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Preparation of a Sustainable Energy Action Plan under the Covenant of Mayors for Identification and Implementation of Energy Efficiency and Climate Change Mitigation Projects in Urban Community of Tsaghkadzor in Armenia

Energy Audit and Energy Efficiency Project

TSAKHKADZOR KINDERGARTEN AND ART SCHOOL BUILDING

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info@esfarmania.org p. 374(0)93 611 619 www.esfarmenia.org

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Executive Summary

Subject of Energy Audit is the kindergarten building which also houses the art school of the capital of Armenia's Kotayq Marz, Tsaghkadzor located at 85 Kecharetsu Street. The building has 2 storeys and is built with capacity of 90 children. While currently working under capacity, it allows to share the building with the recently moved art school. The building fenestration and roof have very poor thermal resistance, the heating system is inefficient and the building is operating at unallowable low level of comfort. The suggested energy saving project includes weatherization, window and door replacement, reduced glazing, and improved efficiency of the heating system with integrated solar water heating for hot water preparation, and other complementary measures.

ESM MEASURES

- *Replacement of old and non-efficient windows with high infiltration rate*
- *Partial replacement of windows by thermal insulated walls (reducing glazing areas)*
- *Replacement of old and non-efficient doors by efficient ones*
- *Thermal insulation of attic, installation of the attic door.*
- *Partial renovation/improvement of roof.*
- *Installation of condensation boiler with the accessories needed for putting a proper heating system in place*
- *Installation of solar water heating system for the domestic hot water supply system.*

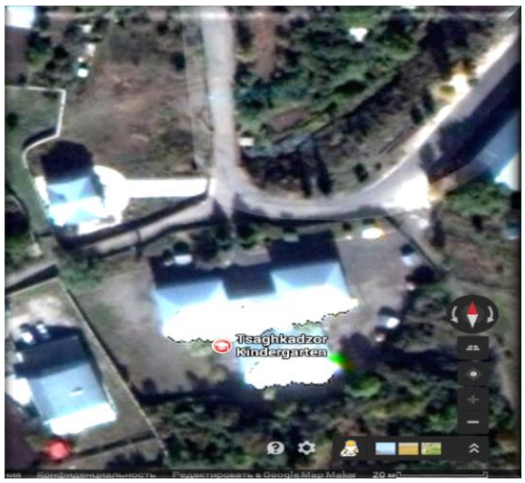
This audit has been elaborated under the project financed by the Global Environmental Fund Small Grants Program in Armenia. The purpose of the audit was to assess the energy saving potential as well as propose investments which can help cut the energy bills of the building, improve the comfort level, while cutting the associated greenhouse gas emissions. This project is the most attractive opportunity of the various energy efficiency options that were considered by the Foundation to Save Energy within the framework of the GEF Small Grant for the Preparation of a Sustainable Energy Action Plan under the Covenant of Mayors for Identification and Implementation of Energy Efficiency and Climate Change Mitigation Projects in Urban Community of Tsaghkadzor in Armenia.

Description of Status Quo

General Information

Tsakhkadzor city (Kotayq marz) is a resort with a 17,00 population. It is located on the east part of Teghenis mountains, 1840m above the sea level and 60km far from the Yerevan.

Kindergarten building consists of two buildings and a passage-way between two buildings. The



building is constructed from a local tufa stone by a laying type of "midis" and has an attic. Art school of Tsakhkadzor is also temporary located in the building of kindergarten.

Heating System

Heating of kindergarten is being implemented with the help of 3 units of 35kW capacity "Eurotherm" double contour, wall mounted, closed-burning chamber boilers. Plumbing part of the space heating system is implemented through a single pipe aluminum radiator system. Domestic hot water is also provided with the installed boilers in both kindergarten groups and in the kitchen. Cooking in the kitchen is being implemented via restaurant type electrical heaters and apartment type gas heaters.

Figure 1. Building Heating System Elements

Roof

Figure 2. Current Status of the Building Pitched Roof with Construction Garbage instead of Insulation

Roof of the kindergarten is generally renovated previously but because of some mistakes in assembly process leakage of water from the roof is observed in winters. Thermal insulation of the roof is implemented by a 7cm slag which does not meet the normative requirements of local thermal insulation standards. Roof should be strengthening by adding additional wooden column supports.

Windows and Doors (Fenestration)

Significant part of the windows and doors are in poor condition and must be replaced because of high infiltration and low thermal insulation parameters. The court-yard of kindergarten is separated by a fence and it is not illuminated during night time.

Figure 3. Building Fenestration Partially Consists of Worn Out Wooden Windows and Doors

Energy consumption

The average annual energy consumption of the kindergarten is presented below

Fuel Use / ***Energy End Use***	**Gas**		**Electricity**	**Total**
	normal m^3	kWh	kWh	kWh
Heating	15577	144866	5670	150536
Hot water	940	8738	2000	10738
Meals preparation	104	971	7130	8101
Other	0	0	1000	30
Total	16621	154575	15800	170375

Analysis of Energy Consumption

As the below chart indicates, most of the energy consumption of the building is laid under the category of space heating (88.4%). hot water preparation: 6.3%, Preparation of meals, lighting, appliances, office equipment, air conditioning and other consumptions do not cumulatively exceed 5%.

Figure 4. Structure of Building Energy End Use

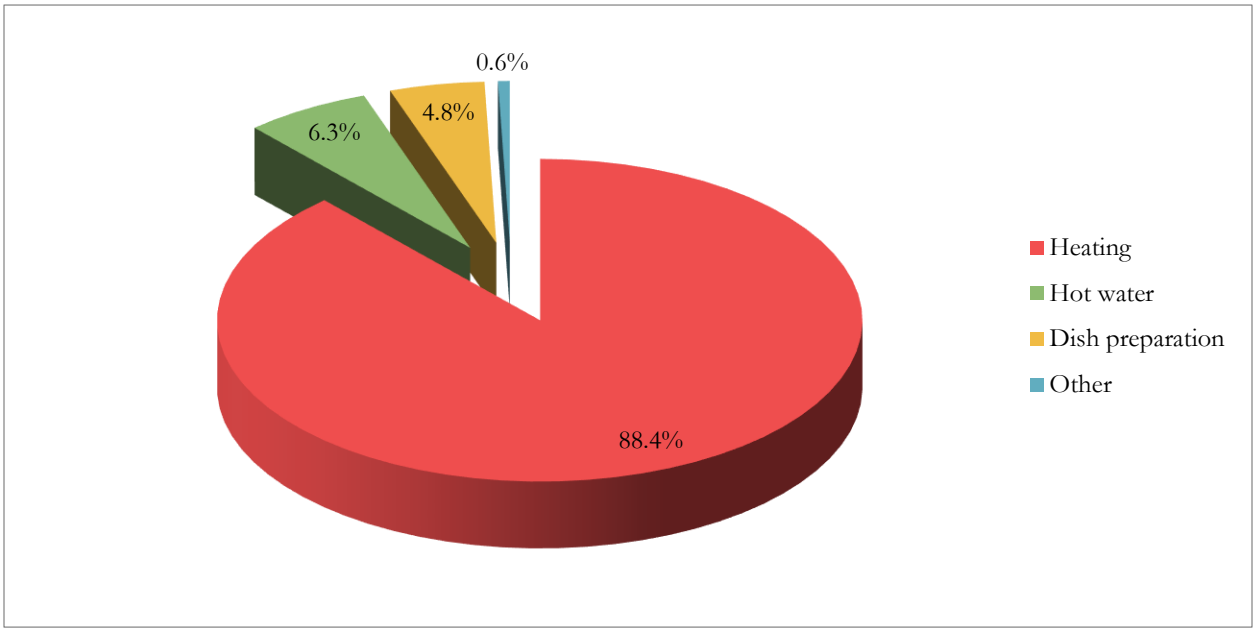


Figure 5. Heat Metrics - Input Parameters for Thermal Energy Saving Calculations

Duration of heating season:	201 days
Average temperature of heating season:	-1.6ºC
Air temperature of the coldest five-day period:	-20ºC (98% peak support) -18ºC (92% peak support)
Coldest month:	January (-8ºC)
Relative humidity during cold months:	69%
Non sunny days in a year:	30 days
Sunray duration:	2355 hours
Average temperature in kindergarten:	20ºC
Heating area:	1035 m^2

Climatic calculation conditions, Energy Demand and Comfort

Annual heating energy demand according to the normative based on optimal comfort conditions is estimated to be 350 MWh while the current actual annual consumption for heating is 151 MWh. Given the difference between the actual and estimated consumptions heating comfort level has been calculated to be as low as 43%. Annual energy demand for water heating has been estimated

to be around 20 MWh while the actual consumption is around 9 MWh. There is no exterior lighting installed for the kindergarten but according to normative based on optimal lighting conditions 22MWh energy would be consumed annually to light up the required areas by conventional lighting fixtures. These flag the need of not only energy efficiency improvements but also urgent need to improve the comfort conditions for the better preservation of children's health.

Energy saving measures

The following energy saving measures are suggested to be implemented to reduce the energy consumption of the building based on the analyzed building structures, infrastructures and energy use patterns, as well as comfort levels and utility bills. The specific measures proposed are presented below

Energy Efficiency Retrofits in Fenestration

Based on the inspection of the deficiencies of the doors and windows, the experts recommended the following energy efficiency upgrades to the building fenestration:

1. Replacement of old and non-efficient windows with high infiltration rate with new, high-efficiency, double glazed windows.
2. Partial replacement of windows by thermal insulated walls (reducing glazing areas
3. Replacement of old and non-efficient doors by efficient ones

These would allow reducing the infiltration losses, save the thermal energy, as well as reduce the draft current which often leads to cold-related illnesses among children

Building Envelop Thermal Modernization (Roof)

Considering the poor condition of the building attic and the leaks of the roof, the following measures are recommended for reduced heat losses from the roof.

- Thermal insulation of attic, installation of the attic door.
- Partial renovation/improvement of roof.

Heating System Upgrade in Combination with Renewable Energy Supplement

While the building is equipped with a local gas-fired boiler system, its efficiency is substantially lower than during the new installation phase. Considering a newer, higher efficiency technical substitute is cost-effectively available, and the heating bill of the kindergarten is one of the major

burdens on the municipal budget, the following measures are proposed to improve the indoor comfort and reduce heating bills of the kindergarten, while utilizing the renewable energy potential.

- Installation of condensation boiler with the accessories needed for putting a proper heating system in place
- Installation of solar water heating system for the domestic hot water supply system, which will provide an average of 800 -1200 liters of hot water to the domestic hot water supply system or preheating to the heat supply system on the boiler entry.

All of the above proposed energy saving measures (ESMs) in aggregate will lead to the reduction of energy consumption for space heating, hot water heating and lighting by 70 %, 100% and 80%, correspondingly.

Note that the solar water heating system will not only supply the kindergarten with hot water but also pre-heat the heating water which would save the gas consumption by the boiler by 30%. In the summer time, when the heating load is absent, the excess hot water from the solar water heating system can be used for two potential purposes:

1. The kindergarten can construct a small swimming pool which would be supplied with warm water for the children to swim
2. In line with the municipality's plans and initiatives to support tourism, and eco-tourism above all, the kindergarten can be equipped with a adjacent shower cabin, which could be used for the children after the swimming pool, can also have a separate section to be offered as a public shower to hikers, campers and eco-tourists which are not housed in the vicinity hotels.

The above would strongly contribute to Tsaghkadzor's efforts of promoting itself as a sustainable community, not only for the environmental conservation purposes, but also for the utilization of sustainable energy and efficiency solutions and low-carbon development tools in a socially visible segments of the municipality.

Financial Parameters

ESM financial Features	Value
Investment value of ESMs:	71 338 USD
Simple payback:	11.2 years
NPV*	8 152 USD
IRR* %	6.4 %

* Calculations have been implemented considering a 20 year life time and 5% discount rate.

Non-financial parameters

Increase in comfort level: 57 %

Increase of indoor air temperature: 4-6^{o}C

After ESMs emissions of carbon dioxide will annually be reduced by 33 tons.

Technical Appendices

Appendix 1. General info about the organization

General info about the organization				
N	**Name**			**Data**
1	General info	name		Tsakhakdzor kindergarten
		Address	Marz	Kotayq
			City	Tsakhkadzor
			Street	85 Kecharecu str.
			Post index	2310
			Tel/fax	0223-60448
			e-mail	
		Tax account No		0300 8231
		Bank account No		Inecobank 2050042008741001
		Status		ՀՈՒԿ
		Director	name, surname	Marieta Asatryan
			tel	096-112220
		Energy engineer	name, surname	Norik Vardanyan
			tel	093-112273
		Auditing person	name, surname	
			tel	
5	Number of users			90
6	Number of working staff			22

Appendix 2. General Building Characteristics and Physical Parameters

General information about the building					
Building Unit		**Block I**	**Corridor**	**Block II**	**Total**
Start of operation		1975	1975	1975	
External dimensions	**length, m**	42.7	6	20.2	
	width, m	13.5	3.3	13	
	height, m	6.6	3.3	3.3	
	surface are in the plan	502	20	263	784
Internal dimensions	**length, m**	41.7	5.7	19.2	
	width, m	12.5	2.32	12	
	height, m	6	3	3	
	surface are in the plan	452	13	230	696
Internal surface area, sqm		814	13	207	1035
Useful srface area, sqm		678	0	173	851
Corrdior, stairway, sqm		136	13	34	183
Heated surface area, sqm		814	13	207	1035
Volume of building	**external, cbm**	3311	65	867	4243
	internal, cbm	4884	40	622	5546
	useful, cbm	4068	0	520	4588
Seismic status		2	2	2	
Technical status of the building (whether it needs renovation or not)	**general**	No	nչ	nչ	
	roof	partly	No	No	
	floor	No	No	No	
	interrior	No	No	No	
	toilets	No	No	No	
Number of floors		2	1	1	
Number of rooms		18	0	9	27
Number of auditoriums		2	0	0	2
Fuel type of space heating	**Gas**	J/K	J/K	J/K	
	Electricity	el. heater	el. heater	el. heater	
Number of heated rooms		20	0	9	29

Appendix 3. Calculation of Expenses for Energy Saving Measures

#	ESM	Quantity	Unit	Total Price ($)
1	Replacement of old and non-efficient windows	115	sqm	9790
2	Partial replacement of windows by thermal insulated walls (reduced glazing area)	15	sqm	930
3	Replacement of old and non-efficient doors by efficient ones	8	sqm	988
4	Thermal insulation of attic by expanded perlite	690	sqm	6600
5	Installation of a door on attic	0,8	sqm	80
6	Partial renovation/improvement of the roof	NA	NA	2500
7	Renovation works associated with the ESMs	NA	NA	900
8	Installation of evacuated tube solar water heaters with 1000 L storage tank for domestic hot water use	17	sqm	13000
9	Installation of evacuated tube solar water heaters for space heating in winter season and water heating servicing the children and community during all the seasons	51	sqm	18000
10	Installation of automatic thermostatic valves on the radiators	70	piece	1750
11	Modification of existing single pipe heating plumbing system to double pipe system	1000	sqm	2000
12	Replacement of existing three boilers by a single condensing boiler	90	kW	7500
13	Installation of 100W LED street lights	10	piece	3700
13	Preparation of design documentation	NA	NA	2500
14	Technical supervision	NA	NA	1500
	Total			**71338**

Appendix 4. Economic calculation of the saved thermal energy

				Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Tootal	kWh			150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533	150533
	gas	kWh			144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866	144866
Heating energy needed before ESMs	gas	cbm			15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577	15577
	gas	$			5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927	5927
	electricity	kWh			5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667	5667
	electricity	$			594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594	594
Heating energy needed after ESMs	Total	kWh			66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938	66938
Heating energy obtained from solar water heaters	sun	kWh			21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730	21730
Energy/fuel needed for heating after ESMs	gas	kWh			45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208	45208
	gas	cbm			4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861	4861
	gas	$			1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850	1850
Energy/fuel needed for domestic ho twater heating before ESMs	gas	kWh			8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742	8742
	gas	cbm			940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940
	gas	$			358	358	358	358	358	358	358	358	358	358	358	358	358	358	358	358	358	358	358	358
	electricity	kWh			200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
	electricity	$			21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Energy needed to provide external lighting according to the standards before	electricity	kWh			16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250	16250
	electricity	$			1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702	1702
Energy needed to provide external lighting according to the standards after ESMs	electricity	kWh			3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250
	electricity	$			340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Fuel annual tarrifs	gas	$/cbm			0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
	gas	$/cbm			0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
	electricity	$/kWh			0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
Initial investment of ESMs	I	$	71338																					
Annual savings	S	$	-71338		6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2	6411.2
Cumultative savings	Sum(S_1:S_n)	$	-71338		6411.2	12822.5	19233.7	25644.9	32056.2	38467.4	44878.7	51289.9	57701.1	64112.4	70523.6	76934.8	83346.1	89757.3	96168.5	102579.8	108991.0	115402.3	121813.5	128224.7
Balance	SUM(S1:Sn)-I	$	-71338		-64926.8	-58515.5	-52104.3	-45693.1	-39281.8	-32870.6	-26459.3	-20048.1	-13636.9	-7225.6	-814.4	5596.8	12008.1	18419.3	24830.5	31241.8	37653.0	44064.3	50475.5	56886.7

Simple payback		year	**11.13**
Discounted payback		year	**16**
Discount rate		%	5%

NPV		$	**8,153**
IRR			**6%**
SIR			**1.12**