PN-ACP-910

SERBIA EMERGENCY ENERGY EFFICIENCY PROJECT

RAPID ASSESSMENT REPORT

Prepared by

Nexant

for

USAID/Serbia
USAID/E&I
Washington DC

May 2002

Contract LAG-I-00-98-00006-00
Task Order 109

23865-109-0001

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Contents

Section		Page
1	**Executive Summary**	ES-1
2	**Project Background**	2-1
3	**Objectives and Desired Results of SEEEP**	3-1
3.1	Objectives	3-1
3.2	Desired Results	3-1
3.3	Nexant's Role	3-1
4	**Rapid Assessment Methodology**	4-1
4.1	Municipality Selection Process	4-1
4.2	Facility Selection and Identification of Energy Efficiency Measures	4-2
4.3	Evaluation of Measures	4-4
4.3.1	Energy Audits	4-5
4.3.2	Evaluation of Savings and Financial Feasibility Analysis	4-5
4.3.3	USAID Review and Approval	4-6
5	**Select Specific Candidate sites and Walk Through Audits**	5-1
5.1	Kragujevac	5-1
5.1.1	Jovan Popović School	5-1
5.1.2	Natalija Nana School	5-3
5.1.3	Music School	5-4
5.1.4	Summary of USAID Approved Energy Savings Measures for the Municipality of Kragujevac	5-6
5.2	Kruševac	5-7
5.2.1	Health Center for Children and Women	5-7
5.2.2	Neven Nursery School	5-9
5.2.3	Street Lighting	5-12
5.2.4	Summary of USAID Approved Installations for the Municipality of Kruševac	5-12
5.3	Novi Pazar	5-13
5.3.1	Vuk Karadžić Primary School	5-13
5.3.2	Stefan Nemanja Primary School	5-14
5.3.3	Summary of USAID Approved Installations for the Municipality of Novi Pazar	5-17

Section **Page**

5.4 Subotica 5-17
5.4.1 Town Hospital 5-17
5.4.2 Senior Center 5-19
5.4.3 District Heating System 5-20
5.4.4 Summary of USAID Approved Installations for the Municipality of Subotica 5-21
5.5 Zrenjanin 5-22
5.5.1 City Hall 5-22
5.5.2 Summary of USAID Approved Installations for the Municipality of Zrenjanin 5-24
5.6 Summary of All the Measures Considered 5-24

Appendix 1: Questionnaire for Energy Audits

Appendix 2: Calculation Templates

Appendix 3: Summary of approved measures

Appendix 4: List of rejected measures

Section 1 Executive Summary

Serbia's energy use, particularly for heat, 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 in the prices for electricity (about 80%) and district heat (ranging from about 40% - 70%) 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.

With this in mind, Western donors responded to the immediate electricity shortage by helping to pay the cost of imported electricity. This is clearly a short-term response that is not sustainable: 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.

As a complement to the demonstrations, SEEEP also aims to develop of an energy market, capable of sustaining the anticipated wide spread duplication of energy saving applications. Market development will be stimulated by the creation of a cadre of Serbian professionals trained in energy efficiency, and the development of a Serbian nucleus of suppliers of good quality energy efficiency equipment.

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. The aggregate capital investment needed to implement these measures was estimated to be approximately $ 990,000, and to produce a total energy saving in excess of $ 300,000 per year, therefore yielding a payback period of 3.2 years.

This Rapid Assessment Report describes the methods and results of the assessment.

The Republic of Serbia, with Belgrade as capital, is part of the Federal Republic of Yugoslavia, and contains the autonomous provinces of Vojvodina, Kosovo, and Metohija. Belgrade has a population of two million and is the administrative, economic and cultural center of Serbia.

Located in the central part of the Balkan Peninsula, on the most important route linking Europe and Asia, Serbia is referred to as the crossroads of Europe, occupying an area of 88, 361 km^2, and with a population of approximately 10 million people. The international roads and railways passing down its river valleys make up the shortest link between Western and Central Europe, on the one side, and the Middle East, Asia and Africa, on the other.

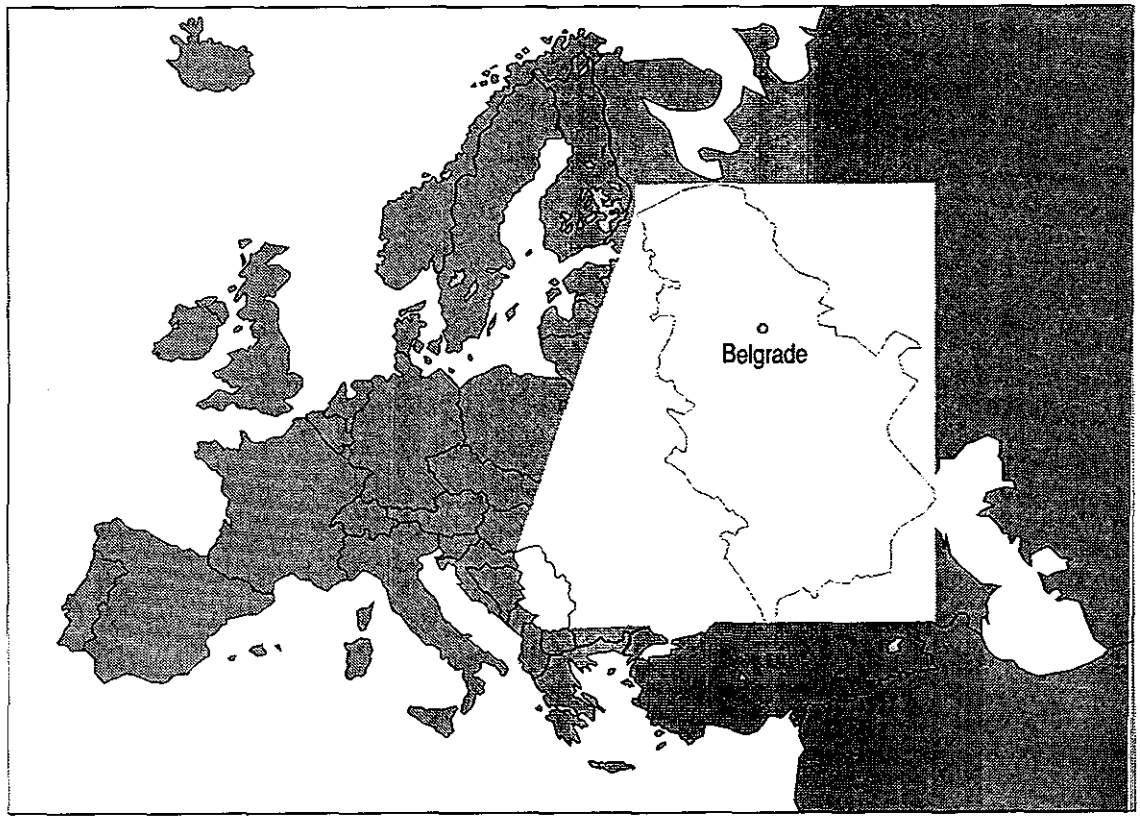

Figure 2-1: Serbia as the Crossroads of Europe

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 electric energy producers face fuel supply shortages. Heavy subsidies in the prices for electricity (about 80%) and district heat (ranging from about 40% - 70%) had exacerbated the situation by encouraging high consumption levels. The budgets of cities and energy enterprises are strained to provide the subsidies, making it impossible to increase supplies and to properly maintain the systems. Despite the heavy subsidy levels, heating bills represent about 33% of the average monthly income, according to the Economic Institute.

5

The electricity supply shortages are largely attributable to the high use of electricity for residential heating. Electricity use in Serbia has actually increased since 1990 despite GDP dropping by about half. This is primarily due to a marked increase in the use of electricity for heating, as rates were heavily subsidized while traditional forms of heating became less available (e.g., coal) and prices for oil and natural gas rose close to international levels. Relative to the price of electricity, coal and natural gas heat are now each about three times more expensive; and oil is about five times more expensive. From roughly equal shares among the three heat sources 10 years ago, electricity now represents about 50-55% ; district heat 35-40% ; coal, wood and others 5-10%.

As a result, residential customers consume about 70% of the Serbia's electric power production, a far higher level than found in other countries. Furthermore, about 4% of residential customers account for 20-25% of all electricity consumption. Estimates of urban households using electricity as their primary source of heating range from about 40% (Economic Institute) to 57% (UN Office for the Coordination of Humanitarian Affairs-UNOCHA). Electric heating is also used as a supplement by many other customers, with other primary forms heating: customers with district heating use electricity to increase comfort levels; customers with gas, coal or oil use electricity due to its lower cost. This would be a highly undesirable development even without the electricity supply crisis, as electricity is a very inefficient and polluting heating source. As subsidies to electricity consumption are removed, the already significant financial burden presently faced by Serbian households, will undoubtedly worsen, as the tariffs increase by a factor of five or six.

Western donors are responding to the immediate electricity shortage by helping to pay the cost of imported electricity, but this is clearly a not sustainable short-term response. Energy efficiency is one way to relieve the supply shortages, while also providing social protection by cushioning the impact of removing price subsides. Although the need to install energy efficiency improvements to cut consumption and energy costs, other donors are not addressing the reduction of energy consumption.

Attractive energy efficiency targets include municipal and other public facilities and households. Energy efficiency investments are one of a few infrastructure projects that can pay for themselves- via the resulting savings on energy costs. Reducing energy costs in facilities such as schools, hospitals, street lighting and buildings, allows municipalities to devote more financial resources to providing essential public services. Lowering energy costs also reduced the pressure to provide subsidies and improves the economic viability of energy enterprises by increasing customer's ability to pay energy bills and making it easier to rationalize energy tariffs. Energy efficiency investments have significant social transition implications by making it easier for households and public institutions to afford the rising energy costs; and, by freeing funds from energy to the provision of services to the population, enabling municipalities to improve the quality of services such as education.

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.

As a complement to the demonstrations, SEEEP also aims to develop of an energy market, capable of sustaining the anticipated wide spread duplication of energy saving applications. Market development will be stimulated by the creation of a cadre of Serbian professionals trained in energy efficiency, and the development of a Serbian nucleus of suppliers of good quality energy efficiency equipment.

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This Rapid Assessment Report describes the methods and results of the assessment.

Section 3 Objectives and Desired Results of SEEEP

3.1 OBJECTIVES

USAID has designed SEEEP with the objective of promoting the reduction of financial burden imposed upon the Serbian government by the present level of energy consumption.

The selected promoting mechanism is the widespread demonstration of financially attractive energy saving technologies, which will attract both private and public financing toward the repetition, on a large scale, of the demonstrated applications. The large number of repetitions will in turn have a substantial impact in reducing the level of energy consumption at national level, with a consequent reduction in government expenditures. This approach has the additional merit of providing some social protection against the unavoidable gradual reduction of subsidies. In fact the promotion of energy saving applications will result in the decrease of the energy bills, counteracting, at least partially, the increases generated by the reduction and eventual elimination of subsidies.

As a complement to the demonstrations, SEEEP also aims at the development of an energy market, capable of sustaining the anticipated wide spread duplication of energy saving applications. Market development will be stimulated by the creation of a cadre of Serbian professionals trained in energy efficiency, and by the development of a nucleus of Serbian suppliers of high quality energy efficiency equipment.

3.2 DESIRED RESULTS

Implementation of energy saving applications with attractive payback, in several institutional buildings selected from several Serbian Municipalities.

3.3 NEXANT'S ROLE

The role assigned by USAID to Nexant, under the SEEEP contract, includes

- Selecting the specific facilities in which to implement energy efficiency improvements
- Determining the specific energy efficiency improvements for each facility
- Prepare designs, specifications, and bills of quantity for all works undertaken under this program
- Procuring engineering/contractor services and equipment and materials for the energy efficiency improvements.
- Overseeing the installation of equipment and materials for the energy efficiency improvements.
- Establishing a baseline of energy consumption and measuring the savings from the energy efficiency improvements.

Various aspects of these activities require coordination with the Alliance to Save Energy (The Alliance). In general, Nexant has been providing technical assistance in the design and

implementation of energy efficiency improvement projects, while the Alliance has been working on the overall policy, planning, public information, training, and dissemination among publicly-owned facilities such as schools, hospitals, orphanages, community centers and housing. The effort consist of representative improvements in three to six communities, to be accompanied by efforts by The Alliance for a public information campaign and a dissemination effort to share the experience with other cities.

The role assigned to Nexant is clearly in tune with the overall objective of this program. In fact, it has been defined with the goal of demonstrating a large number of financially viable energy efficiency projects, and in the process, help developing the nucleus of a Serbian energy efficiency market.

Section 4 Rapid Assessment Methodology

This section describes the methodology adopted in carrying out the first two tasks of Nexant's role, as defined above:

- Selecting the specific facilities in which to implement energy efficiency improvements
- Determining, for each facility, specific energy efficiency improvements and their financial attractiveness

4.1 MUNICIPALITY SELECTION PROCESS

Before SEEEP award to Nexant, the Alliance was already operating in Serbia, under a cooperative agreement with USAID. The Alliance started their work in March 2001, one of their tasks was to survey a number of municipalities and to gauge their interest in participating in an energy efficiency program, funded by USAID. The Alliance conducted the survey by sending out a questionnaire, to which fifteen municipalities responded.

The municipalities that responded to the survey are listed in Table 4-1. The table also lists the type of facility improvements suggested by the municipalities. These improvements encompass the building envelope (windows and doors, thermal and hydro insulation for ceiling and wall, structural reinforcement, etc.), heating system (boilers, burners, district heating, radiators, fuel switching, etc.), and lighting (indoor, outdoor, and street).

The municipality of Preševo was originally a candidate for participation in the program, but due to the political instability of the area it had to be eliminated from the list. Further, the municipality of Kraljevo decided not to participate in the program. This left 14 municipalities in the list, out of which, five municipalities were selected on the basis of several criteria including:

- Commitment of the mayor and the city council to energy efficiency improvement
- Willingness to contribute – financial or in kind - to the projects
- Willingness of the municipalities, district heating companies, and end-users to conduct demonstration projects with the objective of lowering consumption through financially viable energy efficiency improvements
- Presence of a variety of facilities that use electric heating and/or district heating, and are suitable for energy efficiency improvements, for which the facility owners are willing to participate in the energy efficiency improvement program.

The five selected municipalities are: **Kragujevac, Kruševac, Novi Pazar, Subotica,** and **Zrenjanin.** Their location in Serbia is shown in Figure 4-1.

Figure 4-1 Location of the Selected Municipalities

4.2 FACILITY SELECTION AND IDENTIFICATION OF ENERGY EFFICIENCY MEASURES

The identification of the facilities and the associated energy efficiency improvement measures followed the selection of the municipalities. USAID guidelines for the type of facilities to be considered include hospitals, schools, orphanages, retirement homes and other facilities of similar function. The following criteria were used to select the specific facilities:

- Age of the building
- Location
- Social relevance
- Visibility of eventual interventions
- Type and conditions of the construction
- Building management perception of the energy situation
- Building management willingness to maintain the improvements after installation
- Heating requirements of the occupants
- Type and condition of Heating System
- Can the building operation be temporarily disrupted without any major problem?
- Attitude of building management toward the eventual intervention

Table 4-1
List of Municipalties and Type of Requested Energy Efficiency Improvements

	Building Envelope				BOILER			Burners			Radiators		DHS						
MUNICIPALITY	Windows	Doors	Roof Waterproofng	Insulation	Replace	Refurbish	Maintain	Fuel Switch	Replace	Combust. control	Replace	Clean	Connect	Expand	Refurbish	Thermost. & Flow Cont'ls	Piping & Valves	Lighting	Civil Structure reconstr.
Bajina Bašta	■	■	•	•	■	•	•	•	■	•	•	•	•	•	■	•	■	•	•
Cacak	•	•	•	•	•	•	•	•	•	•	•	•	■	■	■	•	•	•	•
Indija	•	•	•	•	•	•	•	■	•	•	•	•	•	•	•	•	•	•	•
Kragujevac	■	•	■	■	■	•	•	•	•	•	•	•	•	•	•	•	•	■	•
Kraljevo	■	■	•	■	■	•	•	•	■	•	■	•	•	•	■	■	•	•	•
Preševo	•	•	•	•	•	•	•	•	•	•	•	•	•	•	■	•	•	•	■
Kruševac	■	■	•	•	■	■	•	■	•	•	•	•	•	•	•	•	•	•	■
Novi Pazar	■	•	■	•	•	•	■	•	•	•	■	■	•	•	■	•	•	•	•
Nis	•	•	•	•	•	■	•	■	•	■	•	•	•	•	■	■	•	•	•
Leskovac	•	•	•	•	•	•	•	•	•	•	•	•	■	•	•	■	•	•	•
Pančevo	•	•	•	■	•	•	•	•	•	■	•	•	•	•	•	■	■	•	•
Zrenjanin	■	•	•	■	■	■	•	•	•	•	•	•	•	•	•	■	•	•	•
Pirot	•	•	•	•	•	■	•	•	•	•	•	•	•	•	•	■	•	•	•
Subotica	■	•	•	•	Build new	•	•	■	•	•	•	•	Disconnect	•	•	•	■	•	•
Zaječar	•	•	•	•	•	•	•	•	•	•	■	•	•	•	•	•	•	•	•

12 -

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As previously indicated the municipalities suggested a number of energy efficiency improvement measures for consideration by USAID. In general, the suggestions included:

- A description of each facility (type, size, heating area, number of occupants)
- A description of each energy efficiency improvement measure
- An estimate of current annual energy consumption for each type of energy used in each measure
- A rough estimate of annual energy saving
- A rough estimate of annual cost saving
- A rough estimate of the cost of improvement
- An indication of the contribution in kind that the Municipality would be willing to make toward the estimated cost of improvement.

4.3 EVALUATION OF MEASURES

The Municipalities' suggestions were the starting point for selecting the measures to be implemented. Nexant, in cooperation with the Mayors and the senior administrators of the five selected Municipalities, organized the first visit to the cities, according to the schedule shown in Figure 4-2.

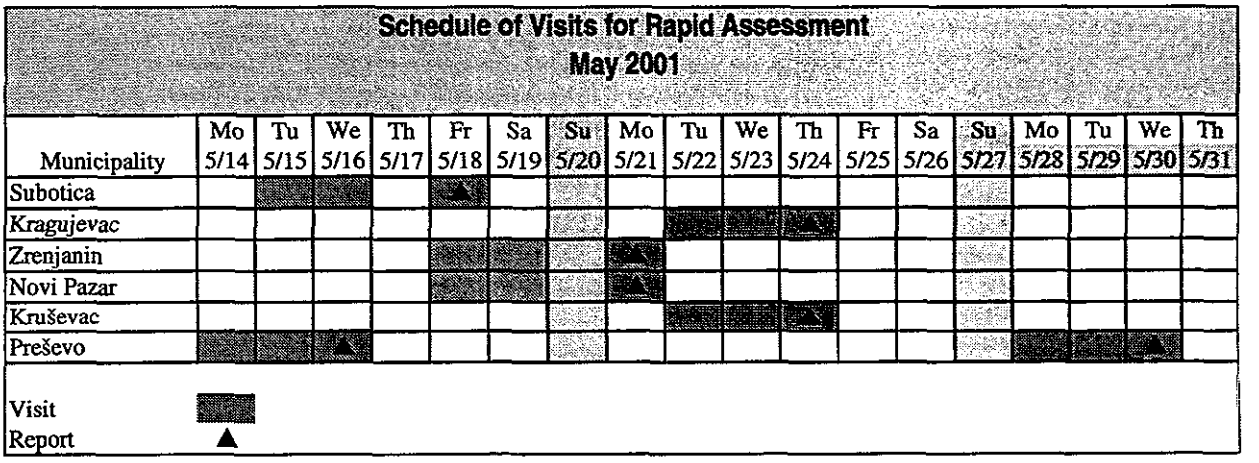


Figure 4-2 Schedule of Visits to the selected Municipalities

On the first visit Nexant performed brief walk-through inspection of the facilities proposed by the Municipalities to determine their eligibility for the program. This first visit led to the elimination of some proposed facilities and/or measures that clearly did not meet the necessary criteria. The two main reasons for elimination were:

- The structural status of the facility requires a substantial investment for infrastructure improvement
- The proposed measure is not a energy efficiency one

13

Nexant then targeted these facilities and measures determined to be eligible for a detailed multi-step selection process, articulated on the steps described in the following paragraphs.

4.3.1 Energy Audits

The audits consisted of multiple visits to each facility, with collection of all available energy and cost data, and physical measurement of certain parameters when the required data were not available. As a guide for data collection, Nexant prepared a questionnaire based on the experience gained during the first walk-through: the questionnaire's forms are shown in Appendix 1.

The audits resulted in the identification of a number of potential measures to be further assessed. The measures included some of the originally proposed measures, such as:

- Single pane or broken and leaky windows – Replace the old windows with new double pane windows
- Old inefficient boilers for space heating – Replace boilers, burners, radiators, and associated accessories, as required
- Electrical heating systems – Replace with central hot water systems
- Radiators placed adjacent to the outer wall or windows – Install radiator shield
- Incandescent lighting – Replace with fluorescent lighting

Beyond the originally proposed measures, additional ones were identified:

- Street lighting – Partial switch off after midnight
- *Constant speed drives for water pump motors*

4.3.2 Evaluation of Savings and Financial Feasibility Analysis

Using the data collected during the audits, the savings achievable by each identified measure were evaluated. The evaluation had to take into consideration two basic facts emerged during the audits:

- All visited facilities complained for not having sufficient heat, or having to supplement the heating supplied by District Heating Plants with portable electric heaters
- The price presently paid by the consumers for fuel and electricity is subsidized, and does not reflect realistic international market levels

Therefore, a correct evaluation of achievable savings required adjustment of the data collected during the audits, to reflect the following assumptions:

- Present energy consumption is calculated as the amount of thermal energy, which would be needed to create, for the building's occupants, a level of comfort equal to the level of comfort experienced after the implementation of the energy efficiency measure.
- Fuel and electricity prices will be considered at a realistic international market level, precisely:

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)

- District Heating Plants (DHP) will be evaluated as virtual centralized building heating systems, where boiler's efficiency includes the efficiency of the hot water transmission line from the DHP to the point of use.

In order to standardize the energy saving calculations, Nexant prepared a series of templates, shown in Appendix 2, which incorporate the assumptions listed above. The templates require simply the input data to automatically calculate the savings, following the guidelines established by:

- **Energy Audit Workbooks for Schools, Hospitals, Commercial Buildings, and other Facilities.** US Department of Energy, 1978
- **Handbook of Enegy Audits**, Fourth Edition, Albert Thumann, Prentice Hall, 1995

After the evaluation of savings, a preliminary design was carried out for each measure, with the objective of identifying and sizing the main components of the system. A market survey then supplied the necessary data for the analysis of equipment costs, availability, and supply schedule.

The estimate of energy savings and implementation costs provided a basis for the evaluation of financial feasibility of the measure, expressed as a payback period.

4.3.3 USAID Review and Approval

A brief technical description of the identified measures, along with the estimate of energy savings achievable, and the analysis of financial feasibility, were submitted to USAID for review and approval. The review, and approval decision, considered several factors, including:

- Repeatability of the measures throughout Serbia
- Electrical energy saving potential
- Cash flow over a period of five years
- Cost of implementation
- Simple payback period
- Social impact of Energy Efficiency Measures
- Implementation schedule
- Use of local equipment

15

A brief description of the measures submitted to USAID is presented in Section 5 of this report.

16

Section 5 Energy Efficiency Measures Selected for Implementation

Descriptions of the proposed measures and Nexant's assessments are presented in this section. The measures include those originally proposed by the selected municipalities, as well as additional others.

5.1 KRAGUJEVAC

The city of Kragujevac is approximately 144 km south from Belgrade, the capital of Serbia. Kragujevac, a 19th century Serbian capital, is situated in a largely farming area that consists of gentle rolling hills. The city occupies an area of 835 km^2 that contains 57 settlements. There are approximately 1,162 private companies and agricultural cooperatives. The population of the city is 200,000 of which 36,000 are students.

Kragujevac industrialized relatively early with the manufacturing of artillery field pieces in the fist half of the 19th century. Today it remains a center of industry, manufacturing passenger cars, commercial vehicles, sport, and hunting arms, as well as possessing a vibrant agricultural sector and food processing facilities.

5.1.1 Jovan Popović School

This is an elementary educational facility for children up to 15 years of age. The facility was built in 1990, and consists of two separated sections: Main and Sumarice. Each section is a one-story building, with an area of 1,540 m^2 and 808 m^2, respectively. Lack of resources force many Serbian schools to operate in two or more shifts. Jovan Popović School operates in two shifts.

Jovan Popovic Elementary School – Sumarice Section

Main Section – This section of the school is heated with accumulator-type electric heaters. The lighting consists of incandescent and fluorescent lamps.

Sumarice section - This section of the school is also heated with accumulator-type electric heaters. The lighting consists primarily of incandescent lamps hung from the ceiling.

5.1.1.1 Municipality Proposed Improvement(s)

The municipality of Kragujevac proposed that the following improvements be made in both sections of Jovan Popovic School:

- **Building Envelope** – Installation of thermal-hydro insulation on the roof. Replacement of single-pane wood-frame windows with double-pane aluminum windows.
- **Heating System** – Replacement of electrical heaters with central coal-fired boilers and radiators system.

- **Lighting** – Replacement of incandescent lamps with fluorescent lamps.

5.1.1.2 Nexant Assessment

Nexant visited both sections of the school and made the following assessment:

- **Building Envelope (Both sections)** - The roofs of the buildings do not have hydro or thermal insulation, which causes high loss of heat through the roof. In addition, structural damage was observed on the building roofs.

  Windows constitute about 40% of the building walls thus causing high heat loss. Moreover, the wooden windows are single pane with poor sealing.

  Although retrofitting roofs and windows would save energy, the measure would not yield a reasonable payback period due to a high cost of improvement and relatively low energy saving.

- **Lighting** - The Sumarice section of the school uses primarily incandescent lamps, and the lamp fixtures are in poor conditions, blocking part of the light from the lamps. The lighting system is thus very inefficient, and the quality of the light is poor.

  The lighting in the Main section is partly incandescent, but primarily fluorescent.

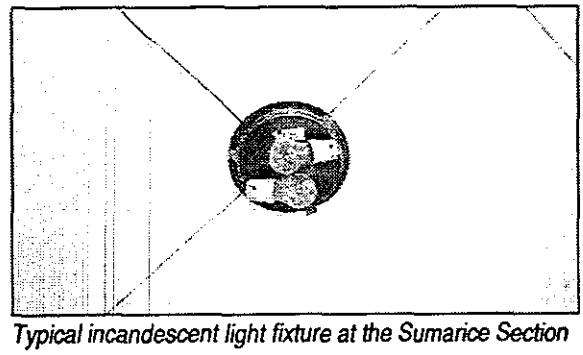
  The replacement of lighting in the Sumarice section would be a cost-effective measure with a reasonable payback period. The Main section has only a few incandescent lamps. Replacement of these would not result in significant energy saving.

- **Heating System (Both sections)** - The both sections of the school use accumulator type electric heaters for space heating. These heaters are very energy-consuming.

  Although the replacement of electric heaters with a fossil fuel fired boiler system with radiators would save energy, the measure would not yield a reasonable payback period due to a high cost of improvement.

5.1.1.3 USAID Approved Lighting improvement

On the basis of Nexant's assessment, USAID decided to implement the Lighting Improvement at the Sumarice section of the School.



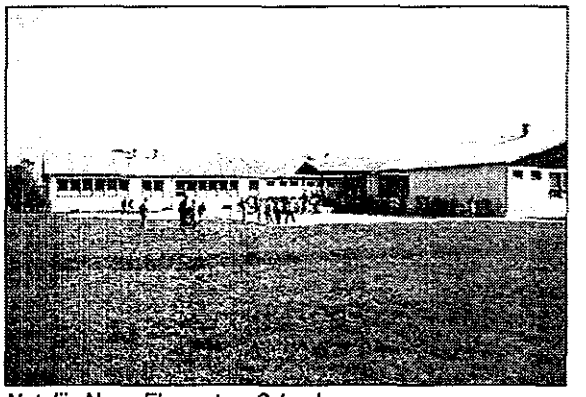
Typical incandescent light fixture at the Sumarice Section

Description. This lighting retrofit is intended to demonstrate that energy can be saved by utilizing new lighting technology. The school will benefit by saving energy and cost and will have a better learning environment for the children. Nexant, on behalf of USAID, will install a new lighting system, complete with fluorescent tubes, electro magnetic ballasts, and fixtures. This will replace a high electrical energy consuming system reliant completely on incandescent lamps. The estimated savings achievable by the new lighting system are summarized in the following:

- Estimated annual energy savings: 11,121 kWh/y
- Estimated annual cost saving: $ 556/y
- Estimated Implementation cost: $ 1225
- Payback period: 2.2 years

5.1.2 Natalija Nana School

This is an elementary educational facility for children up to 15 years of age. The facility was built in 1990. The building has one story only, with an area of 1,137 m^2, 9 large classrooms, 5 small rooms, and several auxiliary rooms. The school space is insufficient to accommodate all the students in one single shift, so they are forced to operate in multiple shifts. Heating is provided by coal and wood stoves, and lighting by incandescent lamps hanging from the ceiling.



Natalija Nana Elementary School

5.1.2.1 Municipality Proposed Improvement(s)

The municipality of Kragujevac proposed the following improvement for the school:

- **Heating system.** Replacement of electrical stoves with central hot water heating system with coal-fired boilers.
- **Lighting** - Replacement of incandescent lamps with fluorescent lamps.

5.1.2.2 Nexant Assessment

Nexant visited the school and made the following assessment:

- **Heating System.** The school uses coal and wood stoves in individual rooms. The stoves are old and inefficient, and cannot provide adequate heating. To supplement the heating, a few of the staff rooms are provided with accumulator type electric heaters. In general, the overall heating system in the school is inefficient and inadequate.

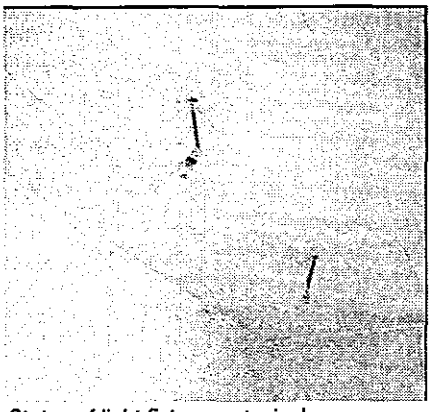
  Although the replacement of electric heaters with a coal fired boiler system with radiators would provide a more comfortable environment, the measure would not save energy.

- **Lighting** - The school uses primarily incandescent lamps, and the lamp fixtures are in poor conditions, blocking part of the light generated by the lamps. The lighting system is very inefficient, and the quality of the light is poor.

  The replacement of lighting in the school would be a cost-effective measure with a reasonable payback period.

5.1.2.3 USAID Approved Lighting Replacement

On the basis of Nexant's assessment and suggestions, USAID decided to implement the Lighting Improvement at the Natalija Nana School.



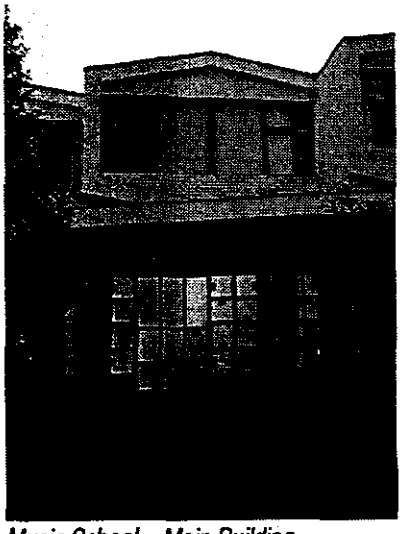
Status of light fixtures – typical

Description. Nexant, on behalf of USAID, will replace the present incandescent lamps system with a new system using fluorescent lamps, electro magnetic ballasts, and new appropriate fixtures. A total of 96 fluorescent lamp assemblies will installed. The estimated savings achievable by the new lighting system are summarized in the following:

- Estimated annual energy savings: 10,809 kWh/y
- Estimated annual cost saving: $ 538/y
- Estimated Implementation cost: $ 2,200
- Payback period: 4.1 years

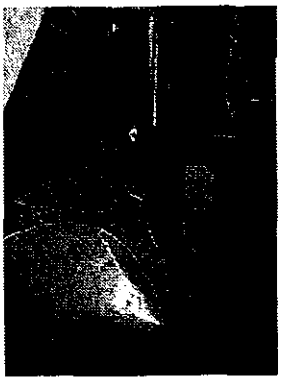
5.1.3 Music School

The school is a multi-disciplinary classical music school, built in 1954 as part of a fine arts center, with students ranging from 6 years to 19 years of age. The school is heated by the municipal district heating plant, through a substation located inside the school building. The municipal district heating plant charges the school a flat heating fee based on its floor area.



Music School – Main Building

DHP Substation – status of equipment



DHP Substation – Heat Exchanger

20

5.1.3.1 Municipality Proposed Improvement(s)

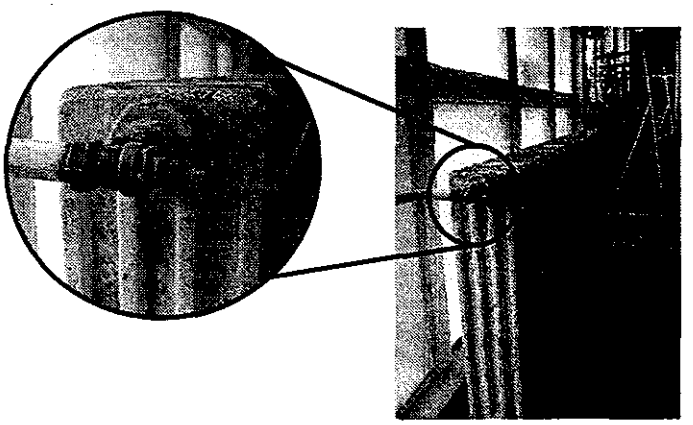
The municipality of Kragujevac proposed the following improvements for the school:

- **Heating System** – Installation of a control system.
- **Building Envelope.** Replacement of wood-frame windows that are in bad shape with double pane aluminum frame windows.
- **Lighting.** Replacement of the existing broken lamps with new lamps.

5.1.3.2 Nexant Assessment

Nexant visited the school and made the following assessment:

- **Heating System** – The heating system has no controls. Thus the heating of the class rooms and other spaces cannot be controlled and energy is wasted due to overheating of the rooms most of the time.



Typical radiator – no control valve-located next to window

A control system at the local district heating substation (within the school) would minimize the heat loss by providing a better control of space heating. Thermostatic control valves on the radiators would also contribute to energy saving. This retrofitting would be a measure with a reasonable payback period.

- **Building Envelope.** Many windows are in a very poor condition and broken, causing very high heat loss. Many frames are warped and glasses broken, locking mechanism inoperable and windows cannot be properly closed. Many rooms experience a high draft. Some rooms also have leaky ceilings. Although retrofitting the windows would save energy, the measure in this case would not yield a reasonable payback period due to high cost of replacing the windows, when compared to the achievable energy savings.

  Lighting. Many existing fluorescent lamps and fixtures are broken. Retrofitting the broken lamps would not save energy.

5.1.3.3 USAID Approved the Heating System Improvement.

On the basis of Nexant's assessment and suggestions, USAID approved the implementation of the heating system at the school.

Description. Nexant on behalf of USAID will install i) a hot water supply control system, ii) radiator thermostatic control valves, and iii) thermal insulation shields on all existing radiators facing cold surfaces (walls or windows exposed to the outdoor atmosphere). The main feature of this heating system improvement is a flow control system at the district-heating substation. This control system will allow hot water flow regulation as a function of the outdoor temperature, the facility hot water usage, and time-of-day operation. The system will also meter the thermal energy supplied by the district heating plant to the facility. The improved heating system will allow the school to control the amount of heat consumed, and as a result will reduce the heating bill paid by the municipality. The estimated savings achievable by the improved Heating system are summarized in the following:

- Estimated annual energy savings: 146,512 kWh/y
- Estimated annual cost saving: 3,174 $/y
- Estimated Implementation cost: $ 10,901
- Payback period: 3.4 years

5.1.4 Summary of Usaid Approved Energy Saving Measures for the Municipality of Kragujevac

The Municipality of Kragujevac will be the recipient of USAID approved energy efficiency measures for a total of:

- Total estimated annual energy savings: 168,442 kWh/y
- Total estimated annual cost saving: 4,268 $/y
- Total estimated Implementation cost: $ 14,326
- Overall payback period: 3.4 years

5.2 KRUSEVAC

Kruševac is located 210 km Southeast of Belgrade. The town itself dates back to the Middle Ages and at one time was one of the cultural centers of Serbia. The town covers 854 km^2, with over 100 settlements. The majority of the land, approximately 57% of the total area, is rural and the rest is considered urban. Kruševac has a total population of 138,000 people, of which 29,000 are in working age. The most important industries are Chemical, Food (beverages), and Agriculture.

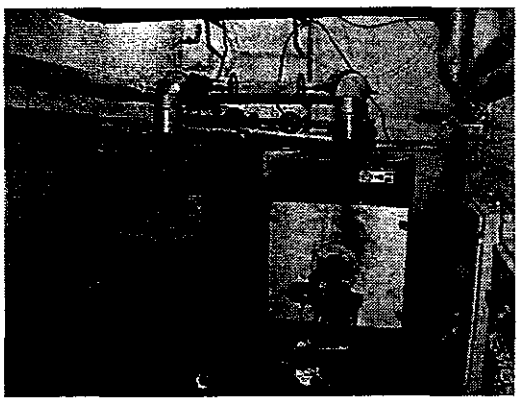
5.2.1 Health Center for Children and Women

The health center is a two-story building located in the city center. The building occupies a site of approximately 2,600 m^2. The center provides maternity care services to the surrounding community, consisting of approximately 140,000 residents.

5.2.1.1 Municipality Proposed Improvement(s)

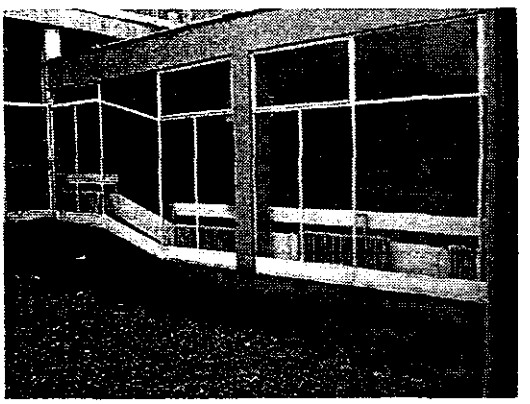
The municipality of Kruševac proposed the following improvement for the Health Center:

- **Heating system.** Complete overhaul of the boiler room, with replacement of the boiler and all the ancillary equipment.



Status of old boilers

- **Building envelope.** Replacement of the windows and thermal insulation of the walls.



Large portions of building envelope made of single glass panels, with radiators next to them

23

5.2.1.2 Nexant Assessment

Nexant visited the Health Center and made the following assessment:

- **Heating System.** The center has its own central heating system, powered by two 500 Kcal/h boilers, fired with solar, and installed approx 25 years ago: in the last 10-12 years the boilers have never been maintained.

  Approximately 60% of the radiators are located near large glass windows, facing the outdoor. The front of the radiators is blocked by wooden enclosures approximately 1/2 inch thick, but the top is free of blockage, allowing for good thermal draft circulation.

  Nexant proposed the installation of a new heating system, composed of two new 700 kW boilers with controls, and new burners. Included in the proposal were also thermal control valves on each radiator, and thermal shields between each radiator facing an external surface and the surface itself.

- **Building Envelope.** The building has a flat roof, with tar and gravel waterproofing, but no thermal insulation. Signs of water damage are clearly visible from inside the building.

  Approximately 40% of the building walls area consists of single pane windows, with badly warped wooden frames, and single pane glass walls, obviously intended to allow natural illumination of the interior.

  Nexant proposed the replacement of the wooden windows with PVC frame double pane windows, of local manufacture, and also the replacement of the single pane glass walls with double pane ones, using the steel frame structure already in place.

  Nexant also proposed the thermal insulation of the flat roof, and of the side-walls. However the proposal pointed out the high cost of this energy efficiency retrofit, when compared with the estimated energy savings achievable, would produce an unacceptable payback period.

5.2.1.3 USAID Approved Heating System and Window Replacement

On the basis of Nexant's assessment and suggestions, USAID decided to implement the Heating System improvement and the replacement of windows and glass walls.

Description Heating System. Two new boilers, with light oil burners, and related ancillary equipment will replace the two obsolete boilers presently installed at the Health Center. Included in this measure are also thermostatic control valves, and thermal shields to be installed on the existing radiators. Improved boiler efficiency and the modulation of thermal energy demand as function of outdoor and indoor temperatures will allow for drastic energy conservation.

Description Window Replacement. The old single pane wooden frame windows will be replaced with locally manufactured double pane windows with PVC frames. Also, all single pane glass panels exposed to the outside air, presently mounted in steel frames, will be replaced with

double pane glass panels mounted in the existing steel frames. This energy efficiency measure will greatly improve the building envelope, and consequently reduce heat losses.

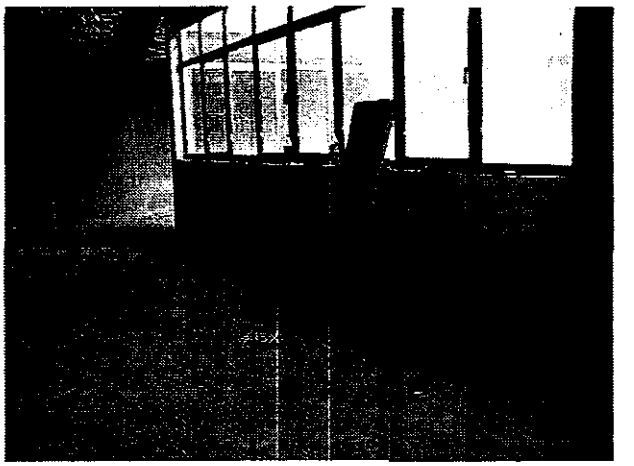
The combined estimated savings achievable by these improvements are summarized in the following:

- Estimated annual energy savings: 2,286,643 kWh/y
- Estimated annual cost saving: 73,847 $/y
- Estimated Implementation cost: $ 223,347
- Payback period: 3 years

5.2.2 Neven Nursery School

The school originally consisted of a one story building, with a total floor area of approximately 1,112 m^2, and two internal atriums, enclosed in glass panels, and open to the outdoor. Recently, a second story has been added, with an additional floor area of 650 m2. The school has 17 classrooms and can accommodate approximately 430 children.

Neven Nursery School



Neven Nursery School – Unfinished second floor

The facility is equipped with two old and badly maintained boilers, one of which has been out of commission for quite some time. The operating boiler is insufficient to provide sufficient heat to the school, as a result, a large number of portable electric heaters are used to bring the indoor temperature to the level needed to provide a comfortable environment for the children. Sanitary hot water is supplied with electric boilers.

5.2.2.1 Municipality Proposed Improvement(s)

The municipality of Kruševac proposed the following improvement for the School:

- **Heating System.** Complete overhaul of the boiler room, with replacement of the boilers and all the ancillary equipment.

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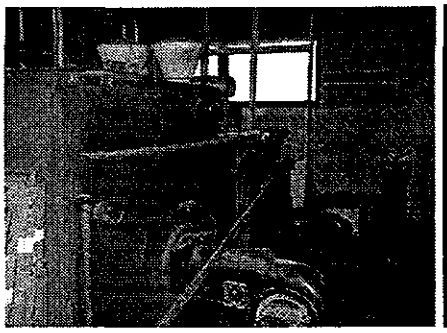


Status of old boilers4

Building envelope at the atriums – Radiators covered and facing single glass panels

5.2.2.2 Nexant Assessment

Nexant visited Neven Nursery School and made the following assessment:

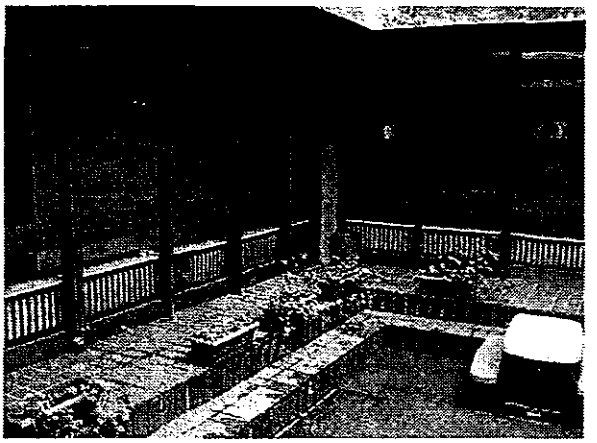
- **Heating System.** The two old boilers are beyond repair, and need to be replaced: the new ones must be sized correctly, to provide the necessary amount of heat to both floors of the school. This will prevent the use of supplementary portable electric heaters, and consequent waste of electric energy.

  Hot water for the kitchen and for sanitary use is supplied by several electric boilers installed in the school. These electric boilers should be taken out of service, and the necessary hot water should be supplied directly from the heating system, through an appropriate heat exchanger.

  Most radiators are covered by wooden casing, on the front and top, while the back is open and faces outside single pane glass panels. Nexant proposed to supply new radiator casing designed to allow good thermal circulation, install thermal shields behind radiators facing outside surfaces, especially when these surfaces are glass.

- **Building envelope.** The school has a large number of windows, with a total surface area of 155 m^2, with old warped wood frames; the school also has two central open-air atriums formed by single pane glass panels. Nexant proposed the replacement of the wood frame windows with new double pane PVC frame windows of local manufacture, and the replacement of the single pane glass panels with new double pane glass panels, also of local manufacture.

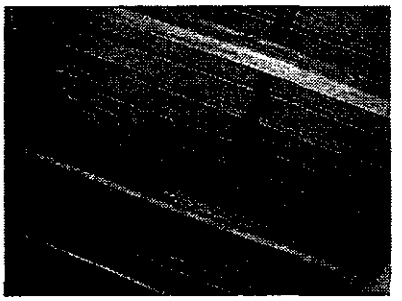
Windows – typical



Atrium

It was observed that the slanted roof of the newly added second floor has no thermal insulation, consisting only of corrugated steel. Nexant proposed to add thermal insulation to the inside surface of the roof, which would drastically decrease thermal losses.

5.2.2.3 USAID Approved Heating System and Windows



Second story roof – no thermal insulation

On the basis of Nexant's assessment and suggestions, USAID decided to implement the Heating System and Building Envelope improvements.

Heating System. Two new 300 kW boilers, will be installed to supply heat and hot water to the school. An additional small 60 kW stand-by boiler will be installed to satisfy hot water needs when the heating system is not in operation (in the summer), a new hot water distribution system to the classrooms, lavatories, and kitchen will also be provided. The improved heating system is sized for the additional floor area of the newly added second floor, and the necessary distribution lines will also be provided.

All radiators facing cold surfaces (walls or windows exposed to the outdoor atmosphere) will be provided with thermal insulators installed between radiator and cold surface. Thermal control valves will be supplied on each radiator. The existing radiator wooden enclosures will be modified, respecting the aesthetic requirements of the school, to allow proper heat transfer.

Building Envelope. All wood frame windows exposed to the outside atmosphere will be replaced. Also, all single pane glass panels, forming the two internal atrium,s will be replaced with double pane glass panels. The frames of the single pane glass panels are still in good condition and will be utilized to frame the new double pane panels.

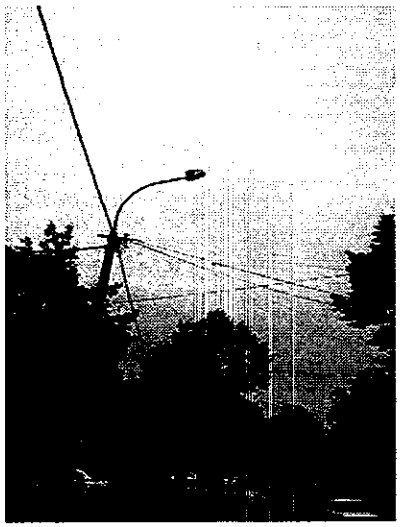
Thermal insulation will be installed on the internal surface of the slanted roof.

The combined estimated savings achievable by these improvements are summarized in the following:

- Estimated annual energy savings: 505,659 kWh/y
- Estimated annual cost saving: 17,229 $/y
- Estimated Implementation cost: $ 63,843
- Payback period: 3.7 years

5.2.3 Street Lighting

From a meeting with the Municipality's Technical Department in charge of street lighting, it became apparent that considerable energy savings could be obtained by switching off, after midnight, every other light bulb of the street lighting system in selected areas of the city. Implementation of this measure is feasible only if the lighting system is three phase wired, and requires the installation of inexpensive radio-controlled, or timer switches. The energy savings and cost of implementation were calculated, and the measure was approved by USAID.



Street light post and fixture – typical

The estimated savings achievable are summarized in the following:

- Estimated annual energy savings: 467,100 kWh/y
- Estimated annual cost saving: 23,355 $/y
- Estimated Implementation cost: $ 4,541
- Payback period: 0.2 years

5.2.4 Summary of USAID Approved Installations for the Municipality of Krusevac

The Municipality of Krusevac will be the recipient of USAID approved energy efficiency measures for a total of:

- Total estimated annual energy savings: 3,564,156 kWh/y
- Total estimated annual cost saving: 114,431 $/y
- Total estimated Implementation cost: $ 291,731
- Overall payback period: 2.5 years

5.3 NOVI PAZAR

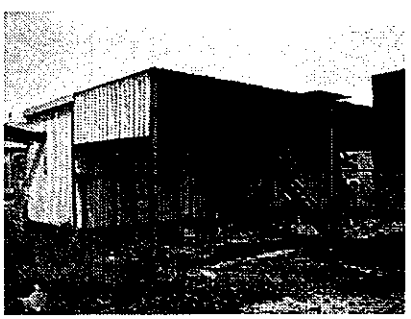
Novi Pazar is located in southern Serbia, approximately 315 km from Belgrade, and covers an area of 742 km^2, of which 49% is agricultural, with 99 settlements. Novi Pazar has approximately 85,000 inhabitants, 70% of which lives in the city, and the rest in the rural surrounding. The city is an ancient commercial centre, dating back to the Middle Ages, with an old monastery, Sopocani (1263-1268), under UNESCO protection.

5.3.1 Vuk Karadžić Primary School

This elementary school was built in 1979 and consists of three floors, with a total area of about 6,760 m^2. There are 23 classrooms, one teacher's room, and several office rooms. The 1,800 students range from age 7 to age 15. The large number of students forces the school to operate in three shifts.

The school has a central heating system, operated by two old, second hand coal boilers dating back to 1984. The boilers are not sufficient to supply adequate heat to the school, as a result, during winter the classrooms are cold, and portable electric heaters are used in the teachers rooms.

Old coal boilers



Old boiler house

Low grade local coal

5.3.1.1 Municipality Proposed Improvement(s)

The municipality of Novi Pazar proposed the following improvements for the school:

- **Heating System.** The Municipality proposes a complete overhaul of the heating system, and conversion to oil.
- **Building envelope.** Replacement of the existing windows.

5.3.1.2 Nexant Assessment

Nexant visited Vuk Karadžić Primary School and made the following assessment:

- **Heating.** The two coal boilers installed at the school are in extremely bad conditions, no data was available to calculate the efficiency, but in Nexant's judgment it is unacceptably low. The coal used to fire the boilers comes from local sources, and it is of inferior quality (close to peat). The boilers have no thermal controls and no combustion control.

The boiler room is outside the school main building, and the line transporting hot water to the school radiators system is above ground and very badly insulated.

Radiators are not provided with thermal control valves, and most are installed against cold wall surfaces facing the outside.

Nexant proposed providing two new 500 kW oil fired boilers, equipped with new burners and controls; thermal insulation of the hot water line; the installation of thermal control valves and thermal shields on each radiator

- **Building envelope.** The windows are double pane glass, with wood frames. The frames show deterioration due to age.

  The roof is flat, covered with tiles, and shows signs of water infiltration. No thermal insulation was originally installed.

  Nexant proposed providing new windows and the thermal insulation of the roof. However, the proposal also indicated that the investment for improving the building envelope, when compared to the savings achievable, would result in a very long payback period.

5.3.1.3 USAID Approved Heating System and Radiator Shield

On the basis of Nexant's assessment and suggestions, USAID decided to approve the Heating System improvement, while rejecting the Building Envelope's one.

Description: Heating System. Two new 500 kW light oil fired boilers and related ancillary equipment will replace two obsolete coal fired boilers presently installed at the School. Given the decrepit state of the existing boiler room, the two new boilers will be housed in a new boiler room, obtained from an existing building adjacent to the school.

Thermostatic control valves and thermal shields will be installed on the radiators already existing in the school. The valves and the shields will facilitate efficient and cost effective space heating in the school.

The combined estimated savings achievable by these improvements are summarized in the following:

- Estimated annual energy savings: 7,976,452 kWh/y
- Estimated annual cost saving: 21,010 $/y
- Estimated Implementation cost: $ 89,630
- Payback period: 4.3 years

5.3.2 Stefan Nemanja Primary School

This elementary school was built in 1979 and consists of three floors, with a total area of about 5,908 m^2. There are 20 classrooms, two teacher's rooms, and several office rooms. The 1,500

students range from age 7 to age 15. The large number of students forces the school to operate in three shifts.

The school has a central heating system, operated by two old, oil boilers. The boilers are not sufficient to supply adequate heat to the school, and as a result, during winter the classrooms are cold, and portable electric heaters are used in the teachers rooms.

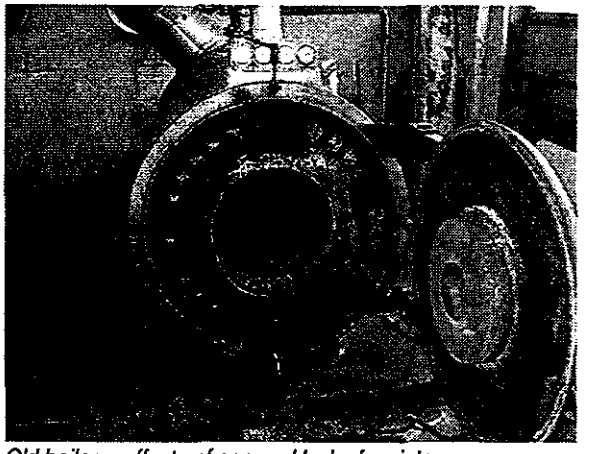
5.3.2.1 Municipality Proposed Improvement(s)

The municipality of Novi Pazar proposed the following improvements for the school:

- **Heating system.** Complete overhaul of the heating system.
- **Building envelope.** Replacement of the approximately 120 windows.

5.3.2.2 Nexant Assessment

Nexant visited Stefan Nemanja Primary School and made the following assessment:


Old boiler – effects of age and lack of maintenance

- **Heating System.** The heating system consists of two 30-year old boilers, burning 90,000 liters of naphtha per season. Maintenance appeared to have been neglected for a long time, and fire tubes were incrusted with combustion products, many were totally plugged. The entire boiler room equipment also appeared to be in bad state of maintenance. The boilers have no thermal control, nor combustion control.

  Nexant proposed the installation of two new 500 kW oil fired boilers, equipped with new burners and controls, ad the installation of thermal control valves and thermal shields on each radiator.

Old windows – typical conditions

- **Building Envelope.** The windows have wood frame, damage by age and, in several places, large gaps were observed between the frame and the wall. The windows have double pane glass, but approximately 30 percent miss one of the two panes.

  The roof of the building is flat, covered with tiles. The roof does have any thermal insulation, the tiles are loose, and water leaks through them.

Nexant proposed replacing the windows with new double pane, PVC frame windows of local manufacture.

Nexant also proposed to install thermal insulation on the roof, however pointed out that the high cost of the installation, when compared with the energy savings achievable with this measure, would produce a very long payback period.

- **Lighting.** The school has a large number of 75W incandescent lamps, operating approximately 2,000 hours per year.

  Nexant proposed replacing the incandescent lamps with high efficiency fluorescent tubes.

5.3.2.3 USAID Approved Heating System and Window Replacement

On the basis of Nexant's assessment and suggestions, USAID decided to approve the Heating System improvement, and part of the Building Envelope improvement.

Description: Heating System. Two new 500 kW light oil fired boilers, burners, and related ancillary equipment will replace the two obsolete oil fired boilers presently installed at the school. Thermostatic control valves and thermal shields will be installed on the radiators already existing in the school. The valves and the shields will facilitate efficient and cost effective space heating in the school.

Description: Window Replacement. A total of 174 wood frame windows, 3 wood frame doors, 2 steel frame windows, and 3 steel frame doors, having a total of approximately 877 m^2, will be replaced with new double pane, PVC frame windows of local manufacture.

Description: Lights Replacement. The 75W incandescent lamps will be replaced with fluorescent tubes.

The combined estimated savings achievable by these improvements are summarized in the following:

- Estimated annual energy savings: 1,981,321 kWh/y
- Estimated annual cost saving: 53,362 $/y
- Estimated Implementation cost: $ 126,135
- Payback period: 2.4 years

5.3.3 Summary of USAID Approved Installations for the Municipality of Novi Pazar

The Municipality of Novi Pazar will be the recipient of USAID approved energy efficiency measures for a total of:

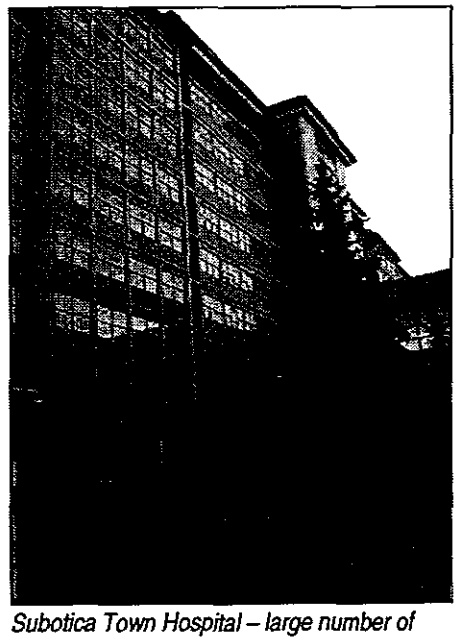
- Total estimated annual energy savings: 9,975,359 kWh/y
- Total estimated annual cost saving: 74,372 $/y
- Total estimated Implementation cost: $ 215,765
- Overall payback period: 3 years

5.4 SUBOTICA

Subotica is located 195 km north of Belgrade, on the border with Hungary. The town lies in the watershed of the Danube and the Tisa rivers. Over 150,000 people live in Subotica, with 100,000 living within the city limits. The town has played an important role historically due to its position near the Hungarian border. 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 and from the 1880s the town's industry started to play an increasingly significant role in the country.

5.4.1 Town Hospital

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 whole hospital is connected to the municipal heating system except nurseries, operating rooms and intensive care. These three facilities are independently conditioned, with dedicated boilers providing steam to the air-conditioning plant.



Subotica Town Hospital – large number of windows

5.4.1.1 Municipality Proposed Improvement(s)

The municipality of Subotica proposed the following improvements for the Town Hospital:

- **Heating System.** Switching boiler fuel from oil to gas
- **Condensate Return System.** Refurbishing the condensate return system.
- **Building Envelope** – Replacing windows of the main hospital building.

5.4.1.2 Nexant Assessment

Nexant visited the hospital and made the following assessment:

- **Heating System.** Two boilers supply steam for heating sanitary water, sterilization, laundry room, kitchen, and other miscellaneous uses.

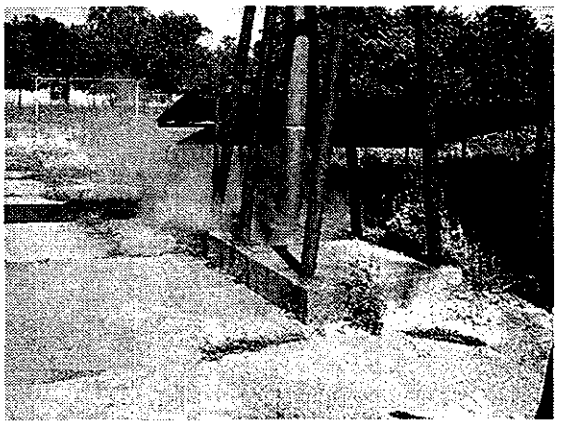
  Switching the boiler fuel from oil to gas would save energy. However, high implementation cost would not make it a cost-effective energy saving measure.

- **Building Envelope** – The main hospital building has 270 metal-frame windows. The windows cause heat loss due to high air infiltration. Most of the frames are warped.

  Since many of the windows are warped, weather-stripping would not be effective. Replacement of windows would entail a high implementation cost, and would not make it a cost-effective energy saving measure.

- **Condensate Return.** The existing condensate return lines including steam traps, valves and fittings are very old and leaky. Only about 10% of the condensate is returned. The rest goes to sewage. Piping length is about 500 meters. More than 80% of the condensate is suitable for return.

  Retrofitting the condensate return system could save a significant amount of energy, and be a cost-effective energy saving measure.



Hot condensate being discharged to city sewage system

5.4.1.3 USAID Approved Condensate Return System

On the basis of Nexant's assessment and suggestions, USAID decided to approve the Condensate Return System improvement.

Description. Nexant will install a new condensate return system for the hospital steam supply and domestic hot water supply system. This will replace the existing badly worn-out equipment and material consisting of steam traps, flash tanks, piping, valves, and controls. Currently, the hot condensate is released into the sewer, wasting a large quantity of reusable thermal energy.

The estimated savings achievable by the improvement are summarized in the following:

- Estimated annual energy savings: 2,511,000 kWh/y
- Estimated annual cost saving: $ 41,295/y
- Estimated Implementation cost: $ 107,646
- Payback period: 2.6 years

5.4.2 Senior Center

Subotica Senior Center

The center consists of two buildings made of brick, which are connected to the district heating plant. However, separate electric heating provides the domestic hot water supply. The kitchen uses propane-butane gas for the stoves. The facility has an oil fired boiler for making steam for use in the laundry.

5.4.2.1 Municipality Proposed Improvement(s)

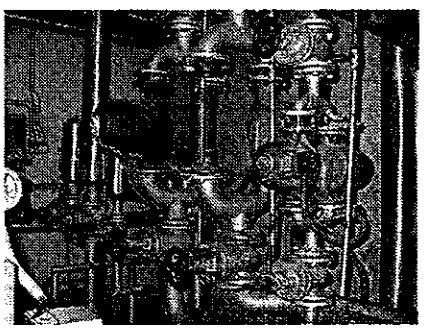
The municipality of Subotica proposed that the following improvement be made to the Senior Center:

- **Heating.** The center proposes to convert the existing heating system to a central gas heating facility.

5.4.2.2 Nexant Assessment

Nexant visited the Senior Center and made the following assessment:

- **Heating.** The center uses district hot water heating system for space heating. However, the hot water supply is at a low temperature estimated to be about 55°C (designed for 130°C). Due to the low water temperature, the room heating is inadequate and rooms are supplemented with electric heaters. The kitchen uses local propane-butane heaters. The laundry room uses local steam boiler fired with oil. The sanitary water heaters are electric.


DHP Substation

Electric Heaters for Sanitary Water

Gas bottles for kitchen use

A new central gas heating plant, using the existing water distribution system, can be implemented. The new central heating system can also be used for heating the sanitary water. In addition, the kitchen gas supply and laundry room steam supply boiler system can be converted to natural gas. The improvement would be a cost-effective measure.

5.4.2.3 USAID Approved Heating System Improvement

On the basis of Nexant's assessment and suggestions, USAID decided to approve the Heating System upgrade.

35

Description. Nexant, on behalf of USAID, will replace the District Heating Plant as the source of heating for the Center, with a central hot water heating system, operated by two new boilers. Nexant will install a gas measurement, regulation, and supply substation, which will supply natural gas to the two new boilers, to the central kitchen, and to the steam boiler for the laundry room. In this installation, two central hot water heating boilers (dual-fuel) will be installed to connect to the existing hot water distribution system of the facility. A new boiler room will be built to house the new boilers. In addition, thermostatic control valves at the radiator inlet, isolation valves at the radiator outlet, and thermal insulation on the wall behind the radiators will be installed.

Typical radiator – no control valve, located next to window

The estimated savings achievable by the improvement are summarized in the following:

- Estimated annual energy savings: 799,200 kWh/y
- Estimated annual cost saving: 38,675 $/y
- Estimated Implementation cost: $ 225,853
- Payback period: 5.8 years

5.4.3 District Heating System

The district heating plant has been converted from a former power plant. Currently the plant has 6 boilers with 145MW of total installed capacity. The plant uses oil and natural gas as its primary fuels. This facility was not included in the original list of facilities proposed by the Municipality as candidates for upgrade.

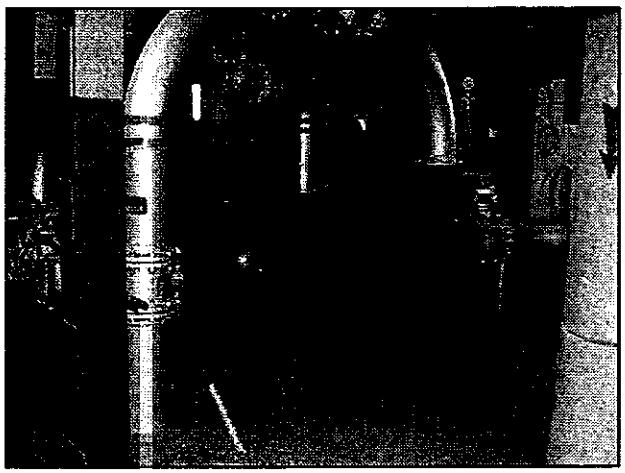
5.4.3.1 Nexant Assessment

Nexant visited the district heating plant and made the following assessment:

- **Water Circulation Pump.** For the circulation of hot water from the boilers to the municipal customers, the district heating plant runs a 315kW pump continuously at full flow. The hot water temperature is controlled based on the outdoor ambient temperature.

  The electricity consumption by the circulation pump can be reduced if the following steps are taken: 1) a variable speed drive is used to vary the pump flow based on the outdoor ambient temperature, and 2) the hot water temperature is maintained constant at some selected temperatures.

5.4.3.2 USAID Approved Variable Speed Drive for Circulation Pump


Main Hot Water Circulation Pump

On the basis of Nexant's assessment and suggestions, USAID decided to approve the installation of a new Variable Speed Drive for the District Heating Plant Circulation Pump.

Description. A variable speed drive (VSD) with all its accessories for the main hot water circulation pump will be installed at the district heating plant. The pump circulates water from the heating plant to the district heating system customers. Installing the VSD will allow the pump to function at a lower speed, and consequently lower power, during lower heating demand situations therefore saving a substantial amount of energy. In addition to the VSD, a flow control station for the circulating water system will be installed to control the flow of water. The flow of water will be controlled based on the ambient temperature.

The estimated savings achievable by the improvement are summarized in the following:

- Estimated annual energy savings: 295, 046 kWh/y
- Estimated annual cost saving: 14,752 $/y
- Estimated Implementation cost: $ 47,250
- Payback period: 3.2 years

5.4.4 Summary of USAID Approved Installations for the Municipality of Subotica

The Municipality of Subotica will be the recipient of USAID approved energy efficiency measures for a total of:

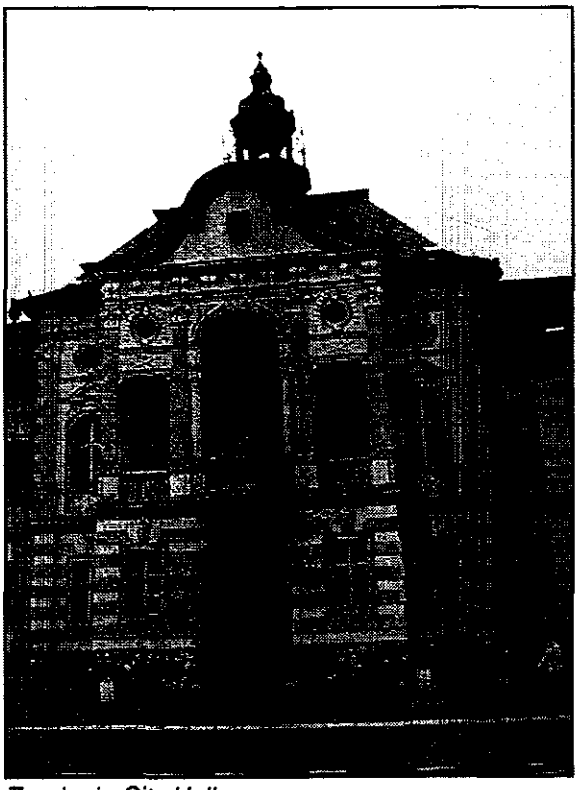
- Total estimated annual energy savings: 3,605,246 kWh/y
- Total estimated annual cost saving: $ 94,722/y
- Total estimated Implementation cost: $ 380,749
- Overall payback period: 4.0 years

5.5 ZRENJANIN

Zrenjanin is located approximately 85 km north of Belgrade. It covers an area of 3 km^2, encompassing 22 settlements. The municipality has a total population of 144,000 and 65% of the population lives in the city. The area is considered one of the most heavily industrialized municipalities in Serbia. Textiles are the largest industry accounting for 25% of industrial output, the metal industry accounts for 20%, and the chemical industry produces 15% of the regions activity. The agricultural processing industry accounts for the biggest portion of the industrial output, at 32%.

5.5.1 City Hall

The municipality of Zrenjanin is responsible for the administration of county as well as the city. The city population is 80,000, but the municipality is responsible for a total population of 150,000. The City Hall houses the administrative offices for the entire county consisting of 5 municipalities and many villages with a total population of 250,000. The City Hall building is 150 years old and is made of brick and is considered a cultural monument and is under federal protection as a heritage site.



Zrenjanin City Hall

5.5.1.1 Municipality Proposed Improvement(s)

The Municipality of Zrenjanin proposed that the following improvements be made to the City Hall:

- **Heating System.** The municipality proposed to eliminate the intermediate heat exchangers and provide a direct connection to the district heating system.
- **Building Envelope.** The City Hall proposes to replace the single pane windows with double pane and well-caulked windows.

5.5.1.2 Nexant Assessment

Nexant visited the Zrenjanin City Hall and made the following assessment:

- **Heating System.** The City Hall currently has a central heating system. It receives hot water from the district heating system. The hot water is then passed through two heat exchangers to a secondary loop. The secondary closed water loop is used to supply hot water to the building. The district water transfers heat to the secondary loop through a set of heat exchangers. This method reduces the hot water temperature supplied to the

building, and cannot provide adequate heat. The building uses electric heaters to boost the heat supply during winter months. The heating company charges the city hall on a unit area basis irrespective of energy use.

DHP Substation – Condition of old Water Supply System

Eliminating the intermediate heat exchanger would improve the hot water supply temperature. In addition, an ambient temperature-activated flow control station would improve energy utilization. Installation of thermostatic control valves on the radiators would further enhance energy utilization.

- **Building Envelope.** Approximately 200 windows on the exterior walls of the City Hall are single pane and in most cases perimeter caulking is in bad condition. As a result, there is a high heat loss through the windows. The City Hall is a historic building and its window-frames are specially made of pine and juniper wood.

  Due to the poor condition of the windows, their replacement would add significantly to energy saving.

  The proposed improvements in the heating system and building envelope will potentially obviate the need for supplemental electrical heating.

Old windows - typical

5.5.1.3 USAID Approved Heating System and Window Replacement

On the basis of Nexant's assessment and suggestions, USAID decided to approve the Heating System improvement, and the replacement of windows.

Description: Heating System. Nexant, on behalf of USAID, will modify and improve the existing inefficient hot water supply system. At present, the temperature of the hot water supplied from the district heating plant is degraded due to the presence of an intervening heat exchanger.

This heat exchanger will be eliminated and a direct connection will be established between the district heating plant and the hot water distribution to the City Hall. This modified system will be capable of regulating the flow of hot water depending on the outdoor ambient temperature and time-of-day operation. The system will also meter the thermal energy supplied to the facility by the District Heating Plant. In addition to the aforementioned measures, thermostatic control valves and insulating shield will also be installed on the existing radiators.

Description: Windows Replacement. City Hall has 192 wood frame windows exposed to the outdoor atmosphere. The wood frames are badly warped and leaky. These panels will be replaced with wood frame double pane glass panels. The style and the number of sections of each window will be the same as those of the existing windows.

5.5.2 Summary of USAID Approved Installations for the Municipality of Zrenjanin

The Municipality of Zrenjanin will be the recipient of USAID approved energy efficiency measures for a total of:

- Total estimated annual energy savings: 672,792 kWh/y
- Total estimated annual cost saving: 18,343 $/y
- Total estimated Implementation cost: $ 89,342
- Overall payback period: 5.0 years

5.6 SUMMARY OF ALL THE MEASURES CONSIDERED

In total, the five selected Municipalities had submitted suggestions for over 40 projects, which they considered energy efficiency measures. On close scrutiny, Nexant determined that a considerable portion of these projects were actually infrastructure improvements, with little or no energy efficiency content. Others were determined to be energy efficiency measures, but yielded very long payback periods, being therefore not financially attractive. In all, Nexant submitted to USAID, for approval, approximately 30 measures, presenting various degrees of financial attractiveness.

USAID approved 16 measures for immediate implementation. A summary of the approved measures, and the relative savings by energy source, is given in Appendix 3

Appendix 4 contains the list of measures proposed by the Municipalities, but rejected either by Nexant, or by USAID.

Appendix 1 Energy Audit Questionnaire

41

BUILDING IDENTIFICATION

NAME _____

ADDRESS _____

_____

_____

Location _____

_____

CONTACTS:	1)	2)	3)
Name	_____	_____	_____
Title	_____	_____	_____
Ph. #	_____	_____	_____
Fax #	_____	_____	_____
e-mail	_____	_____	_____

42.

ENERGY CONSUMPTION DATA

Month	Electricity kWh	Dinars	Natural Gas m3	Dinars	Oil (.....) Tons	Dinars	Oil (.....) Tons	Dinars	Coal Tons	Dinars	Wood Tons	Dinars
January												
February												
March												
April												
May												
June												
July												
August												
September												
October												
November												
December												

FACILITY USE

Average level of Occupancy _____

Working hours _____

Working days per year _____

Seasonal occupancy variations _____

_____

_____

Summer/Winter Vacation Closure? _____

Energy Consumption Data

Notes: _____

_____

_____

_____

_____

_____

BUILDING PHYSICAL DIMENSIONS

Plant and Elevation Drawings available? Y N

NOTE: If Drawings not available, make a sketch as detailed as possible

Overall dimensions

H: L : W:

Orientation of the Building:

Number of floors:

Floor #	Total m2	Number of Rooms	Windows per room	Doors per room

BUILDING CONSTRUCTION CHARACTERISTICS

Roof description and dimensions

Exterior Walls description and dimensions

Describe conditions (cracks, humidity, ….)

WINDOWS

LOCATION:

TYPE:

CONDITIONS

DIMENSIONS & NUMBER

NOTE

DOORS

LOCATION:

TYPE:

CONDITIONS

DIMENSIONS & NUMBER

NOTE

INSULATION

Roof Insulation description and dimensions

Walls Insulation description and dimensions

Basement Insulation description and dimensions

HEATING SYSTEM

System Description

What is the preferred temperature setting in the winter, and how is temperature controlled?

Is the heating system shut off, or set lower at any time during the day?

Is there any period of time, in the winter, when the system is shut off all day?

HEATING SYSTEM cont'd: ELECTRIC HEATING

General Description

Room ID	Heater Type	Number	Rating

HEATING SYSTEM cont'd: CENTRAL HEATING

General Description _____

_____
_____
_____
_____
_____
_____

Boiler Type # A (specify fuel: .....)

	Boiler # 1	Boiler # 2
Overall condition		
Insulation		
Combustion efficiency		

Boiler Type # B (specify fuel: .....)

	Boiler # 1	Boiler # 2
Overall condition		
Insulation		
Combustion efficiency		

HEATING SYSTEM cont'd: CENTRAL HEATING

Circulation Pump Condition

Piping Size, Length, Insulation

Leakages

Radiators

Room ID	Radiator Type	Number	Size	Distance from wall

Radiators (cont'd)

Room ID	Radiator Type	Number	Size	Distance from wall

HEATING SYSTEM cont'd: DHS

Substation

Piping

Insulation

Radiators

Room ID	Radiator Type	Number	Size	Distance from wall

Radiators (cont'd)

Room ID	Radiator Type	Number	Size	Distance from wall

Hot Water System

Type

General condition

Piping (sizes, length, leakages)

Insulation

Hot Water Temperature at the Boiler and at the sink

LIGHTING SYSTEM

Room & Location	Type of Lamp	Number of Lamps	Rating	Light Level	Can it be converted	Time of use	On-Off control

Appendix 2 Calculation Templates

HEATING SYSTEM

INPUTS

FUELS

	Price		LHV	
Light Oil		Din/ton		Kcal/ton
Heavy Oil		Din/ton		Kcal/ton
Coal		Din/ton		Kcal/ton
Gas		Din/m3		kcal/m3

Electricity Price: $/kWh

Heating hours per year
hours/years

Floor Area m2

PRESENT SITUATION

Average unit heat demand (old situation):
kW/m2

Old boiler Eff.

Electricity used for heating
kWh/y

Fuel used in the old boiler

IMPROVED SITUATION

Average unit heat demand (new situation):
kW/m2

New boiler Eff.

Fuel used in new boiler

ESTIMATE OF "INSTALLED" COST FOR HEATING SYSTEM AS FUNCTION OF BOILER CAPACITY

	$ per 100 kW capacity
Boiler	
Boiler Room Equipment	
Installation	
Total:	

RESULTS

PRESENT SITUATION

Total heat power demand:
0 kW

Total heat energy demand
0 kWh/y

Total heat energy supplied by boiler
0 kWh/y

Total heat energy consumed by the boiler
#DIV/0! kWh/y

Annual fuel consumption
#DIV/0! Tons of Light Oil
Tons of Heavy Oil
Tons of Coal
m3 of Gas

Note: put a zero in the consumption column next to the fuels <u>not used</u> in this application

Annual cost of heating
#DIV/0! US $ of Light Oil per year
0 US $ of Heavy Oil per year
0 US $ of Coal per year
0 US $ of Natural Gas per year
0 US $ of Electricity per year

TOTAL: #DIV/0! US $ per year

IMPROVED SITUATION

Total heat power demand: 0 kW

Total heat energy demand 0 kWh/y

Total heat energy consumed by the boiler
#DIV/0! kWh/y

Annual fuel consumption #DIV/0! Tons of Light Oil
Tons of Heavy Oil
Tons of Coal
m3 of Gas

Note: put a zero in the consumption column next to the fuels <u>not used</u> in this application

Annual cost of heating #DIV/0! US $ of Light Oil per year
0 US $ of Heavy Oil per year
0 US $ of Coal per year
0 US $ of Gas per year

TOTAL: #DIV/0! US $ per year

SAVINGS

Thermal Energy Savings: #DIV/0! kWh per year
Electric Energy Savings 0 kWh per year

Cost Savings: #DIV/0! US $ per year

ESTIMATE OF INVESTMENT COST

Boiler Capacity: 0 kW

Estimated Installation Cost 0 US $

Economic Assessment Model

Replacing Windows

Municipality:

Facility:

Note: The input data shown here are for illustration purposes only. The user should use the appropriate data

No. of windows	N =	
Size of each window		
Width, m	W =	
Height, m	H =	
Winter thermostat setting, C	TIN =	
Average outdoor temp. during winter, C	TOUT =	
No. of effective winter days	NWD =	
No. of operating hours per day	OHD	
Cost of energy, Dinar/MJ	COE =	
Crack - percent of window size (Assumed)	CRACK =	
Heat loss coefficient - double-pane windows (U-value)	UDOUBLE =	
Cost of installation of windows, Dinar/M2		
Materials	M =	
Labor	L =	

Area of each door/window, A = W x H		
A =		sq.m
Total area of windows, TA = N x A		
TA =		sq.m
Base heat loss with singhle-pane windows, HLOSSOLD: Use chart for 100 ft2 for the number of hours open per day		
HLOSSBASE =		MMBtu/100ft2/yr
HLOSSOLD =		MJ/m2/yr
Total heat loss with single pane windows (before)		
THLOSSOLD =	0	kWh/yr
Heat loss with double-pane windows, HLOSSNEW: Use nomogram		
HLOSSNEW =		Btu/ft2/yr
=	0	MJ/m2/yr
Total heat loss with double pane windows (after)		
THLOSSNEW =	0	kWh/yr
Cost saved, CSAVE = ESAVE x COE		
CSAVE =		Dinar/Yr.
Payback period, PBP = (M + L) *TA/ CSAVE		
PBP =		Yr.
Implementation cost =	0	Dinar
	$0	

Economic Assessment Model

Roof and Ceiling Insulation

Municipality:

Facility:

Note: The input data shown here are for illustration purposes only. The user should use the appropriate data

Total area of roof/ceiling, m2	AROOF =		Base heat loss per unit area per year before insulation (Use attached nomogram)	BASEOLD =	Btu/ft2/yr
U-value before insulation (see note below)	UOLD =			= 0	MJ/m2/yr
U-value after insulation (see note below)	UNEW =		Actaul heat loss per unit area per year before insulation =BASEOLD x HOURS/4380 x DTnew/DT	ACTUALOLD =	MJ/m2/yr
Winter thermostat setting, C	TIN =		Base heat loss per unit area per year after insulation (Use attached nomogram)	BASENEW =	Btu/ft2/yr
Operating hours per year	HOURS			= 0	MJ/m2/yr
Heating degree days	HDD =		Actaul heat loss per unit area per year after insulation =BASENEW x HOURS/4380 x DTnew/D	ACTUALNEW =	MJ/m2/yr
Solar radiation, Langleys	SOLAR =		Total heat loss before	0	kWh/yr
Cost of energy, Dinar/MJ	COE =		Total heat loss after	0	kWh/yr
Absorption coefficient of the object (See chart)	ABSORB				
			Cost saved, CSAVE = ESAVE x COE		
Cost of insulation, Dinar/m2				CSAVE =	Dinar/yr
Materials	M =				
Labor	L =		Payback period, PBP = (M + L)*AROOF / CSAVE		
				PBP =	Yr.

62

Economic Assessment Model

Wall Insulation

Municipality:

Facility:

Note: The input data shown here are for illustration purposes only. The user should use the appropriate data

Total area of wall, m2	AWALL =	Base heat loss per unit area per year before insulation (Use attached nomogram) BASEOLD =		Btu/ft2/yr
U-value before insulation (see note below)	UOLD =	=		MJ/m2/yr
U-value after insulation (see note below)	UNEW =	Actaul heat loss per unit area per year before insulation =BASEOLD x HOURS/4380 x DTnew/DTol ACTUALOLD =		MJ/m2/yr
Winter thermostat setting, C	TIN =	Total heat loss per year before insulation =	0	kWh/yr
Operating hours per year	HOURS			
Heating degree days	HDD =	Base heat loss per unit area per year after insulation (Use attached nomogram) BASENEW =		Btu/ft2/yr
		=		MJ/m2/yr
Solar radiation, Langleys	SOLAR =	Actaul heat loss per unit area per year after insulation =BASENEW x HOURS/4380 x DTnew/DTc ACTUALNEW =		MJ/m2/yr
Cost of energy, Dinar/MJ	COE =	Total heat loss per year after insulation =	0	kWh/yr
Absorption coefficient of the object (See chart)	ABSORB			
Cost of insulation, Dinar/m2		Energy saved per unit area per year = ACTUALOLD - ACTUALNEW ESAVEUNIT =		MJ/m2/yr
Materials	M =			
Labor	L =	Totral energy saved per year = ESAVEUNIT x AROOF ESAVE =		MJ/yr
		Cost saved, CSAVE = ESAVE x COE CSAVE =		Dinar/yr
		Payback period, PBP = (M + L)*AWALL / CSAVE PBP =		Yr.

Appendix 3 Summary of Approved Measures

64

SUMMARY OF PROJECTS APPROVED BY USAID ON THE BASIS OF RAPID ASSESSMENT ESTIMATE

Municipality & Facility	Proposed project	ANNUAL ENERGY SAVINGS (kWh/y)					Annual Cost Saving, $	Cost of Improvement, $	Payback Period, Yrs
		Coal	Light Oil	Heavy Oil	Gas	Electricity			
ZRENJANIN									
City Hall	Heating System	0	0	0	25,343	209,149	11,170	46,375	4.2
	Windows Replacement	0	0	0	438,300	0	7,173	42,968	6.0
	Total for the Municipality	0	0	0	463,643	209,149	18,343	89,342	4.9
SUBOTICA									
Town Hospital	Condensate Return System	0	0	0	2,511,000	0	41,295	107,646	2.6
Senior Citizen Center	Heating System	0	0	337,800	311,400	150,000	38,675	225,853	5.8
District Heating Plant	Water Pumping	0	0	0	0	295,046	14,752	47,250	3.2
	Total for the Municipality	0	0	337,800	2,822,400	445,046	94,722	380,749	4.0
KRAGUJEVAC									
Jovan Popovic Primary School - Sumerice Section	Lighting	0	0	0	0	11,121	556	1,225	2.2
Natalija Nana Primary School	Lighting	0	0	0	0	10,809	538	2,200	4.1
Music School	Heating System	0	146,512	0	0	0	3,174	10,901	3.4
	Total for the Municipality	0	146,512	0	0	21,930	4,268	14,326	3.4
NOVI PAZAR									
Stefan Nemanja Primary School	Heating System	0	1,572,618	0	0	22,651	37,472	44,223	1.2
	Windows Replacement	0	375,243	0	0	0	15,350	79,901	5.2
	Lighting	0	0	0	0	10,809	540	2,011	3.7
Vuk Karadcic Primary School	Heating System	9,205,200	-1,228,748	0	0	17,586	21,010	89,630	4.3
	Total for the Municipality	9,205,200	719,113	0	0	51,046	74,372	215,765	3
KRUŠEVAC									
Healthcenter for Children and Women	Heating System	0	1,803,903	0	0	117,763	47,414	79,866	1.7
	Windows Replacement	0	338,544	0	0	286,187	26,433	143,481	5.4
Neven Nursery School	Heating System	0	152,807	0	0	246,074	11,036	30,673	2.8
	Windows Replacement	0	98,856	0	0	0	3,867	20,915	5.4
	Roof Insulation	0	52,922	0	0	0	2,276	12,255	5.4
Steet Lighting	Partial Delamping	0	0	0	0	467,100	23,355	4,541	0.2
	Total for the Municipality	0	2,447,032	0	0	1,117,124	114,431	291,731	2.5

Overall results for all the projects:	ANNUAL ENERGY SAVINGS (kWh/y)					Annual Cost Saving, $	Cost of Improvement, $	Payback Period, Yrs
	Coal	Light Oil	Heavy Oil	Gas	Electricity			
	9,205,200	3,312,657	337,800	3,286,043	1,844,295	306,136	991,913	3.2

Representative Rejected Projects			
Facility	Proposed Installation	Measure	Reasons for Rejection
KRAGUJEVAC			
City Assembly Building	Building Envelope	Insulation and Windows	Significant energy savings not expected
	Lighting	Install Fluorescent Lighting	Significant energy savings not expected
	Air Conditioning	Install Air Conditioning	Not EE Project
High School - Toza Dragovic	Building Envelope	Insulation and Windows	Major Infrastructure Improvements
	Gymnasium	Insulation	Major Infrastructure Improvements
Primary School - Jovan Popovic Sumarice	Building Envelope Main School	Insulation and Windows	Major Infrastructure Improvements
	Heating	Central Hot water coal fired Boilers	Does not involve electricity savings
	Building Envelope Sumarice section	Weather stripping and caulking	Significant energy savings not expected
Music School	Building Envelope	Windows	Major Infrastructure Improvements
Primary Schools - Dositej Obradovic	Heating System	Install central Heating	Does not involve electricity savings
Primary School - Natalija Nana	Heating System	Install central Heating	Does not involve electricity savings
KRUŠEVAC			
Secondary Education Center	Building Envelope and Boiler	Envelope repair, Windows, Boiler	Long payback, budget to big
Municipal Swimming Pool	Structural Improvements		Not EE project
Sport Center	Heating and ventilation	Overall Heating and Ventilation	Building Poorly designed

Representative Rejected Projects			
Facility	**Proposed Installation**	**Measure**	**Reasons for Rejection**
NOVI PAZAR			
Municipal Building	Windows	Replace Windows	The "Municipal Building" actually includes a semi burned down theater, an art gallery, and a recreation center. The proposed measure is an infrastructure improvement, not EE measure
District Heating Plant	Heat Exchangers	Replace Faulty heat Exchangers	No energy savings
	Pumps	Replace 26 Pumps	No energy savings
Desanka Maksimovic Primary School	Heating System	Overall heating System	The school is badly damaged, needs reconstruction
	Windows	Replace old Windows	The school is badly damaged, needs reconstruction
SUBOTICA			
Town Hospital	Windows	Replace old Windows	Long Payback Period
Civil Engineering Building	Heating	Install Central Heating	Long Payback Period
Elementary School Duro Salaj	Heating	Install Central Heating	Long Payback Period
ZRENJANIN			
Hospital Surgical Block	Heating System	New heating Systems	Major Infrastructure Improvement
Hospital Buildings	Heating System	New heating Systems	Major Infrastructure Improvement
Residential Block	Heating	Solar Heating for Sanitary Water	Electric Savings not significant
Technical University	Heating	Solar heating for Sanitary Water	Major Infrastructure Improvement
Secondary Ag. School	Insulation	Hydro Insulation against water damage	Major Infrastructure Improvement