UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

20964

MINISTRY OF ENVIRONMENT, FINLAND

VTT ENERGY

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AVECON

LNWT IN ENERGY PRODUCTION IN EAST EUROPE

CASE STUDIES ON WASTE MANAGEMENT AND COGENERATION

By

Yehia ElMahgary	VTT - Energy, Finland
Taunu Kuitunen	Wärtsilä Diesel
Jan Teir	AVECON, Finland
Ionel Radu	Hepardimpex, Romania
Gheorghe Ivnuş	UNIDO Consultant
L. Baranayi	Hungary Academy of Science
Rodolf Štefec	NIS, Czech Rep.

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PREFACE

These case studies were undertaken within the UNIDO Project on Low and Non-Waste Technology (LNWT) in Energy Production jointly financed by The Ministry of Environment of Finland, The Technical Research Centre of Finland (VTT - Energy), UN/DESD, UNEP and UNIDO. The project was executed by VTT - Energy in cooperation with a number of Consulting Agency.

The project included a Workshop and Study Tour held in June 1993 in Finland and Case Studies in a number of participating countries.

The present Case Studies on Waste Management and Cogeneration in East Europe were undertaken by VTT - Energy in cooperation with Wärtsilä Diesel and AVECON OY in Finland and a number of individual consultants in the Czech Republic, Hungary and Rumania.

LIST OF CONTENTS

II. CASE STUDY ON HUNGARY

A. GENERAL INFORMATION ON THE PRESENT ENERGY AND ENVIRONMENT SITUATION IN THE COUNTRY

1. **Present situation in the energy sector**
2. **The environmental aspects of the current situation**
3. **Future plans in the energy sector**

B. ENERGY DEMAND FORECAST AND STRUCTURE OF THE FUTURE ENERGY PRODUCTION SYSTEM IN HUNGARY

C. REVIEW OF EARLIER STUDIES FOR IMPROVING ENERGY EFFICIENCY AND DECREASING ENVIRONMENTAL EMISSIONS.

D. ACTIONS TAKEN INCLUDING LNWT FOR IMPROVING ENERGY SITUATION AND DECREASING EMISSIONS FROM ENERGY PRODUCTION.

E. THE PRESENT SITUATION CONCERNING MUNICIPAL, SOCIETAL AND OTHER BIOLOGICAL WASTES

F. WASTE COMPOSITION, AMOUNTS, LARGE PRODUCERS, TRANSPORTATION SYSTEM AND METHOD OF PAYMENT

G. EXISTING TREATMENT PLANTS/LANDFILLS AND THEIR EXPECTED AGE

H. CASE STUDY ON CCOGENERATION IN HUNGARY

1. **Potential for Cogeneration Diesel Power Plant**
2. **Description of cogeneration Diesel Power Plant**
3. **Applications of diesel power plants**
4. **Environmental aspects**
5. **Performance of a diesel power plant**
6. **Economics of a diesel power plant in a selected case**

III. CASE STUDY ON ROMANIA

A. INTRODUCTION ON THE PRESENT ENERGY AND ENVIRONMENT SITUATION

1. **Installed Capacity**
2. **Energy Production**
3. **Energy Economics and Tariff**

4. **The Environmnet**

B. REVIEW OF STUDIES ON IMPROVING ENERGY EFFICIENCY AND DECREASING ENVIRONMENTAL EMISSIONS

1. **Improving Energy Situation**
2. **Decreasing Emissions from Energy Production**

C. ECONOMIC AND ENVIRONMENTAL COMPARISON OF ENERGY PRODUCTION ALTERNATIVES

D. PLAN OF ACTION FOR THE INTRODUCTION OF LNWT IN ENERGY PRODUCTION

1. **Future investments**
2. **Other Projects on LNWT in Energy Production**

E. FINANCIAL CONSTRAINTS

F. CASE STUDY ON MUNICIPAL WASTE MANAGEMENT IN BUCHAREST

1. **Use of Domestic Wastes**
2. **Waste Management in Bucharest**
3. **Pilot Plant Suggested**
4. **Plant Components**

ANNEX

I. CASE STUDY ON THE CZECH REPUBLIC

A. GENERAL INFORMATION ON ENERGY AND ENVIRONMENT SITUATION IN THE COUNTRY

1. Development of Energy Economy in the Czech Republic

The major negative factors affecting energy sector for the past 45 years were:

* the almost exclusive political and economic orientation of the former USSR
* the acceptance of the model of a centralized management of all sectors and of the entire economy
* abundant red tape including all levels of management in the fuels and energy sector
* environmental data treated as classified material over a number of years.

The complete dependence on oil and gas imports from the USSR has been the most important single factor influencing all concepts and decisions within the energy sector. Even though the general situation in what today is the Czech Republic has changed dramatically in most sectors of the economy and of everyday life, the change sofar has been less remarkable in the fuels and energy sector, because of its large size and because of the associated inertia of the systems involved, and also because of the huge financial resources required.

The Czech Republic depends on imported oil and domestic coal and natural uranium. Total primary energy supply (TPES) used in the Czech Republic (CR) in 1992 were approximately 1.8 EJ. Industrial and construction activities were reduced, GDP fell dramatically from 1989 to 1993. The Czech economy is not expected to show positive GDP growth in 1993. Following a 7.1 % drop in 1992, an additional drop of about 2 % in GDP is expected in 1993.

Energy intensity (TPES/GDP) is increasing from its value in 1990. Of the primary sources, consisting of coal, oil, natural gas, nuclear fuel, hydroelectric power and imports, 67.7 % were produced by domestic sources. The imported oil was 15.3 % and natural gas was 12.6 %. The basic indices of Energy Economy are given in Table 1.

Because of the current economic stagnation, power requirements are now decreasing and are expected to continue doing so for the next one or two years. When economic growth materializes, it would accordingly lead to an increase in energy demand.

Table 1. Basic Indices of Energy Economy

Indices	Unit	1986	1987	1988	1989	1990	1991	1992
GDP	bill. Kcs	475.2	486.2	501.5	511.8	505.6	432.2	401.5
Total Primary Energy Supply	PJ	2188.7	2233.4	2189.5	2151.2	2076.1	1937.5	1800.6
Gross Consumption of Electricity	TWh	58.8	60.9	61.6	62.4	61.9	58.0	56.1
Energy Intensity (TPES/GDP)	PJ/bill.Kcs	4.61	4.59	4.37	4.20	4.11	4.48	4.49
Inhabitants	mil.inhab.	10.34	10.35	10.36	10.36	10.36	10.31	10.32

The hydro power potential of CR is only about 3 % of the total power consumption. The structure of the final energy consumption by type is given in Fig. 1.

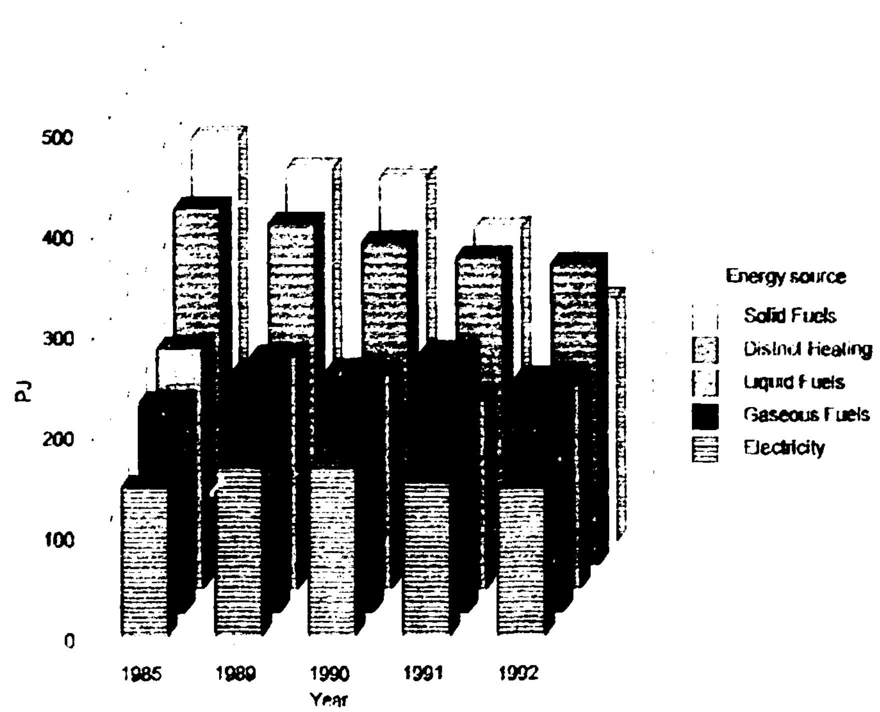

Fig. 1. Energy Consumption by source (PJ)

It is necessary to improve the efficiency in the production and use of energy as well as to conserve energy. The result of a study on Demand Side Management (DSM) indicates that the CR could reduce energy consumption during the next years by applying energy conservation measures.

Energy position in CR and existing energy sources determine the roles of coal and nuclear power. Czech energy sector is characterized by high pollution levels, inefficient production and consumption, and dependence on imported oil and gas. Privatization and market competition are the main urgent tasks to start with in moving to conditions of market-oriented prices for energy.

2. Technology and Environment

Existing technology on the one hand and the present state of the environment on the other hand need to be reviewed.

2.1. Technology

The Czech Republic could be described literally as being over flooded with technology. Not all of it, of course, is up-to-date, and this is particularly true for the energy sector[1]:

- Industry is an energy-intensive sector, with a high share of metallurgy, heavy engineering and similar energy-consuming industries; the efficiency of energy utilization is low and the environmental impacts are considerable.

- Coal continues to be the dominant primary source of energy; again this is considered environmentally as a negative sign.

- The policy of cheap power for industry resulted in a high waste of energy resources; power prices for industry sector are now climbing but they are still lag behind the international level.

- Process upgrading was slow resulting in a general retardation of technological development in the spheres of power generation, transmission and consumption.

- The technical parameters of existing power plants are rather poor; complete overhauls and rehabilitation are required to upgrade performance.

2.2. Environment

The state of environment protection in Czech enterprises within the power and energy sector is known to be rather unsatisfactory in many respects and this applies to almost all the country's installations.

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[1]The average age of thermal power stations in the Czech Republic is 24 years.

The coal-fired power plants emit large quantities of various pollutants of which some affect not only the atmosphere but also the waters and the soil. Sulphur is the main source of pollution in the emissions. Some enterprises/companies have become semi-permanent storage sites of various dangerous wastes which are yet to be disposed of in a safe manner.

Environmental monitoring is in progress, and an environmental audit methodology project is envisaged. Legislation is rather advanced[2] but enforcement is problematic. The following are the official permissible limits (mg/m^3) applied for pollutants emitted by sources having over 5 MW output[3]:

Output	Particulates	SO_2	NO_x	CO
Solid fuels				
5 - 50 MW	15	2500	650	--
50 - 300 MW	100	1700	650	250
over 300 MW	100	500	650	250
Liquid fuels				
5 - 50 MW	100	1700	450	175
50 - 300 MW	50	1700	450	175
over 300 MW	50	500	450	175
Gaseous fuels				
over 5 MW	10	35	200	100

B. ACTIONS TAKEN TO IMPROVE THE SITUATION

A number of steps have already been taken, or follow automatically other actions, to abate pollution, and/or mitigate its effects. For example, in 1991 the level of electric power generation dropped below that of 1980, due to decreasing demand. Power export also has decreased. The first industrial-scale desulfurization unit is already in operation[4]. Implementation of a number of initial steps together with the over-all trend has made it possible to decrease sulfuric dioxide emissions from about 1.3 Mt/yr in 1980 to about 1.0 Mt/yr in 1991. Particulate emissions dropped from 480 kt/y to 100 kt/y over the same period[5].

[2]Environmental laws of the Czech Republic are available in English (over 600 pp. in three volumes).

[3]Official list and limit concentrations of pollutants as per Regulation of the (former) Federal Commission for the Environment, dated January 1, 1991.

[4]Donated by the Government of Bavaria for the Tisová power station. However, the desulfurization there no longer complies with Czech regulations.

[5]The emissions of nitrogen oxides remained at the same level in 1991 as in 1980.

The long-term objective of the Czech fuels and energy policy is a reliable, safe, economic and environment-friendly supply and distribution system throughout the country. The basic steps to achive this goal include

- improved energy utilization with ensuing direct decrease in demand
- learning from the experience of more advanced countries which have demonstrated that money invested in energy-saving and conservation decreases the total energy costs.
- broad desulphurisation programme
- increasing the share of nuclear power
- learning to live with higher energy prices.

C. PROBLEMS AND BARRIERS

The demand for energy sources in the Czech Republic is estimated in Fig. 2[6]:

The global strategy adopted by the Czechoslovak Government and Federal Parliament[7] basically continues to be the strategy of the Czech Government. The only major decision taken sofar by the Czech Republic was the go-ahead sign for the completion of the somewhat controversial Temelín nuclear power station[8]. The strategy is

- to reduce the energy demands of the Czech economy and yet to provide necessary energy for the nation
- to stick to domestic supplies where feasible while protecting the environment, and to continue (or even expand) purchases of fuels and energy from abroad when less expensive
- to do all this mainly through
    * an active pricing policy
    * massive investment in technology upgrading
    * energy-saving programs
    * integration of the Czech system of fuels and energy (power, gas, oil) on the European scale.

And the major goals are

- to continue cutting down lignite and stone coal extraction

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[6]A special study by Vít Štefec.

[7]Prior to splitting Czechoslovakia, the then Federal Government passed one of its major bills in 1991 - the Program of a structural policy of the State as a component of the fundamental economic reform. An important place in this program has been given to the energy policy and the future structure of the energy supply.

[8]Westinghouse won the contract to upgrade and bring to completion this originally Soviet-designed plant located in Southern Bohemia.

- to shut down a total of 1200 MW of thermal power capacity in Northern Bohemia which is the worst polluted area[9]
- to increase the share of natural gas in energy production, to expand the capacity of underground gas storage; to install more gas turbines; to bring in gas from the North[10];

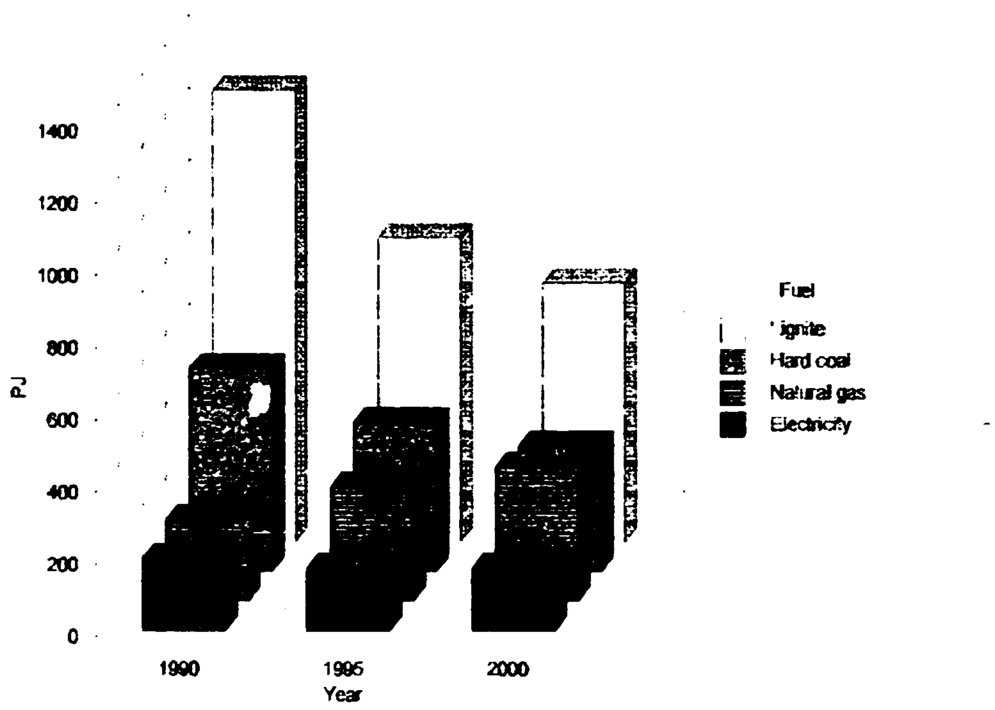

Fig. 2. Estimation of demand growth of some fuels and energy sources.

and to upgrade coal gasification[11], a technology well known and applied in the CR.
- to decrease oil consumption and build oil storage tanks[12]
- to commission a new nuclear power station in Southern Bohemia[13]

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[9] For example, the Tušimice and Prunéřov power stations.

[10] England, Norway, ...

[11] Vřesová coal conversion plant.

[12] The present storage capacity is extremely limited.

original contains color illustrations

- to evaluate continuously the power generation alternatives, i.e.,
  * coal imports vs. domestic extraction
  * coal gasification, liquefaction, and the steam-gas cycle
  * nuclear vs. thermal power
  * renewable sources of energy
- to establish closer ties with the chemical industry
- to diversify energy sources and to make full use of the geographical location in the heart of Europe
- to establish and operate special programs for the highly polluted districts.

One ambitious project aims at replacing one thermal power plant, one power and district heat plant, and a condensing power capacity by state-of-the-art technology for clean power generation based on local coals and residual/waste oil from two petrochemical plants.[14]

Another study perceives the whole of Northern Bohemia, the worst polluted region, as a single "controlled atmosphere" district where the environment would be managed using an interlinked system of monitoring and feedback control.

D. OTHER POTENTIALS FOR ENERGY PRODUCTION

1. Domestic Coal

Lignite and stone coal extraction dropped significantly from the 1984 peak figures[15] but will continue to cover a major portion of the country's energy inputs. The environmental conditions in the mining districts as well as downwind of the power stations is improving. However, the country needs to maintain a strategic reserve in mining capacities in order to guard itself against the instability of the international energy market. The transition to market economy has deeply affected the coal industry which now faces complicated social problems because of closing of mines.

2. Use of LNWT in Power Production

By the year 2005, thermal power generation should be halved. The share of nuclear power plants will increase. Several thermal power stations[16] will be converted to heat plants equipped with desulphurization. Some of the power plants (although shut down) will not be dismantled, but used as a strategic reserve.

* The fluidized bed combustion process will be used more widely, while desulphurization units are expected to be installed virtually in all power plants. This appears to be mainly wet limestone

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[14]The venture is organized as a stand-alone investment providing utilities to the petrochemical facility while receiving a share of its production.

[15]104 Mt of lignite and 26.4 Mt of stone coal incl. the coking grades (for the whole of Czechoslovakia).

[16]For example, one block at Mělník.

desulphurization. Regulated dumping of cinders and soil re-cultivation rank among the other important projects.

* Small hydro-electric power plants, although unable to play a major role in the energy balance, will reappear thanks to private business.

* Storage-pumping hydro-electric power stations[17] will remain to be of some importance for power grid regulation.

* A regional network of heat plants is being developed together with the concept of cogeneration (combined power and heat generation).

* The goals include double-purpose utilization of nuclear and thermal power plants (the latter fitted with desulphurization) for a more effective fuel utilization; utilization of fluidized bed combustion in the heat plants; and utilization of industrial waste heat.

3. Use of Nuclear Energy

The Czech Republic today seems to have no other alternative than use more nuclear energy. This is what the nuclear power advocates say. Among environmentalists, the moderates also tend to side with nuclear power. Ordinary people tend to approve nuclear power. The issue is not so provocative at the moment because of so many things changing so rapidly and other important issues in jeopardy at the pipeline in the Czech Republic for few months. The country's present nuclear power capacity is 1760 MW which is 18 % out of the total installed capacity representing the basic load[18].

Finding suitable sites for new nuclear power plants will be increasingly difficult in the Czech Republic. The bidding process for two new nuclear units which had started several years ago was discontinued. Exceptional attention is now being paid to reactor safety, both during the construction and the operation of the plant, with all the stringent standards of Europe being applied[19].

A separate problem of nuclear industry is fuel manufacturing and stocking[20]. Here, the country is again trying to become independent on Russia, but still seeking a partnership with

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[17]Storage-pumping stations at Dlouhá Stráň in Northern Moravia but also at Dalešice and Štěchovice. In contrast, the hydro power stations at Lipno and elsewhere are of the through-flow type.

[18]Nuclear power stations do not lend themselves easily to regulation. Coal fired power stations can always be shut down and restarted but even here it is a costly and laborious process.

[19]Dukovany in Southern Moravia is the only nuclear power station in operation, raising 1760 MW; Temelín in Southern Bohemia is at an advanced stage of construction.

[20]A contract for Temelín fuel is being negotiated with Westinghouse. New (Western) fuel suppliers are sought for Dukovany, too.

Russia. Some fuel is being imported from Germany[21]. Landlocked in the heart of Europe, the CR has yet to solve the problem of nuclear waste[22].

4. Oil & Gas

The ongoing remarkable increase in the use of natural gas would surely benefit the environment. On the other hand, the country continues importing oil and gas from Russia[23]. Later on, the Czech will have to find other sources to cover the demand and to diversify fuel importers.

5. Renewable and Secondary Sources of Energy

Solar, geothermal, wind, and biomass energy as well as energy from wastes, heat pumps etc. are still regarded as advanced gadgets which have not yet found any widespread use. One reason for that is the long years of subsidized energy prices. In the near future, these new and renewable sources will not be of any major importance. Nevertheless, state support will be given to the development of these sources[24] for local projects.

6. Uranium Mining and Processing

Mining and processing of uranium in the Czech Republic was expected to continue, albeit at a reduced scale[25], until this was reversed by a recent Government decision to put the uranium industry "into stand-still". The policy is to have reserves of all fuels including uranium for nuclear, but also to diversify the sources of fuels and energy and no longer to add to underground pollution bv uranium mining.

7. Utilization of Energy

The concept of energy conservation in the industry is marked with a shift away from the energy-intensive industries due to restructuring. It is hoped that ineffective exports of energy (in the form of energy-intensive products) will also be curbed and that production programs with efficient energy equipment and improved energy utilization will be preferred. Control systems

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[21]From the NORD power station, Peenemunde, Eastern Germany where operations were shut down.

[22]Ukraine has prohibited any transportation of spent nuclear fuel over her territory. Hence the only logical destination, Russia, cannot be reached. Consequently, spent fuel is accumulating at Dukovany in temporary storage; it is estimated that a permanent storage site must be ready by the year 2003. Dukovany shutdown by 2003 is the only other alternative left, unless access to Russia is reopened. Low-radiation waste is solidified and stored.

[23]These rouble contracts will remain valid for some years to come, making gas relatively cheap for the Czech.

[24]The pertinent bill is yet to be made into law.

[25]Until 1993, the uranium produced was being purchased by the State for the state reserves. The Czech Republic is well capable of extracting enough uranium to cover local requirements, but local production is more expensive than purchasing uranium from abroad. Incidentally, Slovakia has no appreciable uranium deposits on her territory.

(power installations and appliances) and measuring devices (mainly. for heat[26]) are in great demand. All this should be oriented to cutting down the over-all consumption of energy.

Wider use of natural gas and wider electrification of households (with the full range of electric appliances, electric heating, etc.) will significantly increase gas and power consumption in the public sector. However, the substantial decrease in energy consumption by the industry is an essential prerequisite. This decrease has to come in all sectors of energy consumption including electric power generation where the efficiency of power utilization should grow.

In order to estimate the future development of the Czech power and energy sector, several scenarios have been elaborated. Their principal items are to decrease ineffective consumption of gas and oil and to continue supplying enough electric power. Oil and gas imports have to be diversified. Diversification of natural gas supply will come with an extended pipeline[27]. Parallel interconnections of refinery capacities by a system of product lines is another promising project. Diversification will give the Czech Republic a chance to join the integrating European oil and gas distribution network[28].

Imports of electric power from USSR and, later, Russia used to be a common practice; as were other imports and exports within the CMEA grid. All other power import and export activities depend on getting the Czech Republic's grid hooked on to the West European system[29].

E. WASTE MANAGEMENT CASE STUDY OF KLADNO DISTRICT

1. Introduction

Kladno district is situated about 20 km NW from Prague. It has 150 thousand of inhabitants who live in 99 communities. The biggest city and the administrative centre is Kladno with population of 75,000. The district has a great industrial potential with metallurgy and coal mining round Kladno and agriculture and other manufacturing industries in the northern part.

Waste management programme was worked out on new legislative background in the Czech Republic. All essential laws, acts and notices were passed in 1991 and 1992 and they are quite similar to relevant mandates in Germany and Austria.

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[26]E.g., to measure the heat consumed by individual households.

[27]Extension of the Trieste-Ingolstadt pipeline to Livínov and Kralupy, and extension of the Trieste-Schwechat line to Bratislava, Slovakia.

[28]Oil and gas imports from a number of different sources were considered at various times: gas from Algeria; evaporation terminal in Yugoslavia; a Mediterranean pipeline via Italy, Yugoslavia, and Austria; oil imports from Iran, Venezuela, Mexico; Tunisia, Cameroon, Gabon, Nigeria. None of these schemes has taken off the ground yet.

[29]The grids should become interconnected in 1993

2. Waste Production

The production of household and municipal wastes in towns and communities was tabulated on the grounds of

a) the records of landfill operators, and
b) statistical accounts by the Local Management Research Institute method.

Because of relatively short-termed records and the lack of scale facilities at present landfills, figures on waste volume should be regarded more as rough estimations with plus or minus 20 % accuracy.

The volume of municipal waste generated annually in the district is 58,000 tonnes. This figure comprises domestic waste, street garbage and back yard waste. Average annual amount per capita in that district is 0.39 tonnes.

In addition, there are other producers of "waste similar to domestic" and their production is 5,570 tonnes. The records from a number of small business and retail companies are unfortunately missing. On the whole, the total figure of municipal wastes generated in the district is 63,570 tonnes/year. The communities also are responsible for rubble and reconstruction waste (99,350 t/year) and sewage waste from household sceptics and sewage tanks (118 870 t/year).

3. Waste Collection

There are several companies which are involved in household waste collection and transportation within the district.

Company	Number of communities (population)		Central/local landfills (locality)
TS Kladno	24	(91 804)	central (Libušín)
TS Slany	5	(22 583)	local landfills
TS Stochov	5	(10 125)	local landfills
TS Slany	6	(3 984)	central (Nabdín)
OU Vinařice	4	(3 033)	central (Vin.hora)

Expl.: TS means Technical Services which is community owned and partly granted company. TS Kladno is to be privatized.

In some marginal parts of the districts, household waste collection and transportation is provided by similar organizations from neighbouring districts (mainly Kralupy). In some smaller communities transportation is provided by local agriculture cooperative companies but as a counter-service they usually use local landfills for dumping their waste.

To sum up the situation, is well organized collection and transportation (garbage cans and containers at the door and special delivery trucks) serves about 80 % of the district's population. Five to 10 % of the population brings their waste to nearby bulk containers (within 10 minutes reach) and the rest of population transports waste to landfills by their own vehicles.

4. Recycling

The following chart of the average composition of household waste is derived from project results of the Local Management Research Institute of Prague.

Household waste compounds	%	tonnes/year
Paper	9.6	4 566
Plastics	5.9	2 801
Textile	3.8	1 804
Wood	0.7	332
Kitchen waste	7.2	3 419
Iron scrap	5.8	2 754
Aluminium waste	0.5	237
Other metals	0.1	47
Glass and shreds	7.0	3 324
Inorganic waste	9.0	4 273
Ash and cinder	50.4	23 925
Total	100%	47 482

These figures are a little bit out-dated (8 years old) and it could be expected that production of ash and cinder is lower due to the installation of natural gas lines in some central and local heating facilities and that the amount of aluminium, plastic and paper package materials have likely increased .

As a result of small-scale privatization, abou. 30 private entrepreneurs have emerged and found small recycling yards. Unfortunately, half of them concentrate only on attractive commodities such as copper, lead, aluminium metals and iron scrap. The following chart shows a summary of recycling yards within the district which accepted a wide range of wastes (raw materials).

In the second half of 1992 the Kladno District area started to be supplied by coloured containers for separated collection of household waste. This is a starting point for the development of a so-called "bring system" where people can bring sorted waste to these containers within their reach (5 minutes walk). By the end of 1992, 15 communities were supplied with containers, including one residential quarter in Kladno. About 26 332 people were served by 109 containers.

Two different systems are being tested:

a) The first standpoint consists of three containers of 2.5 m^3 each for collection of coloured glass, clear glass and paper. This system is developing mainly in urban areas with a high concentration of inhabitants living in block of flats. A short campaign preceded the installation and green leaflets were distributed to surrounding households. Disposal to final recycling facilities is ensured by local company VEP Kladno.

Recycling yards	M	IS	P	G	L	AC	T
Slany U nádraží (Sbs)	+	+	+	+	+	+	+
Slany U brodu (Sbs)	+	+	+	+	+	+	+
Kladno Kročehl (Sbs)	+	-	+	-	+	+	-
Kladno Kročehl (Sbs)			film fixatives				
Kladno Švermov (Sbs)	+	+	+	+	+	+	+
Kladno sídl. 9.5. (Sbs)	+	-	+	+	-	+	+
Kladno Rozdělov (Sbs)	+	+	+	+	-	+	+
Kladno - Slánská (Sbs)	+	+	+	+	+	+	+
Libušín (Sbs)	+	+	+	+	+	+	+
Stochov (Sbs)	+	+	+	+	+	+	+
Tuchlovice (Sbs)	+	+	+	+	+	+	+
Smečno (Sbs)	+	+	+	+	+	+	+
VEP Kladno Švermov	+	+	+	-	-	+	-
Krákorová Velvary	+	+	+	-	-	+	+
Vild Kladno	+	+	+	-	-	-	+
Batelka Jemníky	+	-	+	-	-	-	-
Dryák Loucká	+	+	+	-	-	-	-

Expl.: M metals, IS iron scrap, P paper, G glass, L leather, AC lead accumulators, T textile, Sbs Sběrné suroviny

b) The second system consists of two containers of 1 m^3 each for glass and plastics. That "bring system" is supplemented by casual collection of paper, textile and iron scrap just from the household (kerbside col.). The system which is run by local company is being tested mainly in smaller communities. Mixed plastics are still in storage.

5. Final Neutralization (Disposal)

Incineration of domestic waste was recorded in three communities, even though a bigger portion of incinerated waste is anticipated (in rural areas with local fossil fuel cauldrons). About 840 tonnes of domestic-type waste are incinerated at the energy centre of Poldi Kladno under high temperature. Waste is added to fossil fuel in ratio 1:9 with no flue gas cleanup system. Most of this waste comes from a crushing and sorting facility for old cars.

Municipal waste from towns, communities and other producers is neutralized as follows:

Method of handling	Amount t/year	%
Deposited to landfills	60 000	94.5
Incinerated	974	1.5
Composted	2 583	4.0
Total amount	63 570 t/year	100 %

Small scale composting is operating in 22 communities, producing only 134 t/year of low level compost. Some unsound practice li'ke the usage of fossil fuel ash as an additive cannot be excluded. Composting of 2 200 tonnes of crushed and screened household waste is done on more sophisticated level at Gondard facility in Libušín (operated by Technical Services Kladno). Even that waste sorted at Gondard cannot meet requirements of the Czech norm for "industrial composts" due to a high content of undesirable compounds (glass, small pieces of plastics) and due to heavy metals pollution (Hg, Cd, etc.). These composts are only used for industrial estate reclamations.

Another similar facility which is situated at the town landfill in Stochov (rotatory sorting screens) was determined for backward screening of fermented waste from the landfills. The operations did not occur during 1992 because of lack of market for industrial composts during the last two to three years.

6. Costs and Expenditures

This information refers mainly to household waste disposal in landfills (collection, transportation and site operations). Charges for waste payed at the entrance of landfills varied from 50 to 120 Czech crowns (Kč) per tonne. Kladno citizens payed nearly 400 Kč annually for a 110-litre garbage can. However, in some small communities people payed negligible charges for household waste disposal. The total expenditures in the district were 13.31 million Kč, which means 78 Kč/head with a large difference between the Kladno catchment area and the rest of the district. Limited investments and low operation costs were the main reasons for the unsatisfactory state of waste management in the district as well as in the whole republic.

7. Summary of the Major Problems

a. Limited landfill capacity and poor quality

In Kladno district there are no landfills with proper containment, gas utilization, etc. None of the landfills meet requirements of the new regulation no.. 513/1992. Fortunately, from the environmental point of view, waste disposal in these landfills has become progressively more expensive because of a special tax imposed on each tonne of waste . The tax is higher in the case of landfills that are not well engineered (Fig. 3). The additional taxes go to the Czech Environmental Fund. The following chart shows the development of the taxes.

b. Low charges and lack of investment in waste management

Most of the operators are community-owned companies and as an after-effect of the former economic system they have been hesitating to increase charges and develop market economy principles in waste management, mainly in the field of household waste disposal. Some improvements in the second half of 1992 have been registered.

Landfill groups	Standard (Kč per tonne)	Substandard (Kč per tonne)		
		1992	93	94
1. Soil and mine tailings	0	1	3	6
2. Ordinary waste	10	25	70	140
3. Household waste	20	20	70	210
4. Special waste	40	110	320	640
5. Hazardous waste	250	3000	4000	5000

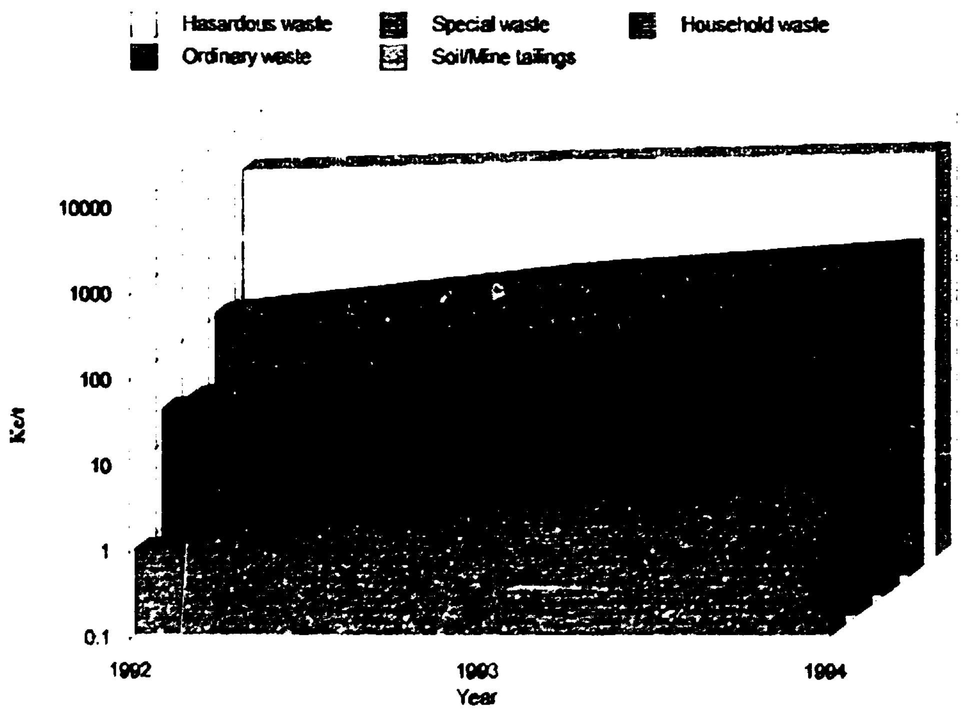

Fig. 3 Augmentation of disposal tax on substandard landfills (note logarithmic scale)

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c. Low recycling

Extremely cheap disposal does not encourage people to recycle or minimize generated waste. It means that a lot of potential raw and potential recycling materials are deposited into landfills. The positive effects of the newly introduced system could be expected within two or three years.

d. A lack of separated collection of hazardous compounds in household waste

A proper recycling scheme for hazardous waste has not yet been introduced even though there is some experience, for instance, with separated collection of small batteries. Thanks to stricter legislature issued recently, new neutralization facilities have emerged during the last two years (neutralization of fluorescent tubes, recycling of acetonic thinners). The only recycling scheme which was developed for car Pb accumulators (batteries) is now threatened by higher costs of transportation and stricter requirements on their storage in the recycling yards.

e. Old landfill sites and potential pollution

Although a survey of most significant landfills in the district was completed, only few of them are regularly monitored, there is a lack of previous landfill records and nearly no reclamation projects are prepared. The coverage of financial expenditures from central funds are necessary and some grants can only be expected in the most significant national cases.

8. Contents of Generated Waste

All information available was transformed into a PC database, accordingly there is a summary of annual production for all sorts of waste in Kladno. The following list is concentrated only on the most significant sorts of waste which annual production exceeded 3 000 tonnes in 1992.

Inert waste

Waste rock and ballast	392 952 t
Excavated soil	40 749 t
Total	**433 702 t**

Ordinary waste

Agriculture and sugar refiner	662 346 t
Iron scrap	252 524 t
Rubble and construction debris	120 836 t
Coal sludge	21 668 t
Metallurgical waste	125 430 t
Metal shaping waste	14 130 t
Other ordinary waste	24 506 t
Total	**1 221 440 t**

Special waste

Waste from energy prod. (ash, cinder)	119 536 t
Electric furnace slag	109 245 t
Sewage treatment sludge	15 735 t
Spoilt vegetable products	4 285 t
Slaughter house waste	3 064 t
Other special waste	1 272 t
Total	**253 137 t**

9. Suggested Solution

The waste treatment in Kladno district relays on landfills. Due to environmental impacts from the disposal places and more stringent regulations regarding emissions alternative solutions should be considered. AVECON International Ltd has developed an anaerobic digestion process suitable for organic household waste and sewage sludge which allows recovery of biogas (methane and carbon dioxide) thus giving possibilities to recover energy from this type of waste and to produce good type of fertilizer. This process is one solution to decrease the biological load on the disposal places, extract energy and usable end products from waste and improve the environmental conditions.

With the report "Waste Management Programme of Kladno District, Petr Kratochvil, February 1993" as a base a study has been realized for an anaerobic waste treatment plant combined with energy production.

a. Start values

The plant is sized to treat the waste generated in the Kladno region and can also receive some de-watered sewage sludge or other industrial type organic waste. The start values used are modified from the report mentioned above.

Waste composition:

Material	Percentage %	Amount tonne/year
Organic kitchen waste	36 %	5 400
Paper	30 %	4 50C
Plastics	12 %	1 800
Metals	3 %	450
Stones	3 %	450
Glass	5 %	750
Sand	5 %	750
Textiles	6 %	900
Sludge (TS = 15 %)		25 000

This composition gives a treatment capacity of 15 000 tonne per year of municipal waste and of 25 000 t/a of sludge.

The waste treatment plant will consist of the following main parts:

(i) Pretreatment Plant (Fig. 4)

Receiving silo
Screen
Crusher
Magnetic separator
Conveyor belts
Control room

(ii) Biological Treatment Plant (Fig. 5)

Mix-separators
Biomass pumps
Digester
Gas cleaning system
Heat recovery
Process water system
Mechanical de-watering equipment
Bio-filter

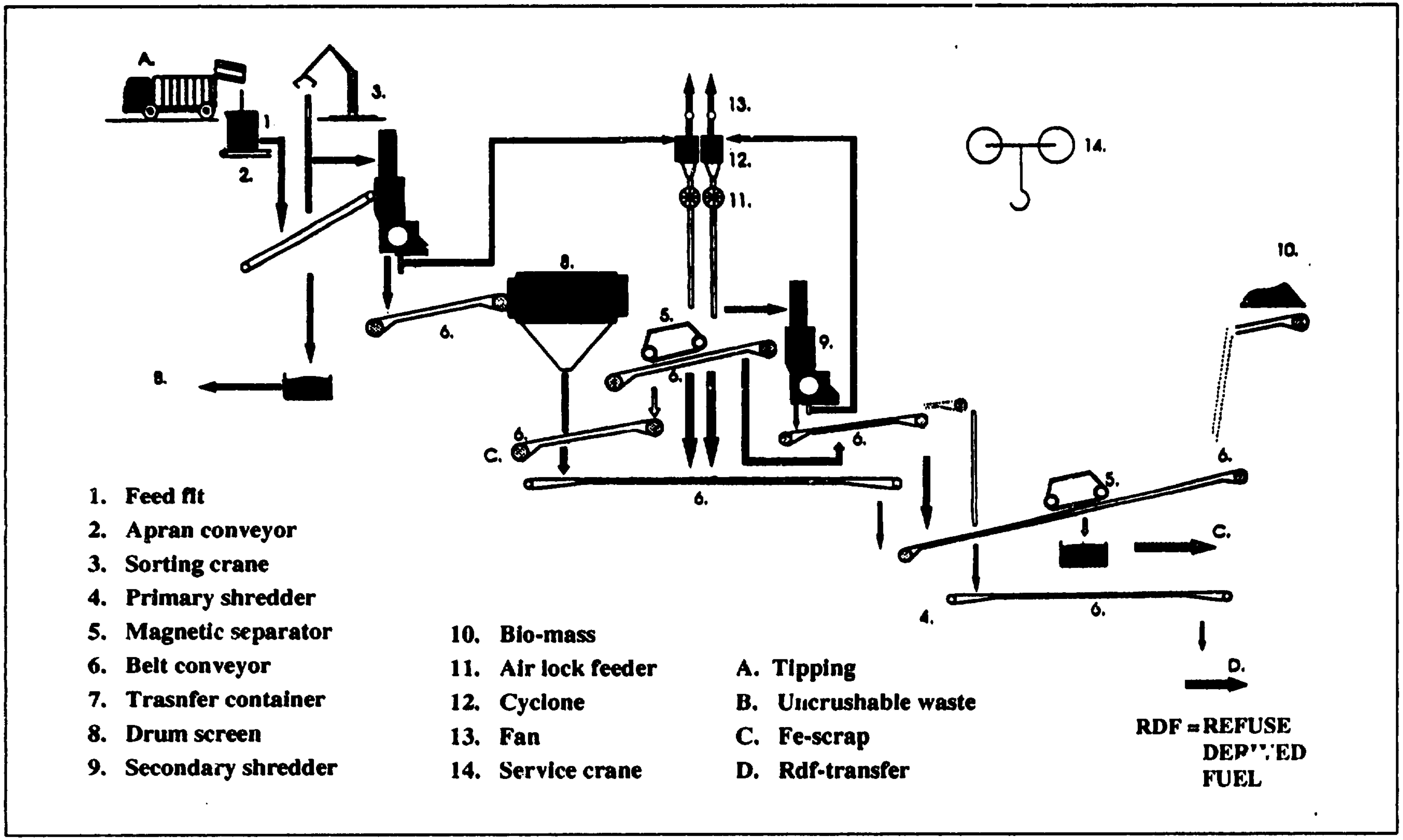


Fig. 4. Components of Pretreatment Plant

The Waasa process includes components as the Mix-separator and the Twin-reactor which efficiently removes undesired materials, such as glass, stones, plastics, from the end material. Therefore the de-watered digested staff is of a higher quality compared to conventional composting end products and may be used in the agriculture. However, the anaerobic process will not remove heavy metals which leaves consumers with a responsibility to separate non-wanted materials.

b. End products

With the input mentioned above the plant will produce the following:

	Amount	Remarks
Biogas	3.2 x 10^6 Nm^3/a	CH_4 59 %
Digestive	14 000 t/a	TS 35 %
Surplus water	18 500 t/a	
Disposable products	3 900 t/a	

(i) Biogas

The biogas is used in a power generation plant, producing electricity a total of approx. 6 000 MWh/a and heat 12 000 MWh/a. The internal electricity consumption of the plant is approx. 700 MWh/a and the heat consumption is approx. 2 000 MWh.

(ii) Slurry

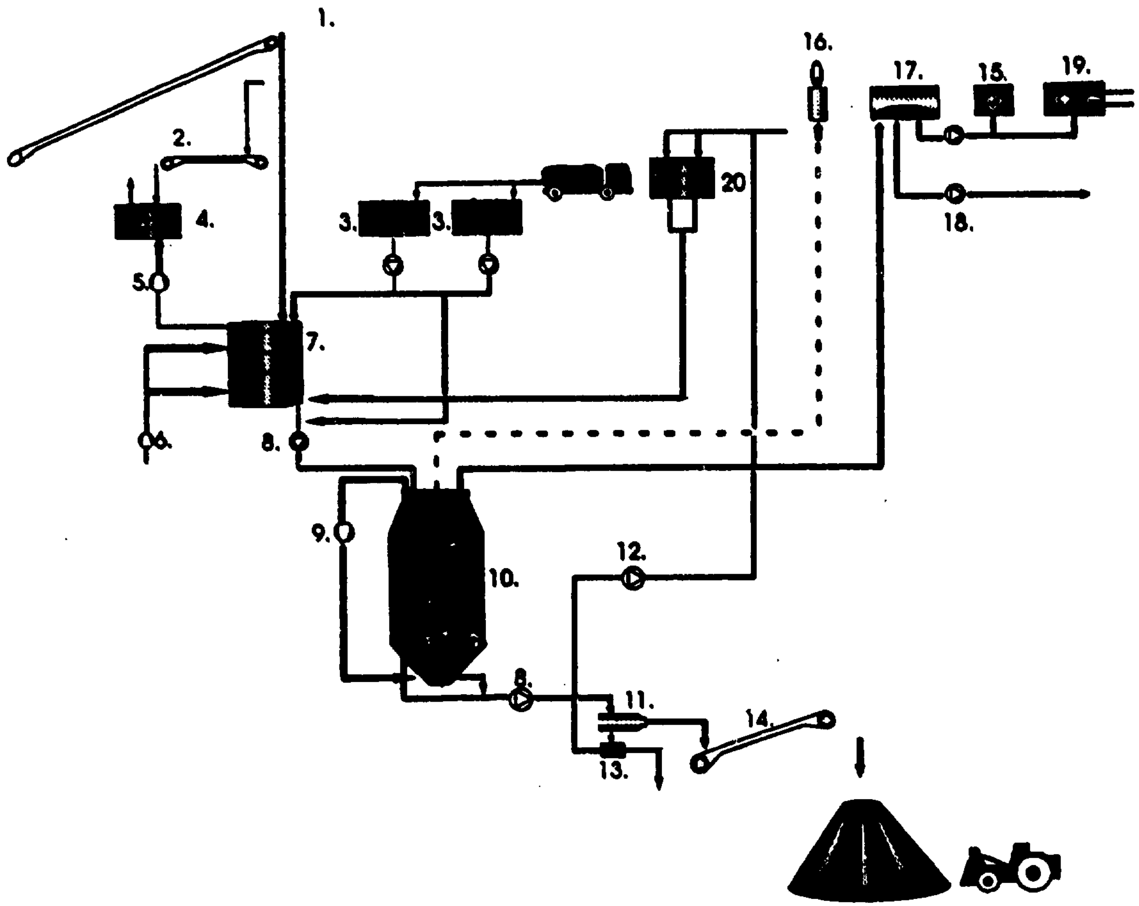
The slurry is a good fertilizer which can replace imported fertilizers in the agriculture. The amount of slurry will be 14 000 t/a. The final usage of the slurry will however depend on the local restrictions for fields and the heavy metal content in the slurry.

(iii) Surplus Water

The surplus water may also be used in the agriculture as a liquid fertilizer, amount approx. 18 500 t/a. If local restrictions don't allow the spreading of liquid fertilizers on fields the water should be treated in a waste water treatment plant.

(iv) Disposable Products

Since the waste is assumed to contain about 30 % inert material this has to be separated and treated. The appropriate treatment for inert waste is disposal, disposing inert materials is no environmental hazard. The amount of disposable products is approx. 3 900 t/a.



1. Waste conveyor
2. Biofilter mass
3. Sludge tank
4. Biofilter
5. Fan
6. Air compressor
7. Mixing tank
8. Biomass pump
9. Gaspump
10. Digester
11. Press
12. Waterpump
13. Well
14. Humus conveyor
15. Gasburner
16. Flame
17. Gas storage
18. Distribution compressor
19. Generator
20. Hydrolysis watertank

Fig. 5. Main Components of Biological Treatment Plant

(v) Sewage Sludge and Other Organic Waste

The plant is prepared to treat 25 000 t/a of de-watered (TS approx. 15 %) sewage sludge. This treatment will enable the recovery of energy from sludge in form of biogas and similarly give a fertilizer as an end product. Vegetable products, slaughter house waste, and other organic, non-toxic waste can also be treated.

c. Needed Operational Personnel

A plant of this size can be operated during 5 days a week, 8 hour per day by 4 operators, not including administrative personnel.

Staff training

The plant in Vasa, Finland which has been in operation since 1990 is involved in training of new operators. On site, practical training will be carried out at the Vasa plant before start-up of new plants.

d. Costs of Plant

The cost of the plant can not be given exactly before undertaking a thorough pre-feasibility/feasibility to determine the parts that will be manufactured in the Czech Republic and those which are going to be imported.

II. CASE STUDY ON HUNGARY

A. GENERAL INFORMATION ON THE PRESENT ENERGY AND ENVIRONMENT SITUATION IN THE COUNTRY

1. Present situation in the energy sector

Hungary is relatively poor in energy resources, the country dependency of the energy system is therefore quite significant (51% of the fuel used, including nuclear fuel, is imported). The former energy policy was subject to political aspects of the region, including the former Soviet dominance; consequently the country's energy system became dependent on a one-sided, unilateral exposure. High capacity pipeline connections were established primarily with the former Soviet Union. The Adriatic oil pipeline has not been working for years because of the war in Yugoslavia. The portion of domestic energy sources to total energy used was about 51% in 1992. Imported oil was 75%and imported gas was 46% of the total amount used.

The structure of the country's energy consumption of fuel is characterised by more dependency on natural gas than on oil. Whereas, coal has an average share, nuclear power's share exceeds the average. The share of renewable energy resources is very modest primarily as a consequence of its high cost. Coal-burning power plants have total power of 2,100 MW, hydrocarbon (oil and gas) power plants have a total power of about 3,300 MW and nuclear based power plants is 1,840 MW.

After the political and economic changes at the end of the eighties, the productive capacity of the economy decreased due to the out-of-date production profile, market losses and restructuring of the economy. As a result, there was a fall in the total energy consumption by 21% reflecting a similar decline in GDP. Accordingly, the total primary energy supply decreased from 30.4 Mtoe in 1989 to 27.3 Mtoe in 1991 and to 24.0 Mtoe in 1992. Whilst coal and oil supplies declined substantially over this period, gas supply decreased only slightly. Production of nuclear power plant remained constant at the level of 13.7 TWh per year.

Total final energy consumption decreased 9% in 1990 and 5% in 1991. Total electricity consumption in 1990 was 39.5 TWh and in 1991 it was 37.4 TWh. The decline in consumption accelerated in 1992 to below 35 TWh; a rate faster than the rate of the decrease of GDP for the same period.

2. The environmental aspects of the current situation

Each process in the chain of energy production and use has negative impacts on the environment. The present mix of power stations is polluting the environment with rates several times higher than the international standards. Ashes, cinders and other pollutants and hazardous wastes emitted by coal firing power stations damage the environment to a great extent; besides, the costs of disposal are increasing.

Improving the performance of these plants has become an issue of major importance, taking the chemical and radioactive qualities into consideration. As part of the reconstruction program of coal firing power plants and as a result of completed investment projects through electrostatic precipitator reducing dust emission, the annual volume of total dust emissions of these power plants have been reduced by one-third of the 1980 figure.

Sulphur dioxide and nitrogen oxides emission are still significant due to the high sulphur content of coals and the environmentally unfavourable combustion conditions. Sulphur dioxide emission should decrease by the end of 1993 by 30% from their level in 1980. An additional reduction of 20% can be expected for some projects for de-sulphurisation of flue gas in some power stations.

The level of emissions of nitrogen oxides in 1987 should be reached by the end of 1994 to meet the obligation stipulated by the Sofia Protocol. Hungary also has international obligations stipulated by the Helsinki Convention.

Nuclear power plants have lower environmental pollution potential than fossil power plants - under normal operating conditions. However, they are a source of high potential risk due to the technology applied, even though their accident risk could be relatively low. In addition, radioactive wastes disposal is still a problem because no site has so far been identified and accepted.

3. Future plans in the energy sector

The productive energy efficiency of the Hungarian economy (defined by the energy used per unit product) is rather poor in comparison with that of developed countries. It is 2-4 times higher than its the level in industrialized countries mainly because of the low technical and quality level of the Hungarian products and services. As soon as the economy gains momentum and begins to grow again in a more up-to-date structure, the tendency of reducing energy demand will presumably arrive at a halt and a certain rate of progression is expected to follow depending on the future growth rate and on the new production structure introduced.

The main goal of the current energy policy is to eliminate the unilateral import dependency and to establish the opportunities of diversified supply; which are both in the national interest. In addition, the existing pipeline connections should be exploited to its maximum to be economically cost effective. Within the framework of profitable exploitation of domestic energy resources, enhanced and efficient exploration of hydrocarbons could be achieved. Utilisation of the deep-mining coal reserves will also be indispensable as long as coal-firing power plants continue to be a dominant factor in electricity production.

Connecting the gas network system to the West-European systems has high priority in the energy policy. The Hungarian gas demand forecasts up to 2000 are 2-3 times higher than today's figure. New resources must be found to meet gas demand forecasts, e.g., by connections to North European and to Algerian gas fields. In long terms the accessibility to the Iranian gas fields would also be taken into consideration.

Crude oil supply can be secured from two sources, viz. the former Soviet region and the Adrian pipeline. Storage capacities should be also developed and sustained. In addition, joint efforts with Austria, Germany, the Czech and Slovak Republics should be explored.

The total energy demand in 2000 is estimated to be in the range of 1200-2000 PJ; and that of electricity is 43-46 TWh. Installation of a base load power station with a high unit capacity is planned for commissioning in the year 2000. The options are: power plant firing domestic lignite, a nuclear power plant, or a coal-firing power plant supplied with imported coal.

On the other hand, flexibility will be a significant criteria of the future's energy plans. This includes adaptation or adjustment to consumer's demands as rational energy supply, high efficiency and environmental soundness. As a result of the uncertain increase of demands, the facility should also be flexibly developed so that it could be quickly adapted to the changing energy demands.

The main points of the energy system modernization from technical aspects can be summarized as follow:

a. Economic exploitation of domestic fuels.

b. Transformation of polluting fuels to a more environmentally sound fuel (as coal gasification) and promotion of the use of waste heat.

c. Development of technology in areas of storage, transportation, transmission and distribution of energy.

d. Expansion of applications of new and renewable energy sources.

e. Promotion of heat pumps' utilization.

f. Developing the base, intermediate and peak capacities of the electricity system.

g. Developing of combined cycle gas turbine plants.

h. Developing of environmentally sound gas turbine plants.

i. Connecting the existing gas and oil pipe-lines to West Europe.

j. Constructing pipe-lines to the new gas and oil sources in order to diversify the energy supply of the country.

k. Expansion of the application of fluid fuel firing technologies.

l. De-sulphurization of flue gases in some power stations.

m. Monitoring the emissions of power stations using up-to-date measuring equipment and methods.

n. Improving energy efficiency by establishing a more modern and profitable energy production structure.

B. ENERGY DEMAND FORECAST AND STRUCTURE OF THE FUTURE ENERGY PRODUCTION SYSTEM IN HUNGARY

The new power plants planned up to the years 2000 and 2007 are summarized in Table2.

Table 2. Summary of New Power Plants needed in Hungary

Type of Generation	Up to 2000 MW	2000 - 2007 MW
Combined cycle gas turbine with co-generation	500 - 750	----
Peak-load gas turbines	200 - 300	150
Fluidised bed combustors,	300 150	150 -350 400
New power plants	---	1200
Total	**1200 - 1500**	**1900 - 2100**

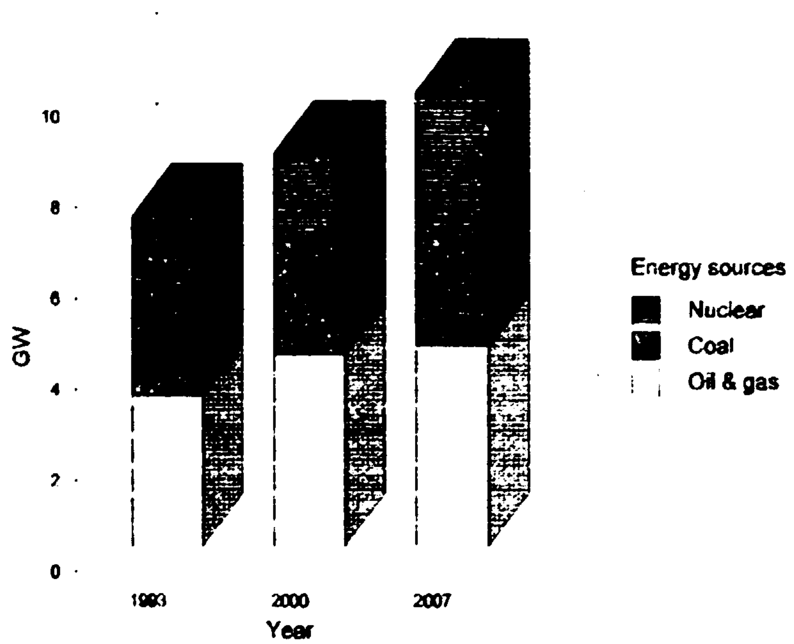


Fig. 6. Forecast of the expansion of the Hungarian power system

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C. REVIEW OF EARLIER STUDIES FOR IMPROVING ENERGY EFFICIENCY AND DECREASING ENVIRONMENTAL EMISSIONS.

After Hungary has turned to the market economy, some international promotion funds became available for improving the national economy. Among them the PHARE program which provides support for the modernization of energy system as well as improving environmental protection. Within the framework of the PHARE program a study has been initiated by the Ministry for Industry and Trade as well as by the Ministry for Internal Affairs in the field of energy production and utilization. A survey is currently in progress but no information on the study is yet available.

D. ACTIONS TAKEN INCLUDING LNWT FOR IMPROVING ENERGY SITUATION AND DECREASING EMISSIONS FROM ENERGY PRODUCTION.

In view of economic difficulties and lack of monetary sources, no comprehensive plans have so far been considered for introducing LNWT. But some alternatives have been considered in the above mentioned PHARE study and in the proposal relating the Hungarian energy policy submitted to the Parliament by the Minister of Industry and Trade.

Among real actions undertaken was the reconstruction of a gas fired cogeneration district heat-power plant with combined gas/steam cycle producing 544 MW electricity and 807 MW heat. In addition, some bilateral discussions between foreign companies and the electricity board on the installation of de-sulphurization and de-nitrification units to the existing big power plants have also taken place.

Among alternatives considered for improving the present energy situation the followings can be mentioned:

1. As was mentioned above, it is difficult to provide reliable forecasts for the total and peak capacities of power production until 2000; due to the transitory character of the economy. Gas turbines which could be later converted into combined cycle gas/steam turbine plants could represent the optimum solution, in view of their flexibility, high efficiency and relatively low specific capital intensity. The application of coal gasification could be thus justified But gas turbine power plants do not represent an alternative to the base load power station to be commissioned in the middle of the 90's. New capacities will be required for replacing the missing imported power and the coal-firing power plants to be de-commissioned. The program of gas turbine development will involve the construction of blocks with relatively low specific capital expenditures and with small per unit capacity, with a total of some 700 MW.

2. District heat supply represents nearly 10% of the total energy consumption. Major share of the heat supplied is generated by hot water boilers of, without combined electricity generation. The district heating supply systems can be expanded on the basis of the combined cycle gas/steam turbine plants through cogeneration. One of the objectives of the energy policy is to increase the combined heat and electricity cogeneration in the energy sector.

3. Renewable energy resources represent some 2% in the total energy consumption. Geothermal energy replaces 80-90 ktoe (kilo tonne of oil equivalent). This can be further increased as the country is rich in geothermal heat sources with due emphasis on the environmental factor. On the other hand, utilisation of solar and wind energy is practically negligible. Expansion potentials of consumption is limited, mainly because solar energy still has high specific investment costs in Hungary, whereas wind energy prospects are limits due to the geographic features of the country. Utilisation of biomass is relatively significant within the category of renewable energy resources. Further increase in the utilisation of this resource is limited mostly by the additional costs related to the collection and transformation process.

4. The energy price system also should be modernised up to the point where consumers prices absorbs the costs of exploration, production, conversion, storage, distribution, re-cultivation and environmental protection of the energy system. This is also a precondition to Hungary's integration to the standardised energy systems. To arrive at satisfactory results in the short-term, energy developments should be implemented using both foreign capital and local funds in the form of construction loans

E. THE PRESENT SITUATION CONCERNING MUNICIPAL, SOCIETAL AND OTHER BIOLOGICAL WASTES

Supervision of municipalities belongs to the Ministry of Internal Affairs and the supervision of hospitals - as main sources of the biological wastes - belongs to the Ministry of Health Care. Local governments can in the future have a significant role in the management and control of the energy sector and waste management.

Public utilities are responsible for the collection and management of municipal, societal and biological wastes. This can be considered to be a well managed sector with a regular collection of household wastes, cleaning the streets and collecting societal wastes regularly from institutions.

F. WASTE COMPOSITION, AMOUNTS, LARGE PRODUCERS, TRANSPORTATION SYSTEM AND METHOD OF PAYMENT

Officials managing public utilities can not give data on the waste composition and amounts of wastes without the authorization by the Ministry of Internal Affairs. Large producers can be considered the same as in any other countries as Hungary is well managed in the field of waste collection. Transportation system can be considered modern and is supplied with western type of special trucks. The payment system is totally centralized: self-governments collect fees from citizens and the public utilities get a budget from self-governments.

G. EXISTING TREATMENT PLANTS/LANDFILLS AND THEIR EXPECTED AGE

Municipal wastes of the capital are processed in a modern incineration plant. This has been operating for some years so its expected age can be considered several decades. Also hospital wastes partly serve as fuel for indoor boilers.

The general way of waste management for municipal wastes is landfill in the country. Landfills are generally not technically designed, not supplied with drainage systems and artificial protecting layers, but mostly natural reservoirs.

H. CASE STUDY ON COGENERATION IN HUNGARY

1. Potential for Cogeneration Diesel Power Plant

In 1994 economic growth was remarkable in Hungary. The volume of foreign investments are far greater than in many of the neighbouring countries. Western investors have faith and confidence in Hungary. Hungary has been granted favourable and long-term loan for investments which is a must for building power plants. The basic principals when improving energy sector are:

* Eliminating dependence of one source energy imports
* Introducing true market conditions in energy supply
* Seeking for low cost, economic and efficient power production means
* Finding environmentally sound energy production schemes
* Meeting energy goals; one of the means is the promotion of combined heat and power production CHP.

The annual growth of power demand is estimated to be between 3 to 5 TWh per year, i.e., about 300 MW per year. The largest part of the fuel is expected to come from gas and oil in the beginning and later also from coal and nuclear power. Most of the large power plants (above 100 MW) will not be cogeneration and it is obvious because such a big heat load which is required to dump the heat is not available or there are too few of them.

The estimated potential in combined heat and power production is in smaller communities. It is estimated that there are c. 80 communities where you have sufficient heat load to utilise cogeneration and where you have already existing district heating pipeline. These are between 10 - 15 MW heat demand during the winter time and 3 -4 MW during the summer time. These typical heat loads makes it possible to install a cogeneration diesel power plant of 5 MW electric and 6 MW heat.

Totally there are about 110 communities that have district heating networks. In those there are 320 of different networks. 10 of the communities have already existing CHP power plant. Calculated total potential of CHP in communities is estimated to be between 500 MW - 700 MW in all; excluding the possible growth in the future.

The potential of CHP and efficient power production lies also in hospitals, in manufacturing industry, large building complexes, green houses etc. This potential can be estimated to be about 300 MW .

2. Description of cogeneration Diesel Power Plant

a. General

The changing trends towards decentralised small scale heat and power production and natural gas becoming increasingly important due to its environmental friendliness. A Wärtsilä diesel power plant concept fulfils the present energy policy targets of efficient power production and environmental protection.

Wärtsilä Diesel power plant concept is a new, small scale power plant in the power range of 1.4 to 26 MW for Combined Heat and Power Production (CHP, Cogeneration). Various district heating applications are typical solutions. The power plant uses natural gas, heavy fuel oil (HFO) or light fuel oil (LFO) as fuel. The electric energy is produced by a diesel generator set, enabling high fuel efficiency in a wide load range. To utilise as much as possible of the thermal energy, the heat is recovered in exhaust gas boiler and also of engine block cooling water, charge air and lubrication oil by heat exchangers. The total efficiency of the power plant is between 82 - 90 % depending on the fuel.

The modular construction based on prefabricated modules enables short delivery time with minimised site works and thus a rapid start of the electricity and heat production. These reasons also minimise the risk.

b. Needs and requirements of combined heat and power production

i. Enough energy should be available at every moment right where it is needed. Decentralised energy production with small scale power plants fulfils most independently all local municipal and industrial needs and demands of district heating and electricity consumption.

ii. The environmental protection to save the nature should be taken into account. This requirement is possible to fulfill with the right choice of fuel, e.g. natural gas instead of coal and/or with technical solutions, e.g. using catalyst etc. for eliminating acidic emissions.

iii. Efficient power production can be realised as high efficiency of the power plant. With an efficient prime mover and heat recovery system the heat and electricity can be maximised from the fuel. This also fulfils the environmental aspects more easily.

iv. Economy is probably still the most important factor when investing in power production. Low investment and operation costs are required. The diesel power plant concept quarantines economically optimal solution with standardised construction and efficient operation.

v. Benefits of small scale diesel power plants in combined heat and power production.

vi. The location of the power plant can be determined exactly where energy is needed, in the city or in the factory close to the consumption.

vii. The right size of the power plant according to the energy demand enables optimisation of the investment costs.

viii. The most efficient power generation is possible to choose depending on the demand of heat and electricity.

ix. The short implementation time minimises the costs during the construction period and allows a quick start of energy production.

x. The flexibility according to the customer requirements allows individual modifications of the basic process or construction concept.

3. Applications of diesel power plants

a. Main application groups are:

- local energy companies with district heating and electricity network
- big building complexes with electricity and heat demand, e.g. hospitals, airports etc.
- industrial enterprises needing hot water or steam for processes, e.g. food industry or breweries.
- industry using exhaust gases for direct heating, e.g. ceramic industry.
- big greenhouses using energy for heating and lighting

b. Process

The heat is recovered both from the exhaust gases and from the engine cooling. The thermal energy can be hot water or partly steam depending of the particular need. This can be fed to district heating network or used in various industrial processes. The electricity is produced by a normal three phase generator connected to the diesel. The energy is fed to the local grid or the power plant can operate as "an island" independently.

4. Environmental aspects

The advantage of cogeneration in environmental side is that the heat and power is produced in the same power plant. This mean considerable reduction of fuel consumption compared to the separate production. Normally the electrical power is produced in big condensing power plants with 30 - 40 % electrical efficiency and the heat in heat central boilers. This means that a cogeneration plant consumes roughly 66% less fuel compared to two separate plants producing the same amount of electricity and heat.

When running on natural gas, nitrogen oxides (NO_x) are the only significant acidic emissions. The plant can be equipped with an SCR-catalyst where ammonia reacts with NO_x and eliminates these to gaseous nitrogen and water. Emission levels required in many countries can be reached by dimensioning a proper size of catalyst. Normal accepted NO_x-emission levels vary between 100 -200 mg/MJ fuel.

In addition the power plant building is constructed to meet very stringent noise abatement requirements. With normal construction the noise level outside is below 45 dB(A) in a 100 m distance. Thus the power plant can be situated close to densely populated area.

5. Performance of a diesel power plant

The diesel power plant has a high total efficiency, up to 90 %. The electrical efficiency is 41 - 44 % and stays almost constant even down to about. 50 % engine load, which enables economical operation also on partial loads if necessary. With the efficient heat recovery system over the heat can be recovered from the exhaust gases and cooling water.

Diesel engines compared to gas turbines are more fuel efficient and therefore the exhaust gases have much less thermal energy. It means that with a gas diesel power plant is possible to produce more electricity towards the same amount of thermal energy.

6. Economics of a diesel power plant in a selected case

In the following, the economics of cogeneration diesel power plant is demonstrated in one case. Appendix 1 gives a brief summary of the case economics. Because of the small heat load it was not possible to dimension the power plant to produce only the internal energy demand. The dimensioning is shown is the heat and power demand curve. (see appendix 2)

It was assumed that the price of kWh of own consumption is what was given 7.24 HFt / kWh and the excess electrical power is sold to the grid (which is expected to open to the market) with a price of 4 HFt / kWh.

The pay-back period of ? years is very short and ROI (Return On Investment) high and demonstrates the efficiency of cogeneration. The calculation is made without any possible local taxes which affects the economics, but anyway the pay-back period is so short that even with high taxes the diesel power plant is going to be very economical.

This case demonstrates the economics of cogeneration and its high efficiency, not to forget the environmental soundness.

III. CASE STUDY ON ROMANIA

A. INTRODUCTION ON THE PRESENT ENERGY AND ENVIRONMENT SITUATION

1. Installed Capacity

The responsibility of the electric and thermal energy for Romania is assumed by RENEL, which was created in November 1990 by reorganizing the enterprises belonged to the former Ministry of Electric Energy.

At the end of 1992 the installed power in the Romanian Power System was 22 225 MW, out of which 92.4 % is in RENEL's Plants (i.e. 20 536 MW).

Coal fired thermal power plants	8 624 MW
from which: condensing units	80.2 %
cogeneration units	19.8 %
Hydrocarbons thermal power plants	6 204 MW
from which: condensing units	45.6 %
cogeneration units	54.4 %
Hydroelectric power plants	5 708 MW
from which: Danube river units	1 922 MW
Down stream units	1 300 MW
Daily storage plants	2 486 MW
Total installed power	**20 536 MW**

In 1992 the electrical energy gross production of RENEL's plants was of 52 376 GWh, 4.2 % less than in the year 1991. In the same year, the thermal energy production of RENEL's plants was 177 796 TJ, out of which 165 321 TJ was in combined heat and power plants and 12 475 TJ in thermal plants (Fig. 7, 8).

At the end of the year 1992, the length of the transmission lines within RENEL's network were 311 589 Km, while the number of transformer points and stations was 129 300 MVA (Fig. 7, 8).

The National Power System operates in parallel with the power systems of the neighbouring countries. High and extra high voltage networks ensure highly reliable electrical energy exchange.

Fig 7. Installed power plants structure considering unit power.

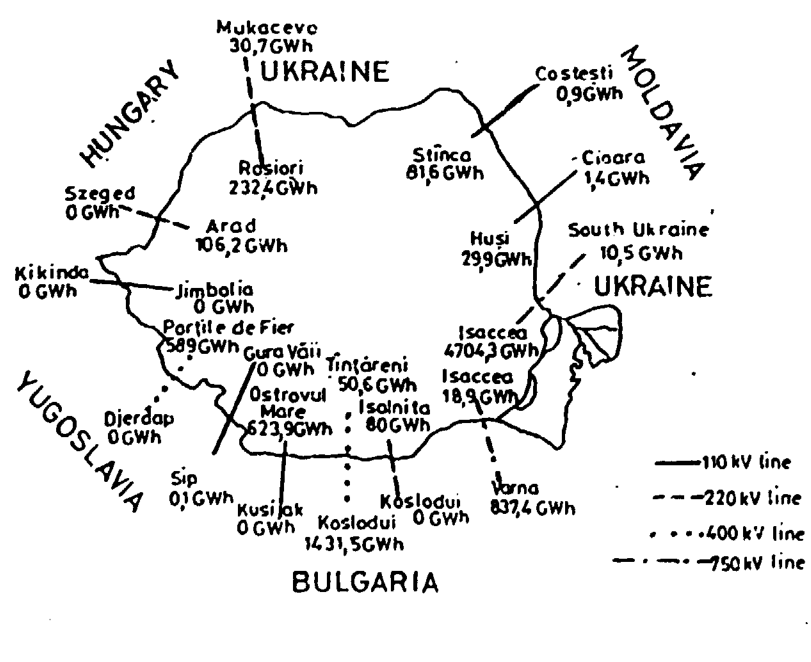


Fig 8. Transmission & Distribution Network.

The main thermal power plants installed in Romania are given below:

Power plant	Nominal capacity (MW)	Operating capacity (MW)	Years of commissioning
Borzesti I	625	510	1955 - 1969
Borzesti II	250	150	1975 - 1983
Braila	960	785	1973 - 1976
Brazi	910	850	1961 - 1986
Bucuresti S	550	440	1965 - 1975
Deva	1 260	875	1969 - 1980
Doicesti	620	336	1952 - 1967
Drobeta	200	160	1986 - 1989
Galati	535	514	1969 - 1984
Iasi	50	45	1960 - 1962
Isalnita	1 035	540	1965 - 1967
Ludus	800	760	1963 - 1967
Palas	250	190	1970 - 1979
Paroseni	300	105	1956 - 1964
Rovinari	1 720	1 000	1972 - 1979
Turceni	2 310	1 000	1978 - 1987
Total	**12 375 MW**	**8 170 MW**	

2. Energy Production

After 1989, the decline in the electric and thermal energy production was due to decrease of the demand in industry, as a result of the political transition and the lack of foreign currency for fuels imports. Romania has a relatively low electricity consumption (3.2 MWh/inhabitant) and a low household consumption (0.3 MWh/inhabitant).

In 1992 electricity consumption (in 1000 MWh) was divided among the different economic sectors consumers as follows (see also Fig. 9):

Industry		29 912 GWh
Civil building		995 GWh
Transport/telecommunication		2 062 GWh
Agriculture/forestry	3 537 GWh	
Public consumption	2 796 GWh	
Domestic consumption		7 549 GWh
Total		**46 851 GWh**

The predominance of industry among the various economic sectors also appears from energy consumption data because the industrialization strategy was based on energy-intensive industries.

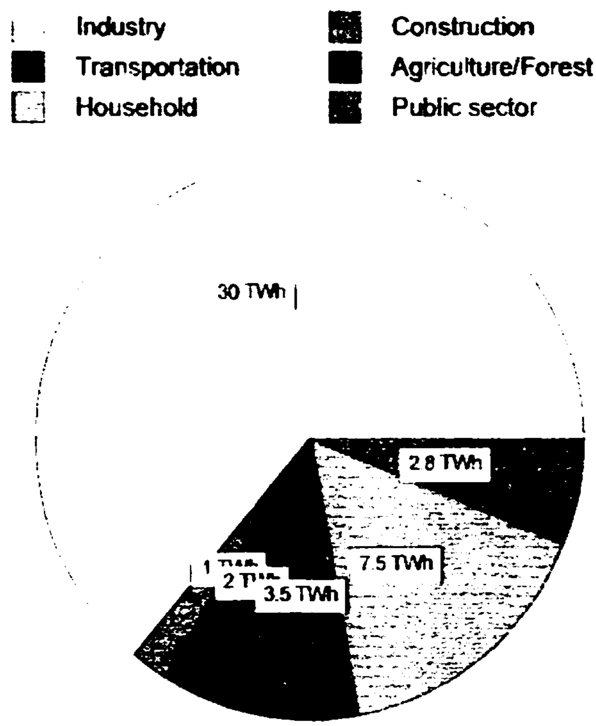


Fig. 9. Electricity consumption by the different sectors in Rumania in 1992

This is also due to the fact that little attention was paid to the other sectors whose development was limited, as the households, the transport and the agriculture sectors.

The following data illustrate the energy demand of various sectors:

	Thermal energy %	Electric energy %
Industry	68.1	60.4
Residential	19.1	11.6
Others	12.8	28.0
Total consumption	100.0	100.0

original contains
color illustrations

The energy intensive industries of Romania are illustrated in Fig. 10.

	Thermal energy %	Electricity %
Metallurgy	9.7	31.7
Chemistry	28.5	20.9
Refining	17.9	6.4
Metal processing	10.3	16.4
Food	12.2	7.5
Others	21.4	17.1
Total manufacturing	100.0	100.0

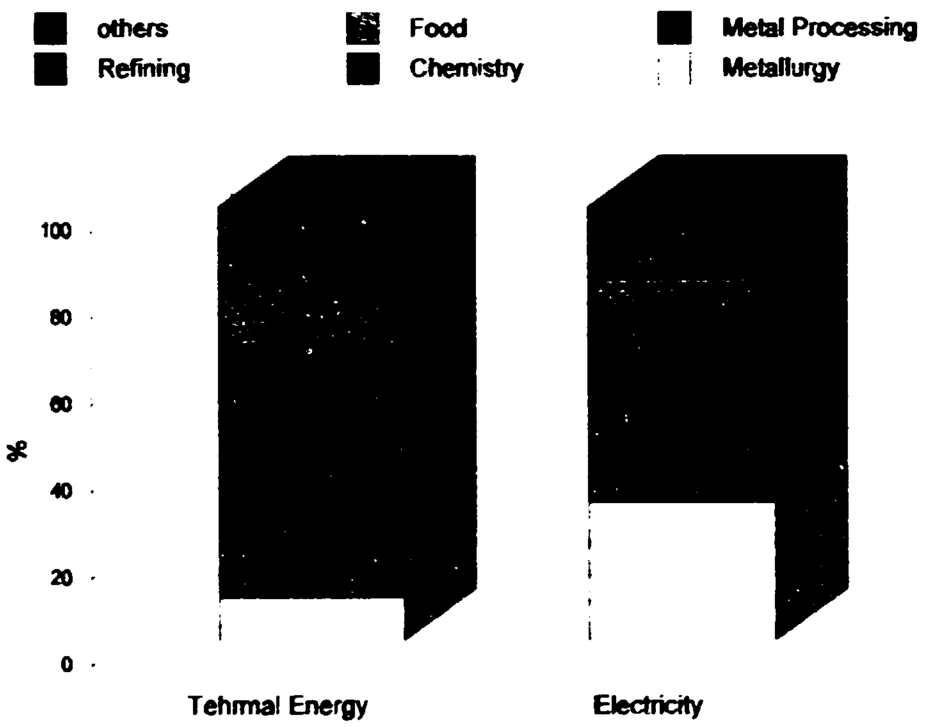


Fig. 10 Distribution of energy used in industry in Romania in 1992

The energy supply of industry by source is shown in Fig. 11. Apart from the biomass which is still broadly used, natural gas is predominant. Steam generation for both space heating and industrial process is the main thermal energy used in Romania.

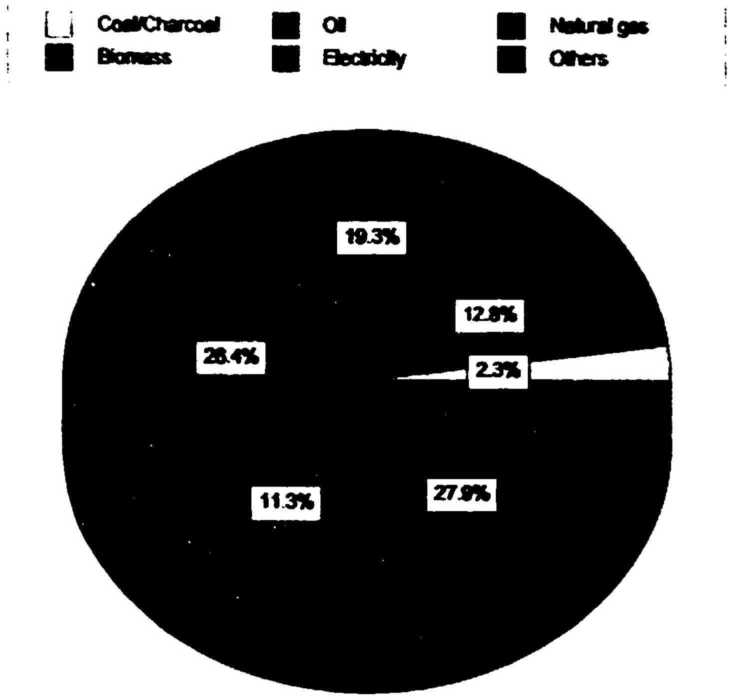


Fig. 11 Energy sources used in industry

The existing thermal power plants are characterized by a high level of the moral and physical wear and a weak endowment with measure and control equipments to check the pollution and the pollutant emissions. Besides, low quality fuels were used. This included domestic lignite with low heat power and fuel oil with over 3 % sulphur.

3. Energy Economics and Tariff

After the introduction of some degree of market conditions in the energy sector, such as raising energy prices, RENEL was prepared to continue revising, developing and/or introducing a new legislation. The reasons for that were: to remove the monopoly status of energy industries and to establish an attractive environment which can attract foreign investments. During the ancient regime the prices of electricity were fixed by the government on political ground. There was not a direct relation with the production costs. The consequence of this has been that prices were very stable during the period 1982 - 1990 as shown from the maximum prices of domestic consumption below in Fig. 12

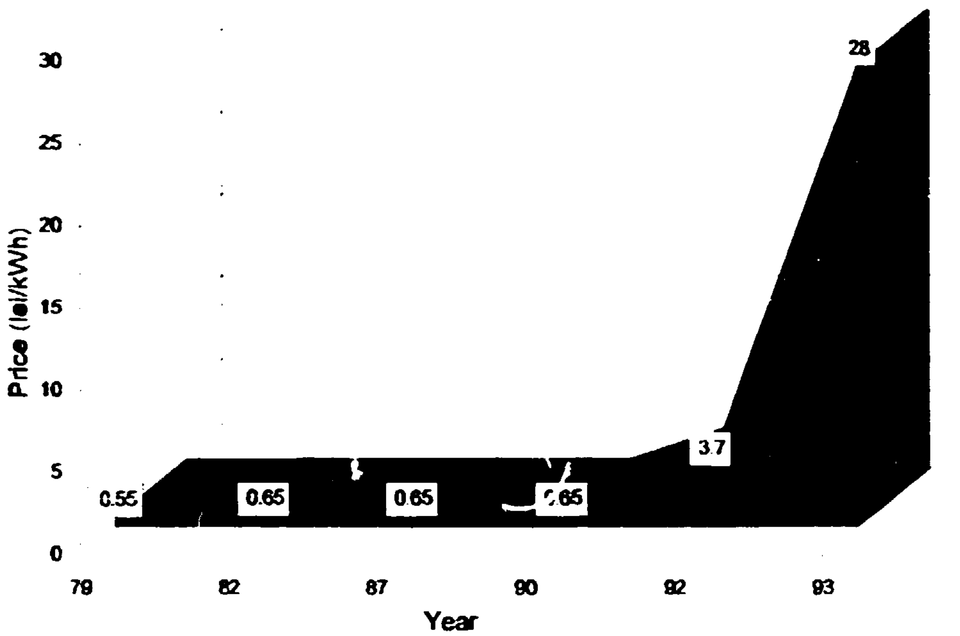


Fig. 12. Electricity prices in Romania during the past 15 years (US$ =470 lei, 1993)
(Notice the distance between the years is not to scale)

Since October 1990 these prices became gradually more market oriented. A cost covering price level is of course a prerequisite for good operation without subsidies. The 1993 price level is deemed to cover all RENEL's costs.

Romania	0.035	US$/kWh
Italy	0.27	"
Germany	0.18	"
France	0.17	"
Netherlands	0.11	"

Electricity prices in Romania are thus still low compared with those in West Europe. Another important factor is the price of the fuels which are not correlated with the quality of the lignite supplied.

On the other hand, the ratio "kWh price/average monthly wage" is in Romania roughly 5 times higher than in Germany or France. At the same time the daily bread and dwelling expenses represent roughly 80 % from the average monthly wage in Romania. These economic and social factors have to be considered in any new energy project.

4. The Environment

a. Air quality

Ambient air quality monitoring in Romania is performed by the Ministry of Health (M.S.) and the Ministry of Waters, Forestry and Protection of the Environment (MAPPM).

Component	ROM	EC	WHO	WB
SO_2 (μg/m^3)				
Annual	60	50	50	100
NO_2 (μg/m^3)				
Annual	40	-	-	100
Particulate (μg/m^3)				
Annual	75	50	50	100
Deposited dust (g/m^3)				
Month	17	-	-	-

ROM Air Quality Standards in Romania
EC Air Quality Standards in European Community
WHO Air Quality Guidelines of World Health Organization
WB Air Quality Guidelines of World Bank

Assessment of air quality from the data available shows that the Romanian Standards for SO_2 are not exceeded. The SO_2 concentration levels are low. The Romanian Standards for NO_2, particulates and deposited dust are frequently exceeded.

The NO_2 emissions are not only caused by the power stations but also by sources as traffic and industries (like fertilizer and metallurgical industries). The level of particulates and deposited dust are also hardly influenced by the power plants. Important sources of particulates are metallurgical and cement factories.

b. Surface waters

Since the mid 1950's Romania has had a monitoring system for the rivers and in the 1970's a national system was elaborated. The usability of the water categories is as follows:

Category I	Usable for drinking water production, process water for food industry and aquaculture.
Category II	Fish water for all kinds of fish except salmon and process water for technological industry
Category III	Water for irrigation of agricultural land and for water power

The situation of the different rivers is as follows:

River	flow	Category	Main pollutant
Danube	2000 - 5000 m^3/s	I	phenol, ammonium, iron
Jiu	11 - 94 m^3/s	I - II	upper course is heavily polluted, a moderately downstream
Mures	30 - 97 m^3/s	II	moderately polluted
Trotus	15 m^3/s	III	heavily polluted by industrial discharges
Ialomita	3 m^3/s	I	water quality good
Dimbovita			no data available
Prahova	13 m^3/s	II	heavily polluted

*c. **Ground water quality***

Ground water resources in Romania are used for drinking water, for industrial use, as a recipient of waste water and as infiltration ponds from agriculture. An average of, 20 % of the drinking water originates from ground water. In the Southern part, 58 % of a water is provided by ground water resources.

Ground water pollution is assessed in 1988 by means of a survey on nitrate contents in shallow wells in rural areas. The survey showed extended nitrate pollution and furthermore pollution with pesticides and heavy metals. Another study, carried out in 80 towns in the Southern part of Romania, which has an intensive agriculture sector, showed extensive ground water pollution by pesticides. Ground water monitoring is carried out on a nation scale by the system including 3 000 wells for background monitoring and 18 000 wells for monitoring industrial impacts.

B. REVIEW OF STUDIES ON IMPROVING ENERGY EFFICIENCY AND DECREASING ENVIRONMENTAL EMISSIONS

The comprehensive thermal power plant/unit rehabilitation and modernization program originates from the Romania Environment Strategy Paper issued July 31, 1992 of the World Bank. On the other hand, a lot of studies regarding the improvement of energy efficiency and decreasing environmental emissions were made by foreign companies as well as by Romanian research and development institutes. The main studies, including those undertaken by some foreign engineering companies, are

a.	Least cost capacity development study	EWBANK PREECE Ltd United Kingdom
b.	Rehabilitation survey of thermal power plants	MERZ and McLELLAND United Kingdom
c.	Bucharest district heating feasibility study	BECHTEL Co United States
d.	Environmental impact assessment study for power and lignite sub-sectors	RAMBOLL HANNEMANN and HOJLUND A/S Denmark, and ENERGY-ENVIRONMENT Netherlands

The main conclusions of the above mentioned studies as far as environment protection and energy efficiency improvement are concerned will be discussed below.

1. Improving Energy Situation

Romanian government being aware of the importance of encouraging more efficient energy production and use, has created in 1991, ARCE, National Agency for Energy Conservation. The main scope of the agency's activity is to promote energy efficiency consumption in industry, residential, commercial, transport, agriculture and other sectors. The Agency's strategy includes:

* Promotion of specific research for energy efficiency equipment and technologies as metering devices, electrical appliances, heat exchangers, dual fuel burners, renewable energy,...

* Promotion of NO_x reduction through upgrading combustion equipment by improved design, better air circulation, advanced low NO_x burner, pulverized and fuel system conversion, control of SO_x, control of CO_x.

  For this purpose ARCE has, since 1992, a budget from the Ministry of Research and Technology, from which it finances some researches on the above mentioned topics.

* Encouragement of investments in energy efficiency, by giving grants, up 30 % of the total investments to several enterprises from a special fund negotiated with the public budget.

  Most of these investments were made to rehabilitate or modernize energy consumers: boilers, furnaces, burners, to procure equipment for energy measurement and accounting, to promote secondary energy recovery and renewable as clean energy sources.

* Promotion of international cooperation in the following subjects:
  - technical assistance, consultancy
  - information dissemination
  - demonstrative actions
  - training
  - logistic support

In this respect, RENEL has in mind to accelerate the up-dating of the equipment and the response for the environment pollution. In the field of institutional reinforcement, ARCE will develop strategies on smaller scale, specific for each of its regional branches, in correlations with the local economic profile. The strategy will be developed in three stages:

a. Emergency face with priority one: to stop energy intensity increase through technical assistance, financial incentives and appropriate legislation.

b. Medium term strategy with the objectives to reduce energy intensity to 0.5 toe (tonne oil equivalent) of final energy consumption/1000 US$ of GDP by: demonstrative actions, financial back up, encouraging utilities to optimize their resources use.

c. Long term strategy, with the main objective of reducing energy intensity to 0.3 toe of final energy consumption/1000 US$ GDP by: dissemination of the successful technologies and replication of the successful demonstrative actions.

The second way to solve the energy problem is to improve the activities in the energy sub-sectors, e.g., in mining, where the following aspects should be taken into account:

- The revitalization of productive activities in the lignite and coal sector (brown coal and bituminous coal).
- The improvement of the quality of coal, by reducing the content of barren.
- The correlation of coal production supply with the national economy demand (coal and lignite) for energy, metallurgy and domestic sectors.
- The initiation of cooperation between Romanian and foreign partners for the rehabilitation of the coal extraction sector.

In the oil and gas sub-sector, the main objectives are as follows:

- To stop oil and natural gas production decline, and to maintain a production rate which would provide high efficiency and optimum reserve rate.
- To up-grade geophysical research activity by the procurement of top level equipment.
- To rehabilitate the drilling rigs for high deep-angles wells and horizontal actions.
- To attract foreign investments for the outline of new hydrocarbon reserves, especially for those existing in high-depth zones. In this respect, ROMPETROL has organized a bidding to attract the foreign investors who shall carry out oil exploration and development works on 15 areas, like AMOCO, SHELL, ENTERPRISE and CANADIAN OCCIDENTAL.

2. Decreasing Emissions from Energy Production

RENEL's policy for decreasing the emissions from energy production is given below.

Policy for the environment	**Priority actions**
Upgrading and control of combustion processes	i. Purchasing instruments for automatic measurement and control of the combustion process
	ii. Changing the combustion process and implementation of reduced NO_x burners
Energy generation improvement through clean fuel technologies	i. Utilization of low sulphur heavy oil in the main cities and towns
	ii. Replacing the autochthonous lignite with imported coal at certain power plants
Increasing the performances of electrostatic precipitators	i. Retrofitting of electrostatic precipitators

Power plants endowment with measurement and monitoring equipment for emissions (SO_2, NO_x, powders, CO_2, CO, hydrocarbons)	i. Purchase of mobile laboratories for emission measurements ii. Endowment of power plants with emissions control equipment
Abatement of ash stockpiles impact on the environment, ash utilization	i. Application of ash stockpiles stabilization technologies in order to avoid its spreading ii. Ash management and marketing
Promoting energy efficiency policy - to the own equipment - at the consumers	i. Rehabilitation of existing power plants ii. Implementation of new clean technologies of high energy efficiency (FBC boilers, combines cycle steam-gas) iii. DSM projects at the electric and thermal power consumers

C. ECONOMIC AND ENVIRONMENTAL COMPARISON OF COGENERATION CYCLES

Cogeneration or the simultaneous production of electricity and heat is a well established technology which has proven its technical and economic viability for many years in Romania. Romania has long experience in designing and operating cogeneration plants. Several methods could be applied for undertaking the economic analysis of cogeneration system.

Cogeneration plants save annually more than 30 % of the primary energy. In other words, the cogeneration unit consumes about 65 % of the fuel needed for running two single plants producing the same output of electricity and heat. This subsequently means that the cogeneration plant will produce about 32 % less pollutants than two single plants producing the same amount of electricity and heat.

The environmental impacts of SO_x, NO_x and CO_2 are already known but the benefits of decreasing their emissions could be difficult to estimate in terms of money. What is sure is the costs of controlling these pollutants in two separate plants are more than the costs of controlling them in one cogeneration plant.

In addition to normal savings in building and running a cogeneration plant in comparison to two single plants, the environmental savings will also result from:

- scrubbing particulates
- scrubbing NO_x
- controlling SO_x
- controlling CO_2

In Romania there is no coal gasification combined cycle, but there are pilot plants in operation in Bucharest. At the same stage of development is the application of pressurized fluidized bed combustors.

D. PLAN OF ACTION FOR THE INTRODUCTION OF LNWT IN ENERGY PRODUCTION

The decrease of emissions from energy production system raises a number of important environmental issues. Among these, are the availability of clean or LNWT (Low and Non-Waste Technology), but the allocation of resources are likely to play an important roll.

1. Future investments

In order to maintain the power system and to improve its technical and economic performances the rehabilitation and modernisation of the power plants, units and network are to be accomplished.

In 1993, RENEL forecasted to operate 200 MW in district heating plants (4 units of 50 MW each) at Arad, Brasov, Bacau, Bucharest, and 25 MW in hydro power plants. Over the period from 1994 to 2000 it is forecasted to provide investments from own resources to build 430 MW thermal power plants and 80 MW hydro power plants. The overall programme of thermal and hydro power plants building, financed by RENEL over the period during 1994 - 2000, requires US$ 2180 millions. At the same time, RENEL owns, at various commissioning levels, thermal, hydro and nuclear power plants, that produce 975 MW. One of these units that have been started and is now at an advanced commissioning level is the Nuclear Power Plant Cernavoda, which was projected and which the construction works started for 5 units 700 MW each, with CANDU reactors.

2. Other Projects on LNWT in Energy Production

Among all the possibilities for improving the energy production and decreasing the pollutant emissions, the LNWT (Low- and Non-Waste technologies) is a potential possible "new" approach.

Two main approaches are possible: the first is the improvement of the already existing systems (methods and/or equipment) to increase the efficiency of energy production. And the second is to reduce the pollutant's emissions, and to use local waste materials as fuel; fostering in such a way both the environmental protection and resources saving strategy.

In the first category, the improving possibilities of existing systems are different depending on the type of plant. In Romania no diesel plants are used for electricity production hence the focus will be on boilers. In all cases, it is important to consider separately the primary methods concerning the burning process itself and the secondary methods concerning the flue gas technologies. Obviously, each primary method has to focus on the nature and content of the fuel and to start (as process flow) with preparation of that fuel. Similarly, each secondary method has to end with waste disposal or better, with waste recycling and re-use.

Cogeneration gives, on the other hand, flexibility for the general parameters of the system. Concerning waste using in energy production, emphasis should be put on biogas technology, incineration and gasification.

E. FINANCIAL CONSTRAINTS

The Government of Romania is currently seeking funds from the World Bank, PHARE Programme and other international multilateral financing agencies to perform comprehensive rehabilitation and modernization for thermal power plant units in connection with a restructuring and rehabilitation of the country's lignite mines.

The World Bank is considering to provide a loan for the above purpose after undertaking all Environmental Impact Assessments needed.

Other studies are financed through a grant from European Communities on EC-PHARE Programme for the Central and Eastern Europe.

In addition to these funds from foreigner organizations, the municipalities from Romanian towns have their own funds allocated by the Romanian Government from the National Budget to improve the environmental conditions.

F. CASE STUDY ON MUNICIPAL WASTE MANAGEMENT IN BUCHAREST

1. Use of Domestic Wastes

Biothermal fermentation of wastes has been developed in Romania with stimulating results for digesting most of animal wastes from farms and to a lesser extent domestic wastes.

The use of this method has the advantage that wastes can be wholly turned to best use, as after completion of fermentation, the resulted product has a calorific power about 6.5 kWh/m^3. This sludge could be dried and used as briquettes for combustion or fertilizer in agriculture. They have the advantage, compared with the synthetically fabricated fertilizers, that the former are biologically degraded and do not pollute the soil, surface and ground waters neither they produce GHG as Nitrous Oxides.

The average consumption of methane gas for Bucharest populations (about 2 millions inhabitants) is 7.56 PJ. On the other hand, the amount of wastes collected in Bucharest is roughly 0.8 kg per capita/day, therefore 300 kg/y per capita, which is roughly 600 000 t/y.

2. Waste Management in Bucharest

According to the data made available by the townhall of Bucharest municipality, the wastes resulted in the capital are:

Domestic wastes	5 500 m^3/day
Street wastes	800 m^3/day
Industrial wastes	1 200 m^3/day

This is equivalent to about 800 000 - 900 000 t/y

Up to the present, these wastes were collected and stored in pits. For environmental protection reasons and as a consequence of the problems raised by storing wastes in such a volume, it was tried to incinerate them. Thus, two pilot units were built, based on Romanian design, in Militari and Pantelimon areas, each one being equipped with two lines for wastes processing with a rated capacity 5 t/h. The technique used is that of 1970's and the incineration technology applied produces noxious chemical compounds which are not retained by the gas discharge units, in amounts exceeding the present regulations concerning the environmental protection. The reliability of the mechanical system is low, and it can only be used for less than 50 % of the annual operating time. For these reasons, the pilot units cannot represent a final alternative to solve the problem of the collected wastes in Bucharest municipality.

3. Pilot Plant Suggested

In the following a pilot plant is suggested to treat a part of the solid waste in the city of Bucharest. The treatment capacity of the plant is assumed to be 60 000 t/y; and the composition of the waste is assumed as follows:

Material	Percentage %	Amount t/year
Organic kitchen waste	81	48600
Paper	8	4800
Plastics	3	1800
Metals	4	2400
Stones/dust	1	600
Glass	3	1800

4. Plant Components

The waste treatment plant will consist of the following main components:

a. Pretreatment Plant (Fig. 4)

The pretreatment plant consists of : receiving silo, screen, crusher, magnetic separator, convey belt and control room.

b. Biological Treatment Plant (Fig. 5)

The biological treatment plant will, on the other hand consist of: Mix-separators, biomass pumps, digesters, gas cleaning system, heat recovery system, process water system, mechanical dewatering equipment and bio-filter.

The Finnish process known as Waasa process includes components as the Mix-separator and the Twin digester which remove efficiently undesired materials such as glass, stones and plastics from the end products. This makes the input staff of much higher quality than in conventional composting, hence the sludge could be used directly in the field. The anaerobic process does not, however, remove metal trace, and the decision to remove them rest with the consumer. The percentage of the metal trace in the sludge depends to a great extend on the amount of industrial waste mixed with municipal waste.

c. The End products

The output corresponding to the input materials mention above is as follows:

End product	Amount per year	Remarks
Biogas	6.6×10^6 Nm^3/y	CH_4 59%
Sludge	24 000 t/y	TS 35%
Surplus water	21 000 t/y	
Disposable products	7 000 t/y	

The biogas product is to used in a cogeneration diesel plant to produce electricity of about 13 GWh/y and heat of about 21 GWh/y. The electricity consumption of the plant itself will be roughly 2.7 GWh/y and the heat consumption, 2.5 GWh/y.

The sludge is a good quality fertilizer and can replace imported and locally manufactured N-fertilizers. Its amount will be about 24 000 t/y. The surplus water may be also used in agriculture as liquid fertilizer. Its amount is approximately 21 000 t/y. If this is not feasible, the water could be treated in waste water treatment plant.

The inert material contained in the waste is separated and treated. Since, it has no environmental hazards it could be disposed of safely. Its amount will be about 7 000 t/y. The sewage waste and other organic wastes as vegetable products, slaughter house waste, and other organic and non-toxic waste could be also added to the input materials. Both the biogas and the fertilizer yields will grow accordingly, and a bigger plant will be needed.

A plant of the above size will operate 5 days a week and 16 hours per day (two shifts). It will thus need 2 x 5 operators. training of the operators on new plants could take place on site in Waasa which has been operating since 1990. The cost of constructing such plant in Romania could be given only after undertaking a detailed pre-feasibility/feasibility study to determine exactly the parts that are going to be manufactured locally and those which are going to be imported.

Annex 1

Economical Evaluation				**Refer.**	**HUN001**	
				Date	**21-3-94**	
	Project			**WN6R25SG**		
		Customer		**St. Imre Hospital**		
A	***Plant Performance***					
		Production		**kW**	**2429**	
			Electrical	**kW**	**1039**	
			Heat	**kW**	**1390**	
		Fuel Input		**kW**	**2692**	
			Main fuel	**kW**	**2692**	
			Pilot fuel	**kW**	**0**	
B	***Annual Operational Production***					
		Full Power Hours				
			Electrical	**h**	**8100**	
			Heat	**h**	**8100**	
		Operational Losses		**%**	**1**	
		Production		**MWh**	**19674**	
			Electrical	**MWh**	**8413**	
			Heat	**MWh**	**11261**	
		Fuel Input		**MWh**	**22026**	
			Main fuel	**MWh**	**22026**	
			Pilot	**MWh**	**0**	
		Annual Net Efficiencies		**%**	**89,3**	
			Electrical	**%**	**38,2**	
			Heat	**%**	**51,1**	
C	***Power Plant Profitability***					
		Investment Data				
			Total Investment	Mill. FIM	6,7	
			Equity Investment	Mill. FIM	1,3	
			Residual Value	Mill. FIM	0,2	
			Net Investment	Mill. FIM	1,1	
		Annual Economical Data				
			Incomes	Mill. FIM /year	3,6	
			Costs	Mill. FIM /year	-2,1	
			Operational Margin	Mill. FIM /year	1,4	
			Capital Costs	Mill. FIM /year	-0,5	
			Net Income	Mill. FIM /year	0,9	
			Income Taxes	Mill. FIM /year	0,0	0%
			Operating Cash-Flow	Mill. FIM /year	0,9	
		Profitability				
			Return On Investment (ROI)	**%**	**22,0**	
			Pay-Back Time	**years**	**1,5**	
			Return On Equity (ROE)	**%**	**67,7**	
			Debt Coverage Ratio		**2,76**	

D Annual Operational Margin

D1	**Annual Operational Margin**	**Mill. FIM**	**1,4**
	Incomes (D2)	Mill. FIM	3,6
	Costs (D3..D5)	Mill. FIM	2,1
D2	**Annual Incomes**	**Mill. FIM**	**3,6**
	Electricity	**Mill. FIM**	**2,7**
	Energy Payment	Mill. FIM	2,7
	Tariff	FIM/MWh	320,0
	Capacity Payment	Mill. FIM	0,0
	Tariff	FIM/kW	0,0
	Heat	**Mill. FIM**	**0,9**
	Energy Payment	Mill. FIM	0,9
	Tariff	FIM/MWh	78,0
	Capacity Payment	Mill. FIM	0,0
	Tariff	FIM/kW	0,0
D3	**Annual Fuel Costs**	**Mill. FIM**	**1,7**
	Main Fuel Costs	**Mill. FIM**	**1,7**
	Energy Payment	Mill. FIM	1,7
	Price	FIM/MWh	78,0
	Capacity Payment	Mill. FIM	0,0
	Tariff	FIM/kW	0,0
	Pilot Fuel Costs	**Mill. FIM**	**0,0**
	Energy Payment	Mill. FIM	0,0
	Price	FIM/MWh	0,0
D4	**Annual Operation and Maintenance Costs**	**Mill. FIM**	**0,4**
	Operation Costs	**Mill. FIM**	**0,1**
	Price	FIM/kWe/year	120,0
	Maintenance Costs	**Mill. FIM**	**0,2**
	Price	FIM/MWh el	25,0
	Lube Oil Costs		**0,0**
	Price	FIM/liter	5,0
	Consumption	kg/year	8413
D5	**Annual Costs for DeNOx reduction**	**Mill. FIM**	**0,0**
	Catalysator Costs	**Mill. FIM**	**0,0**
	Price	FIM/MWh	4,0
	Ammonia Water (25/75 %) Costs	**Mill. FIM**	**0,0**
	Price	FIM/kg	0,8
	Consumption	kg/year	5666,5

Economical Evaluation

Refer.	HUN001
Date	21-3-94

E Investment Costs

E1	**Investment Costs**		**Mill. FIM**	**6,7**
	a	Power Plant	Mill. FIM	5,2
	b	Infrastructure	Mill. FIM	0,6
	c	Indirect Costs	Mill. FIM	0,2
	d	Allowances	Mill. FIM	0,0
	e	Fees	Mill. FIM	0,4
	f	IDC	Mill. FIM	0,1
	g	Land	Mill. FIM	0,0
	h	Reserves	Mill. FIM	0,2
		Basic Investment Costs (a..c)	Mill. FIM	6,0
		Construction Costs (a..f)	Mill. FIM	6,5
E2	**Investment Fees**		**Mill. FIM**	**0,4**
		Commitment Fees	**Mill. FIM**	**0,0**
			%	0,3
		Developement Fees	**Mill. FIM**	**0,4**
			%	6,0
E3	**Interest During Construction, IDC**		**Mill. FIM**	**0,1**
		Construction Time	months	12
		Construction Loan	Mill. FIM	5,2
		Interest rate	%	5,0
E4	**Annual Capital Costs**		**Mill. FIM**	**0,5**
		Loan	Mill. FIM	5,4
		Equity Share	%	20,0
		Total Investment	Mill. FIM	6,7
		Interest rate	%	5
		Amortization	years	15
E5	**Reserves**		**Mill. FIM**	**0,2**
		Fuel Reserves	**Mill. FIM**	**0,0**
		Fuel Effect	MW	2,7
		Reserve Fuel Price	FIM/MWh	0
		Reserve Days	days	0
		Debt Fund Reserves	**Mill. FIM**	**0,0**
		Debt Costs	Mill. FIM	0,5
		Reserve Days	days	30
		Cash Reserves	**Mill. FIM**	**0,2**
		Annual Running Costs	Mill. FIM	2,1
		Annual Full Power Hours	h	8100
		Reserve Days	days	30

Plant Performance Data

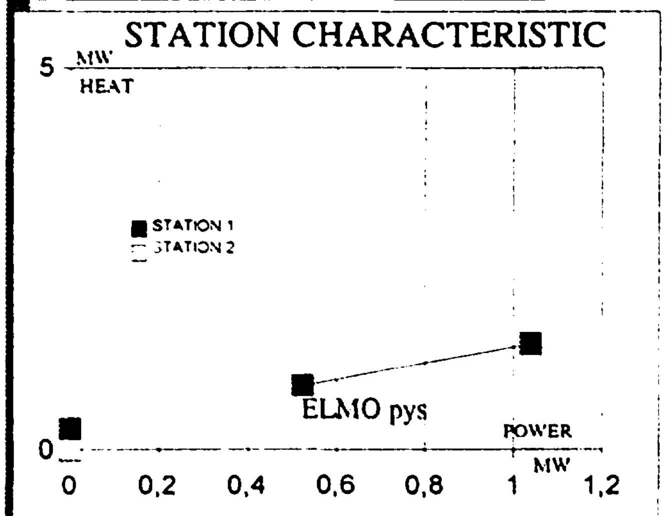
Refer. **HUN001**
Date **21-3-94**

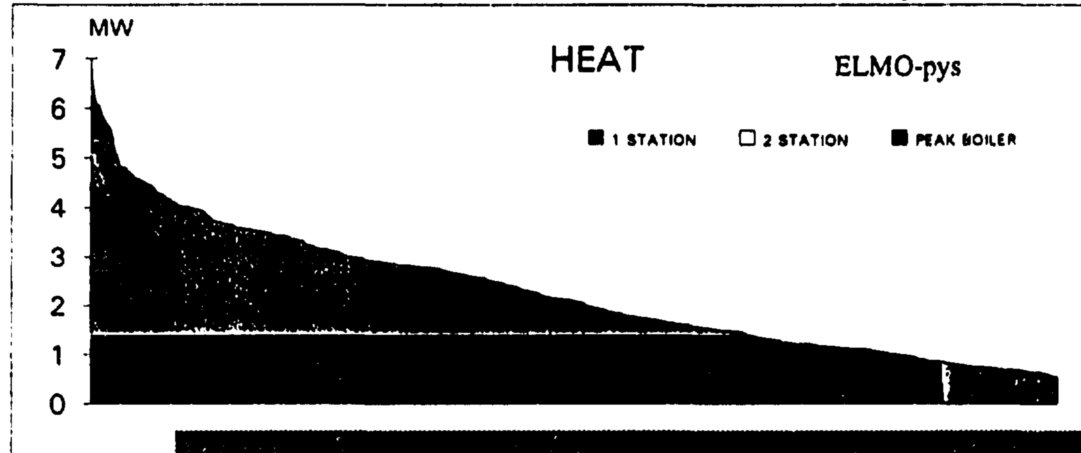
1	***PROJECT***		***WN6R25SG***		
	Customer		***St. Imre Hospital***		
2	***PLANT SPECIFICATION***				
	Number of engines	pcs	1		
	Engine Type		Wärtsilä Nohab WN6R25.SG		
	Engine Speed / Frequency	rpm	1000	50 Hz	
	Main Fuel		Natural Gas		
	Lower Heat Value	kJ/m3(n)	36000		
	Pressure	bar	4		
	Heat Recovery Type		Saturated Steam and Hot Water		
	DeNOx equipment		Installed		
	Auxiliary Cooling Type		Radiator		
	Generator Voltage, power factor	V	13200	0.85	
3	***REFERENCE CONDITIONS***				
	Altitude	m, max	100		
	Ambient temperature	C, max	15		
	0	0	0		

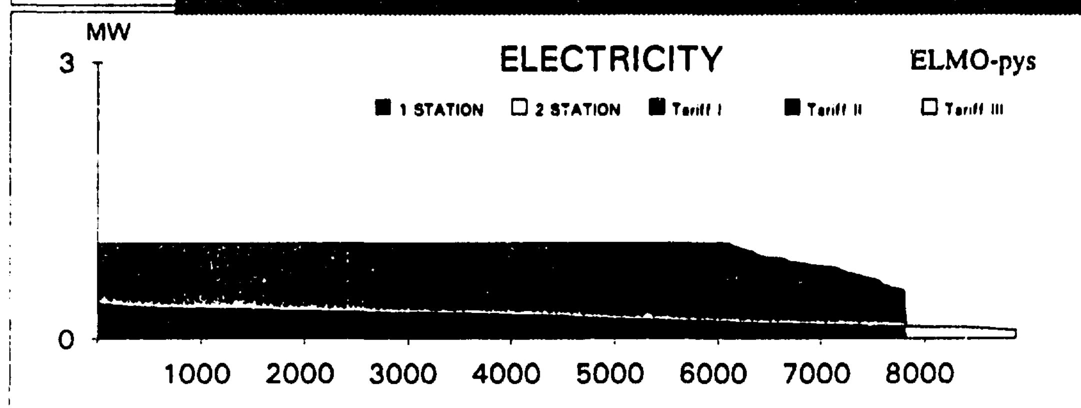
			DG-set	*Plant*	*Efficiency*
4	***PLANT PERFORMANCE***				
	Electrical Production	**kW, net**		**1039**	**38,6%**
	DG-set	kW	1050	1050	
	Steam Turbine	kW		0	
	Paracitics	kW		-11	
	Heat Production	**kW, net**	**1390**	**1390**	**51,6%**
	Saturated Steam	*kg/h*	*950*		
	..pressure	bar, a	6		
	..feed water	C	105		
	Hot Water	*kW*	*777*		
	..return water	C	45		
	..supply water	C	85		
	Total Production	**kW**		**2429**	**90,2%**
	Fuel Consumption	**kW**	**2692**	**2692**	
		kJ/kWhe		9332	

		mg/MJf	ppm-v	mg/m3(n)	mg/m3(n)
5	***EMISSIONS***				
	O2-content		12,0%	5,0%	15,0%
	NOx (calculated as NO2)	162	127	466	173
	CO			390	
	THC (calculated as CH4)			150	
	Ammonia Slip			25	
6	***CONSUMABLES***				
	Lube oil consumption	g/kWhe		1.0	
	Ammonia-Water (25/75 %)	g/kWhe		0.7	

Station characteristic	St. Imre Hospital		03/22/94	name: MODIGEN Oy
[MW]	Power	Heat 1	Heat 2	
LOAD:	**0-load**	0,3	0,0	
min 1	0,5	0,9		
max 1	1,0	1,4		
min 2	######		0,0	
max 2	0,0		0,0	
purchase	0%	0%		
energy GWh/a	2	20		







ENERGY:		Total	1 STATION	2 STATION	other	Tariff II	Tariff III
- Heat	GWh/a	20,0	10,3	0,0	9,7		
- Electricity	GWh/a	2,1	7,6	0,0	-5,6	0,0	0,1

Annex 2

ANNEX 3

1. Operating Performances Processes for Coals Burning in Circulating Fluidized Bed for Following Types of Boilers.

1.a. 30 t/h boiler

Main parameters (free circulation boiler):

steam: nominal flow rate		30 t/h (40 t/h)
	pressure	15.0 bar
	temperature	300 °C
feed water:		104 °C
boiler inlet pressure		24 bar
injection water:		21 bar
environmental air temperature:		25 °C
air excess in firebox:		1.2

Design fuel characteristics:

Q^i	6.49 kJ/kg
C^i	19.3 %
H^i	1.8 %
S^i	0.6 %
O^i	7.3 %
N^i	1.7 %
W^i	41.0 %
A^i	28.3 %

Start-up fuel: methane gas

CH_4	98.4 %	P_{ci}	33.63 MJ/Nmc
C_2H_6	0.48 %		
C_3H_8	0.63 %		
air	0.47 %		

1.b. RO-165 type boiler, free circulation, without intermediate superheating (GANZ - Hungary)

Main parameters:

steam: nominal flow rate		165 t/h
	pressure	13.7 MPa
	temperature	813 K
feed water:		488 K
project coal:		
	Q^i	8820 kJ/kg
	W^i	34 %
	A^i	27.5 %
	MV^i	22 %

1.c. 330 t/h boiler with free circulation and intermediate superheating.

Main parameters:

steam: nominal steam		330 t/h
	pressure	140 bar
	temperature	575 °C
feed water:		240 °C

1.d. 120 t/h boiler

32 bar 420 °C	coupled with DK 00 - 120 type turbine of 12 MW
100 bar 540 °C	coupled with 20 MW turbine

2. Operating performance processes for desulphurization of burning gases for fuel boilers:
   coal
   black oil

3. Processes for making most of various categories of ash from thermal power units (electrofilters hearth from storage) for the fabrication of construction materials as well as other fields of technical and economic interest.

4. Cogeneration processes in plants equipped with interval combustion motors:

   - Cooperation for in site experiments at a Romanian design plant: 30 KW located at University Hospital Bucharest.

   - Elaboration of improved diagrams and the utilization of performing components (heat exchangers with plates) in view of increasing power efficiency.

   - Heavy liquid fuel combustion in motors provided with cogeneration and depollution problems in order to increase the efficiency of the application.

Table 1. Differences in emissions (tons) between the years 2000 and 1992.

Table 2. Emissions of carbon dioxide (10^3 tons) in 2000.

Table 3. Emissions of particulates (tons) in 2000.

Table 4. Maximum annual mean concentrations (μg/m^3) in the surroundings of the power plants.