PD-ABQ-958

99612

ELECTROTEK CONCEPTS

BERZSENYI DANIEL SCHOOL ENERGY EFFICIENCY DEMONSTRATION PROJECT EVALUATION

Final Report, October 1998

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IN ASSOCIATION WITH

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PREPARED FOR

United States Agency for International Development
Budapest, Hungary and Washington D C
Contract No DHR C-00-95-00064-00

And

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1 PROJECT BACKGROUND

The proposed project was selected based on three considerations

1 The site selected (a district heated school) is one of the type of facilities identified in the Hungary Project Work Plan as being seriously in need of energy efficiency improvements,
2 The technologies involved in the demonstration project appear to be very cost-effective, and are also very replicable throughout Hungary,
3 The District and school involved are financially stable and highly motivated to reduce energy consumption and related costs

Berzsenyi Daniel Gymnasium (also referred to as B D) is located in District XIII in Budapest, which is one of the two wealthiest districts (Electrotek and Centech also designed and implemented an energy efficiency demonstration project at Nemetvolgyi school, located in the second, wealthy district, District XII) In addition, walk-through audits were performed at a total of 7 schools in District XII, and detailed engineering feasibility studies were performed for the two best schools (Arany Janos and Varosmajor)

Originally, projects in District XII were intended to serve as back-ups to the B D project , since there was considerable doubt as to whether District XIII would allow B D to proceed with the demonstration project and provide the required financial contribution When B D eventually elected to implement only a portion of the proposed measures, this allowed Electrotek to develop an energy efficiency demonstration project at Nemetvolgyi school in District XII

It was assumed that schools located in these two districts would be financially sound and would have the economic resources needed to meet the 20% co-funding requirement and to support the proposed energy efficiency fund

B D 's baseline energy consumption level for heating was quite high - about 3660 GJ per year The cost of this energy in 1997 was also high - about 9 million Ft ($48,000), which represents an increase of almost 100% since 1994 Both heating and hot water are provided by FOTAV, the primary supplier of district heating in Budapest

B D was seeking to reduce its heating costs in two ways
(1) By renegotiating its current district heating tariff with FOTAV (during the summer of 1997 when the B D workplan was developed, talks were ongoing), and
(2) By reducing its heating-related energy consumption through the energy saving measures proposed by Electrotek and Centech These measures included heating controls, thermostatic radiator valves, and weatherstripping of windows

The District was unsure whether or not to continue to rely on FOTAV for heat and hot water As a result, one of the measures that was evaluated by Electrotek and Centech was an energy efficient gas boiler, which would enable B D to produce its own heat and hot water

2 Description of Project

There were four energy efficiency measures that were originally proposed for implementation

- Energy efficient gas boiler
- Automated controls
- Thermostatic radiator valves (or TRVs)
- Weatherstripping

The proposed measures are described briefly below

Energy Efficient Gas Boiler

Actually, two energy efficient gas boilers were proposed to be installed to meet the building heating load of approximately 640 MW A large (400 kW) and small (240 kW) boiler were proposed These two boilers would have allowed for considerable flexibility in the dispatch of the heating and hot water system The smaller boiler could have been used to meet hot water requirements during the summer months, when school was not in session At the beginning of the heating system, when outdoor temperatures are still moderate, B D could then have switched to the larger boiler to meet its heating and hot water needs Following this, in the harshest winter months, both boilers could have been used to meet building heating and hot water requirements Each of these boilers was 85+% efficient, according to the manufacturer's specifications The payback period for the boiler was estimated to be 3 3 years

In September 1997, B D decided not to install the boiler Although the school officials were very much in favor of installing their own heating system and no longer being subject to the rapidly escalating heating prices charged by FOTAV, they did not have the capital required to pay for 20% of the boiler cost Also, the negotiations with FOTAV for a lower heating tariff were going quite well and eventually resulted in B D being placed on a much lower heating tariff, reflecting 40% lower heating prices

Heating Controls

The B D heating center had heating controls that regulated energy use based on the outside temperature However, these controls did not have the ability to provide for nighttime or weekend temperature setback (when classrooms are unoccupied) The controls installed through this project are fully programmable and allow for temperature-based regulation and reduced nighttime and weekend temperatures It was estimated that the controls would reduce building heating energy use by 15%

TRVs

TRVs reduce energy consumption by automatically shutting off heating energy to the radiator whenever the temperature exceeds the specified set point (20° C) Before the TRVs were installed at B D , windows were usually opened to vent excess heat, resulting in considerable energy waste It was estimated that 50% of the time the classrooms are occupied, the valves would close off heating energy to the classroom, reducing energy consumption by an additional 10% Also, because the TRVs provided for more even heating of the building, additional savings accrue Previously, the building heating system was operated to provide sufficient heat for the coldest room in the building As a result, the building was overheated to an average temperature of 22 5° C With the TRVs and weatherstripping (see below), the building could be heated to a more moderate temperature of 20° C , resulting in additional energy savings

Weatherstripping

Weatherstripping on windows located immediately above the radiators was proposed to reduce infiltration and resulting heat losses from the building Effective weatherstripping is especially important in conjunction with TRVs, since the weatherstripping helps to keep the room temperature at or above the TRV set point B D 's existing weatherstripping was deteriorated and needed to be replaced In addition, some of the wooden window frames had sagged and needed to be planed, so that an effective weatherstripping barrier could be installed It was estimated that these modifications would reduce heating energy requirements by about 8%

3 INSTALLATION OF PROPOSED MEASURES

Originally, it was planned that the proposed energy savings measures would be installed before the start of the 1997-98 heating season (ideally, before the start of the school year) However, the project design, approval process, and procurement of equipment all took longer than expected As a result, the equipment installation took place in November and December of 1997 Despite this delayed schedule, it was still quite early in the heating season and there was sufficient time left to collect monitoring data and do the project impact evaluation

Methodology Used to Compute Annual Energy Savings

To compute the energy savings for this project, both whole-building metered data and direct observations (using data collected through temperature data loggers) were used The following describes the step-by-step method used to estimate the energy savings for the various installed measures was as follows

Step 1 Monthly Data on Total Building Heating Energy Use Was Collected Whole-building heat meter data was collected for the months of January 1998 through April 1998 Note – because the installation of the energy-savings measures was not completed until Christmas break, it was not possible to incorporate observations from the early part of the heating season into the impact evaluation

Step 2 Monthly Heat Metered Data for the Same Months During the Preceding Three Years Was Collected and Averaged The 3-year average is meant to represent a typical base year In previous project evaluations, CENTECH has found that the 3-year average eliminates much of the year-to-year variance due to fluctuations in facility use, occupancy levels, etc It, therefore, is a more accurate benchmark of base period usage than is metered data from the previous calendar year

Step 3 Heating Consumption Data for the Base Period and for the 1998 Heating Season Was Weather Normalized Because the weather during the 1998 heating season was unusually warm, this step was very important Heating degree-day information for a typical year and for 1998 was collected The degree day information that was collected and used in these calculations is shown in the following table

	Degree Days in	
Month	**Typical Year**	**1998**
January	617	529
February	530	398
March	461	470
April	193	181
TOTAL	**1,802**	**1,578**

A degree-day correction factor was developed from this data and subsequently applied to the whole building metered data to correct for the effects of the unusually warm winter After adjusting for the effects of weather, the energy savings estimates for the total project declined from 44% to 36% All subsequent calculations were based on the weather-normalized energy savings figures

The following table provides the monthly estimates of energy savings for the entire project (i e , all installed measures) In subsequent steps, these estimates are further broken down by measure

Month	GJs in Base Year	GJs in 1998 Heating Season	Savings In GJs	Savings As %
January	676	353	323	48%
February	349	197	152	44%
March	294	287	7	2%
April	187	134	53	28%
Total	**1,506**	**971**	**535**	**36%**

Step 4 Total Energy Savings was Disaggregated by Measure For all measures except for the weatherstripping, engineering calculations were used to compute energy savings for each type of measure The engineering savings equations were modified to incorporate <u>actual</u> heating control regimes, indoor temperatures, setback times, etc Interactive effects between measures were incorporated by reducing the heating baseline step-wise for each measure installed Measures were evaluated in decreasing order of cost-effectiveness/payback Thus, heating controls were considered first, TRVs next, and weatherstripping last

a) For heating controls, energy savings was arrived at using the following equation

Energy Savings = (Annual Heating Requirement X % Controlled Floor Space) X (Number of Hours of Setback X # Degrees Reduced X 6% Savings per Degree Reduced during Setback)

b) For TRVs, the energy savings algorithm was as follows

Energy Savings = (Annual Heating Requirement * X % of Floor Space for Classrooms) X % of time classrooms are not occupied X % of time when TRVs Close off Heating**

* Reduced by the energy saved from the heating controls
** Based on actual experience

c) For weatherstripping, the residual energy savings that was not attributable to either the heating controls or TRVs was assumed to be due to the weatherstripping The resulting energy savings level, as a percentage of total energy consumption, is well within the range of savings claimed by weatherstripping manufacturers

The energy savings and simple payback for each of the installed measures is shown in the table below   This table also reports the energy cost savings due to B D 's transfer to a lower-cost tariff   This saved money but not energy

No	Measure	Energy Savings %	Energy Savings GJ/yr ***	Energy Bill Savings %	Energy Bill Savings KFt /yr	Measure Cost in KFt	Simple Payback (months)
1	Tariff change	0%	0	46%	4,304	0	0
2	Heating Controls	20%	732	9%	849	1,150	16
3	TRVs	9%	329	4%	382	1,200	38
4	Weather-stripping	7%	256	3%	297	884	36
5	**Total**	**36%**	**1,317**	**62%**	**5,832**	**3,234**	**7**

*** Over the entire heating season   Please note that the monitoring period was considerably shorter and therefore, the energy savings shown in the preceding table were considerably lower   However, on a percentage basis, they are the same

As the table shows, this project was very cost-effective, based on simple payback   For all measures, the payback was under three and one-half years, with the payback on heating controls the shortest at only 16 months   Paybacks for the other two measures were somewhat longer, in part because the energy baseline used to evaluate these measures was reduced to account for the savings from the heating controls   Nonetheless, all measures were found to be cost-effective