Kyiv Institutional Buildings Sector Energy Efficiency Program

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ABSTRACT

The government of Ukraine, through the State Committee for Energy Conservation (State Committee), is considering the implementation of energy efficiency measures in state and municipal institutional buildings in the city of Kyiv. The State Committee entered into an agreement with the U.S. Department of Energy to assess the efficiency potential in the institutional buildings sector in Kyiv. Results of this assessment would support a loan by the World Bank for implementing an institutional buildings sector efficiency improvement program in Kyiv.

The study evaluated the implementation of high-return energy conservation opportunities (ECOs) in more than 1600 buildings - schools, kindergartens, polyclinics, hospitals, higher education buildings, cultural and other institutional buildings. Packages of ECOs were evaluated in 33 prototype buildings to assess the energy and economic performance of the ECOs using modeling techniques and information on the performance of existing buildings in Kyiv. The program also included an assessment of lending and implementation structures, and a demonstration project in four Kyiv schools targeted at finalizing technical aspects of the implementation process and verifying the cost and performance of the ECOs.

The estimated potential improvements in energy efficiency would result in a reduction in heat consumption by approximately 25%, which translates into about $8.5 million of annual budget savings. Total investment requirements are $38 million. The internal rate of return, by major building category, ranges from 13% to 32%, with a weighted average of 29%. The proposed project also would have secondary benefits including reduced air pollutant emissions, increased employment, reduced energy imports, and development of an energy services infrastructure that could be extended to other sectors of the economy.

Introduction

The government of Ukraine, through the State Committee for Energy Conservation (State Committee), is considering the implementation of energy efficiency measures in state and municipal institutional buildings in the city of Kyiv. The State Committee entered into an agreement with the U.S. Department of Energy to assess the efficiency potential in the institutional buildings sector in Kyiv. Results of this assessment would support a loan by the World Bank for implementing an institutional buildings sector efficiency improvement program in Kyiv.

The assessment was conducted by the Pacific Northwest National Laboratory (PNNL) and its subcontractors, Tysak Engineering, a U.S.-based engineering consultancy; and the Agency for Rational Energy Use and Ecology (ARENA-ECO), a Ukrainian nongovernmental organization that specializes in energy efficiency assessments.

The work is comprised of three components: a technical assessment, a lending and implementation assessment, and a demonstration project. The technical assessment included a survey of institutional buildings in Kyiv and engineering and economic analyses of ECOs in those buildings. The lending and implementation assessment evaluated alternative structures for organizing the loan payment and repayment, and for implementing the installation of ECOs. The demonstration project was intended to increase the confidence of public agencies and organizations that cost-effective energy efficiency measures can be implemented in public buildings. The first two components were completed in August 1997 (Secrest et al. 1997a, 1997b). Installation activities for the demonstration project were completed in the fall of 1997.[1] An evaluation of the performance of the measures is expected to be complete by June 1998.

Background

The consumption of heat in space heating and domestic hot water systems in Ukrainian buildings is 1.5 to 2 times higher than in Western countries that have approximately the same climate conditions. Factors contributing to this high consumption include former building codes influenced by the availability of cheap energy, inefficiency of building heating systems, and inadequate operation and maintenance of the district heating systems. As a result the efficiency potential related to heat consumption in buildings is substantial.

The State Committee has targeted institutional buildings in Kyiv for the implementation of a buildings efficiency program. Institutional buildings are defined as nonresidential buildings owned and occupied by state and municipal organizations. Because of the desire to make the potential loan program more manageable by limiting it to a small number of owing organizations, this assessment focused on those organizations expected to have large numbers of buildings and floorspace under their subordination. These organizations include the Municipal Department of Health, the Ministry of Health, the Municipal Department of Education, the Ministry of Education, and the Municipal Department of Culture.

Institutional buildings have several advantages over other building categories with respect to implementing efficiency improvements. First, institutional buildings generally have only one owner, so one set of equipment is sufficient to meter and control heat consumption to the building. Second, most institutional buildings operate on an occupancy schedule that allows reduced temperatures during unoccupied periods such as nights, on weekends, and during holidays. Finally, operating budgets for institutional building owners are paid through a relatively small set of state and municipal organizations, simplifying the loan payment and repayment process.

[1] A draft report on the demonstration project was produced in January 1998. Copies of this report can be obtained from Tom Secrest, Pacific Northwest National Laboratory, Richland, Washington.

Methodology

The three components of this assessment, though closely interrelated, differ substantially in nature. Hence the methods used to carry out the assessments and demonstration project are quite different. It is beyond the scope of this paper to describe in detail each of these components. Instead a brief description of the methodology is presented as well as commentary on the most challenging aspects of the analysis. The reader is referred to the technical reports cited above for further detail on the assessments.

Technical Assessment

The technical assessment can be broken into three major components: an evaluation of the institutional building stock, estimation of the baseline energy consumption and potential energy savings in this building stock, and estimation of the economic performance of the individual ECOs and packages of ECOs.

Building Survey. Institutional buildings were characterized by surveying the State and Municipal organizations that own and occupy these buildings. The State Committee for Energy Conservation coordinated data collection activities and made initial contacts that were necessary for successful implementation of the work. The data collected present an adequate picture for the following building categories: hospitals, polyclinics, hospital administration and other support buildings, kindergartens, schools, higher education, student hostels, theaters, and art galleries/museums.

The primary descriptors used to characterize institutional buildings are function, age, and size (number of floors), each of which has an impact on thermal performance. The building age categories used are buildings constructed prior to 1958, those constructed from 1958 to 1980, and those constructed after 1980. These age groups conform roughly to periods with particular architectural styles and building codes that impact the thermal performance and applicability of energy efficiency measures (e.g., roof construction impacts the choice of roof or attic insulation as an efficiency measure). Building size categories were selected based on the available data. For institutional buildings, these are 1- to 2-story buildings, 3- to 4-story buildings, and buildings 5-stories or more.

Engineering Analysis. The energy efficiency potential in Kyiv institutional buildings was estimated by evaluating the baseline energy consumption and potential energy savings for 33 prototype buildings. Baseline estimates of heat and hot water energy consumption by the institutional sector were based upon the estimates of building floorspace, type, vintage, and size, and estimates of specific energy consumption as a function of each of these building descriptors. Specific energy consumption estimates for the institutional buildings sector were derived primarily from design heat consumption for space heat, and from estimates of domestic hot water consumption by building type, expressed as a function of total heat demand.

The energy efficiency potential was estimated using the ASEAM5 (A Simplified Energy Analysis Method, Version 5) computer program to model heat losses in buildings. Baseline and post-measure installation heat and hot water energy consumption were estimated for the prototype buildings for each measure, the difference being the efficiency improvement. The efficiency improvement, expressed as a percentage of baseline energy consumption, was then used to estimate energy savings, in gigacalories, by ECO and prototype building. Efficiency improvement calculations for water

heating measures were based on statistical information regarding the use of hot water in Ukraine and manufacturers' performance information.

A total of forty-six ECOs were evaluated for improving energy efficiency in the institutional buildings sector. Of these 46 ECOs, 20 were determined to be applicable to one or more building types and were analyzed with respect to energy efficiency potential, cost, and availability on the Ukrainian market. Using a performance criterion of a 5 year or less simple payback, individual ECOs were selected and grouped into packages for each building category. The package energy savings was then reevaluated to determine the combined performance of the ECOs.

Economic Analysis. To evaluate the attractiveness of each option, the ECOs were analyzed using a number of economic methods or "metrics": simple payback, net present value (NPV), and internal rate of return (IRR). Basic economic assumptions include a real discount rate of 10%, and an analysis period of 15 years.

The method employed to assess the efficiency potential for the institutional sector consisted of three steps: 1) Screen the individual measures by simple payback; measures having a simple payback of less than 5 years were retained for additional analysis, 2) Combine the measures to identify interactive effects to avoid double counting the efficiency potential and to deselect measures that reduced the payback of selected bundles for individual building types, and 3) Evaluate the measure bundles and applicable individual measures for each building type to estimate efficiency potential.

A total of 8 ECOs were selected for application:

- windows and door weather-stripping
- reflectors behind radiators
- ceiling fans
- substation-level controls
- hot water heat exchangers
- low-flow showerheads
- aerators on faucets.

In all cases, building heat meters were included. No direct energy savings are associated with building heat meters. Instead, heat meters provide the building owners with an incentive to save energy.

Lending and Implementation Assessment

The Government of Ukraine is pursuing funding for implementation of this project from the World Bank. The World Bank issues development loans with low interest rates, long maturity periods, and with of a grace period. At the same time, the Bank tries to reduce financial risk by obtaining sovereign guarantees. To minimize risk of guarantee obligations, the Cabinet of Ministers of Ukraine by its Decree #414 (Cabinet of Ministers of Ukraine 1997) established procedures for preparation and implementation of investment projects that use government guarantees. The implementation and lending structures are described below.

Project Implementation. Two important components called for by decree #414 are the creation of an Interagency Work Panel (IWP) and a Project Implementation Unit (PIU) for supervision of project preparation and implementation. The IWP consists of representatives from participating ministries and

organizations. For this project, the State Committee for Energy Conservation is the organization responsible for the project (Project Contractor), and its Deputy Chairman is the Head of the IWP. The IWP tasks include coordination between the financing institution and state executive bodies and the preparation of necessary documents and supervision of the project preparation and implementation.

The PIU is responsible for the specific implementation activities including project scheduling, organization of competitive bidding, management of implementation work, and all analysis, auditing, and reporting functions.

The implementation of the project will last 5 years and includes two major phases. During the first phase (1999/2000 heating season) ECOs will be implemented in a limited number of buildings to verify the measures and installation procedures. The second phase (a full-scale implementation) is scheduled for the 2000/01, 2001/02 and 2002/03 heating seasons.

Loan Disbursement and Repayment. The disbursement process is based on standard World Bank requirements and the Cabinet of Ministers of Ukraine's Decree #414 (Cabinet of Ministers of Ukraine 1997). The World Bank makes direct payments to suppliers/installers, although a certain portion of the loan may be allocated to a special account to cover current payments on smaller contracts. The special account is created in a foreign commercial bank that satisfies World Bank requirements and is approved by the Ministry of Finance, with the special account opened for the Ministry of Finance and sub-borrower (under a license of the Ministry of Finance).

The PIU makes contracts and originates disbursement requests to pay suppliers and installers. The disbursement requests are subject to approval by the Ministry of Finance. In the case of larger contracts, the disbursement requests are delivered to the World Bank to issue payment. The PIU may also have direct access to the special account provided that the Ministry of Finance submits to the World Bank documents confirming that certain persons are authorized to sign applications for withdrawal and certified samples of the authorized persons' signatures.

Financial structures for loan disbursement and servicing range from a centralized process where the Ministry of Finance and Kyiv Municipal Department of Finance retain the responsibility for the loan and deduct the required amount from the energy budget allocated to each agency to a decentralized process where each participating agency is responsible for repayment of its share of the loan. A primary benefit of the centralized option is stronger assurance of repayment and realization of the budgetary savings at the highest level so that priority budgetary items can be addressed. The primary benefit of the decentralized option is that an incentive exits for participants that allows them to redirect the 'savings' from their energy bills to other areas within their purview. Centralized repayment was chosen as the preferred option both because of its simplicity, and because of a new system for making budgetary expenditures in which the State Treasury pays the invoices issued to budgetary organizations directly. In the old system, the State Treasury financed the accounts of budgetary organizations, allowing them more flexibility in disposing of the funds.

In the centralized repayment option, shown if Figure 1, the World Bank lends to the Ministry of Finance of Ukraine with a sovereign guarantee provided by the Cabinet of Ministers. The Ministry of Finance concludes an agreement with the Kyiv Municipality to on-lend part of the loan in the amount necessary to pay for efficiency measures in targeted municipal buildings. Collections by both the Ministry of Finance and the Kyiv Municipality are handled by reductions in the annual budget allocations to the subordinate organizations. The budget reductions correspond to the value of calculated energy savings from baseline consumption levels.

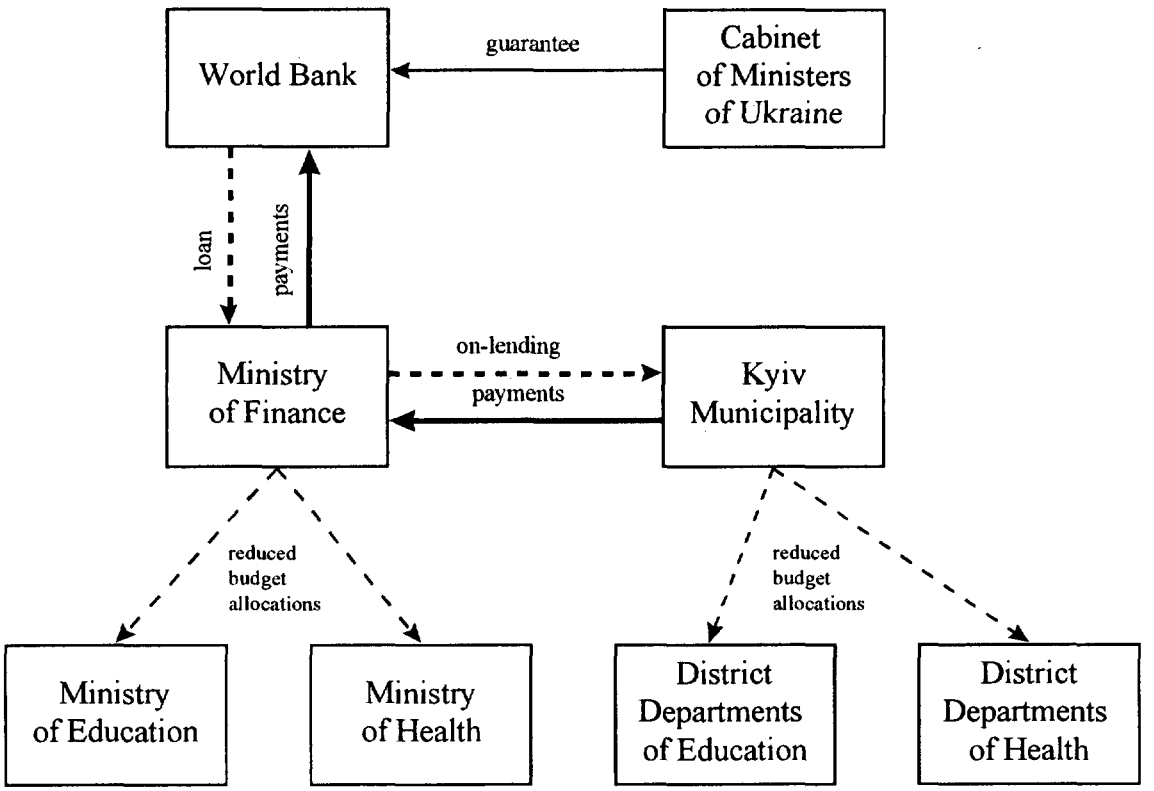

Figure 1. Centralized Repayment Option

The municipal payments are transferred to a special account with the Kyiv Office of the State Treasury attached to the Ministry of Finance. These payments contain the principal, interest, and 1% markup allowed to the Ministry of Finance for loan handling and processing. The Ministry of Finance provides for the loan service according to the schedule set by the loan agreement.

Demonstration Project

The State Committee felt that a demonstration activity was needed to increase the confidence of public agencies and organizations that cost-effective energy improvements can be implemented in public buildings. Four school buildings were selected to demonstrate the effectiveness of weatherization and control measures to reduce the heat consumption provided by the district heating system. School buildings were selected because this category is considered to be high profile and a priority group. School buildings of this type account for 39% of the floorspace evaluated in this assessment.

The two classes of measures selected were weatherization measures to reduce infiltration and improve occupant comfort, and control measures to prevent overheating and reduce the heat energy supplied during unoccupied periods. Retrofits included window and door weatherstripping, caulking to seal cracks, and replacing the hydroelevator-based building heat substation with a heat exchanger substation. In addition, heat meters are included in each installation to provide incentives for building owners to save energy and to verify the performance of the weatherization and control measures in reducing heat energy consumption.

Table 1 summarizes the size, estimated energy efficiency potential, and cost of the demonstration activities in each of the four school buildings participating in the demonstration activity.

Table 1. Demonstration Activity Characteristics

School Building Number	Building Size		Calculated Efficiency Improvement	Measure Costs ($)				
	#Floors	m^2		Heat Meter	Control System	Weatherization	Total	Per m^2
272	3	8,921	43%	3,792	24,130	12,170	40,092	4.49
303	3	10,301	30%	3,829	22,517	6,270	32,616	3.17
324	4	5,026	24%	3,235	17,596	5,160	25,991	5.17
159	4	9,511	17-20%	3,575	20,292	not installed	23,867	2.51
Average		8,440	29%	3,608	21,134	7,867	30,642	3.63

Results

The results of the technical assessment, lending and implementation assessment, and demonstration project are presented below.

Technical Assessment

Table 2 shows the main results from the technical assessment. Of the input estimates in the technical assessment, the variables of greatest uncertainty were the estimates of cost of heat and the estimates of baseline energy intensity. The heat tariff rate structure in Kyiv has traditionally included strong cross-sector cost subsidies. For example industrial customers of Kievenergo, the main heat supplier to the district heating system, paid about 2.7 times as much for heat as residential customers in 1996 (Joseph Technology Corporation 1997). The removal of these cross subsidies is in discussion, however estimating actual heat tariffs in the near future is difficult. The value used in this assessment is $22/Gcal.

Table 2. Technical Assessment Results

Institutional Building Type	Number of Buildings	Floorspace (thousand m^2)	Baseline Energy Use (thousand Gcal)	Efficiency Potential (thousand Gcal)	Percent Savings (%)	IRR (%)
Hospitals	160	637	157	40	25.8	27.8
Polyclinics	110	294	59	16	27.2	24.4
Administration	69	92	16	4	26.2	16.4
Kindergartens	600	1,312	329	86	26.2	31.7
Schools	389	2,804	470	129	27.4	29.1
Higher Education	174	1,229	240	64	26.5	31.6
Hostels	133	731	154	34	22.0	25.4
Theaters	12	48	10	3	28.7	26.8
Art Galleries/ Museums	31	65	12	2	19.6	12.9
Total	1,678	7,213	1,446	378	26.2	29.2

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The verification of baseline energy intensity estimates is made difficult by the lack of metered data in Kyiv buildings. As a test on the validity of using design heat consumption data, an assessment of city-wide heat flows was developed from existing information on fuel consumption and heat capacity demand by building sector (Figure 2). The resulting estimate of heat consumption in residential buildings was then used in conjunction with residential floorspace data to estimate average energy intensity. The value obtained compared favorably with the weighted average value based on design heat consumption, which suggests that design data provide a reasonable estimate of actual energy intensity.

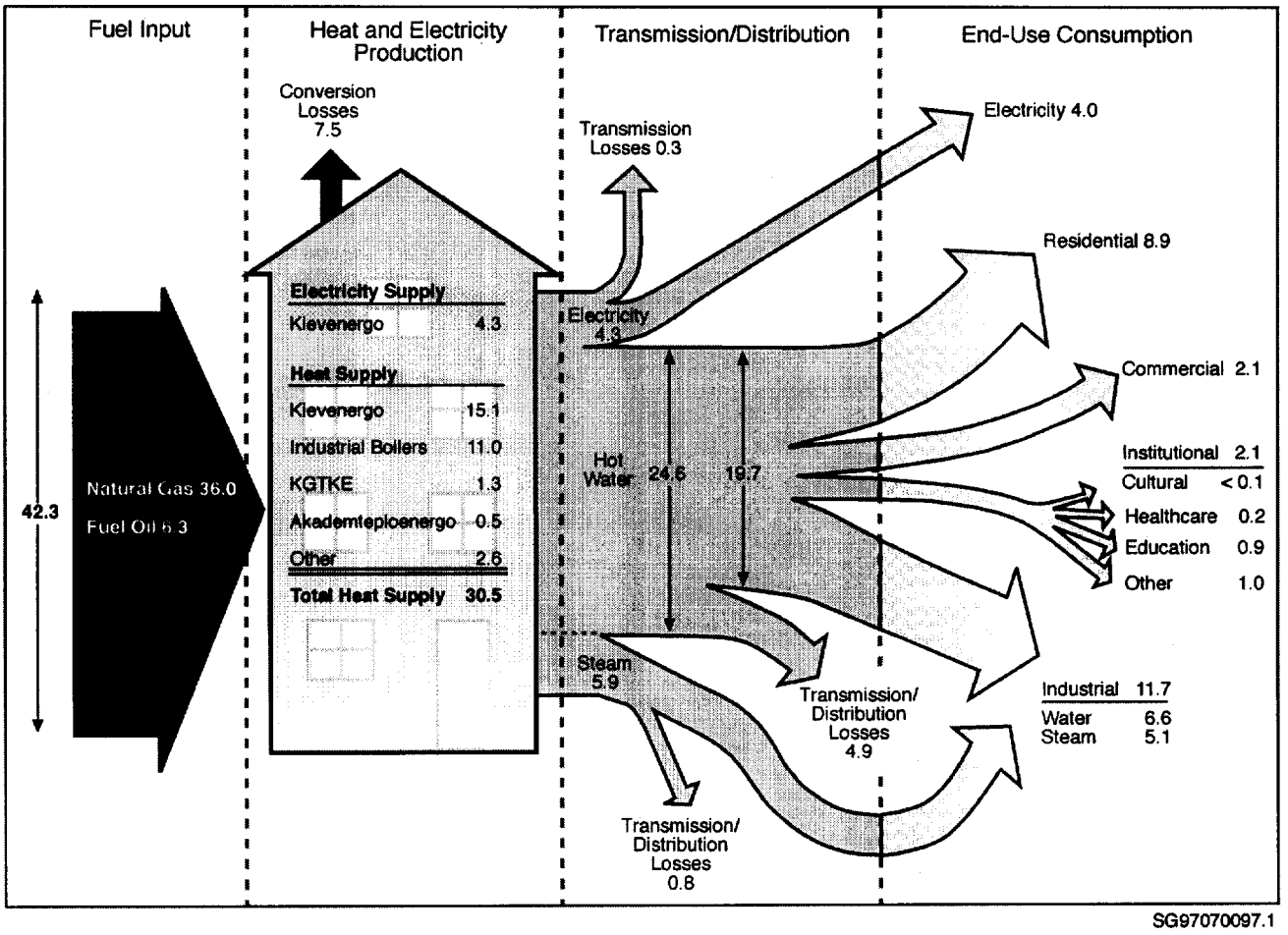

Figure 2. Estimated Energy Flow of Kyiv District Heating System (million Gcal), 1995

The required investment levels were calculated in terms of both investment per building and investment per square meter of floorspace. The per-square-meter estimates are multiplied by the building stock estimates to provide an overall sector investment requirement. These values should be taken as an upper bound, because they are based on the assumption of 100% penetration of the efficiency measure packages into the building stock. In reality, not all existing buildings would be susceptible to retrofit. Total investment requirements are presented in Table 3.

Table 3. Institutional Buildings Sector Investment Requirements

Institutional Building Type	Investment Requirements ($)		
	Per Building	Per Square Meter	Total (thousands)
Hospitals	21,719	5.45	3,475
Polyclinics	14,143	5.29	1,556
Administration	8,309	6.21	573
Kindergartens	11,771	5.38	7,063
Schools	24,987	3.47	9,720
Higher Education	29,581	3.92	4,820
Hostels	23,994	4.37	3,191
Theaters	24,266	5.32	256
Art Galleries/Museums	29,844	6.08	397
Total	25,981	4.31	31,051

The buildings efficiency improvement program will have potential additional economic and environmental impacts. These include impacts on employment, energy security, and air pollutant emissions levels.

The direct employment impacts due to the required retrofit installation work are estimated at 64 full-time equivalents for the second through fifth years of the project. It is expected that domestic suppliers and manufacturers of equipment will also develop, but the associated employment is not estimated.

The reduction in energy expenditures translates directly into reductions of state and municipal expenditures. Budgetary expenditures are projected to decrease by $9 million per year in the last year of the project. This is estimated to result in a redirection of $5.8 million in annual expenditures for fuel imports.

The magnitude of the emissions reduction is a function of the heat demand reduction, the net heat production and distribution efficiency, and the emissions rates of the district heating boilers. Precisely estimating the actual emissions reduction is difficult. However, a reasonable approximation can be made using estimated average emission factors and system performance. Projections indicate that after the year 2003, NO_x emissions would be reduced by 332 tonnes, SO_x emissions would be reduced by 232 tonnes, and CO_2 emissions would be reduced by 85,427 tonnes annually.

Lending and Implementation Assessment

The estimated cost of the program over the 5-year period by cost category is given in Table 4.

Table 4. Program Costs

Component	Investment
Installation	$31.1 million
Administration	$3.5 million
Contingency	$3.5 million
Total	$38.0 million

Alternative lending structures were examined to assess the cash-flow implications and national benefit as measured in cash outflow and equivalent price of natural gas. The lending structures analyzed the repayment term as offered by the World Bank, rapid repayment, and use of third-party financing to supplement funding provided by the World Bank. The terms of the World Bank loan were analyzed for the provision of 80% of the capital at an 8.25% annual interest rate for a 15-year period with a 5 year grace period on the principal; the terms of the third-party loan were for a 25% annual interest rate. This analysis supported the following results:

- The greater the share of the program assumed by Ukraine, the greater the national benefit and the greater the negative cash flow during the initial years of the loan.
- The more rapid the repayment of loan(s), the greater the national benefit.
- It is desirable to obtain as much grant financing as possible to reduce the initial negative cash flow.

If third party financing is relied upon, it is desirable to obtain as low a rate as possible to maximize national benefit.

Demonstration Project

Energy use data from the demonstration project have not yet been analyzed so no actual efficiency improvement results can be presented. Detailed estimates of energy efficiency potential were made for the buildings in the demonstration project, however, and these can be compared to the estimates developed in the technical assessment. Table 5 shows a comparison of the demonstration estimates, including cost data, with those for installation of meters, controls, and weatherization measures contained in the technical assessment.

Table 5. Demonstration Project Comparison with Technical Assessment

Item	Demonstration Average	Technical Assessment
Estimated Efficiency Improvement (%)	29	22.8
Size (m^2)	8,440	7,340
Cost ($)		
Heat Meter	3,608	3,094
Heat Control System	21,134	13,119
Weatherization	7,867	5,728
Total	30,642	21,941
Per m^2	3.63	2.98

Comparing the two estimates shows the cost for the demonstration to be about 22% higher per square meter than for the cost estimated in the technical assessment. This can be explained by a number of reasons, but it is believed that the cost associated with full-scale implementation will be less due to competitive bidding, volume discounts, and installation efficiencies. Hence the actual costs are expected to be very near to those predicted in the technical assessment.

While the efficiency improvement predicted by the demonstration is about 25% greater than the improvement predicted by the technical assessment, it is believed that a 29% improvement is a realistic estimate of the optimistic end of the range while a 23% improvement is a realistic estimate of the pessimistic end of the range. Hence, the two are believed to be realistic bounds of the range of efficiency improvement, which will be verified after completion of 1997/98 heating season.

The financial evaluation contained in the technical assessment is believed to adequately depict the returns associated with this building type. The simple payback of these measures was estimated to be 3.3 years and the internal rate of return was 29%. Since the costs are about the same and the only marked difference is the predicted efficiency improvement, the 29% improvement predicted in the demonstration would only improve the favorability of the simple payback and IRR metrics. Again, the financial measures will be further examined in the verification activity to be conducted in the 1997/98 heating season.

Conclusions

This assessment demonstrates the existence of a cost-effective energy efficiency potential resource in typical institutional buildings in Ukraine and describes a lending and implementation structure for acquiring this resource. In the course of carrying out this assessment contacts with budgetary organizations showed that these organizations are very interested in implementing efficiency measures to reduce energy bills. Existing budget constraints are the primary reason that energy efficiency measures are not implemented. Interest in efficiency improvements was shown not only in Kyiv but in other Ukrainian cities as well.

Because of the lack of budgetary resources, a large-scale efficiency improvement cannot be carried out without help from international financing institutions. The proposed buildings energy efficiency project could also be expanded to other cities of Ukraine using the mechanism of the World Bank Adaptable Program Lending. This mechanism is particularly suitable for supporting long-term development programs.

The proposed investment program would also provide a host of secondary benefits including reduced reliance on imported fuel supplies, reduced emissions of combustion related pollutants, increased job and business opportunities in the energy services sector, and improved working conditions in the buildings. These benefits, in conjunction the direct cost savings from reduced energy use, make this a highly attractive program.

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