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

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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 Kl 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/m^3. Boilers with natural circulation are equipped with closed-loop coal feed and electrostatic filters. Boiler Kl 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$_t$). 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.

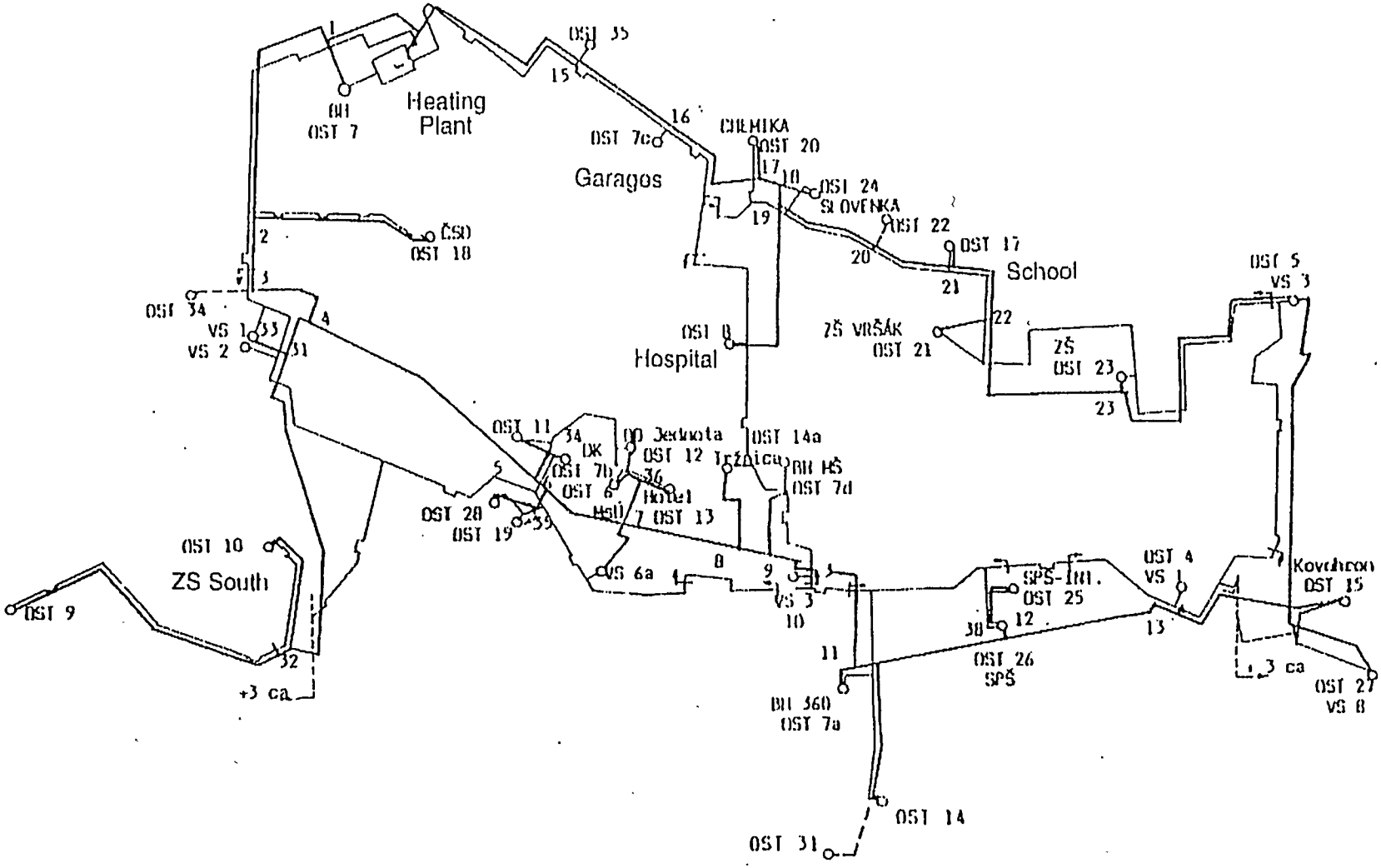

Figure 2.1. Layout of the Handlova District Heating System

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 Pl-I5-NKS	[1982-1991]
Res-6	Two-family detached houses	
Res-7	Single-family detached houses	

For building types Res-l 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 (m^2)					
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_t 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

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 [SK/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	20.50	20.51	20.52	20.53	20.54	20.55
Electricity Price (SK/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 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
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):			0.000	Years to Implement:		0			Total Cost:	0				Supply System Upgrade Cost:		333,653		
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
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	558.9
Heat Price (SK/GJ)		202.97	203.12	204.02	204.76	205.59	226.75	236.37	241.53	247.02	252.90	85.16	84.03	82.65	81.02	79.12	76.93	74.42	71.59	68.39
Heat Sale Revenues (1,000SK)		105,303	105,475	106,042	106,527	107,058	118,188	123,314	126,122	129,110	132,305	44,604	44,044	43,360	42,543	41,585	40,470	39,189	37,731	36,081
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)		133,568	135,453	137,836	140,247	142,822	156,118	163,541	168,786	174,360	180,296	95,503	98,026	100,613	103,264	105,984	108,771	111,629	114,559	117,564
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
Coal Price (SK/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)		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	68,122	69,996	71,923	73,902	75,935
Gas Consumption (1000m3/yor)		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
Gas Price (SK/1,000m3)		3,350	3,445	3,544	3,645	3,749	3,855	3,965	4,078	4,194	4,314	4,374	4,436	4,498	4,561	4,625	4,689	4,755	4,822	4,889
Gas Cost (1,000 SK/year)		12,982	13,363	13,754	14,158	14,573	15,000	15,440	15,892	16,358	16,838	17,087	17,340	17,597	17,857	18,122	18,390	18,662	18,939	19,219
Total Fuel Cost (1,000 SK/year)		59,568	61,230	62,939	64,696	66,501	68,357	70,265	72,226	74,242	76,314	78,200	80,135	82,119	84,155	86,244	88,387	90,585	92,840	95,154
Efficiency Expenditures (1,000 SK)		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	12,876	13,198	13,528	13,866	14,213	14,568	14,932	15,306	15,688
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)		14,902	14,902	14,902	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036
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	2,656	2,686	2,715	2,745	2,775	2,805	2,836	2,867	2,898
Total Operating Costs (1,000 SK)		93,579	95,912	98,291	99,877	102,403	105,006	107,689	110,453	113,302	116,238	118,694	121,213	123,794	126,441	129,155	131,937	134,789	137,713	140,711
Operating Profit - Before Tax (1,000 SK)		39,989	39,541	39,544	40,370	40,418	51,111	55,852	58,333	61,058	64,058	-23,192	-23,187	-23,182	-23,177	-23,170	-23,165	-23,160	-23,154	-23,147
Operating Margin, %		29.9%	29.2%	28.7%	28.8%	28.3%	32.7%	34.2%	34.6%	35.0%	35.5%	-24.3%	-23.7%	-23.0%	-22.4%	-21.9%	-21.3%	-20.7%	-20.2%	-19.7%
Operating Profit - After Tax (1,000 SK)		39,989	39,541	39,544	40,370	40,418	30,667	33,511	35,000	36,635	38,435	-13,915	-13,912	-13,909	-13,906	-13,902	-13,899	-13,896	-13,892	-13,888
Cash Flow from Operations, After Tax		54,891	54,443	54,446	54,406	54,454	44,703	47,547	49,036	50,671	52,471	121	124	127	130	134	137	140	144	148
Working Capital (1,000 SK)	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	6,787	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	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
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	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036
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	162,621	148,585	134,549	120,513	106,477	92,441	78,405	64,369
Net Operating Assets (1,000 SK)		324,742	309,983	295,226	281,296	267,414	252,014	238,110	224,211	210,315	196,424	182,509	168,596	154,687	140,781	126,879	112,980	99,084	85,192	71,304
Increase in Net Operating Assets (1,000 SK)		324,742	-14,759	-14,756	-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	-13,892	-13,888
Net Cash Flow from Operations AfterTax		54,300	54,300	54,300	54,300	54,300	46,067	47,415	48,899	50,531	52,326	0	0	0	0	0	0	0	0	0
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										
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	236,493	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	236,493	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	46,067	47,415	48,899	50,531	52,326	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0
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
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 (SK/year)		12,710	12,719	12,775	12,822	12,874	14,199	14,801	15,124	15,468	15,836	5,334	5,262	5,175	5,073	4,954	4,817	4,660	4,483	4,283

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:	2.85%	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	19 82	19 30	18 77	18 18	17.5	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 (SK/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 SK)		28,266	29,186	30,115	31,051	31,879	32,464	34,442	36,540	38,766	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):		116.19	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 (SK/GJ)		202.97	219.28	238.25	259.27	283.08	370.64	380.22	384.45	389.55	395.65	182.88	167.06	150.09	131.86	112.27	91.22	88.69	85.80	82.62
Heat Sale Revenues (1,000SK)		105,303	108,771	112,763	116,812	121,096	150,120	154,184	156,087	158,348	161,018	74,516	68,153	61,301	53,920	45,966	37,390	36,397	35,254	33,947
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)		133,568	137,957	142,878	147,863	152,975	182,584	188,626	192,627	197,114	202,146	118,150	114,445	110,413	106,024	101,245	96,037	98,617	101,264	103,979
Coal Consumption (tons/year)		68,509	66,894	65,280	63,665	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 (SK/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)		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/yer)		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 (SK/1,000m3)		3,350	3,445	3,544	3,645	3,749	3,855	3,965	4,078	4,194	4,314	4,374	4,436	4,498	4,561	4,625	4,689	4,755	4,822	4,889
Gas Cost (1,000 SK/year)		12,982	12,852	12,704	12,537	12,237	11,686	12,039	12,403	12,777	13,163	13,369	13,578	13,791	14,006	14,226	14,448	14,675	14,904	15,137
Total Fuel Cost (1,000 SK/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 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	15,688
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)		14,902	14,902	14,902	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036
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)		119,839	121,190	122,517	122,978	124,233	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 SK)		13,729	16,767	20,361	24,885	28,742	87,686	91,310	92,817	94,734	97,115	10,902	4,924	-1,438	-8,216	-15,445	-23,165	-23,160	-23,154	-23,147
Operating Margin, %		10 3%	12.2%	14 3%	16.8%	18 8%	48 0%	48.4%	48 2%	48.1%	48 0%	9 2%	4 3%	-1 3%	-7.7%	-15 3%	-24 1%	-23 5%	-22 9%	-22 3%
Operating Profit - After Tax (1,000 SK)		13,729	16,767	20,361	24,885	28,742	52,612	54,786	55,690	56,840	58,269	6,541	2,955	-863	-4,930	-9,267	-13,899	-13,896	-13,892	-13,888
Cash Flow from Operations, After Tax		28,631	31,669	35,263	38,921	42,778	66,648	68,822	69,726	70,876	72,305	20,577	16,991	13,174	9,108	4,769	137	140	144	148
Working Capital (1,000 SK)	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	6,787	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	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
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	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036	14,036
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	162,621	148,585	134,549	120,513	106,477	92,441	78,405	64,369
Net Operating Assets (1,000 SK)		324,742	309,983	295,226	281,296	267,414	252,014	238,110	224,211	210,315	196,424	182,509	168,596	154,687	140,781	126,879	112,980	99,084	85,192	71,304
Increase in Net Operating Assets (1,000 SK)		324,742	-14,759	-14,756	-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	-13,892	-13,888
Net Cash Flow from Operations AfterTax		28,040	31,626	35,117	38,815	42,624	68,012	68,690	69,589	70,736	72,160	20,456	16,867	13,047	8,978	4,635	0	0	0	0
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										
New Funds Borrowed (1,000 SK)	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	0
Loan Balance @ Beginning of Year (1,000 SK)	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	0
Principle Repaid	0	20,935	24,676	28,841	33,473	38,621	44,338	48,772	53,649	59,014	64,915	17,106	14,543	11,595	8,221	4,373	0	0	0	0
Loan Balance @ End of Year (1,000 SK)	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	0
Total Interest Payments (1,000 SK)	0	33,365	33,898	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	0
Total After Tax Loan Repayments (1,000 SK)	0	54,300	58,574	62,976	67,510	72,180	68,012	68,690	69,589	70,736	72,160	20,456	16,867	13,047	8,976	4,635	0	0	0	0
Total Loan Repayments (1,000 SK)	0	54,300	58,574	62,976	67,510	72,180	76,990	76,990	76,990	76,990	76,990	22,690	18,416	14,014	9,480	4,810	0	0	0	0
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
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 (SK/year)		12,710	12,460	12,157.	11,727	11,162	12,467	12,789	12,931	13,103	13,308	6,151	5,619	5,048	4,435	3,776	3,068	2,983	2,886	2,776

25 Year Lovelized Energy Cost	258.35 SK/GJ
25 Year Lovelized Energy Cost Per Flat	10,597 SK/GJ

Cash Flow Forecast: Price Set to Meet Loan Repayments

Handlova Centralized 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)		24 67	24 69	24 70	24.72	24 73	24.7	24.76	24.78	24.79	24 81	24 82	24 84	24 85	24 87	24.88	24 90	24 91	24 93	24 94
Electricity Price (SK/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 SK)		34,270	36,348	38,552	40,890	43,370	46,000	48,789	51,748	54,886	58,214	61,744	65,489	69,460	73,673	78,140	82,879	87,905	93,236	98,890
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):			0.00	Years to Implement:		0		Total Cost:	0					Supply System Upgrade Cost:		290,350		
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
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	558 9
Heat Price (SK/GJ)		183.64	183.11	183.40	183.48	183.61	200.64	208.89	212.58	216.49	220.66	73.99	72.20	70.13	67.75	65.05	61.98	58.54	54.69	50.40
Heat Sale Revenues (1,000SK)		95,223	95,087	95,324	95,457	95,612	104,576	108,980	111,009	113,155	115,439	38,743	37,844	36,792	35,578	34,189	32,609	30,825	28,825	26,589
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	131,435	133,876	136,347	138,981	150,576	157,769	162,756	168,041	173,653	100,488	103,333	106,253	109,250	112,329	115,488	118,730	122,061	125,480
Coal Consumption (tons/year)		91,970	92,015	92,060	92,104	92,149	92,194	92,239	92,284	92,329	92,374	92,419	92,464	92,510	92,555	92,600	92,645	92,691	92,736	92,782
Coal Price (SK/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	64,259	66,027	67,842	69,708	71,625	73,595	75,619	77,698	79,835	82,031	84,287	86,605	88,986	91,434	93,948	96,532	99,187	101,915
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 (SK/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	64,259	66,027	67,842	69,708	71,625	73,595	75,619	77,698	79,835	82,031	84,287	86,605	88,986	91,434	93,948	96,532	99,187	101,915
Efficiency Expenditures (1,000 SK)		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	12,876	13,198	13,528	13,866	14,213	14,568	14,932	15,306	15,688
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	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304
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	2,656	2,686	2,715	2,745	2,775	2,805	2,836	2,867	2,898
Total Operating Costs (1,000 SK)		94,819	97,209	99,647	101,292	103,878	106,542	109,287	112,114	115,026	118,026	120,793	123,633	126,548	129,540	132,612	135,766	139,004	142,328	145,740
Operating Profit - Before Tax (1,000 SK)		34,674	34,226	34,229	35,055	35,103	44,033	48,483	50,643	53,015	55,626	-20,305	-20,300	-20,295	-20,290	-20,283	-20,278	-20,273	-20,267	-20,260
Operating Margin, %		26.8%	26 0%	25 6%	25.7%	25 3%	29.2%	30.7%	31.1%	31 5%	32 0%	-20 2%	-19 6%	-19 1%	-18 6%	-18.1%	-17.6%	-17.1%	-16 6%	-16 1%
Operating Profit - After Tax (1,000 SK)		34,674	34,226	34,229	35,055	35,103	26,420	29,090	30,386	31,809	33,376	-12,183	-12,180	-12,177	-12,174	-12,170	-12,167	-12,164	-12,160	-12,156
Cash Flow from Operations, After Tax		47,844	47,396	47,399	47,359	47,407	38,724	41,394	42,690	44,113	45,680	121	124	127	130	134	137	140	144	148
Working Capital (1,000 SK)	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	6,787	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	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304
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	158,259	146,079	133,902	121,728	109,558	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	-12,183	-12,180	-12,177	-12,174	-12,170	-12,167	-12,164	-12,160	-12,156
Net Cash Flow from Operations AfterTax		47,253	47,253	47,253	47,253	47,253	40,088	41,262	42,553	43,973	45,535	0	0	0	0	0	0	0	0	0
Debt Source Information		Interest Rate on Supply Loan:			10%			Loan Term (years):		10		Loan Amount:		290,350						
Debt Source Information		Interest Rate on Efficiency Loans:			10%			Loan Term (years):		10										
New Funds Borrowed (1,000 SK)	290,350	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	290,350	272,132	252,092	230,048	205,800	179,127	149,786	117,512	82,010	42,957	0	0	0	0	0	0	0	0	0
Principle Repaid	0	18,218	20,040	22,044	24,248	26,673	29,340	32,275	35,502	39,052	42,957	0	0	0	0	0	0	0	0	0
Loan Balance @ End of Year (1,000 SK)	0	272,132	252,092	230,048	205,800	179,127	149,786	117,512	82,010	42,957	0	0	0	0	0	0	0	0	0	0
Total Interest Payments (1,000 SK)	0	29,035	27,213	25,209	23,005	20,580	17,913	14,979	11,751	8,201	4,296	0	0	0	0	0	0	0	0	0
Total After Tax Loan Repayments (1,000 SK)	0	47,253	47,253	47,253	47,253	47,253	40,088	41,262	42,553	43,973	45,535	0	0	0	0	0	0	0	0	0
Total Loan Repayments (1,000 SK)	0	47,253	47,253	47,253	47,253	47,253	47,253	47,253	47,253	47,253	47,253	0	0	0	0	0	0	0	0	0
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
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 (SK/year)		11,493	11,466	11,484	11,489	11,497	12,563	13,080	13,311	13,556	13,817	4,633	4,521	4,391	4,243	4,073	3,881	3,666	3,425	3,156

25 Year Levelized Energy Cost	164.64	SK/GJ
25 Year Levelized Energy Cost Per Flat	10,309	SK/GJ

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%	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)		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 (SK/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 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): 118.19				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 (SK/GJ)		183.64	199.19	217.49	237.81	260.90	349.40	351.66	354.25	357.68	361.95	176.61	160.15	142.69	123.72	103.44	81.62	78.26	74.48	70.22
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	71,919	65,334	58,239	50,591	42,348	33,455	32,118	30,600	28,886
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	144,466	149,807	177,855	183,696	187,468	191,696	196,436	124,046	120,641	116,919	112,852	108,406	103,543	106,482	109,500	112,599
Coal Consumption (tons/year)		91,970	89,881	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 (SK/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 (SK/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	15,688
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	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304
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	110,257	112,829	115,470	118,181	120,964	123,822	126,755	129,767	132,859
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	13,789	7,811	1,449	-5,329	-12,558	-20,278	-20,273	-20,267	-20,260
Operating Margin, %		6 5%	8 5%	10 8%	13 5%	15 6%	45 3%	45 7%	45.4%	45 2%	45 1%	11 1%	6 5%	1 2%	-4.7%	-11.6%	-19 6%	-19 0%	-18 5%	-18 0%
Operating Profit - After Tax (1,000 SK)		8,414	11,452	15,045	19,570	23,427	48,365	50,365	51,076	52,014	53,210	8,273	4,687	870	-3,198	-7,535	-12,167	-12,164	-12,160	-12,156
Cash Flow from Operations, After Tax		21,584	24,622	28,215	31,874	35,731	60,669	62,669	63,380	64,318	65,514	20,577	16,991	13,174	9,106	4,769	137	140	144	148
Working Capital (1,000 SK)	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	6,787	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	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304	12,304
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	158,259	146,079	133,902	121,728	109,558	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	-12,183	-12,180	-12,177	-12,174	-12,170	-12,167	-12,164	-12,160	-12,156
Net Cash Flow from Operations AfterTax		20,993	24,479	28,069	31,768	35,577	62,033	62,537	63,243	64,178	65,369	20,456	16,867	13,047	8,976	4,635	0	0	0	0
Debt Source Information		Interest Rate on Supply Loan: 10%						Loan Term (years): 10			Loan Amount: 290,350									
Debt Source Information		Interest Rate on Efficiency Loans: 10%						Loan Term (years): 10												
New Funds Borrowed (1,000 SK)	290,350	26,260	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	306,058	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	21,686	25,554	29,857	34,643	39,962	43,958	48,354	53,189	58,508	17,106	14,543	11,595	8,221	4,373	0	0	0	0
Loan Balance @ End of Year (1,000 SK)	0	272,132	276,704	278,199	276,201	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	20,456	16,867	13,047	8,976	4,635	0	0	0	0
Total Loan Repayments (1,000 SK)	0	47,253	51,527	55,929	60,463	65,133	69,943	69,943	69,943	69,943	69,943	22,690	18,416	14,014	9,480	4,810	0	0	0	0
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
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 (SK/year)		11,493	11,318	11,097	10,756	10,288	11,550	11,825	11,915	12,031	12,175	5,937	5,387	4,796	4,161	3,479	2,745	2,632	2,505	2,362

25 Year Levelized Energy Cost	236.72 SK/GJ
25 Year Levelized Energy Cost Per Flat	9,697 SK/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 0	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 (SK/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 SK)		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		Efficiency Potential (TJ):			0.00		Years to Implement: 0				Total Cost: 0						Supply System Upgrade Cost:		254,880	
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 (SK/GJ)		226.90	231.88	235.37	238.84	242.65	267.43	282.42	291.42	299.25	307.66	134.73	137.08	139.45	141.87	144.32	146.81	149.34	151.91	154.53
Heat Sale Revenues (1,000SK)		85,605	87,566	88,966	90,361	91,889	101,365	107,148	110,665	113,743	117,049	51,306	52,249	53,202	54,176	55,163	56,165	57,188	58,225	59,284
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)		85,605	87,566	88,966	90,361	91,889	101,365	107,148	110,665	113,743	117,049	51,306	52,249	53,202	54,176	55,163	56,165	57,188	58,225	59,284
Coal Consumption (tons/year)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal Price (SK/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)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Consumption (1000m3/yer)		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 (SK/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)		37,099	39,278	40,438	41,628	42,852	44,117	45,416	46,752	47,453	48,161	48,879	49,612	50,351	51,106	51,868	52,641	53,430	54,226	55,039
Total Fuel Cost (1,000 SK/year)		37,099	39,278	40,438	41,628	42,852	44,117	45,416	46,752	47,453	48,161	48,879	49,612	50,351	51,106	51,868	52,641	53,430	54,226	55,039
Efficiency Expenditures (1,000 SK)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Labor (1,000 SK)		1,800	1,874	1,951	2,031	2,114	2,201	2,291	2,385	2,482	2,584	2,649	2,715	2,783	2,852	2,924	2,997	3,072	3,149	3,227
Overhead (1,000 SK)		2,300	2,386	2,475	2,568	2,664	2,763	2,866	2,973	3,085	3,200	3,275	3,351	3,429	3,509	3,591	3,675	3,761	3,849	3,939
Maintenance & Repairs (1,000 SK)		2,300	2,369	2,440	2,513	2,589	2,666	2,746	2,829	2,914	3,001	3,061	3,122	3,185	3,248	3,313	3,380	3,447	3,516	3,586
Depreciation (1,000 SK)		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 SK)		35	35	36	36	36	37	37	37	38	38	39	39	39	40	40	41	41	41	42
Total Operating Costs (1,000 SK)		53,729	56,137	57,534	58,970	60,450	61,979	63,551	65,171	66,167	67,179	68,097	69,034	69,983	70,951	71,932	72,928	73,946	74,977	76,029
Operating Profit - Before Tax (1,000 SK)		31,876	31,428	31,431	31,391	31,439	39,386	43,596	45,493	47,576	49,870	-16,790	-16,785	-16,780	-16,775	-16,769	-16,764	-16,759	-16,752	-16,745
Operating Margin, %		37.2%	35 9%	35.3%	34 7%	34 2%	38 9%	40 7%	41.1%	41 8%	42 6%	-32 7%	-32.1%	-31 5%	-31 0%	-30 4%	-29 8%	-29 3%	-28 8%	-28 2%
Operating Profit - After Tax (1,000 SK)		31,876	31,428	31,431	31,391	31,439	23,632	26,158	27,296	28,546	29,922	-10,074	-10,071	-10,068	-10,065	-10,061	-10,058	-10,055	-10,051	-10,047
Cash Flow from Operations, After Tax		42,071	41,623	41,626	41,586	41,634	33,827	36,353	37,491	38,741	40,117	121	124	127	130	134	137	140	144	148
Working Capital (1,000 SK)	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	6,787	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	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
Capital Expenditures (1,000 SK)	254,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Depreciation (1,000 SK)		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 SK)	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	61,171
Net Operating Assets (1,000 SK)		250,675	240,623	230,574	220,485	210,444	198,885	188,821	178,763	168,708	158,658	148,584	138,512	128,444	118,379	108,318	98,260	88,204	78,153	68,106
Increase in Net Operating Assets (1,000 SK)		250,675	-10,052	-10,049	-10,089	-10,041	-11,559	-10,063	-10,058	-10,055	-10,050	-10,074	-10,071	-10,068	-10,065	-10,061	-10,058	-10,055	-10,051	-10,047
Net Cash Flow from Operations AfterTax		41,480	41,480	41,480	41,480	41,480	35,191	36,221	37,354	38,601	39,972	0	0	0	0	0	0	0	0	0
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 SK)	254,880	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	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	0
Principle Repaid	0	15,993	17,592	19,351	21,286	23,415	25,756	28,332	31,165	34,281	37,710	0	0	0	0	0	0	0	0	0
Loan Balance @ End of Year (1,000 SK)	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	0
Total Interest Payments (1,000 SK)	0	25,488	23,889	22,130	20,194	18,066	15,724	13,149	10,316	7,199	3,771	0	0	0	0	0	0	0	0	0
Total After Tax Loan Repayments (1,000 SK)	0	41,480	41,480	41,480	41,480	41,480	35,191	36,221	37,354	38,601	39,972	0	0	0	0	0	0	0	0	0
Total Loan Repayments (1,000 SK)	0	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	41,480	0	0	0	0	0	0	0	0	0
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
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 (SK/year)		14,208	14,520	14,738	14,956	15,194	16,748	17,684	18,248	18,738	19,265	8,437	8,584	8,732	8,884	9,037	9,193	9,351	9,512	9,676

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