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**Integrated Assessment of
Supply and Efficiency Resources
for the District Heating System,
City of Handlova,
Republic of Slovakia**

Prepared by
Pacific Northwest National Laboratory
EGU Bratislava
Tecogen

Prepared: May 1994
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Pacific Northwest National Laboratory
Advanced International Studies

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Washington, DC 20024

Summary

The City of Handlova, Slovakia, needs to replace its district heating system, which is old, unreliable, and expensive to maintain. The current plant is owned by a state-run utility, the Slovensky Energeticky Podnik (SEP). The plant is scheduled to be privatized, and the City is examining options for its upgrade.

There has been substantial analysis and preparation for this activity, which is documented in demand-side and supply-side technical and economic analyses and in this integrated demand/supply report. A preliminary business plan was also prepared. The business plan investigated ownership, management, and technology alternatives; the market value of existing assets and investment requirements; and forecasted future cash flows. In this activity, cash flows required to operate the system and pay interest and principal on borrowed money were used as the basis for estimating the price that would have to be charged for the proposed heating plant company to be a viable operation. This document compares the economics of the three supply alternatives (centralized coal/gas cogeneration, centralized coal cogeneration, and distributed natural gas boilers), with and without building efficiency (no building efficiency measures are evaluated with the decentralized system). Given uncertainties in the future inflation rate, all analyses were done on a real basis, with estimated escalation rates for fuel, labor, and other factors of production.

These preliminary projections were developed to indicate that the cost of heating from a cost per unit of energy basis (Slovakian Krowns/gigajoule [SK/GJ]) and from the perspective of an apartment dweller in Handlova on a total cost per year basis. The centralized coal cogeneration option is the least expensive on a levelized energy cost both with and without energy efficiency. The centralized coal/gas dual-fuel cogeneration is a close second, and the decentralized gas natural gas boilers is significantly more expensive. When the effect of building efficiency measures is evaluated, we find that on a levelized energy cost basis (SK/GJ), efficiency always increases the cost. However, on a levelized cost per flat basis, both of the centralized systems with buildings efficiency are less expensive than without buildings efficiency. The results are presented below.

Scenario Description	Levelized Energy Cost	Levelized Cost per Flat
Coal/Gas Cogeneration with efficiency	258.35 SK/GJ	10,597 SK/year
Coal/Gas Cogeneration without efficiency	187.73 SK/GJ	11,755 SK/year
Coal Cogeneration with Efficiency	236.72 SK/GJ	9,697 SK/year
Coal Cogeneration without Efficiency	164.64 SK/GJ	10,309 SK//year
Decentralized Gas Boilers	241.19 SK/GJ	15,103 SK/year

This work has been funded by the U.S. Agency for International Development (USAID) through the U.S. Department of Energy (DOE). The effort has been managed by Pacific Northwest National Laboratory (a DOE national laboratory), with significant support from Tecogen (a U.S.-based manufacturer of thermal equipment), and from EGU, the Slovakian national energy laboratory. Much individual effort and support was required from the officials and citizens of Handlova. Revitalization of the city heating system is a very high priority for Handlova, and the Mayor and his staff have given this effort responsive and effective support.

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1.0 Introduction

The City of Handlova in the Slovakian Republic is examining options for meeting the thermal energy requirements of its citizens. The major issues facing the city are the following:

- The need to replace and/or implement a major rehabilitation of the central heating plant and the transmission and distribution systems that supply the consumers
- The need to reduce emissions in order to improve air quality around the City and to comply with more stringent environmental regulations.
- The need to maintain heating energy prices that are affordable for the City's residential, non-residential, and industrial customers, considering the upcoming decontrol of energy prices, escalating of fuel prices, and elimination of heating subsidies.

The U.S. Agency for International Development (USAID) is providing technical assistance to the City of Handlova through the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (DOE/EE). DOE assigned management and technical direction of the work to its Pacific Northwest National Laboratory (PNNL). PNNL has, in turn, engaged Tecogen (a U.S. engineering firm) and EGU Bratislava (a Slovakian energy research institute) as team members.

The assistance comprises four major elements:

1. Analysis of heat generation (supply) alternatives available to the City, including centralized coal generation of heating and electricity, centralized dual-fuel (coal/gas) generation of heating and electricity, and decentralized gas heat generation.
2. Analysis of energy efficiency (demand management) alternatives available to the City, including building modification and equipment upgrade alternatives for the space and water heat uses in residential and non-residential buildings.
3. Integration of the supply and demand alternatives to develop a least-cost approach for supplying heat to the City (this report).
4. Limited implementation support, including preparation of a preliminary business plan for acquiring financing.

The intent of this project and this report is to present an analysis of options available to the City for meeting its heating needs, not to provide specific recommendations for City implementation.

2.0 Survey of the Existing System

The Handlova Central Heating System includes a heat generating plant, a distribution system, and heat exchanging stations. Figure 2.1 depicts the layout of the system. In general, the system is old and inefficient and needs to be replaced.

2.1 The Generation and Delivery System

The central heating system covers 80% of the current energy demand for space heating and water heating in the city of Handlova. The Heating Plant was built from 1937 to 1940 and was originally designed as a power plant with a condensing steam turbine, which supplied the electricity for the coal mine Handlova. The last major capacity addition to the plant was in 1954, when the boiler K6 (45 tons/hour, 432°C, 3.8 MPa) was built. The power plant was converted to a heating plant in 1965-68 and upgraded with addition of a closed loop condenser cooling system, natural circulation boilers, a closed loop coal preparation and delivery system, and mechanical ash collectors.

The steam distribution system was built in 1965 and heat distribution began in 1968. In 1982, due to equipment age and economically ineffective production of electricity, the cogeneration plant was converted to heat production only. Boiler K1 was retrofitted in 1982, and boiler K5 was retrofitted for dual-fuel (coal and natural gas) operation and a pre-combustion reactor in 1990. Boiler K6, which was installed in 1954, was upgraded in 1989 and was converted to dual-fuel operation. Currently the distribution network consists of 31 heat exchanger stations, 5,300 meters of pipes installed in non-accessible channels, and 2,735 meters of pipes on the surface. Steam is supplied through the non-regulated heat transfer station TG2 at 3.0/0.9 MPa and 250°C. Maximum pipe dimension is DN 400 for the steam distribution lines and DN 150 for the condensate return lines.

The heat generating plant uses industrial grade coal (brown powdered coal) with a heating value of 10.5-11.0 MJ/kg and natural gas with a heating value of 33.4 MJ/m³. Boilers with natural circulation are equipped with closed-loop coal feed and electrostatic filters. Boiler K1 is equipped with a pre-combustion reactor; boilers K5 and K6 are equipped with gas burners with capacity equal to 50% of the boiler total output. Total output of all boilers is 100 ton/hr (60 MW). The plant employs 120 workers and 24 administrative staff members.

The new 115-meter concrete stack was built in 1983; in 1984 and 1985 the flue exhaust system was equipped with electrostatic filters. The old generators have been removed from the building. Ash produced by the heating plant is deposited to a refuse depository outside of the city.

2.1.1 System Thermal Balance

The Handlova heating system thermal balance is provided in Table 2.1, with separate breakout for total Handlova heating consumption and that provided by the Handlova district heating system.

Figure 2.1. Layout of the Handlova District Heating System

Table 2.1. Heat Balance Summary for Handlova Heating System

Energy Use Category	Total Handlova Consumption (GJ/year)		District Heating System Only (GJ/year)	
Space and Water Heating				
Residential	331,340	35.5%	251,033	30.7%
Non-Residential	107,225	11.5%	92,054	11.3%
Industrial	107,671	11.5%	107,671	13.1%
District Heating Losses				
Heating Plant	275,778	29.5%	0	-
Distribution System	91,744	9.8%	0	-
Other System Losses				
Residential	17,442	1.9%	0	-
Non-Residential	2,380	0.3%	0	-
Total	933,610	100%	818,310	100%

About 30.7% of the energy supplied by the district heating system is for space and water heating in the residential sector, with 11% to 13% each in the non-residential and industrial sectors. System losses account for almost 45% of the coal energy provided to the plant.

2.1.2 Fuel Availability

In its letter of August 14, 1993, to SEP Bratislava, the parent company to Sub Bana Handlova, the State Upper Nitra Coal Mines (Hornonitrianske Bane) with headquarters in Prievidza, Slovakia, has guaranteed supply of standard quality coal up to the year 2020. The following coal quality was guaranteed:

Heating value	Qa = 10.5 MJ/kg
Ash content	A = 36.38%
Water	W = 21.46%
Sulfur	S = 1.55%
Carbon	C = 66.51%
Hydrogen	H = 5.4%
Nitrogen	N = 1.28
Oxygen	O = 25.49%

Handlova is a coal mining community. The coal mine is the largest local employer and has a major impact upon the local social environment. The coal used in the heating plant (~70,000 tons/year) is approximately 16% of the industrial grade coal from the mine. If it were not used in the Handlova heating plant, it could likely be sold in another market, but at reduced price. Coal is currently sold to

the heating plant under annual contracts. In the interest of maintaining a long-term customer, the Handlova Coal Mine is interested in entering into a long-term supply contract with the owners of the new heating plant.

The Slovak Gas Company (Slovensky Plynarensky Podnik), the local gas utility, with headquarters in Prievidza, Slovakia, is capable and willing to provide a sufficient gas supply to satisfy the needs of the City of Handlova. Currently, the low pressure gas distribution network in Handlova is in use and serves only small users (residences). A decentralized heating system would require installation of a new piping system.

2.2 The Energy Consumption System

For the purpose of this study, the city was divided into three energy consumption sectors: residential, non-residential and industrial. These sectors were then further subdivided, and the specific parameters needed to support the energy efficiency analyses were identified. Energy consumption in Handlova for space heating, water heating and for industrial processes in 1992 is summarized in Table 2.2 by fuel type.

Table 2.2. City Energy Consumption [GJ/year]

Energy Source	Sectors			Total Energy	
	Residential	Non-Residential	Industrial	GJ/Year	%
Local					
Coal	29,559	0	0	29,599	5
Gas	66,950	50	0	67,000	12
Electricity	1,200	1,684	0	2,884	1
Boiler Houses					
Coal	0	11,080	0	11,080	2
Gas	0	4,737	0	4,737	1
District Heat	251,033	92,054	107,671	450,758	80
Total	348,782 62%	109,605 19%	107,671 19%	556,058 100%	100

2.2.1 The Residential Sector

Residential building data were acquired from the Building Management Company in Handlova (Bytovy podnik Mesta Handlova), from the Administration Office of the City Hall, and from AGS Atelier Company which was involved in city development studies. The residential sector was divided into 7 representative residential building types, as follows:

Res-1	Apartment buildings 2 to 3 floors	[1951-1952]
Res-2	Apartment buildings 3 to 7 floors	[1954-1957]
Res-3	Pre-fab buildings T 06 B	[1968-1984]
Res-4	Pre-fab buildings	[1962-1965]
Res-5	Pre-fab buildings PI-I5-NKS	[1982-1991]
Res-6	Two-family detached houses	
Res-7	Single-family detached houses	

For building types Res-1 through Res-5, the years in which these buildings were constructed is provided in brackets.

Energy use for these buildings is summarized in Table 2.3. The data indicate that approximately 27% of residential heated floor space is in brick-built apartment buildings from the 1950s (Res 1-2), 49% in the pre-fab multifamily housing (Res 3-5), and the remaining 24% in detached single- and two-family houses.

2.2.2 The Non-Residential Sector

Non-residential buildings are classified into 7 sectors (see Table 2.4). In general, these buildings were not characterized to the same degree as the residential building stock because resources were limited, and each of the non-residential building types represents a very small fraction of the total energy consumption (maximum 3.5%). All non-residential buildings together represent less than 20% of total energy consumption.

2.2.3 The Industrial Sector

The industrial sector in Handlova is represented by the following firms: Coal Mine Handlova including garages, Slovenka, Lahke Universalne Konstrukcie, AMK, Chemika, CSD station, and State Agricultural Farm. At each of these sites, thermal energy is used only for space and water heating; industrial use of thermal energy is negligible. Except for the Coal Mine (see Table 2.5), this energy demand sector is relatively small and was not characterized in detail because of the time and budget limitations of the project.

Table 2.3. Residential Building Thermal Energy Consumption Summary

Number of Buildings by Energy Source					
Building Group	District Heat	Coal	Gas	Electric	Total
#1 Apt Bldg, 2-3 floors	0	0	22	0	22
#2 Apt Bldg, 3-7 floors	40	1	6	0	47
#3 Pre-Fab Apt (68-84)	29	0	0	0	29
#4 Pre-Fab Apt (62-65)	10	0	0	0	10
#5 Pre-Fab Apt (82-91)	16	0	0	0	16
#6 Duplexes (2 family)	0	5	128	0	133
#7 Single-Family House	0	256	284	20	560
Total	95	262	440	20	817
Number of Apartments by Energy Source					
Building Group	District Heat	Coal	Gas	Electric	Total
#1 Apt Bldg, 2-3 floors	0	0	232	0	232
#2 Apt Bldg, 3-7 floors	1,198	12	114	0	1,324
#3 Pre-Fab Apt (68-84)	1,567	0	0	0	1,567
#4 Pre-Fab Apt (62-65)	376	0	0	0	376
#5 Pre-Fab Apt (82-91)	868	0	0	0	868
#6 Duplexes (2 family)	0	10	256	0	266
#7 Single-Family House	0	256	284	20	560
Total	4,009	278	886	20	5,193
Heated Area by Energy Source (m²)					
Building Group	District Heat	Coal	Gas	Electric	Total
#1 Apt Bldg, 2-3 floors	0	0	12,517	0	12,517
#2 Apt Bldg, 3-7 floors	70,471	632	7,943	0	79,046
#3 Pre-Fab Apt (68-84)	89,719	0	0	0	89,719
#4 Pre-Fab Apt (62-65)	20,639	0	0	0	20,639
#5 Pre-Fab Apt (82-91)	54,947	0	0	0	54,947
#6 Duplexes (2 family)	0	69	18,412	0	19,106
#7 Single-Family House	0	24,421	34,069	2,511	61,001
Total	235,776	25,747	72,941	2,511	336,975

Table 2.4. Non-Residential Building Energy Consumption Summary

Commercial Sector	Local			Boiler House		District	Total	
	Coal	Gas	Electric	Coal	Gas	Heat	GJ/Year	%
Education	0	0	1,097	5,000	0	45,565	51,662	47.1
Culture	0	0	0	0	0	5,312	5,312	4.8
Health	0	0	200	0	0	19,531	19,7231	18.0
Sports	0	0	0	6,080	0	5,850	11,930	10.9
Office	0	0	0	0	0	928	928	0.8
Service	0	50	387	0	4,737	9,687	14,861	13.7
Hotels	0	0	0	0	0	5,181	5,181	4.7
Total	0 0%	50 .1%	1,684 1.5%	11,080 101%	4,737 4.3%	92,054 84%	109,605 100%	100

2.3 Forecast for Load Growth

The load growth projections for the system are based upon the Urban Development Plan for the City of Handlova that AGS Atelier performed in 1993. The report predicted that the city population would increase from 18,332 in 1992 to 19,500 by the year 2010. Extrapolating the growth curve at a conservative rate produces an estimate that the city population will reach 19,750 by 2022—a population increase of approximately 1,400 people, or 5.22%. Industrial activity in this scenario was assumed to stay at the 1992 level with no increase in thermal energy demand. Under these assumptions, energy demand for space heating and water heating would increase by 18,206 GJ, or 3.22% of 1992 demand levels. The comparable increase in district heating demand is estimated at 11,268 GJ, or 4.5%.

Table 2.5. Industrial Sector Users

Industrial Users	Heating (GJ/yr)	%	Industry Category
Sub Bana Handlova	76,736	71	Handlova Coal Mine
Chemika	5,684	5	Small Chemical Plant
Lahke Konstrukcie	19,177	18	Light Steel Fabrication
Slovenka	2,114	2	Textile Factory
AMK	188	0	Automobile Repair
CSD Station	2,079	2	Railroad Station
State Farm	1,693	2	Farm
Total	107,671	100	

3.0 Description of the Proposed Supply-Side Upgrade

This chapter presents a technical and economic evaluation of three heating source alternatives considered by the town of Handlova: a centralized coal-fired heat/electricity generation system, a centralized dual fuel (coal/gas) heat/electricity generation system, and a distributed gas-fired heat-only system. These systems are briefly described below and are then compared. Note that each of the former two systems requires the replacement of the existing distribution network with a buried, pre-insulated, two-pipe system with pressure independent heat exchanger stations, a central pumping station located in the central heating plant building, and a system temperature gradient of 130/70°C. The new system would be installed parallel to the existing one, as recommended by the study *Transition from Steam to Hot Water Distribution System in Town of Handlova*, which was performed by Energoprojekt Kosice in March 1992. The replacement of heat exchangers in all stations is assumed to be performed in the summer season.

3.1 Supply Alternative #1: Centralized Dual Fuel Generation System

This alternative assumes reconstruction of existing boilers KS and K6, fuel supply equipment, ash removal equipment, and hot water manifolds; completion of a new chemical plant for water treatment; installation of new gas-fired hot water boilers including gas piping, new 6.2-kW electrical distribution center, new mechanical room, new hot water heat exchanger station, and limestone preparation equipment; and a new ash dump site.

3.1.1 Equipment Specification

Boiler K1 - steam boiler made by "Prvni Brnenska Syrojirna," retrofitted in 1982 (up-stream combustion reactor addition.). No major rehabilitation required.

Max. boiler output	30 MW _t
Max. mass flow	35 t/hr
Nominal steam pressure	3.6 MPa
Nominal steam temperature	425°C
Nominal water temperature	110°C
Thermal efficiency	77%
Fuel	brown coal

Boiler K5 - steam boiler made by "Pani Brnenska Strojirna." Recommended reconstruction and installation of up-stream combustion reactor in 1995, including installation of up-stream combustion reactor.

Max. boiler output	30 MW
Max. mass flow	35 t/hr
Nominal steam pressure	3.6 MPa
Nominal steam temperature	425°C
Nominal water temperature	110°C
Thermal efficiency	77%
Fuel	brown coal

Boiler HK1 - gas-fired hot water boiler to be built in 1996, manufacturer SES Tlmace or DjDj-Wanson. The gas burner for inlet gas pressure of 0.1-0.3 MPa, recirculation pump, M&R system, EGA analyzer, and all electrical equipment will be included with the boiler.

Max. boiler output	20 MW _t
Nominal water pressure	3.2 MPa
Nominal inlet water temperature	70°C
Nominal outlet water temperature	130°C
Thermal efficiency	94%
Fuel	Natural gas, 33.4 MJ/m ³

Boiler HK2 - gas-fired hot water boiler to be built in 1997, manufacturer SES Tlmace or DjDj-Wanson. The gas burner for inlet gas pressure 0.1-0.3 MPa, recirculation pump, M&R system, EGA analyzer, and all electrical equipment will be included with the boiler.

Max. boiler output	20 MW _t
Nominal water pressure	3.2 MPa
Nominal inlet water temperature	70°C
Nominal outlet water temperature	130°C
Thermal efficiency	94%
Fuel	Natural gas, 33.4 MJ/m ³

TG1 - 4.8 MW_e back-pressure steam turbine made by "Prvni Brnenska Strojirna." The turbine package includes control and safety equipment, lubrication package, leakage steam condensation package, and piping.

Nominal electrical output	4.8 MW _e
Nominal steam throughput	40 t/hr
Nominal steam parameters:	
• pressure	3.2 MPa
• temperature	420°C
Back-pressure turndown	0.035 - 0.35MPa
Generator:	
• Nominal RPM	3,000 l/min
• Nominal Power Output	6,000 kVA
• Voltage	6.3 kV
• Frequency	50 Hz

Heat Transfer Station - including circulation pumps, piping, a supporting steel structure and electrical installation package.

1 piece of tube and shell steam-to-water heat exchanger

Nominal thermal output	25,0 MW _t
Nominal water parameters	60/94°C
Nominal steam parameters	
• pressure	12 MPa
• temperature	105°C
Design pressure	PN 25

1 piece of tube and shell steam-to-water heat exchanger

Nominal thermal output	20,0 MW _t
Nominal water parameters	60/130°C
Nominal steam parameters	
• pressure	0.35 MPa
• temperature	140°C
Design pressure	PN 25

The Central Management System (CMS) already exists. It is assumed that the CMS will be expanded to the distribution system and to all heat exchanger stations. The 6.2-kV electrical distribution system will be reconstructed, as will the steam line inside the heating plant. Additional elements to be established include limestone and coal preparation equipment, and an ash dump site.

3.1.2 Supply Alternative #1 Investment Requirements

The investment required for reconstruction of the heating plant in this alternative, based on quoted prices is given in Table 3.1.

Table 3.1. Investment Required for Supply Alternative #1

Alternative #1 Investment Category	1000 SK
K5 Combustion Reactors, Materials and Installation	8,000
HK1 & HK2 Hot Water Boilers, Materials and Installation	50,000
Tg1 Turbine, Materials, and Installation	30,000
Heat Transfer Station, Circulating Pumps	20,000
Extension to Central Management System, Materials, and Installation	16,000
6.2-kV Electrical Distribution System	9,500
Steam Piping, Materials, and Installation	6,000
Coal and Limestone Preparation Equipment	25,000
Ash Disposal Site	16,000
Replacement of the Transmission and Distribution System	66,000
Replacement of Existing Heat Exchanger Systems	54,000
Total Investment Required	300,500

3.2 Supply Alternative #2: Centralized Coal-Fired Generation System

This alternative assumes reconstruction of existing boilers K5 and K6, fuel supply equipment, ash removal equipment, and hot water manifolds; completion of a new chemical plant for water treatment, a new 6.2-kW electrical distribution center, new mechanical room, new hot water heat exchanger station, and limestone preparation equipment; and a new ash dump site.

3.2.1 Equipment Specification

Boiler K1 - steam boiler made by "Prvni Brnenska Strojirna," retrofitted in 1982 (up-stream combustion reactor addition.). No major rehabilitation required.

Max. boiler output	30 MW _t
Max. mass flow	35 t/hr
Nominal steam pressure	3.6 MPa
Nominal steam temperature	425°C
Nominal water temperature	110°C
Thermal efficiency	77%
Fuel	brown coal

Boiler K5 - steam boiler made by "Prvni Brnenska Strojirna." Recommended reconstruction and installation of up-stream combustion reactor in 1995, including installation of up-stream combustion reactor.

Max. boiler output	30 MW _t
Max. mass flow	35 t/hr
Nominal steam pressure	3.6 MPa
Nominal steam temperature	425°C
Nominal water temperature	110°C
Thermal efficiency	77%
Fuel	brown coal

Boiler K6 - steam boiler made by "Prvni Brnenska Strojirna." Recommended reconstruction and installation of up-stream combustion reactor in 1995, including installation of up-stream combustion reactor.

Max. boiler output	30 MW _t
Max. mass flow	35 t/hr
Nominal steam pressure	3.6 MPa
Nominal steam temperature	425°C
Nominal water temperature	110°C
Thermal efficiency	77%
Fuel	brown coal

TG1 - 4.8 MW_e back-pressure steam turbine made by "Prvni Brnenska Strojirna." The turbine package includes control and safety equipment, lubrication package, leakage steam condensation package, and piping.

Nominal electrical output	4.8 MW _e
Nominal steam throughput	40 t/hr
Nominal steam parameters:	
• pressure	3.2 MPa
• temperature	420°C
Back-pressure turndown	0.035 - 0.35 MPa
Generator:	
• Nominal RPM	3,000 1/min
• Nominal Power Output	6,000 kVA
• Voltage	6.3 kV
• Frequency	50 Hz

Heat Transfer Station, including circulation pumps, piping, a supporting steel structure, and electrical installation package.

1 piece of tube and shell steam-to-water heat exchanger

Nominal thermal output	25,0 MW _t
Nominal water parameters	60/94°C
Nominal steam parameters	
• pressure	12 MPa
• temperature	105°C
Design pressure	PN 25

1 piece of tube and shell steam-to-water heat exchanger

Nominal thermal output	20,0 MW _t
Nominal water parameters	60/130°C
Nominal steam parameters	
• pressure	0.35 MPa
• temperature	140°C
Design pressure	PN 25

The Central Management System (CMS) already exists. It is assumed that the CMS will be expanded to the distribution system and to all heat exchanger stations. The 6.2-kV electrical distribution system will be reconstructed, as will the steam line inside the heating plant. Additional elements to be established include limestone and coal preparation equipment and an ash dump site.

3.2.2 Supply Alternative #2 Investment Requirements

The investment required for reconstruction of the heating plant in this alternative, based on quoted prices, is given in Table 3.2.

Table 3.2. Investment Required for Supply Alternative #2

Alternative #2 Investment Category	1000 SK
KS & K6 Combustion Reactors, Materials and Installation	16,000
Tg1 Turbine, Materials, and Installation	30,000
Heat Transfer Station, Circulating Pumps	23,000
Extension to Central Management System	16,000
6.2kV-Electrical Distribution System	9,500
Steam Piping, Materials and Installation	6,000
Coal and Limestone Preparation Equipment	25,000
Ash Deposition Site	16,000
Replacement of the Transmission and Distribution System	66,000
Replacement of Existing Heat Exchanger Systems	54,000
Total Investment Required	262,500

3.3 Supply Alternative #3: Distributed Gas-Fired Heat Generation System

The analysis presented in this section was performed by Stavimex, the Slovak contractor. The analysis of the decentralized heat supply was performed for gas fuel only because previous studies have shown that the high cost of flue-cleaning equipment means small coal-fired environmentally friendly heat sources (small boilers) cannot compete with gas-fired boilers. Electric boilers were not considered because of the high cost of electric energy.

The analysis assumes that the decentralized heat supply system will provide heat only to residential and non-residential sectors and will not provide heat to industrial customers. The total installed capacity of all boilers amounts to 42.2 MW_e with annual delivery of 377.28 TJ. The assumed total delivered

thermal energy is smaller than in previous alternatives; however, this should not have any impact on cost of delivered energy. In the case of this system, an increase in the required capacity will increase the investment on a pro-rated basis.

3.3.1 Equipment Specification

The specifications for each boiler and associated equipment were based on the required heat delivery in a given location with respect to code CSN 06 0310, Section 58b. Equipment specifications were duplicated in as many locations as possible to simplify maintenance and reduce parts inventory requirements. The installation of boilers was assumed (where possible) to be in existing heat exchanger station buildings and boiler houses to minimize installation cost. Boiler rooms were designed to comply with code CSN 07 0703.

Following is a listing of characteristics of the proposed boiler room equipment.

Boiler room type #1

Boiler	2x SR plus 602
Condensing units	2x TCR 800
Total installed output	0.7 to 1.24 MW _t
Number of boiler rooms	23

Boiler room type #2

Boiler	2x UnoLyt UL 279
Condensing unit	2x TCR 280
Total installed output	0.56 MW _t
Number of boiler rooms	18

Boiler room type #3

Boiler	2x AtmoGas 66
Total installed output	0.132 MW _t
Number of boiler rooms	1

Boiler room type #4

Boiler	2x ST plus 800
Condensing unit	2x TCR 800
Total installed output	1.86 MW _t
Number of boiler rooms	3

Boiler room type #5

Boiler	3x ST plus 800
Condensing unit	3x TCR 800
Total installed output	2.79 MW _t
Number of boiler rooms	3

Boiler room type #6 (hospital boiler room)

Boiler	3x ST plus 800
Condensing unit	3x TCR 800
Installed output	2.79 MW _t
Steam mini-boiler	2xTDH PU 400
Steam output	800 kg/hr
Cogeneration unit	
• Broadkrown-Dorman	BCHP 6.1 N
• Electric output	200-300 kW
Number of boiler rooms	1

The total number of Hoval boilers to be installed in all boiler rooms:

Hoval SR plus 620	46 pcs
Hoval ST plus 800	18 pcs
HovalUnoLytUL279	36 pcs
Hoval AtmoGas 66	2 pcs
Hoval THD PU 400	2 pcs

Cogeneration unit

Broadkrown BCHP 280	1 pc
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Condensing units

Hoval TRC 280	36 pcs
Hoval TRC 800	60 pcs

The distribution system external to the boiler rooms will utilize the existing secondary distribution system. Hot water will be distributed at 110/70°C in the winter and at 70/40°C during the summer. Domestic hot water heating and space heating water temperature control will be done in individual residential buildings based upon outside air temperature. Buildings will be equipped with GJ meters and water flow meters.

Domestic water heating systems (DWHS) will be designed in one of two modes, depending upon building type:

- Buildings with inside (basement) boiler rooms will have a DWHS with the storage tank installed in the boiler room. The water heating system will use the boiler flue gas condensing heat for preheating cold water.
- Buildings with external boiler rooms (old heat exchanger stations) will have the DWHS installed in the external boiler room.

3.3.2 Supply Alternative #3 Investment Requirements

The investment required to replace the centralized heating system with a distributed gas boiler system is given in Table 3.3.

Table 3.3. Investment Required to Replace Centralized Heating System

Alternative #3 Investment Category	1000 SK
New Equipment, Piping, and Building Structures	203,014
Energy Management System	14,570
Gas Distribution Systems for All Boiler Rooms	11,970
Total Installed Cost	229,554

3.4 Comparison of Supply-Side Alternatives

A comparison of the characteristics of the three supply-side alternatives is provided below in Table 3.4.

Table 3.4. Comparison of Supply Alternatives

	Alternative #1 Coal/Gas Cogeneration	Alternative #2 Coal Cogeneration	Alternative #3 Distributed Natural Gas
System Capacity			
Boiler Capacity			
Steam MW _t	60	90	1.5
Hot Water MW _t	40	--	55.5
Expected System Peak MW _t	70	70	42.5
Electrical Capacity MW _e	4.8	4.8	0.2-0.3
Operational Parameters			
Fuel Consumption			
Coal tons/yr	69,307	93,013	--
Gas mcf/yr	3,947	--	11,074
Internal Consumption			
Electricity MWh/yr	1,790	2,180	500
Thermal Energy GJ/yr	110,234	94,209	--
Delivered Energy			
Thermal Energy GJ/yr	530,086	530,086	377,280
Electricity MWh/yr	20,610	25,020	--
Emissions Produced			
SO ₂ tons/yr	1,073	1,518. 1	--
NO _x tons/yr	256.4	344.1	14.58
Particulates tons/yr	25,218	47,334	--
Total Investment 1000 SK	300,500	261,500	229,554
Jobs created/maintained	55	55	7

4.0 Building Sector Efficiency Assessment

This section presents the estimated efficiency resource in residential and non-residential buildings and the industrial sectors.

4.1 Efficiency Measures

Fifty energy conservation opportunities (ECOs) were considered for evaluation for the residential and non-residential building stock in Handlova. Of these, 24 ECOs were determined to be applicable to more than one building group and were analyzed with respect to energy efficiency potential, cost, and availability on the Slovak market. A summary of their key economic characteristics is presented in Table 4.1.

4.2 Analysis Approach

The 24 measures were analyzed for the 11 residential building types by the six fuel and equipment types identified: on-site gas, on-site coal, boiler house gas, boiler house coal, district heat, and electricity (water heat only). The analysis did not consider the likelihood that base space and water heat use might increase because of improved living standards. Should base use increase, the efficiency potential will also increase.

The ECO economics were analyzed in a number of ways, including present value, net present value, simple payback, and levelized energy cost, using the economic assumptions described below:

Nominal Discount Rate	17.5%
Expected Inflation	8.0%
Real Discount Rate	9.5%
Analysis Period	30 years

4.3 Building Sector Efficiency Assessment Results

This section provides results of the efficiency assessment, based upon four steps: selection of those ECOs with a positive net present value (NPV); combination of the measures with interactive effects in order to avoid double-counting the efficiency potential; bundling measures for each residential building type to estimate residential sector efficiency potential; and extension to the non-residential buildings sector.

Table 4.1. Efficiency Measures Considered and Estimated Per Unit Cost and Lifetime

ECO Number	Energy Saving Option Description	Unit	Cost [\$/Unit]	Lifetime [Years]
Building Envelope				
1	Insulate Exterior Side Walls	m ²	700-800	30
2	Insulate Top Floor Ceiling	m ²	700	30
3	Insulate Attic	m ²	385	30
4	Insulate Floor Above Basement	m ²	650	30
5	Weatherstrip Elevator Penthouse, Stairway, Doors and Windows	m	40	10
6	Weatherstrip Doors and Windows	m	30	10
7	Install Revolving or Double Door in Building Vestibule	Unit	24,000	30
8	Install Triple Pane Windows	m ²	5,409	30
9	Install Storm Windows	m ²	600	30
10	Install Heat Reflectors Behind Each Radiator or Heater	m ²	148	5
11	Remove Draperies from Radiator		0	NA
Domestic Water Heating				
12	Install Low-Flow Water Heads	Unit	400	10
13	Install Flow Restrictors in Faucets	Unit	70	5
14	Insulate Hot Water Pipes in Unconditioned Spaces	m	158	15
15	Install Hot Water Flow Meters	Unit	600	30
Heating System				
16	Balance Heating System Using Existing Valves	Flat	400	5
17	Install Balancing Valves on Each Radiator	Unit	350	15
18	a. Install Thermostatic Radiator Valves	Unit	380	15
	b. Install Heat Allocators/Meters	Unit	67	1
	c. Install Building-Level GJ Meter	Unit	24,000-46,000	30
19	a. Install Zone Valves on Each Radiator	Unit	330	15
	b. Install Central Thermostats with On-Time	Unit	2300	15
	c. Install Building-Level GJ Meter	Unit	24,000-46,000	30
20	a. Install Zone Valves on Each Radiator	Unit	330	15
	b. Install Central Programmable Thermostats	Unit	6,120	15
	c. Install Building-Level GJ Meter	Unit	24,000-46,000	30
21	Install Building Energy Management System (EMS)	Unit - Radiator	7,000	30
Ventilation and Heat Recovery				
22	a. Install Heat Recovery Vent System in Basements	Unit	7,600	10
	b. Weatherstrip Basement Windows and Doors	m	40	10
23	Install Waste Water Heat Recovery Heat Exchanger	Unit	10,200-12,6000	15
24	a. Install Bath/Kitchen Vent Heat Recovery Heat Exchanger	Unit	9,050	10
	b. Install Back-Flow Damper in Kitchen/Bath Vent Duct	Unit	350	15

The following seven measures having an interactive effect were selected for application:

- insulate building exterior side walls
- weatherstrip elevator penthouse, stairway, doors and windows
- weatherstrip windows and doors
- install revolving or double door in vestibule
- install storm windows
- install zone valves on each radiator and install central thermostats with on time counter in each apartment
- install heat recovery vent system in basements.

Depending upon the building type, a subset of these items was selected based upon their combined performance.

The following seven measures which do not exhibit interactive effects were also selected for possible application:

- install heat reflectors behind each radiator or heater
- remove draperies from radiator
- install low-flow shower heads
- install flow restrictors on faucets
- insulate hot water pipes in unconditioned spaces
- install hot water flow meters
- install waste water heat recovery heat exchanger.

4.3.1 Residential Sector Baseline Efficiency

Table 4.2 provides the economic analysis of the residential sector efficiency resource. The residential sector cost-effective efficiency resource of 147,381 GJ annually, is expected to cost about 131.8 Million SK and have a net present value of 198.3 Million SK. The cost of conserved energy (the annualized cost divided by the annual energy use reduction) works out to an average of 136 SK/GJ for all fuels. While high-rise apartment buildings (building types 2-5) supplied by district heat account for

Table 4.2. Economic Analysis of Residential Sector Efficiency Resource

Assumptions	All Fuels All Building Groups	District Heating
Annual Energy Use Reduction (GJ)	147,381.0	116,187.0
Value of Annual Savings (Million 1993 SK)	35.6	31.4
Present Value of Energy Savings (Million 1993 SK)	529.1	480.2
Total Installed Cost (Million 1993 SK)	131.8	114.2
PV of Installed Cost (Million 1993 SK)	198.3	4.0
Simple Payback Period (Years)	4.0	166.5
Net Present Value (Million 1993 SK)	330.8	313.7
Annualized Cost (Million 1993 SK/Year)	20.0	16.8
Cost of Conserved Energy (1993 SK/GJ)	135.8	144.6

about 77.8% of residential sector heat and hot water energy consumption, they account for over 80% of the cost-effective efficiency resource. The 135 SK/GJ estimated cost of this resource appears to be very cost-effective when compared with the current price of 210 SK/GJ for district heat.

The 147,381 GJ of cost-effective savings represents a 42% reduction in current residential sector energy consumption. Residential district heating energy use can be cost-effectively reduced by about 46%, which represents over 78.8% of all of the cost-effective savings. Residential natural gas consumption can be reduced by almost 32%, accounting for almost 15% of the efficiency potential, and coal consumption can be reduced by about 32%, which represents about 6% of the efficiency potential. Residential electricity use can be cost-effectively reduced by 3%, although this represents only 0.03% of total cost-effective savings.

4.3.2 Non-Residential Sector Baseline Efficiency

The non-residential, cost-effective efficiency resource was estimated by applying the percentage of cost-effective energy efficiency in residential buildings to the space and water heating energy use in the non-residential building sector. The estimated non-residential efficiency resource for 1993 using the base economic values and medium fuel prices is

Gas	15
On-site coal	0
On-site electric	84
BH Gas	1061
District Heat	36,822
Total	40,744

Keeping in mind that this is a very rough estimate, the cost-effective efficiency potential in the non-residential amounts to 40,774 GJ annually. This represents about a 37% reduction in non-residential energy consumption and over 90% of this resource is supplied by district heat.

5.0 Integrated Economic Analysis

This section integrates the findings of the demand-side and the supply-side analyses to determine the overall cost of the system. The centralized coal/gas generation alternative (#1) was analyzed with and without efficiency. The centralized coal generation alternative (#2) was also analyzed with and without efficiency. The distributed gas alternative (#3) was analyzed only without efficiency improvements since there were no available data upon which to analyze the combined scenario. Each of these five cases is analyzed according to two decision criteria. The first is the levelized cost of energy on an SK/GJ basis, as this is the price that will need to be paid by all consumers—residential, non-residential, and industrial. The second metric was the levelized cost of energy per flat. This metric measures the degree to which the system will provide the lowest cost of heat to the residential customer, which is one of the company design guidelines.

5.1 Cash Flow Projections

For this analysis, a more detailed economic analysis was conducted than for the separate demand-side and supply-side analyses done earlier. This was possible because more progress had been made on the overall project and more was known about the company structure, cost of financing, and other important variables.

The analyses were done through the development of 25-year cash flow projections for each of the scenarios. These projections are made on a *real basis*, with general inflation not included in the analysis. (The cash flow forecasts are shown in the tables at the end of this chapter.) The projections were made using the capital cost and performance information provided in the supply and demand reports. Funding for supply-side capital improvements was assumed to be provided by a 10% (real) loan with a 10-year term. Funding for demand-side improvements was likewise provided by a series of 10-year loans at 10% interest, one taken out during each of the first five years of operation.

In the cash-flow forecasts, the price charged for heat (SK/GJ) was set on an annual basis so that the resulting cash flows would just cover operating costs and loan repayment (principal plus interest). It was assumed that the company would be operated to deliver the lowest possible cost of heat for the citizens of Handlova—hence, there are no earnings to be retained by the company or returned to the stockholders as dividends. These assumptions can easily be modified to simulate other operating models.

The projections assume the following conditions:

- a 5-year tax holiday from 1997-2001 (tax rate = 0), followed by a 40% tax on earnings from 2002 through the remaining outyears
- real escalation rates as follows:

	1997-2005	2006-2021
Natural gas	2.85%	1.4%
Coal	2.7	2.7
Electricity (sales)	6.0	6.0
Labor	4.1	2.5
Repairs/supplies	3.0	2.0
General overheads	3.7	2.3

- growth rates as follows: electricity sales—the assumption is that all electricity that is generated can be sold. The rate of generation is a function of heat generated by the central system.
- heat sales—the population of Handlova is expected to increase by 5.22% (total) through 2022. It is assumed that this total increase would be covered by the heating plant. Further, it is assumed that 15% of the total energy consumption can be eliminated through strategic deployment of efficiency resources from 1997 through 2001.

5.2 Analysis Results and Discussion

The analysis results are summarized in Table 5.1 below. In all cases, the levelized cost of energy is greater with buildings energy efficiency implemented than is the case when only the supply-side system is retrofit. This occurs because substantially greater capital investment is required for demand-side implementation, and there is no accommodating supply-side capital reduction. Note that in heating systems with substantial growth, demand-side capital can reduce peaks and eliminate or delay needed growth in generation plants, thus providing a substantial benefit to the system. In Handlova, however, where growth is minimal and where the entire system must be retrofit immediately (because of the switch from steam delivery to a hot water delivery system), there is no opportunity for offsetting demand-side and supply-side capital costs, and so the entire burden of funding the efficiency investment is felt in the levelized cost of heat.

Table 5.1. Results of Integrated Economic Analysis

Scenario Description	Levelized	Levelized Cost
Coal/Gas Cogeneration with Efficiency	258.35 SK/GJ	10,597 SK/year
Coal/Gas Cogeneration Without Efficiency	187.73 SK/GJ	11,755 SK/year
Coal Cogeneration with Efficiency	236.72 SK/GJ	9,697 SK/year
Coal Cogeneration Without Efficiency	164.64 SK/GJ	10,309 SK//year
Decentralized Gas Boilers	241.19 SK/GJ	15,103 SK/year

Note, however, that the levelized annual cost of the apartment dweller is lower in each case with efficiency than for the same system without efficiency. This reflects two elements:

- the annual consumption of heat from each apartment is reduced by 46% from current consumption levels, and so while the cost per unit of heat is considerably more expensive, the average apartment dweller will end up spending less overall when the total cost (price/unit x # units) is calculated.
- while industrial users pay the increased incremental cost of heat due to efficiency investments, they are not targets of the demand-site retrofit program, and so are subsidizing the residential customers.

Needless to say, this scenario is one of an endless number of scenarios that could be modeled. For instance, it is not necessary for the industrial sector to subsidize the cost of heat to the residential sector—a differential pricing structure could be developed wherein all building retrofit costs are paid back only through the residential billing system. Likewise, a buildings retrofit program could be initiated for the industrial sector, with those costs included in the overall cost calculations or allocated only against industrial customers.

Cash Flow Forecast: Price Set to Meet Loan Repayments
Handlova Centralized Gas/Coal Cogeneration System
with No Buildings Efficiency

Real Escalation (1997-2005 and 2006-2021)									
Natural Gas:	2.85%	1.4%						Labor:	4.1% 2.5%
Coal:	2.7%	2.7%						Overheads:	3.7% 2.3%
Electricity:	6.0%	6.0%						Repairs/Supplies:	3.0% 2.0%

Financial Information	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Electricity Quantity Sold (GWh)	20.35	20.36	20.37	20.38	20.39	20.4	20.42	20.43	20.44	20.45	20.46	20.47	20.48	20.49	20.50	20.51	20.52	20.53	20.54	20.55
Electricity Price (\$/MWh)	1,389	1,472	1,561	1,654	1,754	1,859	1,970	2,089	2,214	2,347	2,487	2,637	2,795	2,963	3,140	3,329	3,529	3,740	3,965	4,203
Electricity Revenues (1,000 SK)	28,266	29,978	31,794	33,720	35,763	37,930	40,228	42,665	45,249	47,991	50,898	53,982	57,252	60,721	64,400	68,301	72,439	76,828	81,483	86,433
Heat Demand before Efficiency (TJ)	518.8	519.3	519.8	520.2	520.7	521.2	521.7	522.2	522.7	523.2	523.6	524.1	524.6	525.1	525.6	526.1	526.6	527.1	527.6	528.1
Efficiency Information	Efficiency Potential (TJ): 0.000										Years to Implement: 0									
Heat Quantity Sold (TJ)	518.8	519.3	519.8	520.2	520.7	521.2	521.7	522.2	522.7	523.2	523.6	524.1	524.6	525.1	525.6	526.1	526.6	527.1	527.6	528.1
Heat Quantity Generated (TJ)	548.7	549.3	549.9	550.4	551.0	551.6	552.1	552.7	553.3	553.8	554.4	555.0	555.5	556.1	556.7	557.2	557.8	558.4	559.0	559.6
Heat Price (\$/GJ)	202.97	203.12	204.02	204.76	205.59	206.45	207.33	208.23	209.15	210.09	211.05	212.03	213.03	214.05	215.09	216.15	217.23	218.33	219.45	220.59
Heat Sale Revenues (1,000SK)	105,303	105,475	106,042	106,527	107,058	107,645	108,288	108,988	109,745	110,559	111,431	112,361	113,350	114,398	115,505	116,672	117,899	119,187	120,535	121,943
Direct Subsidies (1,000 SK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenues (1,000 SK)	133,568	135,453	137,836	140,247	142,822	145,543	148,423	151,473	154,704	158,120	161,731	165,539	169,556	173,893	178,564	183,581	188,956	194,701	200,828	207,353
Coal Consumption (tons/year)	68,509	68,543	68,577	68,612	68,646	68,680	68,715	68,749	68,784	68,818	68,853	68,887	68,922	68,956	68,991	69,026	69,060	69,095	69,130	69,165
Coal Price (\$/ton)	680	698	717	737	756	777	798	819	842	864	888	912	938	961	987	1,014	1,041	1,070	1,098	1,127
Coal Cost (1,000 SK/year)	46,586	47,868	49,185	50,538	51,928	53,357	54,825	56,334	57,884	59,476	61,113	62,795	64,522	66,298	68,123	69,998	71,923	73,900	75,935	78,035
Gas Consumption (1000m3/year)	3,875	3,878	3,881	3,884	3,888	3,891	3,894	3,897	3,900	3,903	3,906	3,909	3,912	3,915	3,919	3,922	3,925	3,928	3,931	3,934
Gas Price (\$/1,000m3)	3,350	3,445	3,544	3,645	3,749	3,855	3,965	4,078	4,194	4,314	4,438	4,561	4,689	4,821	4,958	5,100	5,248	5,401	5,560	5,724
Gas Cost (1,000 SK/year)	12,982	13,363	13,754	14,158	14,573	15,000	15,440	15,897	16,368	16,838	17,307	17,776	18,245	18,714	19,183	19,652	20,121	20,590	21,059	21,528
Total Fuel Cost (1,000 SK/year)	59,568	61,230	62,939	64,698	66,503	68,357	70,265	72,228	74,242	76,314	78,446	80,635	82,880	85,181	87,539	89,956	92,433	94,970	97,575	100,150
Efficiency Expenditures (1,000 SK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Labor (1,000 SK)	8,750	9,109	9,482	9,871	10,276	10,697	11,136	11,592	12,067	12,562	13,076	13,609	14,161	14,732	15,323	15,934	16,566	17,219	17,893	18,588
Overhead (1,000 SK)	3,000	3,112	3,228	3,349	3,474	3,604	3,739	3,878	4,023	4,174	4,331	4,494	4,663	4,838	5,019	5,206	5,398	5,595	5,797	6,004
Maintenance & Repairs (1,000 SK)	5,000	5,150	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524	6,720	6,923	7,133	7,349	7,571	7,799	8,033	8,273	8,519	8,771
Depreciation (1,000 SK)	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902
Environmental Fees (1,000 SK)	2,359	2,409	2,435	2,462	2,489	2,516	2,543	2,571	2,599	2,628	2,658	2,688	2,718	2,748	2,778	2,808	2,838	2,868	2,898	2,928
Total Operating Costs (1,000 SK)	93,579	95,312	97,091	98,917	100,793	102,718	104,693	106,718	108,793	110,918	113,093	115,318	117,593	119,918	122,293	124,718	127,193	129,718	132,293	134,918
Operating Profit - Before Tax (1,000 SK)	39,989	39,541	39,544	40,370	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418
Operating Margin, %	29.9%	29.2%	28.7%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%	28.8%
Operating Profit - After Tax (1,000 SK)	39,989	39,541	39,544	40,370	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418	40,418
Cash Flow from Operations, After Tax	54,891	54,443	54,446	54,408	54,454	54,500	54,546	54,592	54,638	54,684	54,730	54,776	54,822	54,868	54,914	54,960	55,006	55,052	55,098	55,144
Working Capital (1,000 SK)	5,400	5,991	6,134	6,280	6,388	6,540	6,698	6,861	7,029	7,202	7,380	7,563	7,751	7,944	8,142	8,345	8,553	8,766	8,984	9,207
Change in Working Capital (1,000 SK)	591	143	146	106	154	136	132	137	140	145	150	155	160	165	170	175	180	185	190	195
Net Fixed Assets, Start of Year (1,000 SK)	0	333,653	318,751	303,849	288,946	274,910	260,874	246,838	232,802	218,766	204,730	190,694	176,658	162,622	148,585	134,549	120,513	106,477	92,441	78,405
Capital Expenditures (1,000 SK)	333,653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Depreciation (1,000 SK)	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902
Net Fixed Assets, End of Year (1,000 SK)	333,653	318,751	303,849	288,946	274,910	260,874	246,838	232,802	218,766	204,730	190,694	176,658	162,622	148,585	134,549	120,513	106,477	92,441	78,405	64,369
Net Operating Assets (1,000 SK)	324,742	309,983	295,228	280,473	265,718	250,963	236,208	221,453	206,698	191,943	177,188	162,433	147,678	132,923	118,168	103,413	88,658	73,903	59,148	44,393
Increase in Net Operating Assets (1,000 SK)	324,742	-14,759	-14,759	-13,930	-13,882	-15,400	-13,904	-13,899	-13,896	-13,891	-13,915	-13,912	-13,909	-13,906	-13,902	-13,899	-13,896	-13,893	-13,890	-13,887
Net Cash Flow from Operations After Tax	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300
Debt Source Information	Interest Rate on Supply Loan: 10%										Loan Term (years): 10									
Debt Source Information	Interest Rate on Efficiency Loans: 10%										Loan Amount: 333,653									
New Funds Borrowed (1,000 SK)	333,653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan Balance @ Beginning of Year (1,000 SK)	0	333,653	312,718	289,689	264,357	238,493	205,841	172,125	135,037	94,240	49,364	0	0	0	0	0	0	0	0	0
Principle Repaid	0	20,935	23,029	25,332	27,865	30,651	33,716	37,088	40,797	44,876	49,364	0	0	0	0	0	0	0	0	0
Loan Balance @ End of Year (1,000 SK)	0	312,718	289,689	264,357	238,493	205,841	172,125	135,037	94,240	49,364	0	0	0	0	0	0	0	0	0	0
Total Interest Payments (1,000 SK)	0	33,365	31,272	28,969	26,436	23,649	20,584	17,213	13,504	9,424	4,936	0	0	0	0	0	0	0	0	0
Total After Tax Loan Repayments (1,000 SK)	0	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300
Total Loan Repayments (1,000 SK)	0	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300	54,300
Return to Equity Holders (1,000 SK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Retained Earnings (1,000 SK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Post-Efficiency Flat Consumption (GJ/year)	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6
Cost per Typical Flat (SK/year)	12,710	12,719	12,775	12,822	12,874	12,926	12,978	13,030	13,082	13,134	13,186	13,238	13,290	13,342	13,394	13,446	13,498	13,550	13,602	13,654

25 Year Levelized Energy Cost	187.73 SK/GJ
25 Year Levelized Energy Cost Per Flat	11,755 SK/GJ

Cash Flow Forecast: Price Set to Meet Loan Repayments

Handlova Centralized Gas/Coal Cogeneration System with Buildings Efficiency

Real Escalation (1997-2005 and 2006-2021)									
Natural Gas:	2.65%	1.4%	Labor:		4.1%	2.5%			
Coal:	2.7%	2.7%	Overheads:		3.7%	2.3%			
Electricity:	6.0%	6.0%	Repairs/Supplies:		3.0%	2.0%			

Financial Information	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009 ¹	2010	2011	2012 ¹	2013	2014 ¹	2015
Electricity Quantity Sold (GWh)	2035	1982	1930	1877	1818	175	17.48	17.50	17.51	17.53	17.54	17.56	17.57	17.59	17.60	17.62	17.63	17.65	17.66	
Electricity Price (\$/KWh)	1,389	1,472	1,561	1,654	1,754	1,859	1,970	2,089	2,214	2,347	2,487	2,637	2,795	2,963	3,140	3,329	3,529	3,740	3,965	
Electricity Revenues (1,000 \$K)	28,266	29,186	30,115	31,051	31,879	32,464	34,442	36,540	38,768	41,128	43,634	46,292	49,112	52,105	55,279	58,647	62,220	66,010	70,032	
Heat Demand before Efficiency (TJ)	518.8	519.3	519.8	520.2	520.7	521.2	521.7	522.2	522.7	523.2	523.6	524.1	524.6	525.1	525.6	526.1	526.6	527.1	527.6	
Efficiency Information	Efficiency Potential (TJ): 118.19 Years to Implement: 6 Total Cost: 131,301 Supply System Upgrade Cost: 333,653																			
Heat Quantity Sold (TJ)	518.8	496.0	473.3	450.5	427.8	405.0	405.5	406.0	406.5	407.0	407.5	407.9	408.4	408.9	409.4	409.9	410.4	410.9	411.4	
Heat Quantity Generated (TJ)	548.7	522.2	495.7	469.2	444.9	424.9	425.3	425.8	426.2	426.6	427.0	427.5	427.9	428.3	428.8	429.2	429.6	430.0	430.5	
Heat Price (\$/GJ)	202.97	219.28	238.25	259.27	283.08	307.64	330.22	354.45	389.55	427.88	467.08	507.15	548.15	590.09	633.00	676.91	721.82	767.73	814.54	
Heat Sale Revenues (1,000\$K)	105,303	108,771	112,763	116,812	121,096	125,096	130,120	134,184	138,087	141,838	145,434	148,974	152,459	155,890	159,267	162,591	165,861	169,085	172,263	
Direct Subsidies (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Revenues (1,000 \$K)	133,568	137,957	142,878	147,863	152,975	158,584	163,626	168,666	173,627	178,612	183,518	188,348	193,118	197,819	202,446	207,000	211,532	216,045	220,533	
Coal Consumption (tons/year)	68,509	67,894	66,880	65,665	62,106	60,655	60,686	60,717	60,748	60,779	60,810	60,841	60,872	60,903	60,934	60,966	60,997	61,028	61,059	
Coal Price (\$/Kton)	680	698	717	737	756	777	798	819	842	864	888	912	936	961	987	1,014	1,041	1,070	1,098	
Coal Cost (1,000 \$K/year)	46,586	46,716	46,820	46,895	46,981	47,122	48,419	49,752	51,122	52,529	53,974	55,460	56,987	58,555	60,167	61,823	63,525	65,273	67,070	
Gas Consumption (1000m3/year)	3,875	3,730	3,585	3,440	3,265	3,031	3,036	3,041	3,046	3,051	3,056	3,061	3,066	3,071	3,076	3,081	3,086	3,091	3,096	
Gas Price (\$/1,000m3)	3,350	3,445	3,544	3,645	3,749	3,855	3,965	4,078	4,194	4,314	4,434	4,558	4,686	4,818	4,954	5,094	5,238	5,386	5,538	
Gas Cost (1,000 \$K/year)	12,982	12,852	12,704	12,537	12,337	11,686	12,039	12,403	12,777	13,163	13,569	13,978	14,391	14,806	15,224	15,645	16,069	16,495	16,923	
Total Fuel Cost (1,000 \$K/year)	59,568	59,568	59,523	59,431	59,219	58,809	60,459	62,155	63,898	65,691	67,343	69,038	70,777	72,562	74,393	76,271	78,199	80,177	82,207	
Efficiency Expenditures (1,000 \$K)	26,260	27,048	27,859	28,695	29,556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Direct Labor (1,000 \$K)	8,750	9,109	9,482	9,871	10,276	10,697	11,136	11,592	12,067	12,562	12,876	13,198	13,528	13,866	14,213	14,568	14,932	15,306	15,688	
Overhead (1,000 \$K)	3,000	3,112	3,228	3,349	3,474	3,604	3,739	3,878	4,023	4,174	4,271	4,371	4,473	4,577	4,684	4,794	4,906	5,020	5,137	
Maintenance & Repairs (1,000 \$K)	5,000	5,150	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524	6,654	6,787	6,923	7,062	7,203	7,347	7,494	7,644	7,797	
Depreciation (1,000 \$K)	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	
Environmental Fees (1,000 \$K)	2,359	2,301	2,217	2,132	2,044	1,955	1,977	1,999	2,021	2,044	2,067	2,090	2,114	2,137	2,161	2,185	2,210	2,235	2,260	
Total Operating Costs (1,000 \$K)	119,839	121,190	122,517	122,978	123,333	94,897	97,316	99,810	102,381	105,031	107,248	109,521	111,851	114,240	116,690	119,202	121,777	124,418	127,126	
Operating Profit - Before Tax (1,000 \$K)	13,729	16,767	20,359	24,885	28,742	63,688	61,310	68,817	71,310	72,581	71,370	70,927	70,484	69,966	69,447	68,928	68,409	67,890	67,371	
Operating Margin, %	10.3%	12.2%	14.3%	16.8%	18.8%	48.0%	48.4%	48.2%	48.1%	48.0%	47.9%	47.8%	47.7%	47.6%	47.5%	47.4%	47.3%	47.2%	47.1%	
Operating Profit - After Tax (1,000 \$K)	13,729	16,767	20,359	24,885	28,742	52,612	50,896	57,860	59,840	60,829	59,840	58,829	57,818	56,807	55,796	54,785	53,774	52,763	51,752	
Cash Flow from Operations, After Tax	28,631	31,669	35,263	38,821	42,778	66,648	68,822	69,726	70,876	72,305	73,057	73,991	74,914	75,826	76,728	77,619	78,500	79,379	80,258	
Working Capital (1,000 \$K)	5,400	5,991	6,134	6,280	6,386	6,540	5,176	5,308	5,445	5,585	5,730	5,851	5,975	6,102	6,232	6,366	6,503	6,643	6,785	
Change in Working Capital (1,000 \$K)	591	143	146	106	154	-1,364	132	137	140	145	151	156	161	166	171	176	181	186	191	
Not Fixed Assets, Start of Year (1,000 \$K)	0	333,653	318,751	303,849	288,946	274,910	260,874	246,838	232,802	218,766	204,730	190,694	176,658	162,621	148,585	134,549	120,513	106,477	92,441	
Capital Expenditures (1,000 \$K)	333,653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Depreciation (1,000 \$K)	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	14,902	
Not Fixed Assets, End of Year (1,000 \$K)	333,653	318,751	303,849	288,946	274,910	260,874	246,838	232,802	218,766	204,730	190,694	176,658	162,621	148,585	134,549	120,513	106,477	92,441	78,405	
Net Operating Assets (1,000 \$K)	324,742	309,983	295,226	281,296	267,414	252,014	238,110	224,211	210,312	196,413	182,514	168,596	154,687	140,781	126,875	112,969	99,064	85,162	71,304	
Increase in Net Operating Assets (1,000 \$K)	324,742	-14,759	-14,756	-13,930	-13,882	-15,400	-13,904	-13,899	-13,896	-13,891	-13,886	-13,881	-13,876	-13,871	-13,866	-13,861	-13,856	-13,851	-13,846	
Net Cash Flow from Operations After Tax	28,040	31,628	35,117	38,615	42,624	68,012	68,690	69,589	70,376	72,160	72,650	73,140	73,630	74,120	74,610	75,100	75,590	76,080	76,570	
Debt Source Information	Interest Rate on Supply Loan: 10% Loan Term (years): 10 Loan Amount: 333,653																			
Debt Source Information	Interest Rate on Efficiency Loans: 10% Loan Term (years): 10 Loan Amount: 333,653																			
New Funds Borrowed (1,000 \$K)	333,653	26,260	27,048	27,859	28,695	29,556	0	0	0	0	0	0	0	0	0	0	0	0	0	
Loan Balance @ Beginning of Year (1,000 \$K)	0	333,653	338,978	341,349	340,367	335,589	326,524	282,186	233,415	179,766	120,752	55,838	38,732	24,189	12,594	4,373	0	0	0	
Principle Repaid	0	20,935	24,676	28,841	33,473	38,621	44,338	50,722	57,649	65,014	72,869	81,214	90,049	99,274	108,889	118,894	129,289	139,974	150,949	
Loan Balance @ End of Year (1,000 \$K)	0	312,718	314,301	312,508	306,894	296,968	282,186	233,415	179,766	120,752	55,838	38,732	24,189	12,594	4,373	0	0	0	0	
Total Interest Payments (1,000 \$K)	0	33,365	33,899	34,135	34,037	33,559	32,652	28,219	23,341	17,977	12,075	5,584	3,873	2,419	1,259	437	0	0	0	
Total After Tax Loan Repayments (1,000 \$K)	0	54,300	58,574	62,976	67,510	72,180	76,990	81,940	87,039	92,287	97,684	103,230	108,926	114,772	120,768	126,914	133,210	139,656	146,252	
Total Loan Repayments (1,000 \$K)	0	54,300	58,574	62,976	67,510	72,180	76,990	81,940	87,039	92,287	97,684	103,230	108,926	114,772	120,768	126,914	133,210	139,656	146,252	
Return to Equity Holders (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cumulative Retained Earnings (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Post-Efficiency Flat Consumption (GJ/year)	62.6	58.8	51.0	45.2	39.4	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	
Cost per Typical Flat (\$/K/year)	12,710	12,460	12,157	11,727	11,162	12,467	12,789	12,931	13,103	13,308	13,513	13,718	13,923	14,128	14,333	14,538	14,743	14,948	15,153	

With No Buildings Efficiency

[illegible]

Cash Flow Forecast: Price Set to Meet Loan Repayments

Handlova Centralized Coal Cogeneration System with Buildings Efficiency

Real Escalation (1997-2005 and 2006-2021)									
Natural Gas:	2.85%	1.4%	Labor:		4.1%	2.5%			
Coal:	2.7%	2.7%	Overhead:		3.7%	2.3%			
Electricity:	6.0%	6.0%	Repairs/Supplies:		3.0%	2.0%			

Financial Information	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Electricity: 0.0%		0.0%		Repairs/Supplies: 3.0%					2015
												2007	2008	2009	2010	2011	2012	2013	2014		
Electricity Quantity Sold (GWh)		24.67	23.97	23.27	22.56	21.78	20.9	20.88	20.90	20.92	20.94	20.96	20.98	21.00	21.02	21.03	21.05	21.07	21.09	21.11	
Electricity Price (\$/KWh)		1,399	1,472	1,561	1,654	1,754	1,859	1,970	2,089	2,214	2,347	2,487	2,637	2,795	2,963	3,140	3,329	3,529	3,740	3,965	
Electricity Revenues (1,000 SK)		34,270	35,290	36,310	37,325	38,198	38,768	41,133	43,643	46,305	49,130	52,127	55,307	58,681	62,260	66,058	70,088	74,363	78,900	83,713	
Heat Demand before Efficiency (TJ)		518.8	519.3	519.8	520.2	520.7	521.2	521.7	522.2	522.7	523.2	523.6	524.1	524.6	525.1	525.6	526.1	526.6	527.1	527.6	
Efficiency Information	Efficiency Potential (TJ):	118.10				Years to Implement: 6				Total Cost: 131,301				Supply System Upgrade Cost: 290,350							
	Heat Quantity Sold (TJ)	518.8	496.0	473.3	450.5	427.8	405.0	405.5	406.0	406.5	407.0	407.5	407.9	408.4	408.9	409.4	409.9	410.4	410.9	411.4	
	Heat Quantity Generated (TJ)	548.7	522.2	495.7	469.2	444.9	424.9	425.3	425.8	426.2	426.6	427.0	427.5	427.9	428.3	428.8	429.2	429.6	430.0	430.5	
	Heat Price (\$/GJ)	103.64	109.19	217.49	237.81	260.90	343.40	361.66	354.25	357.66	361.95	376.61	386.16	402.69	423.72	450.44	481.62	518.26	564.48	622.22	
	Heat Sale Revenues (1,000SK)	95,223	98,806	102,934	107,141	111,609	139,087	142,563	143,825	145,391	147,305	151,919	156,334	161,583	167,699	173,724	179,749	185,774	191,799	197,824	
Direct Subsidies (1,000 SK)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Revenues (1,000 SK)		129,493	134,097	139,244	144,468	149,807	177,855	183,686	187,468	191,698	196,438	204,048	210,641	216,919	223,852	231,408	239,643	248,482	257,890	267,589	
Coal Consumption (tons/year)		91,970	90,861	87,751	85,642	83,412	80,951	81,003	81,056	81,108	81,161	81,213	81,266	81,319	81,372	81,424	81,477	81,530	81,583	81,636	
Coal Price (\$/ton)		680	698	717	737	756	777	798	819	842	864	888	912	936	961	987	1,014	1,041	1,070	1,098	
Coal Cost (1,000 SK/year)		62,540	62,755	62,936	63,082	63,099	62,890	64,630	66,418	68,255	70,144	72,084	74,079	76,128	78,234	80,399	82,623	84,909	87,258	89,673	
Gas Consumption (1000m3/year)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Gas Price (\$/1,000m3)		3,350	3,544	3,645	3,749	3,855	3,965	4,078	4,194	4,253	4,313	4,373	4,434	4,496	4,559	4,623	4,688	4,754	4,820	4,888	
Gas Cost (1,000 SK/year)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Fuel Cost (1,000 SK/year)		62,540	62,755	62,936	63,082	63,099	62,890	64,630	66,418	68,255	70,144	72,084	74,079	76,128	78,234	80,399	82,623	84,909	87,258	89,673	
Efficiency Expenditures (1,000 SK)		26,260	27,048	27,859	28,695	29,556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Direct Labor (1,000 SK)		8,750	9,109	9,482	9,871	10,276	10,697	11,136	11,592	12,067	12,562	12,876	13,198	13,528	13,866	14,213	14,568	14,932	15,306	15,689	
Overhead (1,000 SK)		3,000	3,112	3,228	3,349	3,474	3,604	3,739	3,878	4,023	4,174	4,271	4,371	4,473	4,577	4,684	4,794	4,906	5,020	5,137	
Maintenance & Repairs (1,000 SK)		5,000	5,150	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524	6,654	6,787	6,923	7,062	7,203	7,347	7,494	7,644	7,797	
Depreciation (1,000 SK)		13,170	13,170	13,170	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	
Environmental Fees (1,000 SK)		2,359	2,301	2,217	2,132	2,044	1,955	1,977	1,999	2,021	2,044	2,067	2,090	2,114	2,137	2,161	2,185	2,210	2,235	2,260	
Total Operating Costs (1,000 SK)		121,079	122,645	124,198	124,897	126,381	97,246	99,755	102,341	105,005	107,752	110,657	113,629	116,697	119,861	123,120	126,575	130,227	133,976	137,819	
Operating Profit - Before Tax (1,000 SK)		8,414	11,452	15,045	19,570	23,427	80,609	83,941	85,127	86,690	88,683	91,789	95,111	98,729	102,558	106,599	110,863	115,351	120,074	125,030	
Operating Margin, %		6.5%	8.5%	10.8%	13.5%	15.6%	45.3%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	45.4%	
Operating Profit - After Tax (1,000 SK)		8,414	11,452	15,045	19,570	23,427	48,365	50,365	51,078	52,014	53,210	54,687	56,347	58,189	60,212	62,417	64,813	67,400	70,187	73,174	
Cash Flow from Operations, After Tax		21,584	24,822	28,215	31,874	35,731	60,669	62,669	63,380	64,318	65,514	66,977	68,691	70,654	72,867	75,329	78,041	80,992	84,183	87,614	
Working Capital (1,000 SK)	5,400	5,991	6,134	6,280	6,388	6,540	5,176	5,308	5,445	5,585	5,730	5,851	5,975	6,102	6,232	6,366	6,503	6,643	6,787	6,935	
Change in Working Capital (1,000 SK)		591	143	146	106	154	-1,364	132	137	140	145	121	124	127	130	134	137	140	144	148	
Net Fixed Assets, Start of Year (1,000 SK)	0	290,350	277,180	264,010	250,840	238,536	226,232	213,928	201,624	189,320	177,016	164,712	152,408	140,104	127,800	115,496	103,192	90,888	78,584	66,280	
Capital Expenditures (1,000 SK)	290,350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Depreciation (1,000 SK)		13,170	13,170	13,170	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	13,204	
Net Fixed Assets, End of Year (1,000 SK)	290,350	277,180	264,010	250,840	238,536	226,232	213,928	201,624	189,320	177,016	164,712	152,408	140,104	127,800	115,496	103,192	90,888	78,584	66,280	53,976	
Net Operating Assets (1,000 SK)		283,171	270,144	257,120	244,922	232,772	219,104	206,932	194,765	182,601	170,442	158,289	146,139	134,000	121,788	109,585	97,391	85,227	73,067	60,911	
Increase in Net Operating Assets (1,000 SK)		283,171	-13,027	-13,024	-12,198	-12,150	-13,668	-12,172	-12,167	-12,164	-12,159	-12,153	-12,148	-12,143	-12,138	-12,133	-12,128	-12,123	-12,118	-12,113	
Net Cash Flow from Operations After Tax		20,993	24,479	28,069	31,768	35,577	62,033	62,537	63,243	64,178	65,369	66,705	68,189	69,821	71,602	73,533	75,614	77,845	80,226	82,757	
Debt Source Information	Interest Rate on Supply Loan: 10%					Loan Term (years): 10				Loan Amount: 290,350											
	Interest Rate on Efficiency Loans: 10%					Loan Term (years): 10															
New Funds Borrowed (1,000 SK)	290,350	28,260	27,048	27,859	28,695	29,556	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Loan Balance @ Beginning of Year (1,000 SK)	0	290,350	298,392	303,752	308,058	304,896	299,809	259,847	215,889	167,535	114,346	55,838	38,732	24,189	12,594	4,373	0	0	0	0	
Principle Repaid	0	18,218	21,688	25,554	29,857	34,843	39,962	43,958	48,354	53,189	58,508	64,312	70,594	77,362	84,616	92,364	100,606	109,342	118,574	128,306	
Loan Balance @ End of Year (1,000 SK)	0	272,132	276,704	278,199	278,201	270,253	259,847	215,889	167,535	114,346	55,838	38,732	24,189	12,594	4,373	0	0	0	0	0	
Total Interest Payments (1,000 SK)	0	29,035	29,839	30,375	30,606	30,490	29,981	25,985	21,589	16,754	11,435	5,584	3,873	2,419	1,259	437	0	0	0	0	
Total After Tax Loan Repayments (1,000 SK)	0	47,253	51,527	55,929	60,463	65,133	62,033	62,537	63,243	64,178	65,369	66,705	68,189	69,821	71,602	73,533	75,614	77,845	80,226	82,757	
Total Loan Repayments (1,000 SK)	0	47,253	51,527	55,929	60,463	65,133	62,033	62,537	63,243	64,178	65,369	66,705	68,189	69,821	71,602	73,533	75,614	77,845	80,226	82,757	
Return to Equity Holders (1,000 SK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cumulative Retained Earnings (1,000 SK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Post-Efficiency Flat Consumption (GJ/year)		62.6	56.8	51.0	45.2	39.4	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6	
Cost per Typical Flat (\$/Year)		11,493	11,318	11,097	10,758	10,288	11,550	11,825	11,915	12,031	12,175	12,347	12,537	12,745	12,972	13,218	13,484	13,760	14,046	14,342	
25 Year Levelized Energy Cost		236.72 \$/GJ																			
25 Year Levelized Energy Cost Per Flat		9,697 \$/GJ																			

Cash Flow Forecast: Price Set to Meet Loan Repayments
Handlova Decentralized Gas Boiler System
with No Buildings Efficiency

Real Escalation (1997-2005 and 2006-2021)									
Natural Gas:	2.85%	1.4%	Labor:		4.1%	2.5%			
Coal:	2.7%	2.7%	Overheads:		3.7%	2.3%			
Electricity:	6.0%	6.0%	Repairs/Supplies:		3.0%	2.0%			

Financial Information	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Electricity Quantity Sold (GWh)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity Price (\$/MWh)	1,389	1,472	1,561	1,654	1,754	1,859	1,970	2,089	2,214	2,347	2,487	2,637	2,795	2,963	3,140	3,329	3,529	3,740	3,965	
Electricity Revenues (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heat Demand before Efficiency (TJ)	377.3	377.6	378.0	378.3	378.7	379.0	379.4	379.7	380.1	380.4	380.8	381.2	381.5	381.9	382.2	382.6	382.9	383.3	383.6	
Efficiency Information																				
Heat Quantity Sold (TJ)	377.3	377.6	378.0	378.3	378.7	379.0	379.4	379.7	380.1	380.4	380.8	381.2	381.5	381.9	382.2	382.6	382.9	383.3	383.6	
Heat Quantity Generated (TJ)	377.3	377.6	378.0	378.3	378.7	379.0	379.4	379.7	380.1	380.4	380.8	381.2	381.5	381.9	382.2	382.6	382.9	383.3	383.6	
Heat Price (\$/GJ)	226.90	231.88	235.37	238.84	242.65	246.43	250.22	254.02	257.82	261.62	265.42	269.22	273.02	276.82	280.62	284.42	288.22	292.02	295.82	
Heat Sale Revenues (1,000 \$K)	85,605	87,566	89,566	91,566	93,566	95,566	97,566	99,566	101,566	103,566	105,566	107,566	109,566	111,566	113,566	115,566	117,566	119,566	121,566	
Direct Subsidies (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenues (1,000 \$K)	85,605	87,566	89,566	91,566	93,566	95,566	97,566	99,566	101,566	103,566	105,566	107,566	109,566	111,566	113,566	115,566	117,566	119,566	121,566	
Coal Consumption (tons/year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Price (\$/ton)	680	698	717	737	756	777	798	819	842	864	888	912	936	961	987	1,014	1,041	1,070	1,098	
Coal Cost (1,000 \$K/year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Consumption (1000m3/year)	11,074	11,084	11,095	11,105	11,115	11,126	11,136	11,146	11,157	11,167	11,177	11,188	11,198	11,209	11,219	11,229	11,240	11,250	11,261	
Gas Price (\$/1,000m3)	3,350	3,544	3,645	3,749	3,855	3,965	4,078	4,194	4,253	4,313	4,373	4,434	4,496	4,559	4,623	4,688	4,754	4,820	4,888	
Gas Cost (1,000 \$K/year)	37,099	39,278	40,438	41,628	42,852	44,117	45,416	46,752	48,161	49,611	51,106	52,649	54,249	55,901	57,606	59,364	61,176	63,042	64,963	
Total Fuel Cost (1,000 \$K/year)	37,099	39,278	40,438	41,628	42,852	44,117	45,416	46,752	48,161	49,611	51,106	52,649	54,249	55,901	57,606	59,364	61,176	63,042	64,963	
Efficiency Expenditures (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Labor (1,000 \$K)	1,800	1,874	1,951	2,031	2,114	2,201	2,291	2,385	2,482	2,584	2,691	2,804	2,921	3,041	3,166	3,296	3,431	3,571	3,716	
Overhead (1,000 \$K)	2,300	2,386	2,475	2,568	2,664	2,763	2,866	2,973	3,085	3,200	3,317	3,437	3,561	3,689	3,821	3,957	4,097	4,241	4,389	
Maintenance & Repairs (1,000 \$K)	2,300	2,369	2,440	2,513	2,589	2,668	2,746	2,829	2,914	3,001	3,091	3,182	3,275	3,370	3,467	3,566	3,667	3,770	3,875	
Depreciation (1,000 \$K)	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	
Environmental Fees (1,000 \$K)	35	35	36	36	36	37	37	38	38	39	39	39	39	40	40	41	41	41	42	
Total Operating Costs (1,000 \$K)	53,729	56,137	57,534	58,970	60,450	61,979	63,551	65,167	66,827	68,531	70,281	72,077	73,919	75,807	77,741	79,721	81,747	83,819	85,937	
Operating Profit - Before Tax (1,000 \$K)	31,876	31,428	31,431	31,391	31,439	33,386	33,596	33,813	34,039	34,273	34,514	34,761	35,014	35,273	35,538	35,809	36,085	36,366	36,651	
Operating Margin, %	37.2%	35.9%	35.3%	34.7%	34.2%	38.9%	40.7%	41.1%	41.8%	42.6%	43.2%	43.9%	44.6%	45.3%	46.0%	46.7%	47.4%	48.1%	48.8%	
Operating Profit - After Tax (1,000 \$K)	31,876	31,428	31,431	31,391	31,439	33,386	33,596	33,813	34,039	34,273	34,514	34,761	35,014	35,273	35,538	35,809	36,085	36,366	36,651	
Cash Flow from Operations, After Tax	42,071	41,623	41,628	41,588	41,634	43,827	44,033	44,249	44,475	44,711	44,957	45,203	45,450	45,697	45,944	46,191	46,438	46,685	46,932	
Working Capital (1,000 \$K)	5,400	5,591	6,134	6,280	6,388	6,540	5,178	5,308	5,445	5,585	5,730	5,851	5,975	6,102	6,232	6,366	6,503	6,643	6,787	
Change in Working Capital (1,000 \$K)	591	143	148	108	154	-1,364	132	137	140	145	121	124	127	130	134	137	140	144	148	
Net Fixed Assets, Start of Year (1,000 \$K)	0	254,880	244,684	234,489	224,294	214,099	203,904	193,709	183,513	173,318	163,123	152,928	142,733	132,537	122,342	112,147	101,952	91,757	81,561	
Capital Expenditures (1,000 \$K)	254,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Depreciation (1,000 \$K)	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	10,195	
Net Fixed Assets, End of Year (1,000 \$K)	254,880	244,684	234,489	224,294	214,099	203,904	193,709	183,513	173,318	163,123	152,928	142,733	132,537	122,342	112,147	101,952	91,757	81,561	71,366	
Net Operating Assets (1,000 \$K)	250,675	240,623	230,574	220,485	210,444	200,444	190,444	180,444	170,444	160,444	150,444	140,444	130,444	120,444	110,444	100,444	90,444	80,444	70,444	
Increase in Net Operating Assets (1,000 \$K)	250,675	-10,052	-10,049	-10,089	-10,041	-11,559	-10,063	-10,058	-10,055	-10,050	-10,047	-10,074	-10,071	-10,068	-10,065	-10,061	-10,058	-10,055	-10,051	
Net Cash Flow from Operations After Tax	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	
Debt Source Information																				
Interest Rate on Supply Loan: 10%																				
Loan Term (years): 10																				
Loan Amount: 254,880																				
Debt Source Information																				
Interest Rate on Efficiency Loans: 10%																				
Loan Term (years): 10																				
New Funds Borrowed (1,000 \$K)	254,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Loan Balance @ Beginning of Year (1,000 \$K)	0	254,880	238,887	221,295	201,944	180,658	157,244	131,488	103,156	71,991	37,710	0	0	0	0	0	0	0	0	
Principal Repaid	0	15,993	17,592	19,351	21,288	23,415	25,758	28,332	31,165	34,281	37,710	0	0	0	0	0	0	0	0	
Loan Balance @ End of Year (1,000 \$K)	0	238,887	221,295	201,944	180,658	157,244	131,488	103,156	71,991	37,710	0	0	0	0	0	0	0	0	0	
Total Interest Payments (1,000 \$K)	0	25,488	23,889	22,130	20,194	18,068	15,724	13,149	10,316	7,199	3,771	0	0	0	0	0	0	0	0	
Total After Tax Loan Repayments (1,000 \$K)	0	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	
Total Loan Repayments (1,000 \$K)	0	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	
Return to Equity Holders (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cumulative Retained Earnings (1,000 \$K)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Post-Efficiency Flat Consumption (GJ/year)	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	
Cost per Typical Flat (\$/K/year)	14,208	14,520	14,738	14,956	15,194	15,448	15,718	16,004	16,306	16,624	16,958	17,308	17,674	18,056	18,454	18,868	19,298	19,744	20,206	

25 Year Levelized Energy Cost	241.19 \$/GJ
25 Year Levelized Energy Cost Per Flat	15,103 \$/GJ

6.0 Related Publications

This report is one of four reports containing an energy assessment of options for upgrading the district heating system of the City of Handlova in the Republic of Slovakia:

Assessment of Supply-Side Alternatives for the Handlova Heating System.

An Assessment of the Building Sector Efficiency Resource for the Town of Handlova

Integrated Assessment of Supply and Efficiency Resources for the District Heating System, City of Handlova, Republic of Slovakia

Preliminary Business Plan - District Heating Company for the City of Handlova, Slovakia

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