Integrated Heat Demonstration Project – Dnipropetrovsk/Ukraine

Activity Completion Report
P053126

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Integrated Heat Demonstration Project – Dnipropetrovsk/Ukraine

Activity Completion Report

Energy Sector Management Assistance Program
(ESMAP)

Contents

Office Memorandum

DATE: June 30, 2000

TO: Dominique Lallement, ESMAP Manager, INFES

FROM: Anke Meyer, Energy Specialist, INFEG

EXTENSION: 39962

SUBJECT: **ESMAP Integrated Heat Demonstration Project—Dnipropetrovsk/Ukraine (UA-UE-53126)**

OBJECTIVES OF THE PROJECT

The objective of the project was to demonstrate cost-effective and energy-efficient measures—both in the heat and hot water supply system and in buildings—which have a potential for replication on a large scale to improve the efficiency of heat supply companies, reduce the energy consumption of the residential sector in Ukraine, and lead to a decrease in the heating budgets of both the municipalities and consumers.

BACKGROUND

Under the ESMAP project Increasing the Efficiency of Heating in Central and Eastern Europe, one of the cities chosen for a case study was Dnipropetrovsk in Ukraine. The municipal government and the district heating company (DHC) in Dnipropetrovsk were very interested in implementing some of the results of the case study. Therefore, the terms of reference for the Ukraine case study were supplemented to include the definition of a demonstration project consisting of two components: (1) improvement of the heat supply facilities within a limited part of the network, and (2) energy efficiency measures in some buildings. The heat supplied to two buildings—with a total of about 300 apartments—at the end of one of the twelve district heating networks in Dnipropetrovsk was insufficient. The DHC proposed to disconnect the buildings from the district heating network and, instead, supply them with heat from a new local boiler. In addition, the project proposed to reduce the heat load and improve the level of comfort in the buildings by investing in certain energy efficiency measures in the buildings.

The following heat supply alternatives were evaluated:

1. Improvement of the status quo. This included upgrading the existing heat-only boiler (HOB) plant and network, and substation rehabilitation.

2. Decentralization of heat supply with the following options:
   a) Construction of a local boiler-house with gas-fired boilers, or a
   b) Local co-generation unit.

Option 2a turned out to be the most cost-effective heat supply option. An investment of US$0.5 million was proposed for this project component.

The energy-efficiency measures in the two buildings would reduce the heat load, improve the heat distribution within the buildings, and make it possible to control the heat in each building. The proposed measures for each building would consist of a combination of the following: heat meters, heat balancing valves, pipe insulation in basements and attics, staircase improvements (doors and windows), insulation of basements, improvement or change of windows, roof insulation, etc. Based on experience with similar projects in other parts of the FSU, it was estimated that, with a total investment of $100,000 (about $300 per apartment), total heat consumption could be reduced by about one-third. A relatively modest investment would lead to high energy savings, thereby decreasing heat load, fuel consumption, and emissions.

IMPLEMENTATION

This somewhat unusual project has been under implementation since the beginning of 1997, even though funding through Senter started only in July 1997 (for Tebodin for the 2nd phase). ESMAP received the funds for the 1st phase from Senter only in October 1997, and a contract between ESMAP and Tebodin (for phases 1 and 3) was finally signed in April 1998.

The <u>first phase</u> consisted of:

- Preparation of detailed cost estimates;
- Preparation of an information and education campaign for the building residents—this included investigating the possibility of (partial) cost recovery of the energy-saving investment from building residents and ensuring the participation of the residents in the future dissemination of the project results;
- Carrying out a household survey; and
- Launching a measurement campaign in the two buildings to establish the baseline energy consumption against which future energy savings will be evaluated.

The first phase was completed between January and April 1997. As a result, the project cost estimates and a binding budget definition for the second phase were derived.

The implementation of the <u>second phase</u> began in August 1997. It consisted of:

- Detailed engineering of the project,
- Preparation of tender documents,
- Preparation of agreements with local subcontractors,
- Procurement of equipment and services (pso),
- Supervision of project implementation, and
- Testing and commissioning of the equipment.

The energy efficiency measures in the two buildings connected to the new boiler-house proceeded relatively quickly, so that residents reaped the benefits of those measures during part of the 1997/98 heating season. Each household had a choice between a low-flow showerhead or window tightening. In addition, basements and attics and the pipes in those parts of the buildings were insulated. The residents reported that drafts had notably diminished, and those living above entrances or basements felt that apartments had been warmer during cold weather and cooler in hot weather.

The procurement and delivery of the goods and the actual installation proved very challenging, with a huge amount of red tape. The new boiler-house finally started operation in August 1998. The new heating system did however, not function quite as expected, and the DHC asked for additional services and materials. . Senter finally approved those additional expenses and at the date of this memo, the implementation is still ongoing.

To a larger extent than originally planned, the DHC contributed to the project all civil works (including the boiler-house and chimney, connection of the boiler-house to the medium-pressure gas distribution network, and the electricity and water distribution networks); the necessary upgrading of the internal plumbing; civil and electrical works; and connection of new heat exchangers for domestic hot water (DHW) supply in the buildings.

As part of the third phase, "Monitoring and Evaluation," a second household survey was conducted between October 1998 and January 1999. The monitoring of the equipment and the second measurement campaign in the buildings were not carried out until the beginning of the heating season of 1999/2000 due to the problems mentioned above. A workshop was held in Dnipropetrovsk in December 1999, with participants from national, regional, and local governments. A report on the experience with the demonstration project was prepared by the consultant in the spring of 2000. The main part of the report is attached.

RESULTS

The demonstration project resulted in the improvement of the heat supply in a part of Dnipropetrovsk. The energy consumption of the two buildings was reduced by an estimated 27%, compared to the situation before project implementation. In addition, the quality of the heat and hot water supply, and comfort for the residents of the two buildings improved noticeably. The demonstration project did not, however, result in actual energy savings.in Dnipropetrovsk. The district in which the demonstration project is located suffered from a heat supply deficit, and the heat that was "freed up" by the two buildings receiving their own heat source is now consumed in other parts of the network. The reduced energy consumption did not result in reduced energy bills for the residents, since they still pay according to the size (square meters) of their living space. . However, arrears for the two buildings have been reduced, and on-time payment is now above the average in Dnipropetrovsk and better than it was before.

The municipality and the energy supply companies of Dnipropetrovsk acquired knowledge about the technical, economic, financial, and environmental evaluation of heat supply options, and the interaction of the supply and demand sides of heating options. During the dissemination workshop, other Ukrainian municipalities and energy supply companies, as well as government agencies, were informed about the potential cost-saving impact of these technologies on municipal, company, and household budgets.

COST OF THE PROJECT

The total budget to be financed by the Dutch Government was initially estimated to be US$0.9 million. Due to the additional services this increased to US$0.99 million. In addition, the local cost, financed by the district heating company, amounted to almost US$0.5. The table below displays the breakdown of the total costs.

TOTAL PROJECT COST

##	Description	International USD	Local USD	Total USD
1	Equipment & materials supplied, including installation works	431,841.82		431,841.82
2	Construction & engineering infrastructure		476,053.90	476,053.90
3	Technical assistance	445,170.00		445,170.00
4	Buiding improvement measures	96,470.59		96,470.59
	Bank administration fee	16,619.00		16,619.00
5	**Total**	**990,101.41**	**476,053.90**	**1,466,155.31**

PROBLEMS AND LESSONS LEARNED

In my view, the project cannot be considered a successful demonstration project. True, about 300 households now have a much better heat supply. If consumption-based billing were introduced, they would probably also experience lower heating expenditures than the other customers of the DHC. However, it is very doubtful that the project will have much influence on the future actions of most of the stakeholders.

Demonstration projects which aim at the transfer of technologies that are not yet standard in our client countries encounter disproportional barriers. The energy, time, and money spent on getting VAT exemption, import licenses, operating licenses, etc. were disproportional to the size of the project. On the other hand, the experiences with Ukrainian subcontractors and the personnel of the DHC were quite good.

The consultants were so tied up with the problems in the implementation phase that not much effort seems to have been spent on the monitoring and evaluation. As a result, no hard data exist which could prove any energy savings, or which could trace any possible savings to improvements made in the heat supply system or to improvements made in the buildings.

As a further consequence of a technology-oriented approach, not enough effort was spent on an information and education campaign for the residents of the two buildings. The second household survey shows this quite clearly.

Report on the Results of Phase III

Energy efficiency measurements

Dnipropetrovsk District Heating Project

Results 3rd phase, autumn 1999

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INTRODUCTION

The project was carried out under the Joint United Nations Development / World Bank Energy Sector Management Assistance Programme (ESMAP). Tebodin has been awarded by the World Bank ESMAP in collaboration with Dutch Government and with the co-operation of the Municipality/District Heating Company (DHC) of Dnipropetrovsk to carry out an Integrated Heat Demonstration Project. The project consisted of two components:

1. Improvement of the heat supply facilities within a limited part of the network, i.e., replacement of the district heating supply by a dedicated boiler-house for two residential buildings (building A-located at Dzerzinskogo St. #1 and build. B at Rogolyova St .#9) in Dnipropetrovsk, Ukraine.

2. Energy-saving measures in those two buildings with a total of 308 apartments.

The project had been broken up into three phases:

- Phase 1- Preparation
  - Preparation of detailed cost estimates
  - Preparation of information and education campaign
  - Carrying out of household survey
  - Measurement campaign to evaluate the energy savings
- Phase 2- Implementation
  - Detailed engineering of the project
  - Preparation of Tender documents
  - Preparation of agreements with local subcontractors
  - Procurement of equipment and services
  - Supervision of the project implementation
  - Testing and commissioning of the equipment
- Phase 3- Monitoring
  - Second measurement campaign
  - Post-investment survey participating households
  - Workshop

The financing for the entire demonstration project was provided by the Dutch Ministry of Economic Affairs. Phase 1 and Phase 3, consisting entirely of technical assistance, were carried out under the responsibility of ESMAP, while the investments and related technical assistance under Phase 2 were implemented with parallel cofinancing and under supervision of Senter, Agency of the Dutch Ministry of Economic Affairs.

This report concentrates on the third phase, which envisaged monitoring of operation of equipment installed within the framework of the project for the purpose of determining the heating supply efficiency of the buildings A and B, where the relevant energy saving measures were introduced.

Besides, the project's objective was to carry out the comparative analysis of results with data of the first stage of monitoring, i.e. before renovation of the heating systems of the buildings and before actions to decrease heat losses inside of the buildings. Also it was necessary to evaluate the efficiency of the performed activities on improvement of heating of the buildings, considering the results of the comparative analyses. The measurement results of the comfort conditions in both buildings and evaluation of energy saving measures efficiency in the buildings are presented in a separate report.

PROJECT MEASURES

Investments

According to the project plan boiler-house and substations equipment have been supplied and put into operation. Additionally was supplied set of controlling equipment and spare parts on sum DFL 113, 536.00.

The investments into equipment procurement and installation works (phase 2 of the project) are presented in the table 1:

Table 1

##	Item	Contract Price, DFL	Vendor	Notes
1	Heat exchangers	36,000.00	SWEP	
2	Chimney connections	14,164.00	Dalsem	
3	Valves	52,980.00	Econosto	
4	Air heater	1,350.00	Klima	
5	Expansion vessels + misc.additional equipment	20,311.10	Technische Unie (Snikkers)	
6	Pumps	23,075.00	Grundfoss	
7	Electrical and Instrumental equipment	185,665.00	Verkerk	
8	Boilers	181,126.00	Remeha	
9	Tiles, handpainted	900.00	Deltfse Huys B.V.	
10	Tiles, handpainted	1,475.00		2-nd time w.r.t theft of tiles
11	Gas meter	9,986.00	Instromet	
12	Shower heads sets + aerators	3,512.00	Olympia Sanitair	
13	Subtotal	530,544.10		
14	Installation works: boiler house and substations	90,051.00	UTM	Local subcontract
15	Subtotal	90,051.00		
16	Additional equipment			Supplied in year 2000
17	Extension of the existing control system	73,516.00	L&S	
18	Spare parts of the control system	24,740.00	L&S	
19	Spare pumps	2,860.00	Grudfoss	
20	Gas pressure regulators	12,420.00	Fisher Ros.	
21	Subtotal	113,536.00		
22	TOTAL, DFL	734,131.10		
23	**TOTAL, USD**	**431,841.82**		

Table 2 comprises investments have been put on the energy savings measures implementation in both buildings of the project.

Local subcontractor TTR had provided all works, which are included in the table.

Table 2

##	Work discription	Unit	Qantity		Total cost, DFL
			Bld. A	Bld. B	
1	Insulation of the entrance doors incl. Installation of door shutters	pcs	38	10	10,218.00
2	Thermoinsulation and repairing of piping at attic & basement	m	788	1840	30,996.00
3	Insulation of windows & balcony doors of apartments	m^2/pcs	429.9/105	674/191	70,070.00
4	Closing openings of technical premises & exits to the roof	m^2/pcs	5.1/2.0	35/32	10,322.00
5	Insulation of cilings in the entrance halls	m^2	no	288	28,748.00
6	Installation of aerators & shower heads	pcs	72	82	13,646.00
7	Total, DFL				164,000.00
8	**Total, USD**				**96,470.59**

DHC had also completed their scope of activities during the phase two.

Breakdown of the DHC' investments and works performed on this stage is shown in the table 3:

Table 3

##	Description	Amount, UAH	Notes
1	Working design	60,912.00	
2	Boiler-house construction	303,223.00	
3	Exhaust stack fabrication and erecti	34,800.00	
4	Heating network implementation	96,980.00	
5	Telephone network implementation	53,453.00	
6	Electrical network implementation	49,132.00	
7	Gas network implementation	128,820.00	
8	Sewerage network implementation	91,129.00	
9	Water network implementation	91,316.00	
10	Roads (municipal improvements)	158,065.00	
11	Substation A renovation	62,975.00	
12	Substation B renovation	95,884.00	
13	Heat meters, mini-telephone station, accessories	33,972.70	
14	Custom clearance, penalties for free of charge term's expiration (3 days) of goods at custom warehouse	2,500.00	
15	Debt of DHC to subcontructors in the project's scope	165,000.00	Not paid yet
16	Total, UAH	1,428,161.70	
17	**Total, USD**	**476,053.90**	

Table 4 introduces the dynamic of currency exchange rate in period from year 1997 to 1999.

Table 4

Year	1997			1998						1999			
Month	Jan	May	Dec	Marc	June	Jul	Aug	Sept	Dec	March	June	Aug	Nov
Average UAH/USD	1.89	1.86	1.89	2.04	2.06	2.13	2.25	3.40	3.43	3.94	3.95	4.46	4.70

The boiler-house was putting into operation on 2/07/98.

Considering the fact that the exchange rate grows fast in Ukraine it is hardly to evaluate total investments of DHC in the project in dollar' equivalent. Moreover DHC not paid yet a debt to their subcontractors in amount of UAH165, 000.00.

Technical Assistance

Table 5 shows total investments into technical assistance of the project on every phase of its implementation.

Table 5

##	Description	Phase 1, USD	Phase 2, USD	Phase 3, USD	Total, USD
1	ESMAP Staff	13,685.00	0.00	13,685.00	27,370.00
2	International:				0.00
3	Fee	40,000.00	80,000.00	30,000.00	150,000.00
4	Travel	18,667.00	37,333.00	14,000.00	70,000.00
5	Administration incl. Translation	10,400.00	20,800.00	7,800.00	39,000.00
6	Local	13,813.00	27,627.00	10,360.00	51,800.00
7	Workshop/Traning	0.00	7,000.00	20,000.00	27,000.00
8	Reporting	0.00	0.00	5,000.00	5,000.00
9	Sundries	10,000.00	60,000.00	5,000.00	75,000.00
10	**Total**	106,565.00	232,760.00	105,845.00	**445,170.00**

Total project cost

Summarised joint investments in the project implementation are shown in the table 6:

Table 6

##	Description	International, USD	Local, USD	Total, USD
1	Equipment & materials supplied inc. installation works	431,841.82		431,841.82
2	Construction & engineering infrastructure		476,053.90	476,053.90
3	Technical assistance	445,170.00		
4	Buidings improvement measures	96,470.59		
	Bank administration fee	16,619.00		
5	**Total**	**990,101.41**	**476,053.90**	**1,466,155.31**

HEAT CONSUMPTION MEASUREMENTS OF BUILDINGS A AND B

All measurements were done by Dnipropetrovsk District Heating Company (DHC) employees and handed over to Tebodin experts as a hard copy for further processing and analysis.

The heat consumption measurements of building A and B were carried out in two stages:

- Round 1. 1997-1998 heating season
  2-30 December 1997

- Round 2. 1999-2000 heating season
  24 October - 22 November 1999

In the course of the first round of measurements heat and hot water were supplied to the buildings A and B by the district boiler house located at 36, Lenina St (old boiler house).

The second round of measurements was performed after commissioning and final adjustment of the equipment and automatic control system of the boiler house located at 9, Rogoleva St. (new boiler house), which were supplied within the framework of the project.

During 1997-1998 heating season the heat meters were installed in the substations of buildings A and B, which could measure the heat supplied to the heating and hot water supply systems of the building, as well as the temperatures and consumption of heat carrier in time.

Ultrasonic water and heat meters HBM-93.02 manufactured by SEMPAL (Ukraine) were installed.

The main technical characteristics of the SEMPAL heat meters are as follows:

Operating range of heat carrier temperature - 0…150°C
Operating pressure – up to 1.6 MPa (16 kg/sm2)
Deviation margins:

- for temperature measurement - 0,2°C
- for consumption, volume and mass of heat carrier measurements - 1,5 %
- for heat power and heat energy measurements - 2 %
- for time measurements - 0,01 %

Each substation was equipped with three heat meters in conformance with drawing No.2159001 (Attachment A).

The amount of heat used for heating is measured by meter VI 1.5, the flowmeter of which is installed inside the feeding pipeline of the secondary heat carrier, while the temperature detectors are installed in the feeding and return pipelines.

The amount of heat used for hot water supply is calculated as a difference in readings of meters VI 2.5 and VI 3.5. The flowmeter of the meter VI 2.5 is installed in the feeding hot water pipeline, while the temperature detectors are installed in the feeding pipeline and cold water pipeline. The flowmeter of the meter VI 3.5 is installed in the pipeline of hot water recirculation, and temperature detectors in the recirculation pipeline and cold water pipeline.

The data on heat consumption, water volume, operating time, flow consumption, temperatures in supply and return pipelines, and astronomic time are displayed on the control panels of the heat meters.

The attachments 1-12 describe the results of the temperature measurements and heat carrier consumption measurements, as well as heat consumption of buildings for heating and hot water supply before and after the project's implementation.

RESULTS OF THE MONITORING

Operating efficiency of the boilers REMEHA

After putting into operation of boiler-house there were commissioning works conducted. Adjustments were carried out to achieve the best operating characteristics of the boilers. Evaluation of the boilers efficiency has been based on exhaust gas analysis provided by representatives of DHC testing laboratory.

Results of the tests are presented in the table below.

Index	Boiler 1		Boiler 2		Boiler 3	
	Burner output		Burner output		Burner output	
	Low	High	Low	High	Low	High
CO_2,%	9.0	11.0	7.4	10.1	7.7	11.0
O_2,%	4.9	1.3	7.8	3.2	7.2	1.1
Air coeff.	1.27	1.06	1.53	1.16	1.47	1.05
CO,%	0.0033	0.0028	0.0002	0.0002	0.0002	0.0000
Temp., ^{0}C	169	243	164	242	150	218
NOx, mg/m^3	171	167	197	199	200	189
Boiler efficiency, %	90.4	89.2	89.3	88.4	90.2	90.3

The maximum efficiency of the boilers, which is declared by manufacturer, is 92% with gas caloric value equals 8200 Gcal/kg. Putting into consideration that real gas caloric value on the tests moment equalled 7960 Gcal/kg, it is reasonably to evaluate boilers operation as efficient and very close to name plate parameters.

Control of heat consumption of the buildings

The graphs 13, 16 present the values of average daily outdoor temperature and average daily heat consumption of buildings A and B before renovation.

The conclusion can be made that during heating of the buildings by the old boiler house the heat supply was carried out without strong dependence on the outdoor temperature. Moreover, sometimes under higher outdoor temperatures an increase of heat consumption was observed, which implies a non-sufficient level of regulation of the heating output of the boiler house.

The graphs 14 and 17 present the same dependence after the new fully automated boiler house was commissioned. In spite of the fact that changes of outdoor temperature during measurements were not as significant as in the course of the first round of measurements and ranged between -6,9 °C and +9,5 °C, a strong dependence of changes in heat supply on the outdoor temperature fluctuations was observed.

In this case the automatic control system provides efficient heat supply to consumers depending on outdoor temperature. Comparing with the previous situation considerable fuel saving if is achieved in this case.

Heating curves

The graphs 15 and 18 describe heating curves for each building, representing the dependence on the outdoor temperature of the amount of the supplied heat for consumer's heating. In conformance with the normative documentation, the calculation temperature for Dnipropetrovsk district is - 23 °C. At this temperature, the heat supply source has to provide maximal supply of heat to consumers. The heating season is stopped under average daily outdoor temperature + 8 °C kept for 3 days.

In the course of the first round of measurements the range of outdoor temperature changes was between - 25°C and + 5,7 °C i.e. practically covered the entire range of the heating season temperatures.

During the second round the range of outdoor temperature changes was between - 6,9 °C and + 9,5 °C. Taking into account the fact that the dependence of supplied heat for heating on the outdoor temperature is linear, the heating curve was extended onto the whole range of the heating season temperatures.

The heating curve for the automatic boiler house as developed on the basis of the measuring results is a practical reflection of the heating characteristic programmed into the control system program.

During the heat supply of buildings from the old boiler house the heating load of the building A was as follows:

- 1,1 MW at - 23 °C
- 1,0 MW at + 8°C

Such insignificant difference in the amount of the supplied heat by the boiler house under outdoor temperature fluctuations of 31 degrees means that in this case regulation of heat supply is simply absent.

The heating load of the building B is as follows:

- 1,0 MW at - 23 °C
- 0,67MW at + 8°C

The heat supply for the building B was performed more efficiently, which is reflected by the inclined character of the heating curve.

The difference in performance of heat supplied to every building can be explained by unequal operating conditions of equipment installed in the secondary heating circuits of the buildings.
Considering the average temperature of the heating period for Dnipropetrovsk district of - 1°C, the assumption can be made that considerable heat saving and, correspondingly, fuel saving can be achieved when using an automatic system exactly in the range of the average temperature of the heating season.

Introduction of energy saving in both residential buildings during the project implementation and relevant calculations of the heating regime allowed to decrease considerably the absolute level of supplied heat and to increase the inclination of the heating curve.

The second round of measurements showed that maximum heating load of the buildings was:

- Building A – 0,76 MW
- Building B – 0,82 MW

I.e. it was reduced by 24% for two buildings, and in the range of average heating season temperature – by more than 40% in total for both buildings. It is also worth to note that a bigger effect of heat saving was achieved for building A, which can be explained firstly by absence of heat supply regulation and secondly by the worse condition of heat insulation of the building before the project.

Specific energy consumption

The table below shows specific energy consumption for heating calculated on degree-days basis per month:

Month	Averag e outside t, ^{0}C	Amount of days	Target $t_{0,}$^{0}C		Degree-days	Heat consumed, MWh		Specific heat consumption, Wh/m^2*DD	
						Bld.A	Bld.B	Bld.A	Bld.B
Dec'97	-2.95	28	18		586.6	599.42	525.96	161.53	53.23
Oct'99	4.45	16	18	140	216.8	120.5	181.4	87.9	49.7
Nov'99	2.52	28	18	253	433.4	217.2	325.2	79.2	44.5
Dec'99	0.7	31	18	344	536.3	296.1	445.9	87.3	49.4
Jan'00	-5.4	31	18	439	725.4	377.2	568.4	82.2	46.5
Feb'00	-1.7	29	18	345	571.3	296.6	446.7	82.1	46.4
March'00	1.8	31	18	309	502.2	265.9	400.2	83.7	47.3

The data of specific heat consumption before the project shows significant difference between heat supplied to buildings. It can be concluded that heat consumption of building A was high due to low performance of regulation in the substation. This fact is corresponding to almost absence of heating curve declination on pre-project stage (see Attachment 15). Another influential factor can be bad air- tight of the building i.e. high heat losses into atmosphere.

The data after the project shows that specific heat consumption was reduced as result of energy savings measures provided into both buildings.

Present difference in figures of specific heat consumption can be explained by construction particularities of the buildings.

Building A with a 19-th flows height and concrete panel wall requires more heat per square metre than bld. B, which has only 9 flows and break walls. For example, Ukrainian regulation (SNIP 2.04.05.91 -HVAC) recommends figures of specific heat consumption for Dnipropetrovsk region (3001-3500 degree-days): for one-section buildings with above 16-th flows- 67 Wh/m^2 and for sectional buildings with 9-10 flows about 50 Wh/m^2.

Old boiler-house status after the project implementation

The old boiler house is located in the downtown of Dnipropetrovsk and supplies heating and hot water to the buildings situated near by boiler house. Total installed capacity is 40 Gcal/h that was not sufficient to ensure proper heating and hot water supply.

According to information provided by DHC implementation of the new boiler house has improved heating and hot water supply to the rest of the buildings while the gas consumption of the boiler house remains the same.

Gas consumption

Data on gas of the old boiler house in 1997 that was submitted to Tebodin by DHC did not contain information about gas consumption to generate heat for each building separately.

That is why the only way to obtain data on gas consumption for heating and hot water supply of buildings A and B is to make some estimating calculations, as done below.

According to DHC data, the heat carrier supply from the boiler house at 36, Lenina St. to buildings A and B amounts to 12.8 % of the total heat carrier output to all consumers of the boiler house.

The total gas consumption of the old boiler house in 1997 was 7,145,480 n.m3. The share of gas conventionally consumed to supply heat to buildings A and B consisted of:
7,145,480 x 0.128 = 914,621 n.m3.

It is impossible to evaluate annual gas consumption based on heat amounts registered by heat meters in the substations due to shortage of metering data (only data of December'97).

Another important factor is that sensors of heat meters are installed into secondary circuit i.e. there is undefined influence of heat exchangers operating conditions on heat supplied by old boiler-house.

The new boiler house provided by the project is equipped with a gas meter manufactured by Instromet, Belgium. Since the boiler house start-up (2.07.98), and during one year of operation, the gas consumption was 665,613 Nm3. Thus the gas saving is:
914,621 -665,613 = 249,008 Nm3.

Therefore, the gas saving after installation of the new equipment and introduction of energy saving measures in the residential buildings amounted up to 27.2%. Attachment 19 shows the decrease in fuel consumption after the project.
Comparison of gas consumption based on degree-days per year is presented in the table below:

	Abs. gas consumption, nm^3	DegreeDays	Specific gas consumption, nm^3/DD	Gas savings, nm^3/DD	%%
Season 97-98	914621	3216	284.4		
Season 99-00	665613	3209	207.4	77.0	27.1

Currency evaluation of fuel savings can be performed on the basis of gas price, which is differed during the project from \$ 83/1000 m^3 in year 1997 to \$ 49/1000 m^3 in 1999.

The annual profit of the DHC caused by reduction of gas consumption to about 27% can come to:

- $ 20667 (based on the rate of year 1997)
- $ 12210 (based on the rate of year 1999)

HOT WATER SUPPLY

The registered data on heat consumption and heat carrier parameters related to hot water supply, as provided by DHC, are presented in the attachments 2,3,8 and 9.

The data analysis proved that in the first round of measurements the temperature of hot water supplied was about 45 °C. At this, the amount of heat consumed with supplied hot water is practically equal to the heat of re-circulation hot water (not used water). Such situation is theoretically possible only if the water consumption is absolutely absent. That is why this round of measurements looks rather doubtful.

Another proof of incorrectness of provided data is temperature T2, i.e. the temperature of cold water. According to the data under consideration this temperature is about 24 –23 °C, which is not possible in December. The practice shows that in this period the cold water temperature consists 3-5 °C. Data incorrectness could be caused by either incorrect commutation of cold water detectors or by failure of the detectors themselves.

The second measurements round proved that the average temperature of hot water supplied is about 60 °C, which corresponds to the control system settings.

The average daily amount of heat supplied with hot water amounted to:
- Building A - 4,53 Gcal/day (5,27 MWh/day)
- Building B - 5,00 Gcal/day (5,815 MWh/day)

The average daily amount of heat not used with hot water amounted to:
- Building A- 1,8 Gcal/day (2,093 MWh/day)
- Building B - 0,965 Gcal/day (1,122 MWh/day)

The average daily amount of heat used with hot water amounted to:
- Building A- 2,74 Gcal/day (3,186 MWh/day)
- Building B- 4,035 Gcal/day (4,69 MWh/day)

Based on the practical constancy of hot water consumption, the assumption can be made that the amount of heat used with hot water before the project was at the same level, but that the new boiler house provides a higher temperature of hot water (60 °C). During the previous supply from the old boiler house the same amount of heat was provided by increased consumption of water with the temperature of 45 °C.

According to Ukrainian regulation the amount of hot water has to be consumed by one person per day is 105 liters.

Based on metering data of Nov'99 the average consumption of hot water by tenants of building A was 133 l/day*person.

This figure is calculated on basis of registered number of tenants, but real number of tenants can deviate from official data.

The real picture of hot water consumption can be obtained only under implementation of water- meters in every apartment of the buildings. In such situation the tenants will pay for real consumption of hot water, but do not for average rate. This measure also could give to DHC their real income.

IMPACTS ON THE CONSUMERS

Results from the household survey

Kiev International Institute of Sociology carried out an independent poll among the dwellers of the house to find out how housing conditions have been changed after Project implementation.

The data obtained from the poll is shown in Technical Report.

A brief review of this poll can be performed as follows:

- In comparison with the period before project implementation, the number of those unsatisfied with the quality of heating and hot water services has become twice as low.
- Almost twice in comparison with the period before project implementation the portion of those who think it is too cold or quite cold in the apartment lessened.
- The majority of respondents pointed at a change for the better - 91% mentioned that after the reconstruction it wasn't as cold in their apartment, and 93% think that the warmth comfort improved in their apartment, 62% noted that the problems ceased to exist after the reconstruction.
- Although in comparison with last year the portion of respondents who independently warm windows in the winter has somewhat decreased, it still makes up the majority.
- During 2 years most of the dwellers carried out the following worming works: warming of window frames, warming of doorframes, slashing of cracks and crevices in the walls. Majority of the respondents answered that warming works are still functioning.
- As before, more than half of the respondents want to regulate the heat of batteries, although this number has somewhat diminished - 68% in 1998 and 82% in 1997.
- As last year, the majority of respondents valued the hot and cold water pressure to be fully or partly satisfactory.
- 81% of the respondents noted that water has become hotter, and 34% said that hot water supply has become more reliable.
- 43% of respondents would like to install a cold water meter, 50%- a hot water meter.
- The majority of respondents (79%), as before, have problems paying monthly apartment bills.

Results from the measurements in the apartments

The first measurement campaign was carried out in the winter season of 1997 (16 February - 9 March). The second measurement campaign was carried out after energy-saving measures were completed in the heating-season of 1999 (26 October - 19 November).

The following measurement were carried out:

Continuously measurements

- Outdoor temperature
- Indoor temperature
- Radiator-supply temperature

Data-loggers were installed in building A and building B. The data-loggers measured temperature each 10 minutes during three weeks.

Spot measurements

- Surface-temperatures of construction parts
- Airtight windows

- Heat distribution within radiator

This temperatures were measured with an infra red-pyrometer. This instrument detects thermal (cold) bridges and determents if floor- and ceiling temperatures are within comfort-limits. It shows also if the windows are airtight. The heat distribution within a radiator can be checked.

It is possible to review the measurement campaign as follows:

- Overall the temperatures in the apartments are far too high. Set point of the supply temperature of the central heating water has to be lowered.

During the measurement session it can be seen that set points are lowered already, but not enough.

Due to this conclusion it is impossible to say something positive about the improvement of the indoor climate (comfort) in the apartments thanks to the energy saving measures. The indoor- and the floor temperatures are too high to be comfortable.

- In general the indoor room temperatures are constant (± 2°C)
- The weather dependent control in the new boiler house is working well. The supply temperature of the radiator various with the outside temperature.
- In the apartments, where measurements were executed, the radiators perform rather well.
- The insulation of the floor above the entrances gives very good results in relation to the surface temperature of the floor in the apartments above the entrances.
- Making the windows more airtight is successfully executed. No draft (or cold spots) is found near windows, which are treated.

Notable experiences in the apartment building were taken in relation with the energy efficient measures in the building:

- pneumatic door closers are all demolished;
- a lot of the electrical lights in entrance and staircases are demolished;
- some of aerators in bathroom and kitchen are removed;
- low flow showerheads are well received;
- making the windows more airtight is very well executed;
- in building B people on the second floor, above the technical floor, are complaining about cold floor, as a result of the insulation of the heating pipes in the technical floor and no insulation of the ceiling of this technical floor (not proven by measurement);
- tenants living in apartments above the entrances say they don't have cold feet anymore;
- tenants are content with the temperature of hot water and room temperature: people say they are very comfortable, even though the temperatures measured are much too high. When the supply temperature of the heating water will be lowered (±21°C) it is likely to be expected that all tenants will complain about a too low indoor temperature. Regarding to this aspect it is very important to inform the people very good. Learn them about comfort parameters and let them know what is happening in order to prevent complains.
- tenants performed also energy saving measures themselves in the period between the two measurement campaigns
  - closing balconies,
  - making the windows more airtight,
  - even placing extra radiator

The impact of the project on heat bills and payment collections

Energy tariffs that had been in power during the project implementation were issued in 1995 and existed as following:

- heating- 0,38 UAH /m^2;
- Hot water- 4,82 UAH/tenant (only for heating of cold water) per month
- Cold water- 1,28 UAH/ tenant per month
- Cost of heat energy – 57 UAH/Gcal

It should be remarked that on first stage of the project Housing Maintenance Company was responsible for bills collection but then this duty was entrusted to DHC.

For reducing of monthly payments of tenants the common practise is to share charge for heating on whole year. This means that tenants pay their heating bills based on average rate through hot period of the year as well as cold one.

In June 2000 tariffs have been changed into the city to higher. And nowadays situation is:

- heating- 0,69 UAH /m^2;
- Hot water- 10.41 UAH/tenant (only for heating of cold water) per month
- Cold water- 1,28 UAH/ tenant per month
- Cost of heat energy – 69 UAH/Gcal

Statistics of the energy bills payments

Two tables below reflect the status of heat energy bills payment by tenants of the project buildings in period before and after implementation.

	Time period	Oct'97-Sept'98	Oct'98-Sept'99	Oct'99-March'00
Building "A"	Sum, charged by DHC, UAH	37210	28362	29487
	Sum, paid by tenants, UAH	27638	26976	22677
	Percentage of payment, %	74,3	95,1	76,9

	Time period	Oct'97-Sept'98	Oct'98-Sept'99	Oct'99-March'00
Building "B"	Sum, charged by DHC, UAH	33756	37903	18900
	Sum, paid by tenants, UAH	42505	35415	25482
	Percentage of payment, %	122,9	93,4	134,8

It is hard to comment this data because of the absence of proportion between amount of charges and actual living space of the buildings. It can be explained by long period debts in payments and also by presence of different kind of discounts for definite groups of people.

According to DHC information the average rate of the payments on time in Dnipropetrovsk in years 1997-1998 was on level 80%. During the last heating season of years 1999-2000 this factor dropped down to 77%. Compared to average level of payments on time through the city there is considerable growing of paying activity by tenants of building B. The percentage above 100% can be explained by paying off old debts to DHC accumulated by tenants from previous time. It should also be taken into consideration that prior to the project implementation building B was in worse heat supplying conditions then building A.

Before the project the tenants of building A were about 3% less active in payments in time to compare with average, but tenants of building begun to pay more then 40% above average.

Obviously tenants of building B were better known about coming construction of a new boiler house. There is considerable growing of payments on time in both buildings in the first heating season of new boiler-house operation and it was 13-15% above Dnipropetrovsk' average rate. If it would be the case when DHC will begin to charge energy bills based on actual heat consumed then picture of charges will look as in the next table:

	Cost, UAH (rate 57 UAH/Gcal)		Cost, UAH (rate 69 UAH/Gcal)	
	Bld. A	Bld. B	Bld. A	Bld. B
1997-1998	113749.2	171758.1	137696.4	207917.7
1999-2000	81920.4	123370.8	99166.8	149343.6
Tentative energy bills reduction	31828.8	48387.3	38529.6	58574.1

The table presents the only comparison of hypothetical payments based on changes in heat tariffs and heat consumption.

According to specific heat consumption data shown in section 4.4 the tenants of build. A consume about by 20% more of heat per square metre and the tenants of build. B about by 9% less comparing to the SNIP's norms. In this case it will be reasonable to charge energy bills in proportion to real heat consumption i.e. families of build. A have to pay by 20% more and families of build. B by 9% less of average norms.

But the real charging system used by DHC and dictated by municipal authorities is based on average indicator for the city and is not influenced by particular construction features of buildings.

Moreover the tariffs of city enterprises are much higher because they include payments for significant part of the heat supposed to be consumed by the residents.

CONCLUSIONS: ENERGY SAVINGS AND MONITORING EXPERIENCE

- During the project a 27.2% decrease of fuel consumption was achieved. The saving was obtained due to replacement of outdated equipment by new high efficiency equipment with an automatic control system and due to introduction of energy saving measures in the residential buildings.

- The temperature regime inside of apartments showed about 5 °C exceeding of target temperature. Based on this it is possible to reduce the consumption of heat supplied by the boiler house even further, by means of changing the relevant settings of the control system. This can provide additional fuel saving.

  A further analysis of the temperatures in the apartments is required in order to make such decision.

- The control system of the boiler house envisages the option of reduction of heat consumption during the night. Currently this option is excluded as it was agreed with DHC. This option will be taken into operation by the next heating season and DHC will achieve additional fuel saving.

- Prior to the project DHC could not control the heat supply in a way that it leads to a predetermined temperature in the apartments. After implementation of the boiler house control system it is possible to perform controlled heat supply depending on the outside temperature and agreed inside temperature of the apartments.

- Energy savings measures with a target to reduce hot water consumption were implemented by installation of low-flow shower heads and tap water aerators in about 50% of the apartments. During the monitoring it was observed that tenants dismantled some of installed devices because the wire mesh of the show heads and aerators clogged due to mud and sand concentrated in cold water supply system. Improvement of cold water supply system was out of the project bounds.

- Implementation of the new boiler house provided not only energy savings for the project buildings, but also improved comfort conditions for residents in other buildings of the heating district.

SEMINAR

General

On December 14, 1999, a seminar took place in Dnipropetrovsk to disseminate the achievements and results of the project amongst an audience of experts and authorities related to the district-heating sector. Attachment 20 contains the following information related to the seminar:

- the program
- the list of participants
- the seminar brochure

The seminar was organised by Tebodin Ukraine, in co-operation with the municipality of the city of Dnipropetrovsk.

Results of the seminar

The seminar was characterised by:

- Two television stations and several journalists were present to record the opening of the event and to interview the main participants. The event was broadcast the same day.
- The total number of participants was about 80: officials from Dnipropetrovsk municipality, managers from district heating companies in other cities in Ukraine, officials from state committees, institutes, etc.
- The speakers presented a diverse range of issues, not overlapping each other and contributed to the overall picture of the project, district heating and energy saving issues.
- A large quantity (about 90) of information brochures was taken or distributed, and the contents were received positively.
- During the seminar and the visit to the boiler house, participants showed their positive attitude towards the idea of energy saving by implementing similar equipment in Dnipropetrovsk and other cities (e.g. Sevastopol, Kiev, Zaporizhzhia).
- The day was concluded with a dinner for 40 participants. The acting mayor of Dnipropetrovsk was present, together with some high-ranking officials from the municipality and Dnipropetrovsk district. The dinner was the main event during which the results of the project and the future possibilities were discussed amongs participants.