy efficient materials, technologies for subsequent replication of the best experience in the similar standard buildings nationwide. All pilot sites were commissioned in September 2012.

1. New 2-floor school for 315 students in Andijan oblast.
2. New 2-floor school for 216 students in Navoi oblast.
3. Oqtepa SVP in Pskent rayon of Tashkent oblast. SVP was built based on standard design in 1999, design capacity – 50 visits per day.
4. Dehibaland SVP in Nuratau rayon, Navoi oblast. Building was built in 1950 based on standard design, design capacity – 25 visits per day.
5. School №2 in Chek Jaloer settlement, Rishtan rayon of Ferghana oblast. Building has 2 floors, was built based on standard design in 1988. The school is designed for 320 students.
6. School №20 in Mirmiron settlement of Qarshi rayon in Kashkadarya oblast. Building is 2-floor, was built based on standard design in 1980, designed for 320 students.
7. School №5 in Beshkupir settlement, Qonlikol rayon of Karakalpakstan. Building is a standard one, 1-floor, was built in 2001. Annex with classrooms for 40 students was built along with a gymnasium in 2012. The school is designed for 260 students.
8. School №35 in Yangirabot settlement, Khatirchi rayon of Navoi oblast. Building is a standard 1-floor building, was built in 1968, designed for 260 students. In 2012 in the process of major rehabilitation, one-floor annex with classrooms for 120 students was built.

These sites were included in the State Investment Programme for 2012 specifying the percentage of co-financing of the Government and UNDP/GEF. Average indicator of the cost of EE activities totaled 17%, which is quite comparable to the indicators in European and CIS countries.

Secondary thermal insulation was applied at all pilot sites, with consideration of the climatic conditions of the area (requirement of KMK 2.01.04-97*), essential indicators of heat insulation materials for external layer of the building (foundation, socle, outer walls, attic partitions, coating above the cellar) were identified by estimates). Multi-layer outer walls were recommended and used in the design and implementation of technical solution as the most energy efficient.

<u>Thermal insulation of the socle of the façade and the foundation</u> was done using PCB-30 and Polyplex extruded polystyrene boards, as this thermal insulation material has higher density and moisture resistance compared to the materials made from mineral wool and basalt materials. Foamed concrete bricks were used at the school №5 in Qonlikol rayon of Karakalpakstan

Technology of extruded polystyrene envisages fire-safety efforts, including fireproof splittings made from fire-proof basalt fibre around the windows and entry doors. Thermal insulation and metal reinforcement mesh were attached using plastic plated dowels with subsequent glue-and-cement plaster. Heat insulation of the floor and attic partitions at six sites was done using PJ-175 heat insulation material made by Ahangarancement OJSC, and Tizol-n basalt fiber insulation mats at 2 others. The thickness of the heat insulation layer of the walls for each pilot sites was estimated case-by-case basis depending on the climate of the area of construction.

Fragment : "Wet façade" wall insulation

"Wet facade" technology is the most prevalent, used in 7 of 8 pilot sites. After installation of heat insulation, cement and glue plaster was applied, whereas "*ventilated façade"* was used only at pilot school # 39 in Qorgontepa rayon of Andijan oblast.

Ventilated façade technology includes the layer of air between the facing and the insulation materials, attached to the outer walls using plated dowels. *M-75* mineral wool insulation material with low heat conductivity and high fire-safety qualities (made in Uzbekistan) was used for insulation. Russian-made Isospan-A heat-and-moisture-proof membrane is designed to retain the layer of heat insulation from possible strong air flow, moisture, and removal of the moisture steam as well as prevention of mold and other fungi, which speed up decay of the material. Magnesium-glass sheet with high durability, moisture-proof and other important characteristics was used as the casing of the façade.

Fragment 2: Ventilated façade

Fragment 3: Heat insulation of attic

Notably in the design of pilot sites, given the energy efficient technical solutions, the main requirement of national and international project consultant was to use heat insulation materials with heat conductivity below 0,040 watt/(m^2*K) manufactured domestically.

Energy efficient plastic window frames with 3-4 chamber profile and double-glazing were installed at all sites. Significant difference of this novel technical solution (as opposed to the traditional installation of window frames in the middle of the aperture) is installation of the window frames on one same line as the outer wall of the building with no additional costs for implementation. This technical solution enables to significantly reduce the emergence of cold bridges between apertures and walls, thus, enhancing insulation of the building.

Fragment 4: Installation of plastic windows using new technical solution

Entrance vestibules were built and entry doors made from plastic profiles were installed at all sites (requirement of SHNK 2.08.02-09*). This technical solution will enable to preserve heat in winter and cool air in summer as well as durability of the structures, whereas the air between two doors will act as a buffer to prevent the inflow of cold air in winter and hot air in summer. Main entry at all pilot sites is now arranged through the entrance vestibules.

Fragment 5: Entrance vestibule made of plastic frames and double-glazing

Heat-reflecting foil sheets were installed behind radiators. This low-cost technical solution will enable the maximum amount of heat to be reflected back into the premises. Efficiency – up to 2% of total energy savings, whereas the costs are nearly zero (on average USD 60 per one pilot site).

Layout of the piping of the heating system at 6 reconstructed pilot sites has been fully modernized. Old rusty metal pipes have been replaced by new polypropylene pipes with main advantage – resistance to thermic and chemical impact, thus, have longer service life. Obsolete boilers were replaced by modern energy efficient boilers with efficiency up to 90%, whereas modular boilers operating on natural gas and coal were installed at newly built two schools, equipped with all essential control and measurement devices (pressure gauges, thermometers, burner controls, circulation pumps, electronic gas meters, etc.). Autonomous power sources were installed as the backup source of power at new schools, which enable continuous operation of recirculation pumps of modular boiler houses.

Fragment 6: Use of wall-mounted energy efficient boiler

Fragment 7: Installation of aluminum radiators with thermal regulation valves

Access ramps were built at the main building entrances of all pilot sites.

Fragment 8: Access ramp (requirement of KMK 2.08.04-04*)

Maximum use of locally manufactured domestic heat insulation materials became an important requirement in the process of design and construction / renovation of pilot sites, which enabled to optimize transportation costs in the implementation of energy efficiency steps in the construction and refurbishment of pilot sites.

2. Summary Data of the Findings of Energy Audits at Demonstration Sites

In order to obtain actual data on the use of energy and other quantitative indicators of pilot sites, energy audits were conducted at all eight demonstration sites in 2013-2014. Main goals of this energy audit were as follows:

- Acquisition of quantitative data for assessment of the efficiency of the use of heat and electricity at demonstration sites;
- Conducting quantitative assessment of energy efficiency, monetary savings, reductions of emissions of greenhouse gases as well as assessment of other non-energy benefits;
- Producing experimental energy passport for each of demonstration sites.

Based on the results of the audits of demonstration sites, respective reports were submitted for each of them.

Each report contains:

1. General description of the building, heat- and electricity supply systems of the demonstration site;
2. Findings of instrumental measurements of the systems of energy use, temperature and moisture regimen and illumination of the premises and their assessment;
3. Findings of thermal vision screening of the walls and heating equipment;
4. Monitoring of energy and climate indicators in the annual cycle;
5. Experimental energy passports of the buildings defining their category of energy efficiency according to the requirements of the standards «Systems of certification of the buildings for energy efficiency».

Main technical and energy efficiency indicators obtained based on the audits of pilot buildings, are given below in tables (Tables 1 to 5)

2.1 Conducting Instrumental Measurements of Temperature and Moisture in the Pilot buildings and the Findings

Microclimate in the premises is the essential sanitary and hygienic factor, which in many respects affects human health and capacity to work, and indoor air temperature is one of the basic indicators. The ultimate purpose of the measurements is to identify real indicators of all factors, which affect the working environment in the premises.

In order to identify real air indicators including its humidity inside the premises, instrumental measurements of temperature using miscellaneous devices were conducted according to the Standard Methodology of Energy Audit of Social Sector Buildings approved by the State Architecture and Construction Committee of Uzbekistan on September 9, 2011. Daily measurements of the microclimate inside and outside of the buildings were conducted for 3 days. All findings of microclimate measurements are compared against the statutory requirements of GOST 30494-96.

Let us review the findings of the measurements in the example of several pilot sites located in different climate zones:

School №39 in Qo'rgontepa rayon, Andijan oblast

Summary Climate Indicators, Indoors and Outdoors

Indicator		Day 1	Day 2	Day 3
Temperature, ºC	indoor	13.5/15.1	13.5/ 13.9	13.6/14.2
	outdoor	5	2	3
Relative humidity, %	indoor	55.1/57.7	58.2/57.3	55.8/55.9
	outdoor	58	80	80
	outdoor	1.16-1.34	1-1.12	0.96-1.03

Based on the results of the measurements of the temperature and humidity in the school №39, following conclusions can be made:

- Outdoor temperature: maximum: +12 ºC; minimum: +2 ºC; average: +7 ºC;
- Indoor temperature: maximum: +15,3 ºC; minimum: +13,2 ºC; average: +14,3 ºC;
- Relative humidity outdoors: maximum: 98 %; minimum: 62%; average: 80%;
- Relative humidity indoors: maximum: 63 %; minimum: 51%; average: 57%.

Maximum decline of outdoor temperature was observed at night and in the early morning.

Indoor temperature in the premises ranges between +13 and +15 ºC. It reaches the maximum (+14-+15 ºC) between 9:00 and 17:00, i.e. during the classes, whereas in the absence of students, indoor temperature is maintained between +13 – +15 ºC, which is ***below regulatory requirements of GOST 30494-96 (permissible indicator between 18-24 ^{0}C).***

School №5 Qonlikol rayon of Karakalpakstan

Summary Climate Indicators, Indoors and Outdoors

Indicator		Day 1	Day 2	Day 3
Temperature,ºC	indoor	16	15.9	16.1
	outdoor	-12	-9	-7
Relative humidity, %	indoor	41.1	41.7	40.5
	outdoor	72	62	75
	outdoor	1.73-2.17	1.56-1.95	1.61-2.15

Based on the findings of temperature and humidity measurements, following conclusions can be made.

- Outdoor temperature: maximum -3 ºC; minimum: -12.5 ºC; average: -7.7 ºC.
- Indoor temperature: Premises 1) maximum: +23.1 ºC; minimum: +15.3 ºC; average: +18.0 ºC.
- Premises 2) maximum: +22.3 ºC; minimum: +15.9 ºC; average: +18.1 ºC.
- Relative humidity outdoor: maximum: 87.9%; minimum: 57.4%; average: 73.1%.
- Relative humidity indoor: maximum: 58.8%; minimum: 40.1%; average: 49.9%.

Maximum decline of outdoor temperature was observed at night and in the early morning.

Indoor temperature in the premises ranges between +16 and +22ºC. It reaches the maximum (+19-+22ºC) between 9:00 and 17:00, i.e. during the classes, whereas in the absence of students, indoor temperature is maintained between +16- +17ºC, ***which conforms to the regulatory requirements of GOST 30494-96 (permissible indicator от 18-24 ^{0}C).***

Oqtepa SVP, Pskent rayon, Tashkent oblast:

Summary Climate Indicators, Indoors and Outdoors

Indicator		Day 1	Day 2	Day 3
Temperature, ºC	indoor	19,8	19	18
	outdoor	-4,2	2	-2
Relative humidity, %	indoor	36,3 %	38,4 %	40,6 %
	outdoor	32,1-38 %	50-59 %	66-70 %
	outdoor	0,46-0,53	0,15-0,2	0,28-0,34

Based on the findings of temperature and humidity measurements, following conclusions can be made:

- Outdoor temperature: maximum: + 4.6 ºC; minimum: -5.1 ºC; average: -0.8 ºC.
- Indoor temperature: maximum: + 22.3 ºC; minimum: + 14.7 ºC; average: + 16.5 ºC.
- Relative humidity outdoor: maximum: 93%; minimum: 64%; average: 80.8%.

- Relative humidity indoor: maximum: 40.1%; minimum: 44.3%; average: 42%.

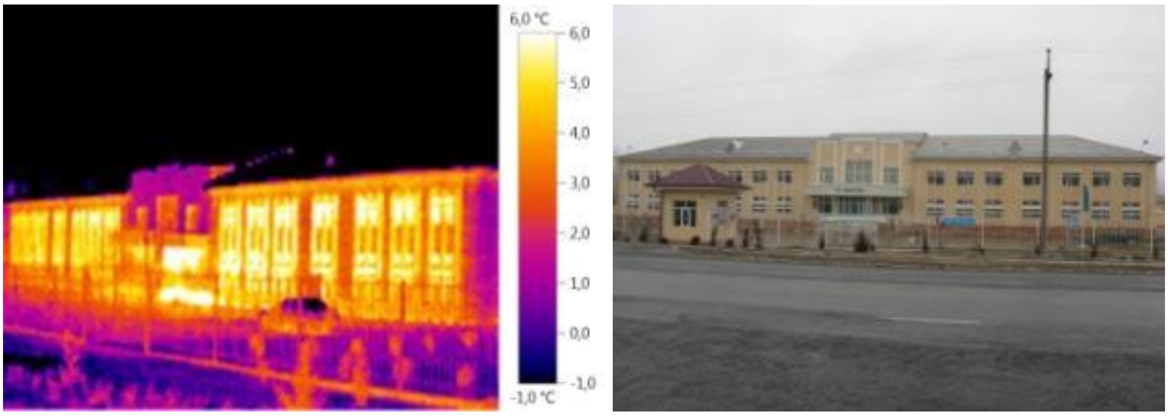
Maximum decline of outdoor temperature was observed at night and in the early morning, indoor temperature is within 16 and 22 ºC. It reaches the maximum temperature (19-22 ºC) between 9:00 and 17:00, i.e. close to the regulatory requirements of ***GOST 30494-96 (permissible indicator from 18-24*** ^{0}***C).***

2.2 Thermovision of the outer structure to determine the quality of activities for thermal insulation of the buildings

These efforts in the framework of energy audit is amongst the critical components of the survey of outer walls, respectively, the quality of thermal insulation of the buildings as well as to detect possible hidden construction defects or cold bridges.

Thermal vision surveys of some pilot sites are given as examples:

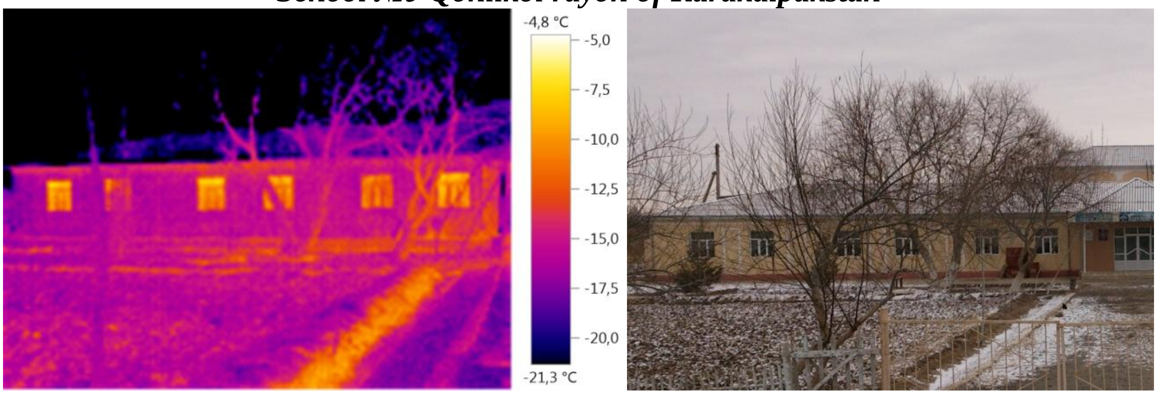
School №39 in Qo'rgontepa rayon, Andijan oblast



Thermogram of the Front Facade

Windows account for the most of heat losses (heat losses are levelized). Maximum temperature on the windows reaches +8.1 °C. Average temperature on the surface of the wall, highlighted by marker – direct line, is +3.0 °C.

School №5 Qonlikol rayon of Karakalpakstan



The thermogram displays the section of front facade

The windows account for the most of heat losses (heat losses are levelized). Maximum temperature -7.5 °C is reached on the windows highlighted by markers as quadrangles. Average temperature on the surface of the wall in this section is -15.6 °C.

Oqtepa SVP Pskent rayon Tashkent oblast

The thermogram displays the section of front facade

Maximum temperature of -1.2°C is on the window, highlighted by marker as a rectangle. Average temperature on the surface of the wall in this section is -3.3°C. The difference between the average temperature on the window and average temperature on the surface of the wall is 1.1°C. Windows account for the most of heat losses (heat losses are levelized).

Thermographic survey was also done on other sections of the façade and miscellaneous heating equipment and devices of all eight pilot buildings, based on the results of which, conclusion can be made regarding these three examples (this analogy exists at all sites):

Results of the thermographic screening of the building of the school №39:

1. Outer facade has several zones with higher heat losses (apertures): average temperature of the walls ranges from +0.8 up to +3.3°C, zones of higher heat losses are highlighted by markers.
2. Main sections of insignificant heat losses are window frames. Maximum temperature reaches +10,4°C. The difference in temperature in some sections of the windows is over 9°C higher compared to the average temperature of the walls. The causes of higher air flow through the windows were as follows:

- Shutters are not well-regulated (sealants are not adequately pressed);
- Sealant is damaged or sub-standard;
- Field joints were not properly done in the installation of windows;
- Window ventilators.

It was recommended to fine-tune the window shutters, check the quality of sealants, and if required, replace them.

Result of Thermographic Screening of the Facade of the Building of the School №5

1. Outer facade has several zones with higher heat losses: average temperature of the walls of the academic building ranges from -10,8 up to -16,5°C, gymnasium – -9,4 and -14,3°C; zones of higher heat losses are highlighted by markers. Heat insulation blocs are not adequately closely installed, and there are small cracks between them.

2. Main sections of insignificant heat losses are window frames. Maximum temperature reaches +2,4°C. The difference in temperature in some sections of the windows is over 12°C higher compared to the average temperature of the walls. The causes of higher air flow through the windows were as follows:

- Shutters are not well-regulated (sealants are not adequately pressed);
- Sealant is damaged or sub-standard;
- Field joints were not properly done in the installation of windows;

Recommendations:

1) Fine-tune the window shutters, check the quality of sealants, and if required, replace them.

2) Install (related only to the school gymnasium) heat reflectors behind all heating devices to improve their efficiency, and reduction of the heating of the walls behind the heating devices.

Findings of Thermographic screening of the Facade of the building of Oqtepa SVP

1. Outer façade has several zones with higher heat losses: average temperature of the walls ranges from -3,3до -5,9°C, zones of higher heat losses are highlighted by markers. Heat insulation units are not adequately installed and there are small cracks between them throughout entire SVP. The different in the temperature of cracks and the temperature of the walls is less than 0.5°C.

2. Main sections of insignificant heat losses are window frames. Maximum temperature reaches +2,4°C. The difference in temperature in some sections of the windows is 14°C higher compared to average temperature of the walls. The causes of higher air flow through the windows were as follows:

- Shutters are not well-regulated (sealants are not adequately pressed);
- Sealant is damaged or sub-standard;
- Field joints were not properly done in the installation of windows;

It is recommended to fine-tune the window shutters, check the quality of sealants, and if required, replace them.

***Conclusion**: based on the results of thermographic screening of the facades of eight pilot buildings one can conclude that no serious construction defects were found in thermal insulation works or installation of window frames and entry doors, whereas some minor deficiencies were found and recommended to be addressed.*

2.3 Мониторинг energy and climate indicators and его Findings

Based on the collected information, the database of actual indicators of the use of energy resources in 2013-2014 was generated, which enabled to identify total use of heat at eight pilot sites, and thus, to estimate the use of energy resources (natural gas, coal), but notably these data are tentative estimates (Tables 5 and 8).

2.4 Design Experimental Energy Passport and Define Category of Energy Efficiency of the Building

The Republican Center for Standardization and Certification of Construction drafted 17 State Standards for the "*System of Mandatory Certification of Buildings for Energy Efficiency*". One of the important aspects of this system is to design energy passport of the building and to define the category of the building on energy efficiency (see, Table 4).

The GOST «O'z Dst … 09 System of Certification of Buildings for Energy Efficiency – Energy passport. Requirements to the form, content, and processing" contains the form of the energy passport of the building. According to this standard, in addition to the energy passport of the building, an annex to the energy passport is also drafted, which includes additional sections in addition to the passport itself.

3. Emissions of greenhouse gases and Reduction thereof compared to the Results of Previous Energy audits

As a result of the activities to improve energy efficiency of the buildings, "measurable" reduction of emissions of the greenhouse gases has been obtained. Reduction of emissions is done against the baseline. Baseline is the scenario of the emissions of greenhouse gases before the activities to enhance energy efficiency of the buildings (before refurbishment buildings).

In order to identify direct reduction of CO2 emissions, the buildings of six sites, where energy audits were conducted before refurbishment and the activities to enhance energy efficiency, are considered.

For the purpose of comparative estimates of CO2 emissions from the use of heat, the data on the use of heat for heating the building in the heating season, before and after implementation of the activities (see Table 7) are considered.

Energy efficiency activities enabled to reach the reductions of CO2 emissions per annum at six pilot sites, with consideration of heating systems by **290.3 tons of CO2/annum or by 68%**.

Overall, the reduction of total (including the heat supply system) of emissions of greenhouse gases at all eight pilot buildings, based on the results of the estimates, amounted to **380 ton CO2/ annum or by 53%** (see, Tables 6).

CONCLUSIONS

According to the results of estimates, based on the energy audit, indicators of eight sites amounted to:

Annual indicators BEFORE implementation of energy efficient solutions:

- Total energy use for heating – **2 705 511 kWh**
- Total CO_2 emissions – **715.2 tons of CO_2/annum**
- Financial costs (at current tariffs, 6 buildings) – **50 752.84 thousand soums**

*Annual indicators **AFTER** implementation of energy efficient solutions*:

- Total energy use for heating – **1 290 779 kWh**
- Total emissions CO_2 – **335.2 tons of CO_2/annum**
- Financial costs (at current tariffs, 6 buildings) – **16 242.93 thousand soums**

***Implementation of energy efficiency solutions enabled to*:**

- Total reduction of energy use per annum – **1 414 732 kWh (52%)**
- Total reduction of CO_2 emissions per annum – **380 tons of CO_2/per annum (53%)**
- Total reduction of financial costs per annum (at current tariffs at the time of energy audit of the data on 6 buildings) – **34 509.91 thousand soums. (68%)**
- Natural gas savings **– 114,1 thousand m3**
- Coal savings – **156.8 tons**
- Overall savings of energy resources (based on exports tariffs) – **USD 44.2 thousand**
- Cost recovery period of energy efficiency solutions (based on export tariffs**)** **– 7.6 years (average)**
- Compliance of the buildings with the 2-nd level of heat insulation – **Compliant**
- Assessment of the level of energy efficiency of the buildings **– Compliant**

Maximum level – 3 pilot buildings

Improved level – 3 pilot buildings

High level – 2 pilot buildings

Non-energy benefits may include improved climate conditions in the premises, lower morbidity of students (patients at SVP) and the staff of the demonstration sites, improved awareness of the staff of the pilot sites and their families in the issues of energy efficiency in the buildings, improved environment thanks to the reduction of the emissions of greenhouse gases.

Note: for preparation of this analytical report, the data of *Energy Audit of Social Sector Demonstration Buildings*, the final report on the 4^{th} stage of the energy audit conducted by the Institute of Energy and Automation of the Academy of Science of Uzbekistan were used

Table 1 Geometric and Climate indicators of pilot sites

Indicators	Unit of Measurement	School № 5 Qonlikol rayon	School № 20 Qarshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qo'rgontepa rayon	SVP Pskent rayon	SVP Nuratau rayon
					Building A	Building B				
Number of floors	Number	1	2	2	1	1	2	2	1	1
Total area of the building A	m^2	924	1753	1122	873	436	1828	2246	313	396
Heated space in the building V_h	m^3	2495.55	5432.94	3534.05	2619.00	1308.24	6531.02	8262.82	939.36	1189.41
Estimated indoor air temperature in the heating period	°C	20	20	20	20	20	20	20	21	21
Estimated air temperature outdoors in the heating period	°C	-20	-14	-12	-13	-13	-15	-13	-12	-15
Average temperature of the air outdoors in the heating season	°C	1	5.2	3.5	4.4	4.4	4.1	3.2	5.1	4.1
Length of the heating season	days	182	152	161	170	170	169	162	154	169
Degree-days of the heating season	°C*day	3458	2250	2657	2652	2652	2687	2722	2449	2856
Estimated temperature of the indoor air in the warm season	°C	25	-	25	25	25	25	25	-	-
Estimated air temperature outdoors in warm season	°C	37.3	-	35.8	37.2	37.2	37.8	36.4	-	-
Average air temperature outdoors in warm season	°C	25.5	-	25.6	27.1	27.1	26.5	26.5	-	-
Length of the heating season	days	48	-	52	58	58	41	53	-	-

Note: because of the construction of additional classrooms and buildings in 2 schools – №35 Khatirchi rayon and school №5 Qonlikol rayon, the area of the sites increased against the initial data.

Table 2. Heat Conservation Indicators of pilot sites (resistance of outer structures to heat transmission)

Outer structure	Unit of Measurement	School № 5 Qonlikol rayon	School № 20 Qarshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qo'rgontepa rayon	SVP Pskent rayon	SVP Nuratau rayon
					Building A	Building B				
Outer wall	$m^2 \cdot {}^oC$/watt	2,2	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8
		2,3245	1,8050	1,953	2,23	2,1311	2,2971	2,1452	2,1093	2,1908
Energy efficiency rate of outer walls		II	III	III	II	II	II	II	II	II
		High	Improved	Improved	High	High	High	High	High	High
Camp ceiling (garret floor)	$m^2 \cdot {}^oC$/watt	2,56	2,08	2,08	2,08	2,08	2,08	2,08	2,08	2,08
		2,107	2,2483	2,3615	2,0969	2,1172	2,0814	2,9147	2,8998	2,3481
Energy efficiency rate of camp ceiling		II	II	II	II	III	III	II	II	II
		High	High	High	High	Improved	Improved	High	High	High level
On the ground, floor over the cold basement or cellar	$m^2 \cdot {}^oC$/watt	1.68	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
		7.77	6.87	1.94	5.35	7.14	8.15	8.74	5.65	5.19
Energy efficiency rate of the floor over cold basement or cellar		I	I	II	I	I	I	I	I	I
		Maximum	Maximum	High	Maximum	Maximum	Maximum	Maximum	Maximum	Maximum
windows, balcony doors	$m^2 \cdot {}^oC$/watt	0,43	0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,39
		0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,39	0,39
Energy efficiency rate of the windows		III	III	III	III	III	III	III	III	III
		Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved	Improved

Note: in general indicators of resistance to heat transmission of the walls buildings meet the requirements of the 2nd level of heat protection.

Table3. Data on Assessment of energy efficiency of heating systems and heat supply of pilot sites

Typw of the systems	School № 5 Qonlikol rayon	School № 20 Qarshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qo'rgontepa rayon	SVP Pskent rayon	SVP Nuratau rayon
				Building A	Building B				
Heating system	0,765	0,765	0,765	0,765	0,765	0,765	0,765	1	0,9
	< 0,80	< 0,80	< 0,80	< 0,80	< 0,80	< 0,80	< 0,80	0,96÷1,00	2,0785
Energy efficiency of heating system	IV	IV	IV	IV	IV	IV	IV	I	II
	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory	High	Average
Heating system	0,85	0,85	0,7	0,85	0,85	0,85	0,85	0,85	0,7
	0,82÷0,85	0,82÷0,86	0,65÷0,70	0,82÷0,86	0,82÷0,86	0,82÷0,86	0,82÷0,86	0,82÷0,86	0,65÷0,70
Energy efficiency rate of heating systems	I	I	IV	I	I	I	I	I	IV
	High	High	Low	High	High	High	High	High	Low

Note: in general, all pilot sites have heating systems of high level of energy efficiency, except for school №2 in Rishtan rayon, where design capacity of the heating equipment is low.
Installation of additional heating equipment is recommended (done in 2014 using the funds of general contractor)

Table 4. Data on Assessment of the Level of Energy efficiency of the buildings of pilot sites

Indicators	Unit of Measurement	School № 5 Qonlikol rayon	School № 20 Qarshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qo'rgontepa rayon	SVP Pskent rayon	SVP Nuratau rayon
					Building A	Building B				
Levelized specific use of heat for heating and ventilation	watt/m^2	107	74	74	100	100	74	74	94	94
Specific use of heat for heating and ventilation	watt/m^2	50,808	49,791	50,25	53,34	59,148	52,714	47,759	50,833	59,002
Category of energy efficiency of the building	**%**	**-48,15%**	**-28,6%**	**-6,51%**	**-41,92%**	**-34,82%**	**-23,77%**	**-30,55%**	**-56,10%**	**-38,13%**
Energy efficiency rate		**A**	**B**	**C**	**A**	**B**	**C**	**B**	**A**	**B**
		Maximum	**Improved**	**High**	**Maximum**	**Improved**	**High**	**Improved**	**Maximum**	**Improved**

Table 5. Indicators of the Annual and Specific Reduction of the Use of Heat (considering the systems of heat supply)

Pilot site	Area of the building	Use of heat		Reduced by		Use of energy		Reduced by	
		Before	After	Amount	%	Before	After	Amount	%
Units of Measurement	m2	kWh/annum	kWh/annum	kWh/annum	%	kWh/m^2	kWh/m^2	kWh/m^2	%
School №39 Qo'rgontepa rayon (new building)	2246	520 176	294 873	225 303	43.3	231.6	131.3	100.3	43.3
School №54 Nuratau rayon (new building)	1828	490 496	246 562	243 934	49.7	268.4	134.9	133.5	49.7
School №5 Qonlikol rayon	924	267 712	135 325	132 387	49.5	289.6	146.4	143.2	49.5
School №20 Qarshi rayon	1753	405 086	192 453	212 633	52.5	231.1	109.8	121.3	52.5
School №2 Rishtan rayon	1122	315 286	156 016	159 270	50.5	281.0	139.1	142.0	50.5
School №35 Building A Khatirchi rayon(renovation)	873	319 360	124 734	194 626	60.9	365.8	142.9	222.9	60.9
School №35 Building B Khatirchi rayon (new building)	436	98 965	39 586	59 379	60.0	226.9	90.8	136.2	60.0
Oqtepa SVP	313	109 327	39 368	69 959	64.0	349.2	125.7	223.4	64.0
Dehibaland SVP	396	179 103	61 862	117 241	65.5	451.7	156.0	295.7	65.5
Total:	**9 891**	**2 705 511**	**1 290 779**	**1 414 732**	**52**				**52**

Note: Annual and individualized indicators of the use of heat are illustrated disregarding the use of electricity.

Table 6. Summary Estimated Data on Reduction of the Emissions of greenhouse gases CO2 at eight pilot sites (with consideration of the systems of heat supply)

Indicators	Unit of Measurement	School № 5 Qonlikol rayon	School № 20 Qarshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon		School № 54 Nuratau rayon	School №39 Qo'rgontepa rayon	SVP Pskent rayon	SVP Nuratau rayon
					Building A	Building B				
Total emissions BEFORE implementation of the activities	ton CO2/annum	60.7	96.7	110.1	72.0	19.9	99.0	169.8	24.0	62.7
Total emissions AFTER implementation of the activities	ton CO2/annum	27.3	38.9	53.2	25.2	11.1	49.8	100.6	8.0	21.1
Reduction	ton CO2/annum	33.4	57.8	56.9	46.8	8.8	49.2	69.2	16.0	41.6
Total BEFORE	ton CO2/annum	**715,2**								
Total AFTER	ton CO2/annum	**335,2**								
Total reduction	ton CO2/annum	**380**								
Total reduction	%	**53**								

Note: Data on CO_2 emissions at 2 new schools (school №39 and school №54) and the new academic building of the school №35 are given as estimates.
(indicators on CO_2 emissions are given disregarding the emissions from the use of electricity in the buildings)

Table7. Direct reductions of CO_2 emissions at six pilot sites

Indicators	Unit of Measurement	School № 5 Qonlikol rayon	School № 20 Qarshi rayon	School № 2 Rishtan rayon	School № 35 Khatirchi rayon Building A	SVP Pskent rayon	SVP Nuratau rayon
Use of heat for heating of the building in the heating season, BEFORE implementation of the activities	kWh·ч	267 712	405 086	315 286	319 360	10 9327	179 103
Use of heat for heating of the building in the heating season, **AFTER** implementation of the activities	kWh·ч	135 325	192 453	156 016	124 734	39 368	61862
Type of Fuel used		natural gas	natural gas	coal	natural gas	natural gas	coal
CO_2 emissions generated in the use of heat BEFORE implementation of the activities	Ttons of CO_2/**annum**	60.77	96.70	110.15	72.07	24.06	62.74
CO_2 emissions generated in the use of heat **AFTER** implementation of the activities	tons of CO_2/**annum**	22.29	28.71	40.86	19.86	7.70	16.74
Direct reduction of CO_2 emissions	**т**	**38.48**	**67.99**	**69.30**	**52.22**	**16.36**	**46.0**
Reduction of CO2 emissions	**%**	**49.5**	**52.5**	**50.5**	**60.9**	**63.9**	**65.4**
Total reduction of emissions CO_2 in the use of heat at 6 sites	**tons of CO_2/annum**	**290,35**					

1. Overall at the sites using coal as the fuel for heating, reduction of emissions CO_2 amounted to 115.3 tons of CO_2/annum or 39,7% of total reduction of emissions of greenhouse gases.
2. At the sites heated by natural gas, reduction of emissions CO_2 amounted to 175,05 tons of CO_2/annum or 60.3% of total reduction of emissions of greenhouse gases.

Table 8 Indicators of Savings of Energy, Energy Resources, and Cost Recovery Period of the Energy Efficient Solutions

Pilot Site	Investments into EE	Use of heat		Reduction		Natural gas savings	Coal savings	Savings based on export tariffs	Cost Recovery at Export Prices
		Before	After	Amount	%				
Units of Measurement	USD, thousand	kWh/annum	kWh/annum	kWh/annum	%	thousand m^3	tons	USD, thousand	years
School №39 Qo'rgontepa rayon (new building)	124.88	520 176	294 873	225 303	43.3	0.0	70.4	7.0	16.8
School №54 Nuratau rayon (new building)	54.7	490 496	246 562	243 934	49.7	30.5	0.0	7.6	8.9
School №5 Qonlikol rayon	33.85	267 712	135 325	132 387	49.5	16.5	0.0	4.1	8.2
School №20 Qarshi rayon	35.2	405 086	192 453	212 633	52.5	26.6	0.0	6.6	5.3
School №2 Rishtan rayon	21.34	315 286	156 016	159 270	50.5	0.0	49.8	5.0	5.1
School №35 Building A Khatirchi rayon(renovation)	22.4	319 360	124 734	194 626	60.9	24.3	0.0	6.1	3.6
School №35 Building B Khatirchi rayon (new building)	12.46	98 965	39 586	59 379	60.0	7.4	0.0	1.9	6.9
Oqtepa SVP	15.6	109 327	39 368	69 959	64.0	8.7		2.2	7
Dehibaland SVP	14.91	179 103	61 862	117 241	65.5		36.6	3.7	4.8
Total:	**335.34**	**2 705 511**	**1 290 779**	**1 414 732**	**52**	**114.1**	**156.8**	**44.2**	**7.6**

Note: *Export price of natural gas: 1000m^3=250 USD* (http://neftegaz.ru/news/view/107164)
Average commercial price of coal: 1cu.m. =100 USD http://4037.uz.all.biz