PN-ACR-977

SERBIA EMERGENCY ENERGY EFFICIENCY PROGRAM

ENERGY CONSERVATION MEASURES IMPLEMENTED IN THE MUNICIPALITY OF SUBOTICA

EVALUATION REPORT

May 2002

Prepared by

Nexant

for

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Section 1 Introduction

Serbia's energy consumption, particularly for space heating, imposes serious challenges to the country's recovery. Households and Municipal Institutions are facing difficulties paying for energy/heat, while energy producers- particularly electricity- face supply shortages. Heavy subsidies to the prices of electricity and district heat had exacerbated the situation by encouraging high consumption levels. The budgets of cities and energy enterprises are strained to provide the subsidies, making it difficult to increase energy supplies. Energy efficiency is clearly one of the methods to relieve the supply shortages, while also providing social protection against the inevitable removal of subsidies.

USAID designed the Serbia Emergency Energy Efficiency Program (SEEEP) with the objective of promoting energy efficiency at national level. The key element of the program is the widespread demonstration of financially attractive energy saving technologies, which will attract both private and public investments toward the repetition of the demonstration projects. The anticipated large number of repetitions will in turn have a substantial impact in reducing energy consumption at national level, with a consequent reduction in government expenditures.

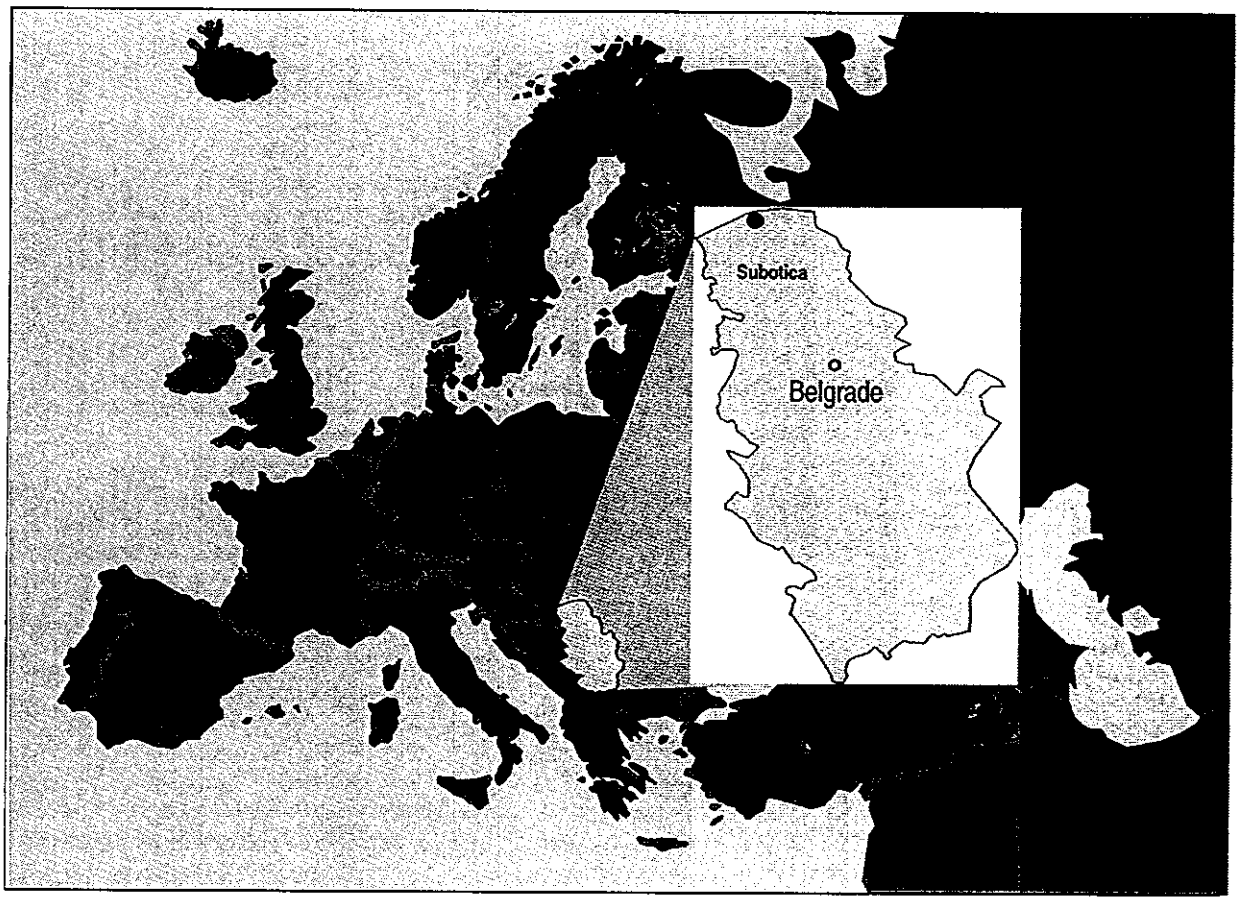
The practical implementation of SEEEP consisted in the installation of numerous energy efficiency demonstration projects. For the purpose of evaluating the energy savings achieved by each project, it was decided to use winter season 2000-2001 as the energy consumption baseline period, and winter season 2001-2002 for the measurement of energy consumption after the implementation of the projects.

As USAID contractor for SEEEP, in Spring 2001 Nexant performed a rapid assessment of the potential thermal and electric energy savings achievable in selected institutional buildings, to use as demonstration projects throughout Serbia. The assessment identified, in five Serbian Municipalities, approximately forty potential energy efficiency measures, offering various degrees of financial feasibility, and submitted them to USAID for approval. USAID reviewed them and approved 16 for immediate implementation.

One of the Municipalities in which several approved measures had been implemented is the Municipality of Subotica.

Subotica is located 195km north of Belgrade, on the Hungarian border, and has approximately 150,000 inhabitants. The town lies in the watershed of the Danube and the Tisa rivers. In 1743 the town received a licensed country-town status and an administration based on civil organization. The real development of Subotica came with the completion of the Szeged-Subotica railway line in 1869. From the 1880s the town's industry started to play an increasingly significant role in Serbia's economy, today Subotica is one of the country's most important towns as well as a major industrial and agricultural center.

This Post-Implementation Evaluation Report illustrates the energy efficiency measures implemented in the Municipality of Subotica, and the resulting savings.


Subotica
Belgrade

The methodology applied for the calculation of savings achieved by the energy efficiency measures implemented by Nexant within the framework of the Serbian Emergency Energy Efficiency Program is based on the guidelines established by the International Performance Measurement & Verification Protocol (IPMVP, Ref. 1), issued by the U.S. Department of Energy in October 1997.

The methodology is discussed in detail in Nexant report entitled "Measurement and Verification Plan". The specific steps used for the collection of the necessary energy consumption data, and the calculation of savings, achieved by the various measures, are described in this report. The methodology has been applied consistently to all the measures. The data collected and the results of the analyses are presented in a latter section of this report.

2.1 CALCULATION PROCEDURE

The energy saving due to an Energy Conservation Measures (ECM) implemented in a facility is determined by comparing the quantity of energy consumed in the facility, or part thereof, during a specified baseline period (in this case winter season 2000-2001), before the installation of the ECM, and the quantity of energy consumed during a corresponding period of the same characteristics, i.e. length, weather conditions, etc..., after the installation of the ECM (in this case winter season 2001-2002). By subtracting 'actual energy consumption after ECM installation' from 'adjusted energy consumption before ECM installation' we obtain:

Energy Saving = Adjusted energy consumption before ECM installation -
-Actual energy consumption after ECM installation

2.2 ADJUSTED ENERGY CONSUMPTION BEFORE ECM INSTALLATION

Energy consumption before ECM installation is estimated either from direct measurement of various parameters or from historical data obtained from the utilities, municipalities, or other relevant sources.

In most situations, energy consumption pattern or parameters affecting the energy consumption change for various reasons after installation. These changes typically include change in operating hours, change in operating or ambient temperature, change in energy requirement, change in level of comfort, etc. To estimate energy saving, it is necessary that the measurements, before and after, reflect energy usage under similar conditions. Two important parameters that changed from the baseline period to the after ECM installation period have been addressed already in Nexant's Rapid Assessment Report, precisely:

- All facilities complained that during the baseline period, i.e. winter season 2000-2001, the quantity of heating fuel available was not sufficient to create an adequate level of comfort for the occupants of the facility. Use of supplementary portable electric heaters improved somewhat the situation, but not to satisfactory levels. To equalize the conditions before and after the ECM installation, the before energy consumption was adjusted to reflect an

adequate level of comfort (i.e. approximately 18-20 °C indoor temperature). The adjustment was obtained by multiplying the effective consumption, estimated from the information received, by the following factor:

Comfort Level factor = $(T_c - T_{w1}) / (T_a - T_{w1})$

Where:
- T_c= Indoor comfort temperature (approx 20°C)
- T_a= Indoor temperature actually experienced in Winter 2000-2001, as estimated from verbal information obtained during site visits
- T_{w1}= Monthly average outdoor temperature in Winter 2000-2001, as obtained from the Serbian National Weather Institute

- The prices charged for heating fuels and electricity were heavily subsidized during the baseline period, and did not reflect the realistic international market levels toward which prices are now inevitably moving, as government subsidies are being reduced or abolished. To reflect a realistic estimate, the calculation of energy costs has been based on the following realistic prices:

Electricity	$ 0.05 per kWh
Light Oil	$ 0.23 per Litre
Heavy Oil	$ 0.18 per Litre
Natural Gas	$ 0.10 per m^3
Coal	$ 33.5 per ton (this reflects price of locally produced coal, not an international price)

Other important parameters considered for the adjustment include:

- The baseline winter season 2000-2001 has been an exceptionally mild one, while winter season 2001-2002, during which the measures have been implemented, and the after ECM installation measurements taken, is the harshest winter on record in Serbia for the last 30 years. The adjustment was obtained by multiplying the effective consumption, estimated from the information received, by the following factor:

Winter Rigidity factor = $(T_c - T_{w2}) / (T_c - T_{w1})$

Where:
- T_c= Indoor comfort temperature (approx 20°C)
- T_{w1} = Monthly average outdoor temperature in Winter 2000-2001, as obtained from the Serbian National Weather Institute
- T_{w2} = Monthly average outdoor temperature in Winter 2001-2002, as obtained from the Serbian National Weather Institute

- In case of applications where new high efficiency lighting technology is used, the wattage of the old lamps has to be adjusted to reflect the illumination level (Lux) provided by the

new system. This is obtained by multiplying the Wattage of the old lamps by a factor equal to the ratio of the new illumination level to the old illumination level.

These adjustments made the winter season 2000-2001 energy consumption data comparable to the winter season 2001-2002 energy consumption data.

2.3 ACTUAL ENERGY CONSUMPTION AFTER ECM INSTALLATION

The usual method for deriving energy consumption data after ECM installation is to use direct measurements or recording of various parameters. However, since the ECM installations were completed in February 2002, the only measured data available refer to March and April 2002. These data were used as a basis to extrapolate the data to cover the months of October 2001 through February 2002, when the ECMs were still being installed.

The extrapolation of the actual consumption data measured in March-April 2002 was done under the basic assumption that *the rate at which thermal energy is consumed is linearly proportional to the indoor-outdoor temperature differential.*

To extrapolate the March-April 2002 consumption data to the months of October 2001 through February 2002, we must derive the equation of the line representing the consumption on the Cartesian plane defined by axis X (temperature differential) and axis Y (hourly thermal consumption). The line contains the two known points:

$$P_1 (X_1, Y_1) \quad \text{and} \quad P_2 (X_2, Y_2)$$

Where:

X_1= hourly consumption in March 2002
Y_1= indoor-outdoor temperature differential in March 2002
X_2= hourly consumption in April 2002
Y_2= indoor-outdoor temperature differential in April 2002

The equation of the line is then derived as:

$$\boxed{aX + bY + c = 0}$$

Where:

$a = Y_1 - Y_2$
$b = X_2 - X_1$
$c = X_1 Y_2 - X_2 Y_1$

The extrapolated consumption data for the months of October 2001 through February 2002 are then obtained by entering the known indoor-outdoor temperature differentials in the equation, calculating the hourly consumptions, and multiplying it by the known number of hours of operation per month.

2.4 ENERGY SAVING, COST SAVING, AND SIMPLE PAYBACK PERIOD

Annual energy saving was calculated by subtracting the post-installation energy consumption from the adjusted pre-installation energy consumption, over the entire winter season, i.e. from October 1st through April 15th.

Annual cost saving was calculated by multiplying the annual energy saving by the realistic price of fuel and/or electricity.

Simple Payback period was calculated by dividing the capital cost of the implementation by the annual cost saving.

All calculations were performed using Excel spreadsheet programs.

This is a very large facility, serving the Municipality of Subotica and the surrounding communities. The building is approximately 30 years old, is made of brick and steel, and consists of 6 floors.

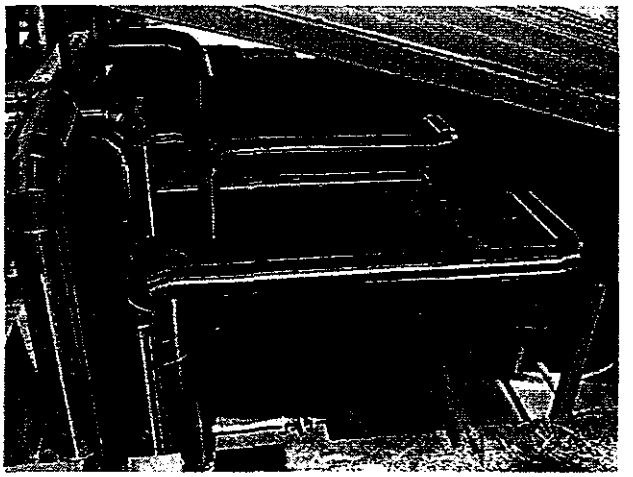
The hospital is connected to the municipal District Heating Plant, except the nursery, operating rooms and intensive care unit. The steam needs of these facilities, for heating sanitary water, sterilization, laundry room, kitchen, and other miscellaneous uses, are met by two dedicated boilers.

Insert pictures # 815 and 816

3.1 CONDENSATE RETURN AND STEAM LINE UPGRADE

The two dedicated boilers are connected to the end use equipment with a steam line and a condensate return system. The existing steam line is very old and badly maintained, allowing vast amounts of steam to leak to the atmosphere. The existing condensate return lines including steam traps, valves and fittings are also old and leaky: only about 10% of the condensate is returned, while more than 80% is suitable for return.

Nexant has installed a new condensate return system, complete with steam traps, valves and fittings. Also, the steam line has been repaired, replacing entire sections of the line where necessary.



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Installation was completed at end of March 2002, therefore the only consumption data available, at the time of preparation of this report, refers to April 2002. The data was received from the hospital's Technical Department, is shown in the following official letter:

ЗДРАВСТВЕНИ ЦЕНТАР СУБОТИЦА
ZDRAVSTVENI CENTAR SUBOTICA
EGESZSEGUGYI KÖZPONT SUBOTICA
HEALTH CENTER SUBOTICA
Изворска 3
24000 Суботица
Југославија
Телефони: (024)
Централа: 555-222
Директор: 552-931
Факс: 26-055
Дом здравља: 25-339
Жиро рачуни:
46600-603-6-3002736 Делта банка
46600-603-3-2002736 Војвођанска банка

INCOMING MAIL LOG NO.
LNBM 02-0554
DATE RECEIVED 10 MAY 2002

"NEXANT" BEOGRAD
Dečanska 4/2
B E O G R A D
za gosp. Ivan Martinović
fax: 011-3342 936

O B A V E Š T E N J E

Posle izvedene analize u potrošnji energenta – mazuta za proizvodnju tehnološke pare u subotičkoj bolnici, a nakon završetka ulaganja u radove na iskorišćenju kondenzata pare, konstatujemo:

potrošnja	april 2001.	april 2002.
– mazut	95,5 tona	64 tona
– kuhinjska so za pripremu vode u kotlovima	1.300 kg	950 kg

Po ovim pokazateljima mesečne uštede su vidljive u 31,5 tona mazuta i 350 kg kuhinjske soli.
Ovome treba pridodati i smanjene troškove u potrošnji električne energije i vode, za čije merenje nemamo parcijalna merila.
Da bih podatci iz analize bili još precizniji, potrebno bi bilo uporediti temperature vazduha u posmatranim vremenskim periodima, broj hospitalizovanih bolesnika i drugo.

7.05.2002.

NAČELNIK ODELJENJA ZAJEDNIČKIH MEDICINSKIH SLUŽBI

Vojin Šećerov

TRANSLATION

After the measurement of fuel consumption (crude oil – mazut) for steam production at Subotica Town Hospital, and after installation of the new condensate return system, we can say:

Consumption	April 2001	April 2002
Crude Oil (mazut)	95.5 tons	64 tons
Sodium Cloride (Water Treatment System)	1,300 Kg	950 Kg

According to these data, the monthly savings are 31.5 tons of mazut, and 350 Kg of sodium cloride.
Additional savings have been achieved in the reduction of electric power for city water pumping, but unfortunately this saving cannot be separated from the overall electric bill.
For correctness, the above data must be corrected to account for difference in outdoor temperature between last year and this year, as well as for eventual difference in number of patients, etc...

Vojin Secerov
Technical Department Manager

3.1.1 Baseline Energy Use

Consumption of steam at the Town Hospital is not used for heating, and therefore is not limited to the winter season, but it extends to entire year: in this particular case the baseline energy use refers to the entire year.

According to the data received directly from the Hospital technical staff, in year 2001 the Hospital consumed a total of 1,073.23 tons of oil for steam production. In particular, in the months of April and May 2001 the total consumption was 171,740 tons

3.1.2 Post-Installation Energy Use

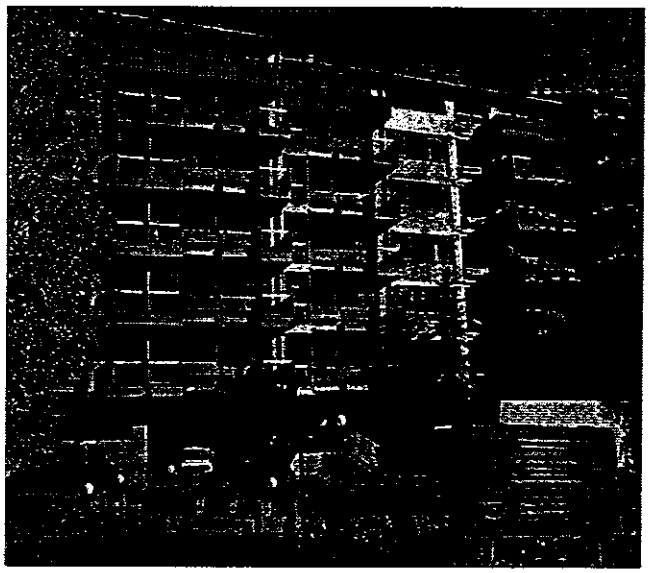
According to measured data received from the hospital's Technical Department, fuel consumption in April and May 2002 was 122.84 tons.

3.1.3 Energy Savings

Comparing the April-May 2002 measured consumption, with the April-May 2001 measured consumption, we see that the installation of new condensate return system and the repair of the steam line have generated an approximate 28% saving in fuel consumption. Extrapolating this result to the entire year:

Yearly fuel savings:	**1,073.23 tons x 0.28 = 300 tons/year**
Yearly cost savings:	**64,712 $/year**
Investment cost:	**$ 89,631**
Payback Period:	**1.4 years**

The center consists of two large buildings, connected to the District Heating Plant (DHP). Given the distance of the Center from the DHP, and the excessive number of users connected to the same DHP, the amount of thermal energy reaching the Center was insufficient to adequately heat the buildings: the heating line was designed for 130 °C, while the effective temperature was 55 °C . The Center also had two separate electric boilers for the supply of sanitary water, and an additional oil boiler for the production of steam needed in the laundry. The Centrer's kitchen used propane-butane gas bottles.

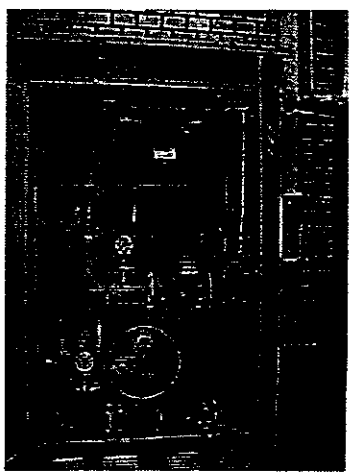


4.1 HEATING AND FUEL SWITCHING SYSTEM

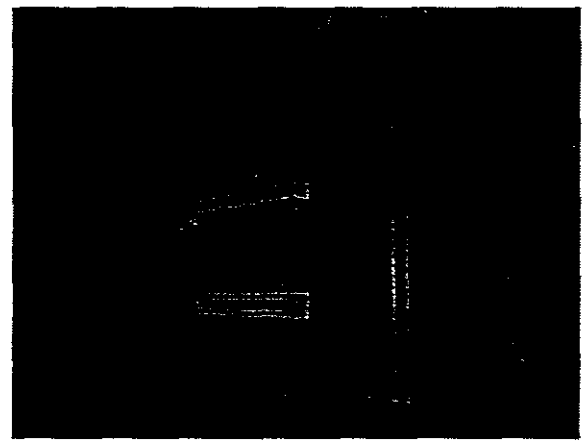
The center has been disconnected from the District Heating Plant, and supplied with a new Central Heating System, consisting of two new 750 kW boilers, with dual fuel burners and automatic control station; this new heating system has been housed in a new boiler room. In addition, a 132 kW boiler has been supplied for sanitary water. Also, the existing steam boiler has been supplied with a new dual fuel burner. Connection to the municipal natural gas distribution network has also been supplied.

Thermostatic Control Valves have been installed on all radiators, and thermal shields have been installed between radiators and cold outfacing walls.

New boilers



Natural gas substation



Automatic control cabinets

Installing shield *Radiator with heat shield*

4.1.1 Baseline Energy Use

Thermal Energy Consumption - Historical thermal energy consumption data for every month during the winter season of year 2000-2001 was obtained from the Municipality.

Electrical Energy Consumption - Historical electrical energy consumption data for every month during the winter season of year 2000-2001 was obtained from the Municipality in the form of utility bills for each month. Since the electricity consumption for heating and lighting are not metered separately, the utility bills include combined consumption for both heating and lighting. To separate the two components, the monthly consumptions for the entire year was examined. The consumption during non-winter months essentially consists of lighting. This consumption was extrapolated for the winter months using approximations and subtracted from the respective monthly total electricity consumption during the winter season. This process gives the approximate monthly electricity consumption for heating.

Operating Hours –The Senior Center operates 24 hours per day, seven days a week.

Average Outdoor Ambient Temperature – This information was obtained, for each winter month, from the National Weather Institute.

Adjusted pre-installation energy consumption. The historical energy consumption, obtained from the Municipality was adjusted as described at paragraph 2.2 above

Pre-Installation (Baseline) Measurement								
		2000			2001			
	Annualized Average/Total	October	November	December	January	February	March	April
District Heating Energy Consumption, kWh	3,702,230	308,000	603,900	650,000	702,000	580,000	550,000	308,330
Laundry Room Boiler Energy Consumption, kWh	197,050	28,150	28,150	28,150	28,150	28,150	28,150	28,150
Kitchen P-B Gas Energy Consumption, kWh	70,875	10,125	10,125	10,125	10,125	10,125	10,125	10,125
Electrical Energy Consumption (ESTIMATE FOR HEATING ONLY), kWh	100,000	10,000	15,000	16,000	17,000	16,000	16,000	10,000
Adjusted Thermal Energy Consumption, kWh	5,386,221	561,064	953,865	1,114,838	913,846	663,470	669,157	509,980
Adjusted Electrical Energy Consumption (ESTIMATE FOR HEATING ONLY), kWh	138,317	16,974	22,742	26,500	21,203	17,247	18,353	15,239
Average Outdoor Ambient Temperature, °C	—	11	5	1	(2)	1	6	11
Average Indoor Ambient Temperature, °C	—	19	18	17	17	17	18	19
Average Differential Ambient Temperature, °C		8	12	16	18	15	12	8
Average Wall Temperature °C - Outside Surface	—	13	6	2	-	2	7	12
Average Wall Temperature °C - Inside Surface	—	25	25	26	27	26	25	25
Average Differential Wall Temperature, °C	—	13	19	25	27	24	19	13
Average Wall Thickness, m	—	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total Shield Surface Area, m^2	—	200	200	200	200	200	200	200
Average Wall Thermal Conductivity, W/m^2-°C/m	—	2	2	2	2	2	2	2
Total Heat Loss thru Wall Across Radiators, kWh	139,608	12,600	19,152	24,696	27,216	24,192	18,648	13,104
Adjusted Total Heat Loss Across Radiators, kWh	192,787	21,387	29,037	40,903	33,945	26,077	21,390	20,047

Average Indoor Ambient Temperature – the estimate of average indoor ambient temperature was obtained from Senior Center.

Pre-Installation (Baseline) Measurement								
		2000			2001			
	Annualized Average/Total	October	November	December	January	February	March	April
District Heating Energy Consumption, kWh	3,702,230	308,000	603,900	650,000	702,000	580,000	550,000	308,330
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Electrical Energy Consumption (ESTIMATE FOR HEATING ONLY), kWh	100,000	10,000	15,000	16,000	17,000	16,000	16,000	10,000
Adjusted Thermal Energy Consumption, kWh	5,386,221	561,064	953,865	1,114,838	913,846	663,470	669,157	509,980
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Average Differential Ambient Temperature, °C		8	12	16	18	15	12	8
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Average Wall Temperature °C - Inside Surface	—	25	25	26	27	26	25	25
Average Differential Wall Temperature, °C	—	13	19	25	27	24	19	13
Average Wall Thickness, m	—	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total Shield Surface Area, m^2	—	200	200	200	200	200	200	200
Average Wall Thermal Conductivity, W/m^2-°C/m	—	2	2	2	2	2	2	2
Total Heat Loss thru Wall Across Radiators, kWh	139,608	12,600	19,152	24,696	27,216	24,192	18,648	13,104
Adjusted Total Heat Loss Across Radiators, kWh	192,787	21,387	29,037	40,903	33,945	26,077	21,390	20,047

4.1.2 Post-Installation Energy Use

Thermal Energy Consumption – Was estimated on the basis of periodic readings of the gas meter.

Electrical Energy Consumption – Was obtained from the Center's monthly bills. It has to be noted that the total energy consumption for Winter season 2001-2002 is larger than the one for Winter season 2000-2001: this is due to the fact that heating from the DHP was not available during the installation of the new boilers, and the only source of heat available in this period were portable electric heaters.

Average Outdoor Ambient Temperature – Was obtained from the National Weather Institute.

Average Indoor Ambient Temperature – Was recorded several times a day over a 24-hour period, at three typical different locations in the Center, on the first day, last day, and two intermediate days of the month. The average indoor ambient temperature was then derived averaging these data.

Post-Installation Measurement									
			2001			2002			
			Adjusted Monthly Data						
		Annualized Average/Total	October	November	December	January	February	March	April
Thermal Energy Consumption, kWh		1,742,467	194,685	284,742	402,275	344,272	251,161	206,135	59,197
Electrical Energy Consumption, kWh		550,398	48,252	104,232	123,672	131,264	67,152	59,504	16,322
Total Energy Consumption, kWh		2,292,865	242,937	388,974	525,947	475,536	318,313	265,639	75,519
		-	-	-	-	-	-	-	-
Average Outdoor Ambient Temperature, °C	—		9	3	(5)	(1)	5	8	10
Average Indoor Ambient Temperature, °C	—		22	22	22	22	22	22	22
Average Ambient Temperature Difference, °C	—		13	19	27	23	17	14	12
		-	-	-	-	-	-	-	-
Average Wall Temperature °C - Outside Surface	—		12	1	-	4	8	11	13
Average Wall Temperature °C - Inside Surface	—		23	16	15	19	23	24	24
Average Wall Temperature Difference, °C	—		11	15	15	15	15	13	12
		-	-	-	-	-	-	-	-
Average Wall Thickness, m	—		0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total Shield Surface Area, m^2	—		200	200	200	200	200	200	200
Average Wall Thermal Conductivity, W/m^2-°C/m	—		2	2	2	2	2	2	2
Average Heat Loss, kWh		96,768	11,088	15,120	15,120	15,120	15,120	13,588	11,612

Please insert here the Table on frame # 9

4.1.3 Energy Savings

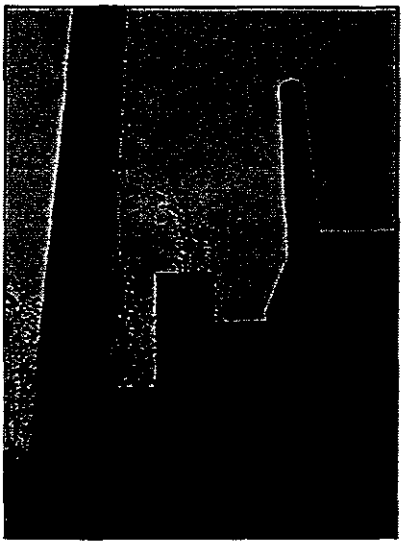
As mentioned, the energy savings were calculated as the difference between the adjusted pre-installation consumption , and the post-installation consumption. The result is summarized in the following tables, the first of which refers to the savings achieved by the new heating system, and the second to the savings achieved by the radiators thermal shields.

Please insert here two Tables: one from frame # 10 and one from frame # 11 (NOTE: the titles outside the table frames are wrong, please do not use them).

Annual Energy and Cost Saving		
	For Facility	
	Estimated	**Actual**
Thermal Energy Saving, kWh/Yr	649,200	3,643,754
Electric Energy Saving, kWh/Yr	150,000	138,317
Thermal Cost Saving, $/Yr	$31,175	$83,022
Electric Cost Saving, $/Yr	$7,500	$6,916
Total Cost Saving, $/Yr	$38,675	$89,938
Implementation Cost, $	$225,853	$173,307
Simple Payback Period, Yrs	**5.8**	**1.9**

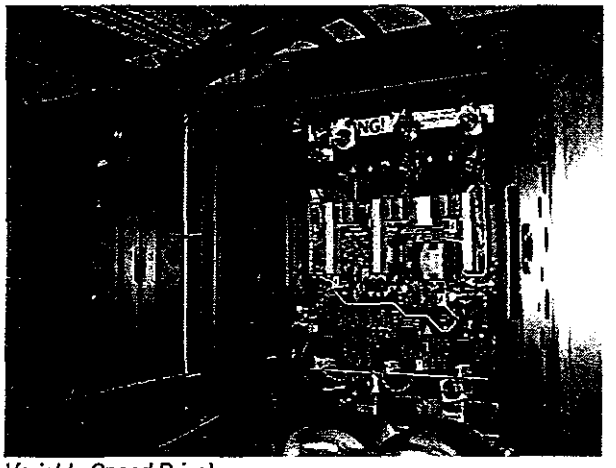
Annual Energy and Cost Saving		
	For Radiator Shield	
	Estimated	**Actual**
Thermal Energy Saving, kWh/Yr	44,000	96,019
Electric Energy Saving, kWh/Yr	--	--
Thermal Cost Saving, $/Yr	$1,003	$2,188
Electric Cost Saving, $/Yr	--	--
Total Cost Saving, $/Yr	$1,003	$2,188
Implementation Cost, $	$6,090	$6,090
Simple Payback Period, Yrs	**6.1**	**2.8**

The heating plant has been converted from a former power plant. Currently it has 6 boilers with 145MW of installed capacity. The plant uses oil and natural gas as its primary fuel

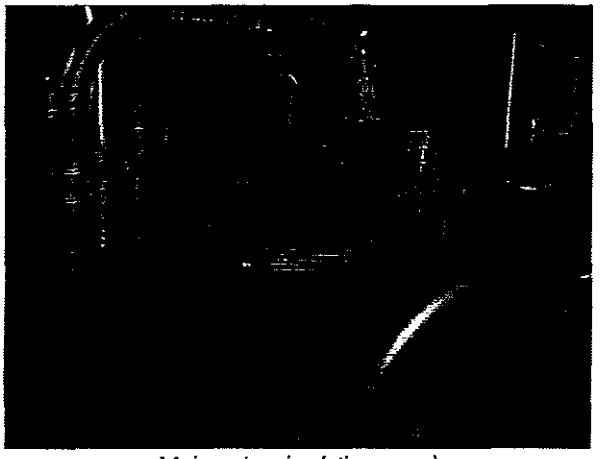


5.1 VARIABLE SPEED DRIVE FOR MAIN WATER CIRCULATION PUMP

A variable speed drive (VSD) with all its accessories for the main hot water circulation pump was installed at the district heating plant. The 315 kW pump circulates water from the heating plant to the district heating system customers. A flow control station modulates the flow of water by controlling, through the VSD, the main pump speed as a function of the outdoor temperature. In this mode of operation, the pump's power demand is lowered.



Variable Speed Drive)



Main water circulation pump)

Installation of the VSD was completed in mid April 2002, after the end of the heating season. The DHP will put the device in operation during winter season 2002-2003. Measured data for the calculation of effective savings are not available at this time, only the savings estimates derived during the Rapid Assessment are available, precisely:

Annual Energy and Cost Saving	
Thermal and Electric Energy Saving, kWh/y	295,000
Total Cost Saving, $/y	$14,750
Investment Cost, $	$43,850
Payback Period, Yrs	3