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Energy Audit Report
Energy Audit Report of the Academic O. Ghudushauri National Medical Center

March 31, 2010

Prepared by Sustainable Development and Policy Center for Winrock International on March 31, 2010.

Energy Audit Report of the Academic O. Ghudushauri National Medical Center

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1 Summary

To ensure normal operating conditions, the baseline for energy consumption of the O. Ghudushauri National Medical Center is approximately 3.472.742kWh/year *for space heating,*1.205.144 kWh/year *for domestic hot water supply (DHW) with local boiler* and 2.081.068 kWh/year for *electricity*This totals to 184.3 kWh/m² year.

The Energy Auditing has identified a considerable energy efficiency improvement potential for this hospital building blocks:

For the package 1- All EE measures

Savings in delivered energy	1.507.037	kWh/year
Net savings	128.358	GEL/year
Investments	1.214.592	GEL
Payback	9.5	years

For the package 2- Profitable EE measures

Savings in delivered energy	1.362.587	kWh/year
Net savings	104.615	GEL/year
Investments	705.077	GEL
Payback	6.7	years

The energy savings potential for identification of energy efficiency and renovation measures is summarised in the following table, with ranking of measures and their profitability (NPVQ):

EE Potential - Energy Audit						
O. Ghudushauri National Medical Center		**Conditioned area:**	**36682 m²**			
EE measures		**Investment**	**Net savings**		**Payback**	**NPVQ**
		[GEL]	**[kWh/yr]**	**[GEL/yr]**	**[year]**	*****
1.	Installation of CFL bulbs	4.210	80.334	11.762	0.4	4.03
2.	Installation of heating system	297.416	702.845	50.030	5.9	0.51
3.	Monitoring of " housekeeping approach"	1.425	15.160	2.057	0.7	0.35
4.	Installation of new windows	402.026	564.248	40.766	9.9	0.05
5.	Installation of three UPS units	509.515	144.450	23.743	21.5	-0.68
Total all measures		**1.214.592**	**1.507.037**	**128.358**	**9,5**	
Profitable EE measures						
1.	Installation of CFL bulbs	4.210	80.334	11.762	0.4	4.03
2.	Installation of heating system	297.416	702.845	50.030	5.9	0.51
3.	Monitoring of " housekeeping approach"	1.425	15.160	2.057	0.7	0.35
4.	Installation of new windows	402.026	564.248	40.766	9.9	0.05
Total all profitable measures		**705.077**	**1.362.587**	**104.615**	**6.7**	

* Based on 7.3% real interest rate

For the investment and savings to be valid, all measures should be implemented as one project. The figures have an accuracy of ± 10-15 %.
The presented savings for the package of profitable measures in delivered energy are divided into savings per energy carrier:

Energy carrier	Unit	Present (baseline)	After measures	Savings
Electricity	kWh/year	2.081.068	1.841.124	239.944
Local heating and DHW	kWh/year	4.677.886	3.410.793	1.267.093
Gas needed for local heating and DHW	m^3/year	452.845	330.183	122.662

The reduction of CO_2 emissions achieved by implementation of all measures is –341.88 tons/year.

2 Introduction

2.1 Background

The scope of the work led by Winrock International, Georgia and assigned by the NATELI to Project Component 1. Energy Management, and carried out by Sustainable Development and Policy (SDAP) Center includes carrying out an energy audit in the Otar Ghudushauri National Medical Center. The results are given in this report.

The National Medical Center was formally brought into operation in 1991. The Medical Center is not actually one building, but consists of 4 building blocks: “A”, “V”, “Z” and “G” connected inside by corridors. The total heated area of the hospital is 36682 m^2, which makes it one of the largest buildings in the country.

It was constructed based on the Soviet assumption that the large public facilities could meet the needs of a population more efficiently than smaller ones. Today, due to changed socio-economic conditions it is visibly underutilized, with maximum capacity of 227 in-patients, average actual number is about 148 registered at the time of the audit, i.e. approximately 162 m^2 per patient.

We managed to ascertain an acceptable norm per patient in wards worldwide, which is approximately 7-7.5 m^2i That is to say, only 1700 m^2 needs to be occupied by wards in the Center, leaving about 35000 m^2 for all other hospital needs. Thus there is very unfavorable ratio of actually used and idle spaces, which negatively affects hospital maintenance, especially from the energy efficiency point of view. There are large volumes of underutilized or idle spaces, which under the existing situation should nevertheless be heated in winter, since with the existing heat supply system it is impossible to exclude them.

From the beginning the O. Ghudushauri Hospital has encountered problems, first in the construction process as the timing coincided with the collapse of the Soviet Union and a rocky transition period for Georgia. The medical centre building blocks were renovated twelve years later and from 2002-2003, the hospital has been operating constantly.

O. Ghudushauri Hospital’s heating system was not properly constructed from the very beginning and unfortunately during renovation of the hospital its problems weren’t fixed.

Moreover, problems associated with the sealing of the building envelope – the reduction of infiltration through the windows—was also not fixed.

The decision to undertake an energy audit was made because renovation was carried out without prior evaluation of the energy consumption in the National Medical Center building blocks. The aim of energy audit is to estimate the energy consumption and energy conservation (ENCON) potential in the building.

At present, the heat losses of the hospital building blocks in the winter period are covered by a single pipe space heating system with the old Soviet type cast-iron M140 AO radiators in " A" ,"V", "Z" "G" building blocks and partly by a central air-conditioning system functioning in the "G" building operating theater and the resuscitation department rooms.

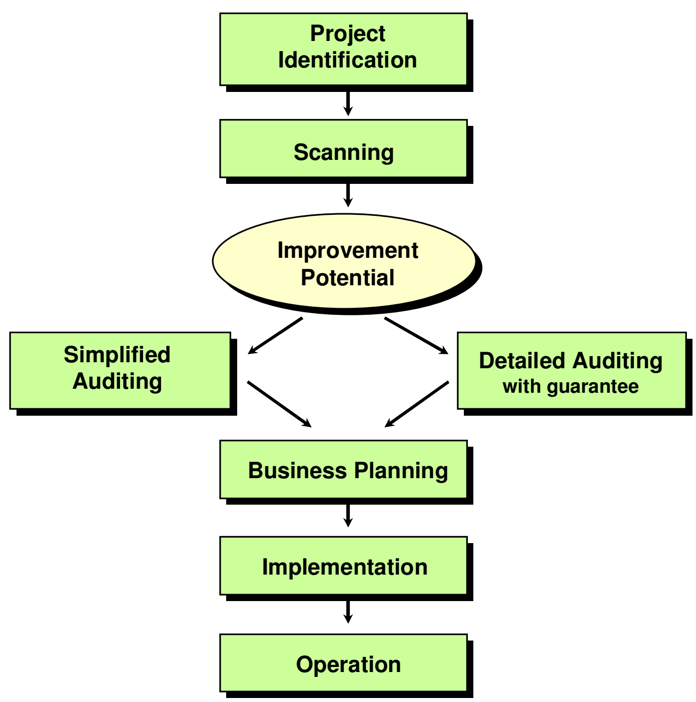
The results of assessment and evaluation of these measures are given in this report. The aim of the project is to reduce the energy costs, improve the indoor environment, and ensure more efficient operation and maintenance of the building and the technical installations.

2.2 The Project Development Process

Project development includes evaluation and implementation of profitable energy efficiency (EE) measures in the building. Each building is unique and each project must be treated separately to find individual energy savings possibilities. The building owners might have various plans for renovation and different requirements on the level of profit to be realized from implementing EE measures.

Hence, the total Project Development Process is divided into six main activities as illustrated in the flow chart.

1. Project Identification
2. Scanning
3. Energy Audit
4. Business Plan
5. Implementation
6. Operation



This report is based on a detailed Energy Audit.

3 Project Organization

Name of project/building/site:	JSC Academic O. Ghudushauri National Medical Center
Address: Contact person: Phone: Fax:	0159 Tbilisi 18/20 Lubliana st. Levan Samarguliani 899 99 50 98 38 (mobile)
Role in the project:	Beneficiary. Results of evaluation of energy consumption in the JSC Academic O. Ghudushauri National Medical Center will be communicated in the form of Energy Audit Report.
Building owner:	**Georgian Government/ Ministry of Economic Development of Georgia**
Contact person for the Energy Audit:	Karina Melikidze
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Role in the project	Director of the SDAP Center
Expert:	Karina Melikidze
Phone:	893 14 62 54 (mobile)
Role in the project:	In charge of conducting energy audit by ENSI Key Number software program and writing report
Consultant:	T. Jishkariani – GTU Professor
Phone:	893 79 00 84
Role in the project:	Energy Auditor
Consultant:	N. Kevhishvili –GTU Professor
Phone:	897120 332
Role in the project: Consultant:	Energy Auditor K. Tsereteli – GTU Professor
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Role in the project:	Energy Auditor

4 Standards and Regulation

The following Standards and Regulations are relevant for energy efficiency and renovation measures:

- Heating, Ventilation and Conditioning СНИП 2.04.05-86
- Boiler Plant
- Sanitary Regulations
- Construction Thermal Engineering СНИП II-3-79*

From these standards and regulations, the following requirements are relevant:

- Heating, Ventilation and Conditioning СНИП 2.04.05-86
- Boiler Plant
- Sanitary Regulations
- Construction Thermal Engineering СНИП II-3-79*

5 Building State Description

5.1 General conditions

Type of building		JSC Academic O. Ghudushauri National Medical Center							
Year of construction		1991			In regular operation since (year)				2002/2003
		Weekdays			*Saturday*		*Sunday*		
Occupancy schedule		24			24		24		*(hours/day)*
Heating schedule		24			24		24		*(hours/day)*
1st shift from:	n/a	till	n/a	*o'cloc*	2nd shift from:	n/a	till	n/a	*o'clock*
3rd shift from:	n/a	till	n/a	*o'cloc*	4th shift from:	n/a	till	n/a	*o'clock*
Holidays (in addition to normal holidays, specify)		n/a							

Number of occupants (for hospitals, schools, etc. please include the number of patients, respectively students, etc.)		
Permanent inhabitants/staff	800-900	*Persons*
Temporary inhabitants/staff	148	**148 patients on average are occupying National medical Center**

Average indoor temperatures					
Condition			Norms		
Temp. when heated	18 on average	*°C*	Temp. when heated	20 oin average	*°C*
Temp. when setback	n/a	*°C*	Temp. when setback	n/a	*°C*

Installed meters and their location
electricity meter # D 31 CT 322 96612 is installed in the area to which only authorized personnel has access. gas meter # 75061413

Existing service contracts for Operation & Maintenance	**Operation & Maintenance manuals available for staff**
n/a	n/a

There are approximately 1000 persons simultaneously working or being treated in the building at any given point—on average 148 in-patients and 850 staff members when the hospital is occupied. The overall number of patients may constitute 227.

A single-pipe heating system with water-heat carried agent is installed in the National Medical Center building blocks. This single-pipe system isn't operating properly due to the restricted water flow circulation resulting from sedimentation in the raiser pipes and the depreciation of the heating distribution system itself.

Building data

Total area	**41.922**	*m²*	Conditioned area	**36.682**	*m²*
Total volume	**127.065**	*m³*	Conditioned volume	**119.484**	*m³*
Floor area (footprint)	**5240**	*m²*	Number of floors	**6**	

External walls								
General evaluation of the condition of the walls			medium thermal capacity					
Total area external walls		**17.516**	*m²*	Uvalue(average)		**1.25**	*W/m²K*	
Orientation	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
Wall area, m^2	5.043.0		3.851.0		4.771.0		3.851.0	
Material type	m1 bricks		m1 bricks		m1 bricks		m1 bricks	
Insulation type	n/a		n/a		n/a		n/a	
U value, W/m^2K	1.25		1.25		1.25		1.25	
Material type m1	The coefficient of thermal conductivity for bricks was taken as λ=0.64 W/m K with thickness δ= 0.38m, outdoor plaster: cement sandy mortar was taken as δ=0.03 m λ=0.93 W/m K and for indoor plaster: grout mortar as δ=0.02m, λ=0.64 W/m K. The thermal resistance value was calculated as: **R_0= 1/ 8.7 +0.03/ 0.93 + 0.38/0.64 +0.02 /0.64 +1/23= 0.80m^2 K/W** Approximate heat transfer value: **U= 1/0.80= 1,25W/m^2 K**								
Insulation type 1	n/a							

The exterior walls of the hospital buildings are characterized with medium thermal capacity properties. The energy audit team was provided by project materials and drawings of the heating system.

Windows								
General evaluation of the condition of windows					double glazed windows with wooden and metal frames			
Total area windows				**2.863.43**	*m²*	U value (average)	**3,5**	*W/m²K*
Orientation	Material[1]	Type[2]	Size A x B *m*	Area *m^2*	Q-ty *n*	g	Joints *m*	U value *W/m^2K*
N	W&S	2G	1.4x1.4 2.0x1.7 0.7x2.5 0.7x1.4 2.35x1.7	358.68 204 47.3 6.98 332	183 60 27 7 83	0,58	1.024.8 444 172.8 29.4 672.3	3,5
Total				949.0	360		2.343.3	

E Total	W&S	2G	1.4x1.4 2.35x1.7	362.6 215.73 578.33	185 54 239	0/58	1.036 437.4 1.473.4	3,5
S Total	W&S	2G	1,4x1,4 2.0x1.7 0.7x2.5	554.7 204 24.5 783.2	283 60 14 357	0,58	1.584.8 444 89.6 2.118.4.	3,5
W Total	W&S	2G	1.4x1.4 2.35x1.7	337.12 215.73 552.9	172.0 54.0 226	0.58	963.2 437.4 1.400.6	3.5
Total				**2.863.43**	**1.182.0**		**7.335.7**	
Material [1]				Wood (W), Aluminium (Al), Plastic (P), Steel (St)				
Type [2]				Single-frame (S), Double-frame (D), Bonded frame (B), Single glazed (1G), Double glazed (2G), Triple glazed (3G)				

Windows are not acceptable. The space between the glass pains is not filled with inert gas and frames aren't stripped and caulked. Additionally, the window frames are in poor condition. The U-value for windows was not obtained from the certificate. It was taken after site inspection and evaluation of the general windows and frames condition. The energy audit team made the recommendation to replace windows by plastic framed sealed windows with the double glazing filled with inert gas.

Doors							
General evaluation of the condition of doors			Glazed				
Type of doors			Single				
No. of doors	**126**	Total area doors	313.9	*m²*	U value (average)	**4,65**	*W/m²K*

Doors							
General evaluation of the condition of doors			iron				
Type of doors			Single				
No. of doors	**15**	Total area doors	83.1	*m²*	U value (average)	**5,5**	*W/m²K*

Roof							
General evaluation of the condition of the roof			acceptable with the attic				
Total roof area	**5.240**		*m²*	U value (average)		**1.1**	*W/m²K*
Roof type	Material type	Insulation type	Insul. thickn. *m*	Slab thickn. *m*	Avg. temp. *°C*	Area *m²*	U *W/m²K*
roof with the attic	m1	n/a	n/a	-		5240	1.1
Total							
Material type m1	concrete slab, clinker volcanic slag						
Insulation type i1	n/a						

The roof with the attic is directly above heated space.

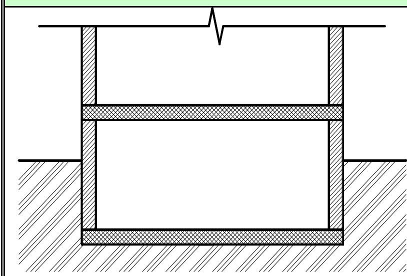
Some components of roof layer construction materials were provided to the energy audit team. The U value for the roof was defined as 1.1 W/m²K based on the roof layer information and site inspections. Below is given a description of the main roof material components over the attic.

concrete slab δ=20 cm; λ=0,99 W/mK;

clinker volkanic slag δ=80 cm; λ= 0.47;
water-proof rolled coating.

Floor (with heat losses to outdoor air, though ground or unheated basement)					
General evaluation of the condition of the floor		Acceptable			
Total floor area	**5.240**	*m²*	U value (average)	**0.9**	*W/m²K*
Type of floor	Floor Type 2 with windows in unheated basement.				
Floor construction materials	n/a				

Floor type 2
Suspended floor/Unheated basement



There is a cold basement under the floor. During site observations and the audit team's thermal engineering analysis, the U-value was identified as average U-value for the floors in that type of the buildings.

5.2 Heating system

Type of generation/supply/carrier	heat carrier-water				
Type of distribution system	**single pipe system**				
Condition of heating system	**Poor**				
Boiler/HX in operation since (year)	2002/2003	Heating system in operation since (year)	2002/2003		
Total capacity, heating system	2.266 kW	*kW*	Type of fuel	Gas	
Material and condition pipes	**Metal**				
Material and condition insulation	**Poor**				
Type/number of heat emitters	**cast – iron M140 AO radiators**				
Automatic control system	**Poor**				
Individual heating appliances, type	split systems				
Quantity	62	*pcs*	Capacity:	93	*kW*
Quantity	38	*pcs*	Capacity	68.4	*kW*

The heating system is designed as a single pipe distribution system with the main line installed in the basement. The heat emitters are old Soviet type cast – iron M140 AO radiators. There are 4 boilers installed in the boiler room, each with 1000kW capacity, total installed capacity constitutes 4000 KW. Although there are four boilers, the hospital management operates two boilers and two remain in reserve. The baseline capacity for the heating system constitutes 1921 kW and for DHW 345 kW, thus total capacity constitutes 2266 kW. The circulation of the heat carrier water in the heating distribution system is designed in the "dead end" way. The feeding loop of the distribution heating system is installed in the attic and the back loop is located in the basement.

Split system air conditioners are used for heating in premises where, due to the failure of the existing heating system operation, it is impossible to reach internal thermal comfort norms without their use.

As it was already mentioned there are parts of the premises in the Medical Centre building blocks where the heating system isn't functioning at all, due to system malfunctions. In the electronic Key Numbers Software Program the heat balance was calibrated with the consideration of the total heated area.

The potential to improve this component was identified during energy auditing. The auditors recommend replacing the existing heating system with the efficient double-pipe modern heating-system that uses a water energy carrier.

5.3 Ventilation system

The hospital has a draw-in and exhaust ventilation system in the Center's building blocks. However, the draw-in ventilation system isn't used. The exhaust ventilation system is used occasionally. The air conditioning system is used in the block "G" in the operating theater and the resuscitation department premises.

Five central air conditioners are installed for these purposes on the technical floor of the "G" block. The energy audit team determined that there are 4 central air conditioners, 2 over each "A" and "V" blocks (on the technical floor) which have never been used.

Equipment	Power cap. Total (kW)	Quantity (pcs)	User pattern (h/week)	Supply temperature (°C) Design	Measured
Central air conditioners in the "G" block	180	5	168	23	-
Central air conditioners in the "A" and "V" block	144	4	not operating	-	-
Air conditioners (window-mounted or split) heating					
Other					

5.4 Domestic hot water system

Heat supply / heat generation	
Type of system	Combined with the heating system heat carrier-water
Energy carrier	Natural gas

Domestic hot water actually wasn't operating properly during 2009 due to a local gas supply shortage. According to the utility bills gas wasn't supplied for several months.

Domestic hot water is heated by the same boilers that are used in the heating system (to heat the water).

5.5 Fans and pumps

Fans / Pumps	Installed capacity *kW*	Simult. power *W/m²*	Operation period *h/week*	Type of control / comments
burner/fan	n/a			
Pumps, heating	22.0	0.60	168	
Total				

There are installed two heating pumps, each with a capacity of 22 kW in the boiler room. One is considered for operation and another one remains in reserve.

5.6 Lighting system

Luminaries	Quantity *pcs*	Installed capacity *kW*	Average power *W/m²*	Type of control / comments
Incandescent 60 W	561	33.6		
Incandescent 100W	50	5.0		
Other energy efficient bulbs	5092	120.2		
Total	**5.703**	**158.8**	**4.32**	

Lighting		
Average power demand	4,32	*W/m²*
Operation period	40	*h/week*
Operation period	52	*weeks/year*
Max. simultaneous power	5,0	*W/m²*

The major part of the lighting system can be evaluated as an efficient lighting system, but there are still improvements to be made. Several incandescent bulbs are installed and should be replaced with efficient, compact fluorescent lamps. Actually it was determined that 611 incandescent bulbs should be replaced by efficient ones.

5.7 Various

Various exploitable	Quantity *pcs*	Installed capacity *kW*	Average power *W/m²*	Comments
Computers	130	52		
Copiers 0. 65kW	2	1.3		
Printers 0.35kW	40	14.0		
Elevator 7.100kW	2	14.2		
Elevator 3.800kW	3	11.4		
Dialysis apparatus 2.0kW	30	60.0		
D.c. Other		5.0		
Sterilizer steam 20 cu ft pass through		36		
Mammography unit		3.7		
X-ray film processor, floor unit		2.5		
automatic injector		1.1		
X-ray unit, mobile		12		
Other medical equipment		50		

Other (kitchen) stove	1	4.5		
Washing machines	3 (50)kg	6.6		
Wringer	1(25)kg	2,2		
Iron	1	1,6		
Total		**278.1**	**4.0**	

Various exploitable		
Average power demand	4.0	*W/m²*
Operation period	-	*h/week*
Operation period	52	*weeks/year*
Max. simultaneous power	5.0	*W/m²*

The list of the non-installed or non-exploited equipment is given below.

Various unexploitable	Quantity *pcs*	Installed capacity *kW*	Average power *W/m²*	Comments
intraoral x-ray		2		
washer ultrasonic benchtop		1		
day light processing machine		3		
Other		9.7		
Other		20.4		
Total		**36.1**	**1.0**	

Various unexploitable		
Average power demand	1,0	*W/m²*
Operation period	25	*h/week*
Operation period	38	*weeks/year*
Max. simultaneous power	2.0	*W/m²*

5.8 Cooling

Cooling system name/no.							
Type of cooling system	**split system**						
Condition of cooling system	**acceptable**						
In operation since (year)							
Installed cooling/air conditioning system:							
Total capacity	165.9	*kW* *	Operation period	36			*h/week*
Summer design temp	26,7	ºC	Cooling season from	01July	to	15 Sept	(*dd/mm*)

Maximum indoor temp	34.7	ºC	Supply air temp.	**26,7**	ºC
Automatic control system					
Pipes					
Insulation					

* Total electrical power demand

There are 62 split system units, each with the 1.5 kW capacity. There are 38 split system units each with the 1.8 kW capacity and 3 BK old Soviet type air conditioners each with the 1.5 kW capacity. Split systems are used in the winter period—only in those premises where heating system isn't operating. In the summertime, the split systems are used for cooling purposes.

5.9 Outdoor

It was planned that O. Ghudushauri National Medical Center Building Blocks will get electricity supply from the JSC company "Telasi" through substations "Digomi 1" and "Digomi 2". Currently the hospital isn't receiving its electricity supply from "Digomi 1" substation, due to the damaged distribution cable and supply is provided only from "Digomi 2" substation. The Central Distribution Center (CDC)-1400 is fed from the above substations. In addition to supplying the National Medical Center with electricity, there are other large consumers relying upon the CDC-1400 (see Figure.1).

There are two transformer substations located on the territory of the National Medical Center. Considering the fact that hospital is the #1 consuming facility, the energy audit team identified that reliability of the supply to the National Medical Center isn't sufficient; the team suggests the hospital administration return to this problem in the future.

The National Medical Center has an autonomous, backup electricity-supply system consisting of two autonomous diesel generators with capacities: 200kW and 312 kW. The autonomous system is used during electricity supply shortage as well as mostly in situations where the electricity current fluctuates.

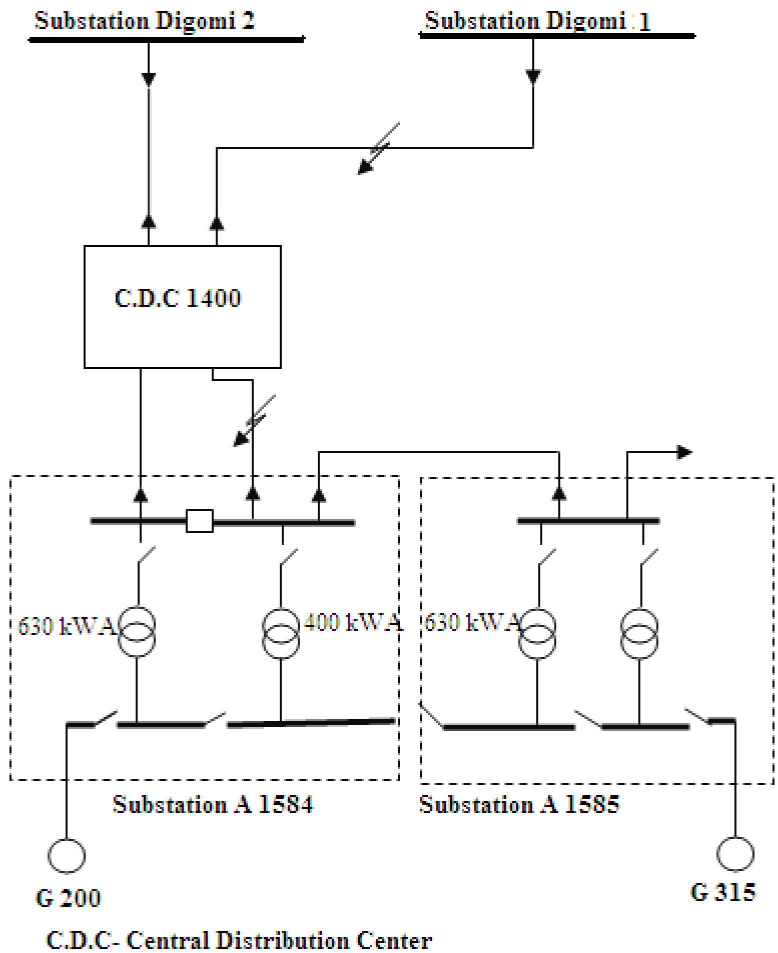


Figure 1. The outdoor electricity supply scheme of the Medical Center building blocks

6 Energy Consumption

6.1 Measured energy consumption

The data on electricity, gas, and diesel fuel as well as water consumption was provided to the energy audit team. The electricity meter is installed inside of the substation building to which only authorized personnel have access.

As a large consumer facility, the National Medical Center has the following tariffs:
tariff for electricity is 0,1489 GEL/kWh ;
tariff for gas is 0,75 GEL/Nm^3 ;
tariff for cold water 4.4 GEL/ m^3.

The second floor of the "V" block was leased and is occupied by the separate medical entity "Via Vita". The Electricity tariff for "Via Vita" constitutes 0.17 GEL. "Via Vita" gets heating from the O. Ghudushauri National Medical Center distribution heating system, only electricity bills are played separately by this organization.

The following table shows the measured energy consumption and its costs in the building during the year prior to implementation of energy efficiency measures:

Year 2009	District heating, gas	Electricity	Diesel	Other "Via Vita"	Water m^3	Total	
Energy costs	2.236.684.5	266.508.2	23.588.45	22.939.49		2.549.720.6	GEL
Energy consumption	2.982.246	1.789.847	186.533.4	134.938.6		5.093.565	kWh/y
Specific consumption	81.3	48.8	5.09	3.68		138.9	kWh/m²
Water consumption,					150.199	660.875.6	GEL
Tariffs valid since	for electricity-15.05.2006						

*) Power, fixed fees, etc.

The calorific value is:

Energy carrier	Calorific value	Unit	Comments
Gas	37190	kJ/m3	or 10330 kWh/1000Nm3, value equal to 8884 kCal/1000Nm3.

The above net calorific value for gas and prices were used for future calculations.

6.2 Calculated and baseline energy consumption

The baseline energy consumption of the O. Ghudushauri National Medical Center was determined as approximately 3472 742 kWh/year *for space heating,* 1205 144 kWh/year, *for domestic hot water supply (DHW) with local boiler* and 2081068 kWh/year for *electricity* or totally 184.3 kWh/m² year.

The building is characterized by medium capacity thermal properties.

The decision to undertake an energy audit was made because the building renovation was carried out without prior evaluation of energy consumption in the building, thus the aim of energy audit is to estimate the energy consumption and ENCON potential in the building.

Energy Budget

The calculated and measured energy consumption before and after implementation of energy efficiency and renovation measures are summarized in the following Energy Budget Table.

ENERGY BUDGET - ENERGY AUDIT				
Budget Item	**Before EE Calculated [kWh/m²year]**	**Before EE Measured [kWh/m²year]**	**Before EE Baseline [kWh/m²year]**	**After EE and renovation [kWh/m²year]**
Heating	76.7	76.1	94.7	62.4
Ventilation	5.8	6.6	11.6	10.9
DHW	11.8	5.2	32.9	30.6
Fans/ Pumps	4.8	5.2	5.4	5.4
Lighting	12.6	12.6	12.6	10.4
Various	18.2	23.1	18.2	14.6
Cooling	8.8	10.1	8.8	8.8
Total	138.9	138.9**	184,3***	143.2****

ENERGY BUDGET - ENERGY AUDIT				
Budget Item	**Before EE Calculated [kWh/year]**	**Before EE Measured [kWh/year]**	**Before EE Baseline [kWh/year]**	**After EE and renovation [kWh/year]**
Heating	2.814.615	2.791.500	3.472.742	2.289.860
Ventilation	213.330	240.634	426.660	400.938
DHW	433.669	190.746	1.205.144	1.120.933
Fans/pumps	177.517	190.746	199.439	199.439
Lighting	462.721	462.721	462.721	382.388
Various	669.446	843.686	669.446	535.557
Cooling	322.802	373.532	322.802	322.802
Total	**5.094.102***	**5.093.565****	**6.758.954*****	**525.1916******

** Form the computer model*
*** Measured real consumption*
**** Normalised baseline after switching to gas without energy conservation measures*
***** After switching to gas with energy conservation measures*

At present the installed single pipe heating system with water heat–carrying agent isn't functioning properly. It should be mentioned that the boiler room equipment was inspected during the site visit. The energy audit team identified the following problems regarding boiler room equipment:

- old Soviet (Duk type) gas regulators can't provide for acceptable heat generation due to irregular gas inflow;
- the system is working without a water system compensator tank;
- three boilers are operating without hatch insulation (lining);

As it was already mentioned, the heating system itself experiences problems with water circulation through raisers, due to wear and tear on the system. It isn't possible to install design indoor temperature in the hospital premises with this heating system. It is known that part of the hospital premises, according to standards should maintain required temperature level. To fulfil this required temperature level +25^0 C, for instance in the gynecology department, the hospital management was adding electric heaters, in the rooms where the current central distribution heating system was actually operating.

The numbers presented in the energy budget table confirm information obtained from the site inspection, assessment of project materials and electricity, gas and diesel fuel consumption bills (column "Measured"). This information was inputted into the calibrated model of energy consumption of the building in the Key Numbers Software Program (column "Calculated").

Column- "Baseline" presents required energy consumption for comfortable conditions in the building under present operation conditions. In the ENSI Key Numbers Software, the last column –"after implementation of Energy Efficiency measures", presents the reduced energy consumption estimates as a result of implementing suggested ENCON measures. See Figure 2, below.

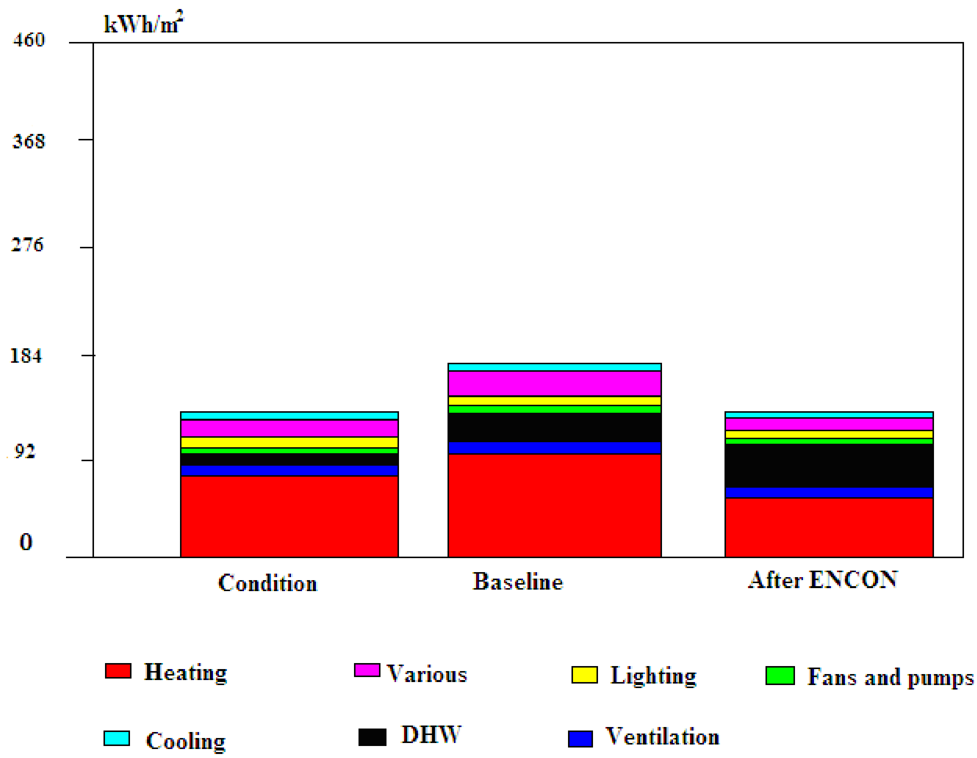


Figure 2. Annual energy consumption calculated by ENSI Key Numbers Software Program

7 Energy efficiency potential

The numbers here result from modelling economic calculations made with the Economy Software Program. The Energy Auditing Team has identified considerable energy efficiency improvement potential for this building, which is presented below:

For the package 1- All EE measures

Savings in delivered energy	1.507.037	kWh/year
Net savings	128.358	GEL/year
Investments	1.214.592	GEL
Payback	9.5	years

For the package 2- Profitable EE measures

Savings in delivered energy	1.362.587	kWh/year
Net savings	104.615	GEL/year
Investments	705.077	GEL
Payback	6.7	years

The energy savings potential for identification of energy efficiency and renovation measures is summarized in the following table, with ranking of measures and their profitability (NPVQ):

EE Potential - Energy Audit						
O. Ghudushauri National Medical Center		Conditioned area:		36682 m²		
EE measures		**Investment**	**Net savings**		**Payback**	**NPVQ**
		[GEL]	**[kWh/yr]**	**[GEL/yr]**	**[year]**	*****
1.	Installation of CFL bulbs	4.210	80.334	11.762	0.4	4.03
2.	Installation of heating system	297.416	702.845	50.030	5.9	0.51
3.	Monitoring of " housekeeping approach"	1.425	15.160	2.057	0.7	0.35
4.	Installation of new windows	402.026	564.248	40.766	9.9	0.05
5.	Installation of three UPS units	509.515	144.450	23.743	21.5	-0.68
Total all measures		**1.214.592**	**1.507.037**	**128.358**	**9,5**	
Profitable EE measures						
1.	Installation of CFL bulbs	4.210	80.334	11.762	0.4	4.03
2.	Installation of heating system	297.416	702.845	50.030	5.9	0.51
3.	Monitoring of " housekeeping approach"	1.425	15.160	2.057	0.7	0.35
4.	Installation of new windows	402.026	564.248	40.766	9.9	0.05
Total all profitable measures		**705.077**	**1.362.587**	**104.615**	**6.7**	

* Based on 7.3% real interest rate

It is important to pay attention to the first package of measures shown in the upper part of the table and summarized as "Total all measures". There are some measures that may be comparatively expensive, but are still worthwhile depending on the hospital's other objectives. For instance, despite the fact that installation of 3 UPS units constitutes a very high investment and actually results in a negative NPVQ (indicating that this investment isn't profitable) the hospital administration may still wish to take this measure into consideration, as ENSI software does not monetize "the reliability factor" and other externalities. In the case of the 3 UPS units, this investment will protect against electricity current fluctuations, which may threaten the life of patients or ruin expensive hospital equipment, depending on the life support systems designs. This benefit is not monetized in the table above.

As one can see in the table above, the package of total profitable measures is included The presented savings in delivered energy are divided into savings per energy carrier:

Energy carrier	Unit	Present (baseline)	After measures	Savings
Electricity	kWh/year	2.081.068	1.841.124	239.944
Local heating and DHW*	kWh/year	4.677.886	3.410.793	1.267.093
Gas needed for local heating and DHW*	m^3/year	452.845	330.183	122.662

The reduction of CO_2 emissions achieved by implementing all measures identified through the energy audit is estimated as –341.88 tons/year compared to the baseline consumption. These numbers are resulting from the last table (see section environmental benefits). Savings divided by the energy carrier are multiplied by CO_2 emission coefficients. Then they are summarized and multiplied by the total building area (36682m^2).

6.54x0.3999=2.62 (kg/m^2a)
34.55x0.194=6.70 (kg/m^2a)
2.62+6.70= 9.32 (kg/m^2a)
9.32x36682=341.88 (t/year)

8 Energy efficiency measures

8.1 List of measures

The following EE and renovation measures are evaluated and described in detail in the following chapters. A table with information for each profitable measure is presented separately. First, though, a list of profitable EE measures is provided in the table below:

Energy efficiency and renovation measures
1. Installation of modern heating system
2. Installation of new windows
3. Installation of CFL bulbs
4. Installation of 120 kVA UPS
5. Monitoring of the “housekeeping approach”

8.2 Measures

A description of all measures that have been evaluated is given below.

Measure. 1. – Installation of the heating system
Existing situation Currently the single-pipe heating system isn’t functioning properly due pipe to sedimentation and overall system depreciation. Each winter the hospital management has to repair existing parts of the system to restore circulation of water in the raisers. With the use of existing heating system it is impossible to maintain and control temperature in premises where high temperature level is required according to hospital standards.
Description of measure It was considered to suggest replacement of the current single pipe heating system by the

modern one. To this end a double pipe, modern heating system with thermostatic valves has been selected. Thermostatic valves are recommended for installation since they will maintain temperature control level in premises and wards, especially in those where there are very rigorous temperature requirements. A Modern heating system will also provide flexibility to the hospital management, as they try to save energy by switching off regulating valves in those premises where heating isn't needed at that time. This measure incorporates all costs that are necessary to be considered for design and installation of the heating system as well as improvements that should be carried out in the boiler room. While examining the boiler room, it became clear that separate problems should be fixed as they are interrelated:

- installation of four gas regulators each with capacity 100 m^3/ h;
- installation of the gas filter;
- installation of the compensator tank control system with the level monitor;
- insulation of three boiler hatches.

The boiler room scheme with above mentioned items is given in the Appendix A.

Calculation of savings (by ENSI® Key Number Software or other tool)

Investments for boiler room improvements with the VAT include:

- four gas regulators each with capacity 100 m^3/ h- 2.124 GEL (531 GEL each);
- gas filter-1.168.20 GEL;
- compensator tank control system with the level monitor -649 GEL;
- insulation of three boiler hatches 1.770 GEL (590 GEL each);

Total investment for boiler room improvement constitutes -5.711.2 GEL

Investment needed for the installation of the modern double pipe heating system according to the specification include:

costs for total number - 967 radiators, with regulating and thermostatic valves are specified as 157.803 GEL .

Separately various radiators are specified as follows:

93 radiators with the size 600x400;
116 radiators 600x500;
114 radiators 600x600;
179 radiators 600x700;
128 radiators 600x800;
97 radiators 600x900;
47 radiators 600x1000;
67 radiators 600x1100;
48 radiators 600x1200;
15 radiators 600x1300;
33 radiators 600x1400;
15 radiators 600x1500;
2 radiators 600x1600;
13 radiators 600X2000

Other investment costs for pipes of various diameters and other parts constitute 45.442 GEL.
Total cost for installation of the new heating system constitutes: 203.245 GEL.
Total cost of the new modern heating system with the boiler room improvement measures constitutes 208.956.2 GEL.

The amount of energy needed for heating of the National Medical Center building blocks is defined as a baseline from Key Number Software Program as 3.472.742 kWh/y for heating and 1.205.144 kWh/y for DHW or the total amount is 4.677.886 kWh/y to satisfy the indoor comfort temperature. It should be noted that this amount is specified in the case of existing windows. By installing a modern heating system with thermostatic and regulating valves, the temperature will be controlled; comfort will be improved as well as distribution losses will be significantly reduced. Operation and maintenance will become more efficient thus innovative system provides an opportunity for more efficient maintenance.

A modern heating system would result in the reduction of energy consumption and contribute to improvements in the heating automatic control, minimization of distribution losses, improvements in O&M and energy supply efficiency.

Energy savings resulting from these improvements are specified by program as 702.845 kWh/y.

By converting this energy savings into gas equivalent we will receive gas savings identified as 68.039 m^3 /year. In monetary terms total cost of savings will constitute: 68.039x0.75= 51.030 GEL.

Investment:

Design/Planning	2.500	**GEL**
Project Management	1.800	**GEL**
Components for heating system	208.956.2	**GEL**
Installation	76.460.0	**GEL**
Control and testing	3.500	**GEL**
As-built documentation	900	**GEL**
Other expenses	3.300	**GEL**
Total investment	**297.416**	**GEL**
O&M expenses per year (+/-)	**1.000**	**GEL /year**
Net savings	**50.030**	**GEL /year**
Economic lifetime	**15**	**years**

Measure. 2. – installation of the new metal plastic windows

Existing situation

Windows are not acceptable. Despite that fact that they actually are double glazed, they have inadequate wooden / metal frames thus heat losses are significant especially on windy days. Glazing also isn't sufficient itself. The energy audit team arrived to the assumption that they weren't factory made.

Description of measures

The energy audit team decided to offer replacement of existing windows with the efficient ones. By installing new windows the heat losses of the National Medical Center blocks will be significantly reduced.

Calculation of savings (by ENSI® Key Number Software or other tool)

Installation of new windows will require replacement of 2863.43 m^2 window area. The energy audit team suggests to install "REHAU" windows. The frames are produced by a German company, and are characterized by good quality and a long economic life time about 22 years. Investment for windows was identified as 277.752.7GEL The amount of energy that can be saved in the case of installation of the new windows was identified in the Software program as 564.248 kWh/y. This will result in gas savings identified as: 54.622. 3 m^3 /year. In monetary terms this will constitute 54.622.3 x0..75= 40.967GEL.

Investment:

Design/Planning	2.000	**GEL**
Project Management	2.500	**GEL**
Components of the windows	277.319	**GEL**
Installation	114.857	**GEL**
Control and testing	3.600	**GEL**
As-built documentation	350	**GEL**
Other expenses	1.400	**GEL**
Total investment	**402.026**	**GEL**
O&M expenses per year (+/-)	**1.000**	**GEL/year**
Net savings	**41.175**	**GEL/year**
Economic lifetime	**20**	**Years**

Measure. 3 – Lighting. Installation of CFL bulbs

Existing situation

The lighting system of the Gudushauri National Medical Center mostly consists of various types of efficient bulbs specified as 5.092 bulbs. There are also installed 611incandescent bulbs among which are**:** 561ps- 60 W and 50ps-100 W.

Description of the measure

It is advised to replace 60 W incandescent bulbs (total number of 561) by compact fluorescent bulbs (CFL.) with capacity 15W each, as well 100 W incandescent bulbs (50 bulbs) by 25 W CFL bulbs. It is known that the CFLs provide the same intensity of lumens but use only one-quarter of the energy.

Calculation of savings (by ENSI® Key Number Software or other tool)

The price of the compact fluorescent bulb constitutes, on average, 5.0 GEL per unit. Total investment will constitute 3.055 GEL.

It was identified from the software program that the amount of energy that can be saved in the case of installation of the CFL. This amount is about 80334 kWh/y electricity. Calculating this amount of energy by the electricity tariff we will get savings in monetary terms: 80334 x 0,1489=11962GEL.

Investment:

Design/Planning	10	**GEL**
Project Management	100	**GEL**
Components	3.055	**GEL**
Installation	700	**GEL**
Control and testing	100	**GEL**
As-built documentation	10	**GEL**

Other expenses	235	**GEL** **GEL**
Total investment	**4.210**	**GEL**
O&M expenses per year (+/-)	**200**	**GEL/year**
Net savings	**11.762**	**GEL/year**
Economic lifetime	**2**	**Years**

Measure 4. – Installation of three 120 kVA UPS units

Existing situation

The National Medical Center has an auxiliary autonomous electricity supply system consisting of two autonomous diesel generators with the capacities: 200kW and 312 kW (see Figure 1).This system is used during electricity supply shortages as well as in cases of electricity current instability resulting in fluctuations. In such cases the hospital uses only one 312kW generator to cover the needs of the life support systems. Based on the assumption that this is a minimum amount of energy which the hospital needs to cover in case of emergency we propose to install three 120 kVA UPS units.

In this case we approximately meet the minimum necessary requirements for uninterrupted power supply(25% over minimum need). Use of diesel generators leads to unnecessary extra expenses. In most cases diesel generators are put in operation during the electric current fluctuations, which are rather frequent, although usually last only a few minutes. Total failure of electricity supply is a rather unusual event. Nevertheless any current fluctuation necessitates compensation by diesel generators, since a number of highly sensitive medical apparatuses depend on stable electricity supply and disruption of their operation may be life-threatening for some patients, especially in the intensive care unit. Such operation consumes additional energy, work and money, creating additional stress for equipment and personnel. Each life-supply system is equipped by its own Uninterrupted Power Supply equipment, which usually can compensate electricity supply for up to a few minutes. Nevertheless generators are switched on immediately and often work idly, when supply is back to normal in a short time. Besides they do not cover all energy needs of the clinic, but only the most sensitive equipment.

Description of measure

The above situation cannot be accepted in the long run, thus we suggest remedy it by use of Uninterrupted Power Supply equipment, which should be powerful enough to cope with all life-support systems and other highly sensitive equipment in hospital. According to preliminary calculations three KVA 120 UPS may be sufficient to this end, providing up to 30 minutes of uninterrupted supply almost totally eliminating the need for diesel generators. These latter may be used only in very unusual occasions, when current fluctuation or total blackout may last longer than that. Taking into account the fact that such cases nowadays in Georgia are very rare we can specify that the lion's share of this money is wasted due to the current fluctuations.

Calculation of savings (by ENSI® Key Number Software or other tool)

Actually in 2009 the amount of energy generated by diesel generators (as specified in utility bills) constituted 186533.4 kWh. The total cost of this diesel fuel was 19370 liters or 34.866 GEL. It should be mentioned that this electricity amount costs the hospital extra money because the price of diesel fuel nowadays on the Georgian market is 1.8 GEL/liter. In applying the electricity saving concept to this measure, our assumptions are based on the understanding that at minimum, diesel fuel consumption may be reduced significantly for cases where the diesel generators are

compensating for electricity-current instability and fluctuations. These generators could be replaced with UPS KVA 120. The amount of saved electricity generated by diesel generators is specified in utility bills as 144.450 kWh/y or 15000 liters of diesel. In monetary terms this price will be 27000 GEL. The price of one KVA 120 UPS is about 168.755 GEL, for three UPS units we will need 506265 GEL. The team also identified the amount of electricity that will be needed for charging UPS 120 KVA batteries: 15.160 kWh/y. In monetary terms this will constitute: 15.160x0.1489=2.257 GEL. The total number of savings in monetary terms will be: 27.000-2.257=24.743 GEL.		
Investment:		
Design/Planning	2.000	**GEL**
Project Management	200	**GEL**
Components incl. VAT	506.265	**GEL**
Installation	300	**GEL**
Control and testing	500	**GEL**
As-built documentation	100	**GEL**
Other expenses	150	**GEL**
Total investment	**509.515**	**GEL**
O&M expenses per year (+/-)	**1000**	**GEL/year**
Net savings	**23.743**	**GEL/year**
Economic lifetime	**10**	**years**

Measure 5. – Monitoring of "housekeeping approach"

Existing situation

As it was already mentioned the heated area of O.Ghudushauri National Medical Center is 36682m^2 and the maximum number of patients' is 227 persons. Unfortunately, the ratio of utilized to idle spaces is quite low. This large volume of underutilized spaces negatively affects hospital maintenance, especially from the energy efficiency point of view. Another problem associated with this is that today there is no clear, working management scheme for allocating areas of responsibility and functions to staff in charge of energy supply and maintenance. So in addition to the difficulties associated with maintaining energy supply to a huge volume of under- and/or unutilized-spaces, there is no clear understanding of how to manage these spaces in order to avoid unnecessary energy applications and extra losses in addition to loses due to deficient energy supply systems and leaks through the building envelope. It is necessary to stress that such a situation is not restricted to this particular facility, but is created by the obsolete Soviet approach, which encouraged large facilities by providing an abundant supply of very cheap energy and disregarding the loses and inefficiency.

Description of measure

It is suggested for the upper level of hospital management:

a. To develop the scheme of allocation of responsibilities to staff engaged in energy supply and maintenance;
b. To develop instructions on energy saving for working with energy consuming systems and equipment obligatory for implementation by all employees;

c. To read electricity meters every week in order to establish the consistent picture of energy consumption in the facility;
d. To develop and maintain logs for registry and evaluation of use and consumption of electricity;
e. To establish a energy monitoring team under the Center administrator and appoint the person in charge of monitoring energy use.

Besides improving overall electricity use patterns in the Center, the above measures will lay down a foundation for introducing and implementing energy monitoring and management concepts of the USAID NATELI project led by Winrock International, Georgia.

The above measures are suggested, bearing in mind the necessity to minimize unnecessary electricity use through eliminating supply to under-/un-utilized spaces and equipment.

Calculation of savings (by ENSI® Key Number Software or other tool)

The amount of electricity that can be saved in the hospital building blocks, due to better management and implementation of the simple "housekeeping measures" as identified from the ENSI software program may be at least 15160 kWh/y. In monetary terms this will be: 15160x 0.1489= 2257GEL. This measure doesn't call for special additional investments, since it is well within daily duties of the hospital administration.

Investment:		
Design/Planning	225	**GEL**
Project Management	150	**GEL**
Components	250	**GEL**
Installation	-	**GEL**
Control and testing	500	**GEL**
As-built documentation	200	**GEL**
Other expenses	100	**GEL**
Total investment	**1.425**	**GEL**
O&M expenses per year (+/-)	**300**	**GEL/year**
Net savings	**2.257**	**GEL/year**
Economic lifetime	**-**	**years**

9 Environmental benefits

Calculated savings in delivered energy and related reductions in CO_2 emissions for area - F= 36382m ^{2} are as follows

	Energy carrier				
	District Heating	Electricity	Gas	Oil	Other
Present situation – baseline (kWh/m²a)	na	56.73	127.53	na	na
After EE and renovation measures (kWh/m²a)	na	50.19	92.98	na	na
Savings (kWh/m²a)	na	6.54	34.55	na	na
Savings (kWh/a)	na	239.944	1.267.093	na	na
CO_2 emission coefficients (kg/kWh)	na	**0,3999**	**0,194**	na	na
CO_2 emission reductions (kg/m²a)	na	2,28	1,32	na	na
CO_2 emission reductions (t/year)	341.88				

The reduction of CO_2 emissions achieved by implementation of all energy efficiency measures identified through the energy audit is estimated as –341.88 tons/year

6.54x0.3999=2.62 (kg/m^{2}a)

34.55x0.194=6.70 (kg/m^{2}a)

2.62+6.70= 9.32 (kg/m^{2}a)

9.32x36.682=341.88 (t/year)

Appendix A

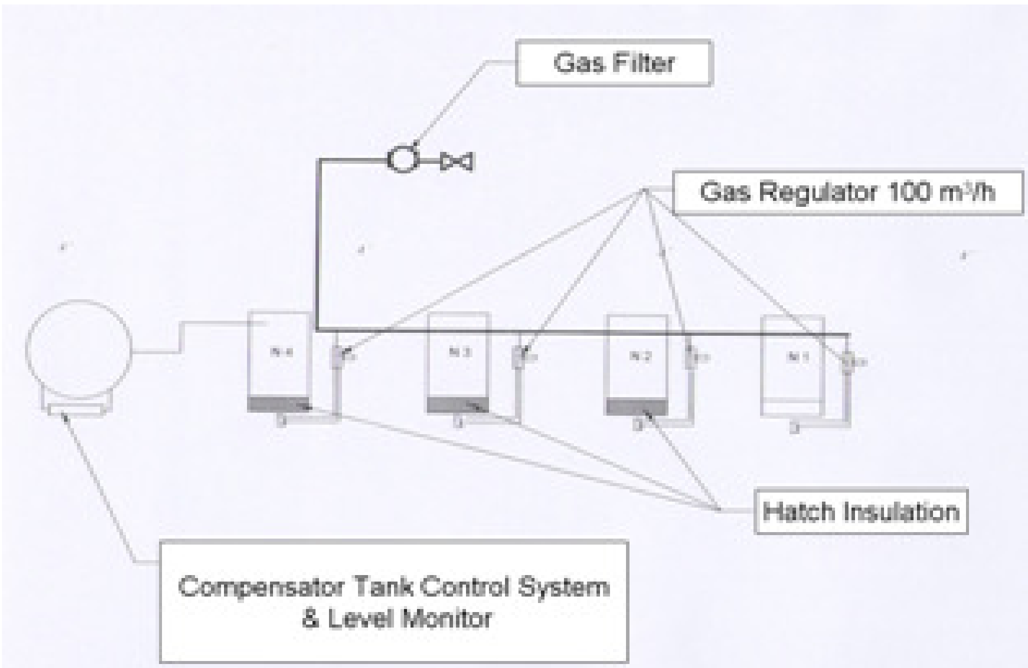


Figure 3. Specified boiler room improvement measures

Appendix B

Photo materials of the existing energy use systems in O. Ghudushauri National Medical Center

Boiler room

Hospital basement with the heating system main loop pipes

The old, single-pipe, heating-distribution system (restricted water flow)

Technical floor (attic) with the air conditioner, which was never used

Pipelines with the damaged insulation