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

MINISTRY OF ENVIRONMENT, FINLAND VTT ENERGY UNIDO NREA WÄRTSILÄ DIESEL

LNWT IN EGYPT

CASE STUDIES ON WASTE MANAGEMENT AND COGENERATION

By

Ragy Farid Kagy	NREA, Egypt
Yehia ElMahgary	VTT Energy, Finland
Hassan Gomaa	NREA, Egypt
Kimmo Tuominen	Wärtsilä Diesel

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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 Egypt was undertaken by VTT - Energy in cooperation with New and Renewable Energy Agency (NREA) in Egypt, Wārtsilā Diesel and AVECON OY in Finland.

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A. PROSPECTS OF LNWT IN ENERGY PRODUCTION IN EGYPT

1. INTRODUCTION

Egypt's development plans require intensive programs in land reclamation, load production, industrialization and community development. Primary energy requirements have drastically increased during the 1980's and expected to exceed its resources before the end of the century. Today the total primary consumption is about 1.63 EJ (39 millions toe) expected to reach 2.51 EJ (60 millions toe) by the year 2005.

The Egyptian Government has to take several measures to meet the ever increasing demand for energy. These are:

a) Raising of energy prices (fuel and electricity) to reach their economic level.

b) Diversification and altering of the present mix of energy sources and technologies.

c) Strong emphasis on energy conservation.

The current generated electric energy exceeds 45 TWh, the normal rate of the growth is about five per cent reaching about 85 TWh by the year 2005. Most of hydro-power resources (about 85%) in Egypt are already used to supply 23% of Egypt's electric energy, this percentage will reach 14% by the year 2005, assuming that 95% of the hydro-power resources are used at that time.

Fossil fuel resources in Egypt are being quickly depleted. This is particularly true for oil and natural gas (N.G.). Average annual rate of growth of petroleum products consumption is 5.1% for oil and 13.8% for natural gas. Life expectancy of oil reserves in Egypt is estimated to be ten years, while that for natural gas is estimated to be fifteen years.

Due to what has been previously mentioned, energy conservation (E.C.) measures, renewable energy (R.E.) technologies and LNWT energy have to be introduced promoted.

The government of Egypt has realized early 1980's the fact that energy resources will fall short to satisfy the demand. A national strategy for the development of energy conservation measures and renewable energy applications have been formulated. The strategy targeted to the following:

* saving ten per cent of the projected energy consumption through the implementation of E.C. measures and efficiency improvement of existing facilities.

* developing R.E. technologies to supply five per cent of national primary energy by the year 2005.

It is obvious that the implementation of such strategy will be an essential element in the national plans for achieving sustainable development and protection of the environment via upgrading energy efficiency and replacing conventional polluting resources by the renewable resources.

Intensive efforts were directed towards the following:

* Assessment of energy consumption in each sector and identification of energy conservation and efficiency improvement options, particularly in the industrial, electric and domestic sectors.

* Renewable energy resources assessment and identification of short and long term programs for its development and utilization.

* Identification of appropriate mechanisms and formulation of specialized bodies to effectively implement national plans in this area.

* Coordination of national efforts and actions towards the realization of the strategic objectives.

* Adopting measures for the mitigation of the environmental impacts of the energy sector.

2. APPLICATION OF LNWT

2.1 Energy Efficiency Programs

Targets were adopted to develop energy efficiency in the different economic sectors. Emphasis was put on both the electricity generation and industrial sectors as they incorporate the highest potential for efficiency improvement in the supply and demand sides of the processes included.

2.1.1 Efficiency improvement in electric sector.

In electricity generation sector, the current policy, committed to efficient utilization of Egypt's limited energy resources from production to end use, have produced fruitful results in many aspects.

2.1.1.1 Maximizing Generation Efficiency

A number of adequate measures were adopted by the electricity sector since mid 1980's to maximize the generation efficiency. These include the use of combined cycle (C.C) technology, the use of waste heat, rehabilitation of some existing plants, and introduction of modern large units with better efficiency. Egypt has, since 1989, added more than 1220 MW from combined cycle plants to the net, and rehabilitated power plants of 280 MW. In the current rehabilitation program, the capacity is expected to reach 600 MW soon.

The accumulated energy savings during nine years reached about 632 PJ (15.14 million toe). This was achieved by reducing the average rate of fuel consumption from **331 g/kWh** in 1983 to **241 g/kWh** in 1992/1993 based on the gross electric generation shown in Fig 1.

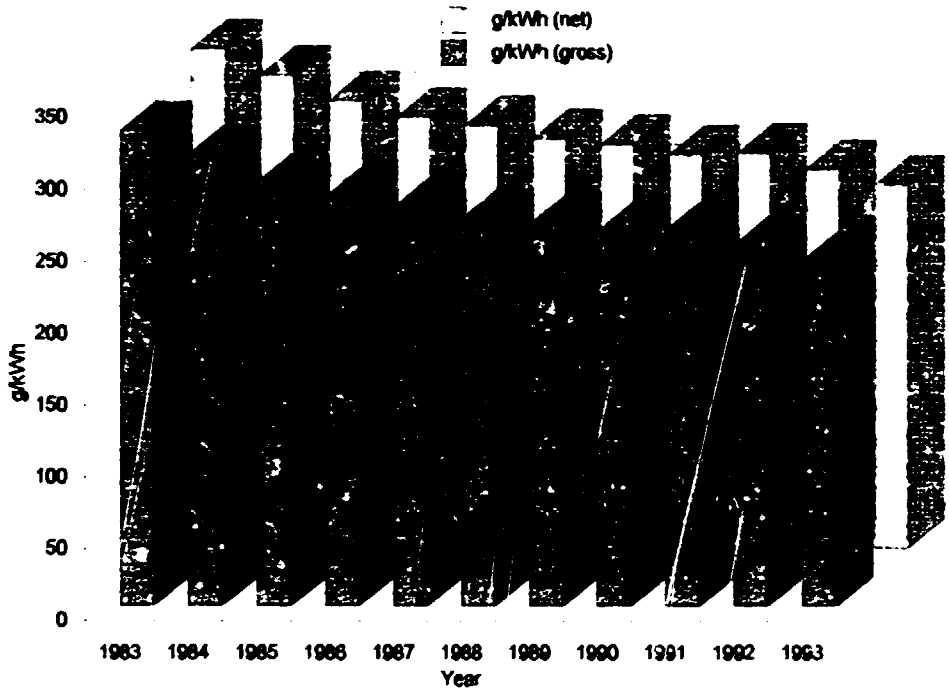

Fig.1 Average Rate of Specific Fuel Consumption for Electricity Production in Egypt

In addition, the economic programmed dispatch operation of the power system units according to the order of merit has led to considerable improvement in the overall efficiency.

2.1.1.2 Minimizing Transmission and Distribution Losses.

Upgrading the electricity transmission and distribution nets in Egypt's power system has lately received attention. Reliable measures are being undertaken to install the necessary capacitors at some transmission and distribution points. This has resulted in an improvement in line losses from **22%** in 1981/1982 to **14.4%** in 1990. Estimates indicate that this promotion accumulated today about 11 TWh saving of generated energy. Efforts are under way for line losses to reach about (12-14%) by the end of the century.

2.1.1.3 Demand side management and electricity end-use efficiency

Energy conservation offers simple method for potential energy saving reducing environmental adverse effects due to fuel combustion. Some steps for rationalizing energy consumption, which grows at an average rate of 12% annually in the 1980's were adopted for industrial, transmission, commercial and residential sectors (power factor improvement, efficient thermal insulation, efficient electrical appliances, load management strategy for power intensive industries such as cement, new tariff system for both peak and off-peak...etc).

These steps have influenced over the years the peak load growth; which dropped from 12% in 1981/1982 to about 4% in 1993.

2.1.2 Efficiency improvement and E.C. in industrial sector.

The industrial sector of Egypt consumes almost 50% of the national primary energy. Such consumption reached about 630 PJ (15 million toe) in 1990. Studies have shown that 20-30% of the industrial energy consumption used is wasted due to poor maintenance, inefficient processes and other reasons. So, it is obvious that energy conservation and efficiency improvement in the industrial sector can be a major contributor to energy saving on the national level. Different national institutions have set targets and programs to improve energy efficiency in industrial sector. The following give a brief description of such programs.

Since early 1980's the Organization for energy planning OEP is conducting industrial audits for different types of industries, which was a real help identifying energy conservation opportunities and its economic viability. Similar programs were conducted by the energy commission of the " Academy of Scientific Research and Technology " OEP programs has demonstrated the following:

- Industrial plants were grouped into sectors according to their activities and production. The energy audits identify the energy saving potentials, the capital investments required and the payback periods. The audits performed in the industrial sector show a potential saving of 27% of the energy consumed in the audited plants.

- Table 1 shows a summery of the annual energy saving potentials, costs of energy saved, investment costs and the simple payback periods of the conducted audits during the period (1985-1990). In addition, a complete energy conservation audits in five out of seven Egyptian refiners were performed in the year 1990.

TABLE 1. SUMMARY OF ENERGY AUDITS CONDUCTED IN SELECTED PLANTS IN CONJUNCTION WITH FOREIGN FIRMS (1985 - 1990), UNITS IN TOE.

Sector name	Energy consumption	Annual energy saving	Energy saving potential	Cost of energy saved (1000$)	Investment cost (1000$)	Simple payback period (years)
1. Ministry of industry						
A. Metal industries	21889	8945	41 %	1684	2597	1.5
B. Chemical industries	346285	129129	37 %	18328	16830	0.9
C. Food industries	80710	23112	29 %	3079	6353	2.1
D. Engineering industries	2866	141	5 %	61	60	1.0
E. Spinning & weaving industries	30345	9983	33 %	2180	3757	1.7
Total industry	482095	171310	36 %	25332	29597	1.2
2. Ministry of housing						
Cement industry	416288	77075	19 %	11946	19440	1.6
Sand industry	6300	2862	45 %	433	1255	2.9
Total housing sector	422588	79937	19 %	12379	20695	1.7
3. Ministry of health						
Health sector	9750	1487	15 %	190	95	0.5
4. Ministry of petroleum						
Petroleum sector	399136	96520	24 %	12297	22300	1.8
GRAND TOTAL	**1313569**	**349254**	**27 %**	**50198**	**72687**	**1.4**

Source: Ref. 2.

The two columns of Table 1 are drawn in Fig. 2 to compare between the energy consumption and potential energy savings of the different sectors.

-Table 2 gives a summary of the total annual expected fuel financial/savings due to implementation of various conservation means in four refiners, the necessary required investments and the payback periods.

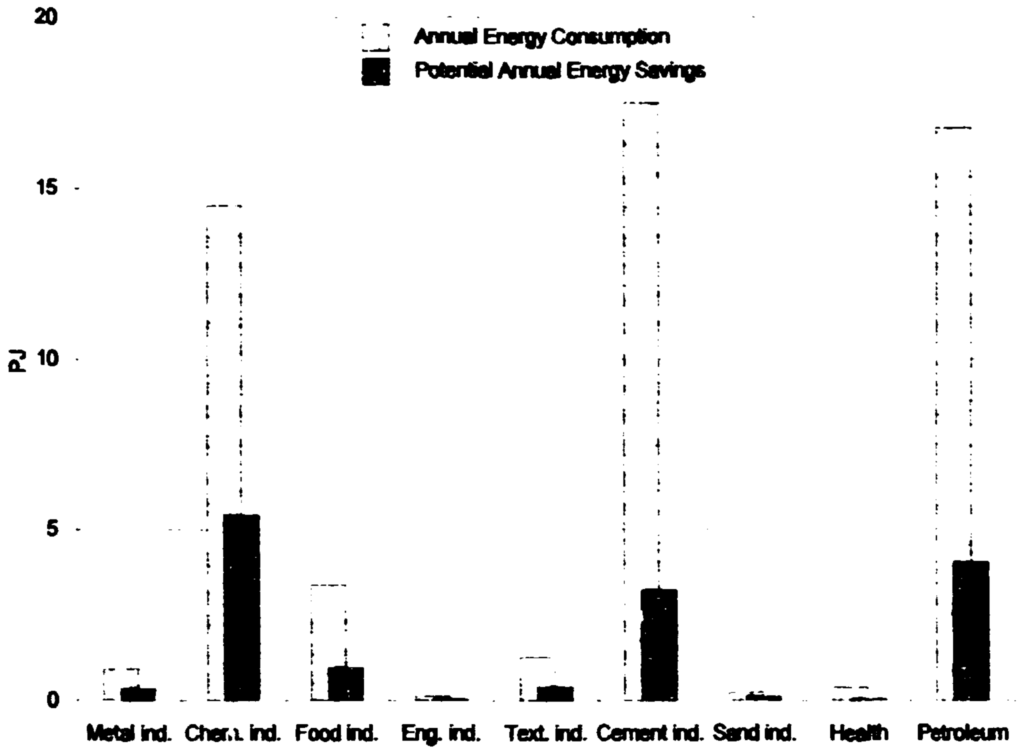

Fig. 2 Annual Energy Consumption and potential Savings in the Different Sectors

TABLE 2. A SUMMARY OF THE TOTAL ENERGY SAVINGS, INVESTMENT REQUIRED AND THE PAYBACK PERIOD OF AUDITED REFINERIES

Refinery name	Annual energy savings (toe)	Cost of energy saved (1000 LE)	Investment cost (1000 LE)	Simple payback period (years)
El Suez	31571	3764	1600	0.4
El Nasr	14979	1486	1048	0.7
El Ameria	10118	1845	2150	1.2
Cairo (Mostorod)	8101	648	262	0.4

Based on local prices. Source: Ref. 2.

2.1.3 Energy efficiency and conservation in Domestic sector.

Different efforts have been devoted to energy efficiency and conservation in domestic sector, specially for lighting and appliances. In addition, some running activities are targeting the improvement of energy efficiency in transport and agriculture sector. However, it is felt that sufficient appropriate programs are not yet developed for such sectors.

2.1.4 Renewable Energy (R.E.) Development.

Renewable energy strategy was developed and incorporated as an integral element of national energy planning in 1980 . The present energy saving by R.E. technologies count for 6.3 PJ (150 thousands toe) annually. More than 80% of this amount was achieved due to commercialization of domestic solar water heaters. The next coming years will show more rapid introduction of R.E. technologies into field applications; and the annual energy saving is expected to reach 125 PJ (3.0 million toe) by the year 2005. The following describes the milestone achievements regarding the major activities in R.E. field .

2.1.4.1 Resources assessment and planning

Significant progress has been made in data base development and resource assessment for solar, wind and biomass energy.

2.1.4.2 Demonstration and field testing:

The research, development and demonstration activities have been intensified since late 1970's . A hug number of demonstration and field testing projects were under taken by different Egyptian organizations. Some field testing and demonstration programs were quite successful in enhancing the data base and in achieving technology transfer and a reasonable level of commercialization.

Solar thermal technologies have been widely demonstrated for domestic solar water heaters, solar industrial process heat, as well as, crop drying and protected agriculture. Different photovoltaic applications were demonstrated and tested for photovoltaic pumping, clinical refrigerators, telecommunication systems, as well as , Reverse Osmos's desalination and hybrid photovoltaic diesel ice making machines. Some of low photovoltaic power systems are currently used on commercial bases at remote areas.

Encouraged by average high wind regimes at the Red Sea area (6.5-10.5 m/s), and the North Coast (4 - 6 m/s), both water pumping and grid connected wind farms were demonstrated and tested by New and Renewable Energy Authority (NREA). Currently two (400 kW) wind farms are in operation at Ras Ghareb and Hurgada and are interconnected to the local electric grid in each site. Recently, a 3 MW farm is being installed at Hurgada and is planned to be expanded to reach a total capacity of 4.8 MW. Currently, a study is on-going to establish a wind farm of 60 MW at Zaafarana to be connected to the national grid; and is expected to be operational in 1996/1997.

More than 200 biogas digester for rural areas demonstrated and improved designs were developed.

2.1.4.3 Technology transfer and application of mature technologies.

A number of R.E. technologies, proved to be acceptable, were applied on a reasonable scale . The annual production capacity of solar water heaters exceeds 80,000 m^2, a serious program for local manufacturing of wind turbine has started in 1989. About 45% of the wind turbine components are manufactured locally.

2.1.4.4 Testing and Certification

NREA in cooperation with European Community and Italy is establishing an advanced specialized testing and certification centre including indoor and outdoor testing laboratories for solar thermal, photovoltaic, wind biomass and energy conservation technologies.

Table 3 and Fig. 3 below show the forecast of energy savings from 1990 through 2005 by the introduction of solar thermal, Biomass, Wind and Photovoltaic Technologies.

Table 3. Estimations of Energy Savings by NRSE Resources
(In Thousands TOE)

	SOLAR				WIND			BIOMASS			Total	Savings
Year	WH	PH	El.	Sum	Pum.	El.	Sum	Rural	Urban	Sum	NRSE	%
1990	13.6	1.2	0.25	15.1	0.1	1.5	1.6	0.1	-----	0.1	16.8	0.05
1995	114	116	4.0	234	3.0	24	27	25	15	40	301	0.77
2000	250	820	15	1115	20	144	164	90	60	150	1429	2.98
2005	506	2050	54	**2610**	50	320	**370**	160	120	**280**	3260	**5.44**
Percentage Savings (in 2005)	**4.35**				**0.62**			**0.47**			**5.44**	

NRSE New and Renewable Sources of Energy
WH Domestic Solar Water Heating
PH Solar Industrial Process Heating.

2.2 Energy From Waste

2.2.1 Biomass system development

The arable land in Egypt contitutes 4 % of the surface area of the country. For these reason Egypt has been classified as an 'agriculture deficit' country. Therefore, it is unlikely that biomass energy production will have a major impact on the energy mix of Egypt.

Nevertheless, there is a potential for the utilization of biomass energy resources in Egypt, leaning on the fact that Egyptian rural areas depend upon biofuels to meet 50% of their energy needs.

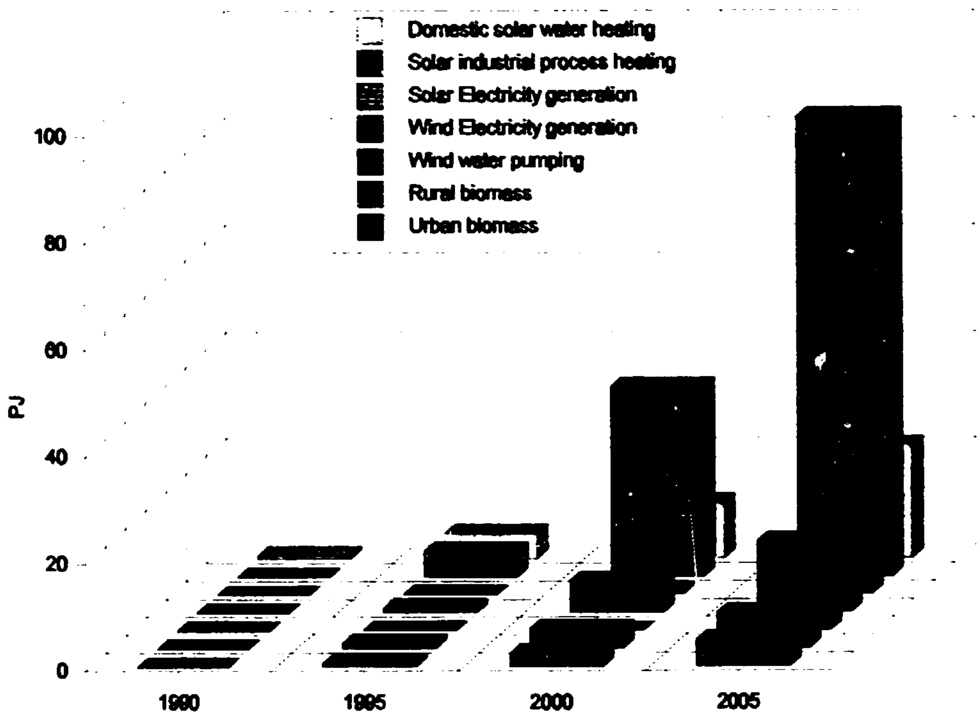

Fig. 3. Estimations of Energy Savings by Renewable Energy Sources in Egypt

Main sources of biomass in Egypt are agriculture and livestock wastes, poultry waste, municipal refuse, and sewage slug. Biomass resources are ineffectively utilized due to traditional inefficient technology applied: as direct combustion in open fuelwood stoves/ovens in villages. paultry, municipal and sewage biomass resources are used so far only as fertilizers.

Research and development activities are carried out for better utilization of biomass, however, most of these activities are geared to biogas production.

Potential of Biogas Technology (BGT) in rural areas in Egypt is given in Table 3, where development of different types of digester is considered. These development are aimed at overcoming the different constraints in Egyptian rural areas including:

a. Lack of land space sufficient for installing house-scale units due to cluster nature in most village housing areas

b. Insufficient animal wastes for many households because of insufficient animal ownership.

c. Low gas productivity in winter under no heating conditions.

It is obvious from Table 4 that the number of biogas units can be more that one million. These units can produce about 0.9 million ton of kerosine equivalent per year. The biogas produced can serve about 9 million persons in rural areas if the proposed program is implemented to its fullest extent.

Despite its multiple outputs and benefits, BGT has been far from achieving the rate of propagation expected in many developing countries. The main reason of this is believed to be the inability of concerned agencies to integrate BGT into the target social systems so that it meets real perceptible needs at an affordable cost, as well as, to provide effective organizational infrastructure that can plan, implement, maintain and follow up with due regard to resources and constraints.

2.2.2 Agro-Industrial Waste

Agro-Industrial Wastes are derived mainly from the biomass available in Egypt. The current method of handling, storing and burning these residues not only causes energy waste, but it also poses a serious threat to the ecological balance. Bagasse from sugar-cane industry and rice husks offer two important sources of energy for processing industries. From the 3 Mt estimated annual production of Bagasse, about 70% per cent is used as fuel in the sugar production. Similarly, from 40 kt of rice husks produced annually, about 15 kt are used in rice mills as fuel. Large amounts are used off-site as fuel in brick manufacturing.

A study had been made in the year 1986 about sugar industry in Egypt. New steam generation equipment was planned for factories to produce 140 -160 MW. The project was not realized as production of paper and particle board from bagasse was more attractive than energy production.

2.2.3 Energy from Industrial Waste

2.2.3.1 Waste heat recovery and condensate return

The sectorial energy analysis in Egypt has always shown that the highest consumption is in the industrial sector, which consumes almost 50% of the total national primary energy consumption. This consumption reached 643 PJ (15.3 Mtoe) in 1990 distributed among oil fuel (45%), electricity (36.6%), and natural gas (18.4%). Moreover, studies have proved that about 20-30% of the industrial energy consumption is wasted due to low maintenance, inefficient processes and other reasons; with waste heat being the largest source of waste. NREA within its program for field testing solar industrial process heat system has identified the large potential of waste heat recovery in the Egyptian industry.

TABLE 3. ROUGH ESTIMATIONS OF POTENTIAL NUMBER OF DIGESTERS FOR RURAL AREAS OF EGYPT CLASSIFIED ACCORDING TO TYPE AND CHARACTERISTICS

Type of digester	Possible number 10^3	Operating conditions		Expected gas rate M^3/M^3 of digester volume per day	Total digester volumes 10^3 M	Expected amount of gas 10^6 M^3/year	Share %
		Temp. °C	Retention time d				
READY MADE MINI	350	22-40	30-40	0.35-0.7	525	92.2	6.5
EGYPTIAN-CHINESE	206	20-30	40	0.3	1740	182.7	12.87
BORDA & INDIAN	174	20-30	40	0.3	1980	207.9	14.65
DRY FERMENTER	440	20-35	100	0.2	4600	322.0	22.7
FLEXIBLE BAG	51	23-33	40	0.5	430	75.2	5.3
TUNNEL TYPE	14.9	20-35	30-40	~0-8	2050	539.0	37.98
TOTAL	**1235.9**					**1419**	**100**

Industrial processes heat consumes more than 60% of the total industrial energy consumption distributed among the different types of industry as shown in Fig. 4. Textile and food industries are major contributes, particularly at temperature ranges below 150°c. The specific consumption of these sectors is as follows (1985):-

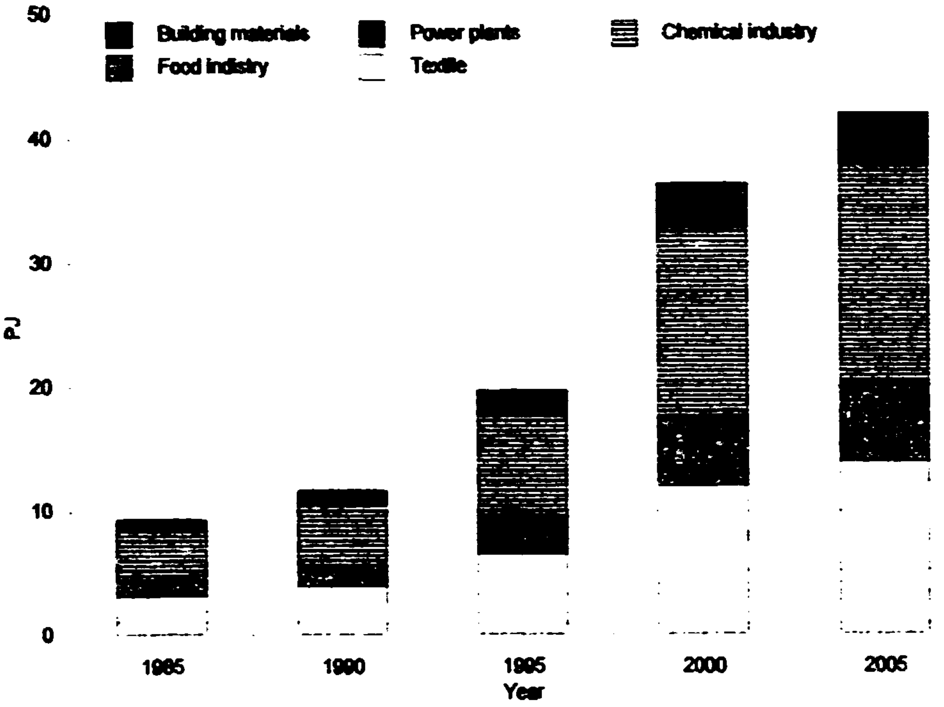

Fig. 4 Projections of annual energy demand of process heat in different industries

Textile industry = 3.57 PJ (85,000 toe) /year out of which 87% is < 150°c
Food industry = 1.18 PJ (28,000 toe)/year out of which 84% is < 150°c

To satisfy the strategic objectives, NREA formulated a program field testing and dissemination of " Solar Industrial Processes Heat and Waste Heat Recovery System" in Egyptian industry. The first set of projects implemented through the program are :-

- The poultry processing plant project hosted by the **united chicken Co. Ministry of Agriculture.**

- The Misr Helwan Textile Project hosted by, the **Misr Helwan Textile Co. Ministry of Industrial.**

These two large projects have been designed, built and tested for condensate return system and waste heat recovery in poultry and textile plants. Over 13000 barrels/year of fuel oil are saved annually by both projects. The average savings recorded in the poultry plant account for about 30% of the plant total energy consumption. Concerning the textile project, the payback period of the project ranges from three to eight years according to the number of daily shifts (one-three shifts/day).

Both projects were financed through the Renewable Energy Field Testing Project "REFT" financed jointly by **NREA** and **USAID**.

2.2.3.2 Co-generation

The Energy Conservation and Efficiency Project (ECEP) is designed to help local industries and commercial institutes to improve their overall energy efficiency, by providing technical assistance to both public and private sector organization as well as demonstrating power energy efficient technologies.

A medium sized co-generation project was implemented in the "Egyptian Company for Aluminum Products" early in 1993 where commissioning of a system producing electricity and steam simultaneously. The natural gas fired co-generation units enabled the company to shut down its existing boiler plant and to reduce its electric demand by 525 kW. Energy costs are expected to be cut by 30%. With an annual energy bill of around L.E. 2.5 million, the investments in the project will be recovered in about 3.5 years.

B. PROPOSED CASE STUDIES

1. WASTE MANAGEMENT

1.1 The present situation

The potential of municipal including sewage wastes and other biological wastes as autumn tree leaves from gardens, parks, streets, etc., will be summarized below, whereas the present situation of sewage and other solid municipal wastes will be emphasized due to its importance to the study.

1.1.1 Sewage Waste (S.W.)

Sewage consist primary of human excreta admixed with variable proportions of industrial effluent. The total human excreta potential per year based on population figures during the period (1980 - 1988) is 3 - 3.7 Mt (million tonnes) of dry solids (DS). It can reach 4.44 Mt of DS/year in 1995.

1.1.2 Municipal Solid Waste or municipal refuse (MSW)

MSW is the familiar household and commercial garbage generated in every community. In Egypt MSW is composed mainly of waste food 50-60%, paper 15-13% metals 3.5-3%, glass 3-2.5%, plastics 2-1.5% Bones 1.2-1%, rubber 0.6-0.5%, scrape 3-2.5% others 21.5-16%. It varies in composition from time to time and place to place. The compostible and digestible materials represents about 75%. Based on the population figures during the period (1980-1988) the MSW is estimated to fall in the range 4.5 - 5.6% Mt of dry waste per year, and to reach 6.75 Mt of DW/year in 1995.

1.2 Future Plans

Biomass utilization technologies has been given much attention within some of the Egyptian Scientific Research Centres. Field demonstrations was conducted in various biomass utilization technologies to improve those applications and appliances of poor efficiency to most of the agriculture wastes as open air firing and direct combustion in open fire stoves in the villages. Most of the solid municipal, animal and sewage wastes are either used as fertilizers or burned.

The future targets of Egypt include large projects for dissemination and adoption of improved technologies as biomass fired power plants, large scale biogas plants using SW as well as medium and household scale biogas plants using animal and agriculture wastes, large scale factories for fertilizers production from municipal wastes and gasifiers. Financial difficulties are the major problem for the realization of these plans.

Table (5) shows the expected annual Egyptian biomass resources in year 2000 based on 2.3% increase in the average annual growth rate of population.

Table 5. Expected annual biomass resources of Egypt in the year 2000

Resources	Total biomass potential		Available for energy	Current treatment of biomass		Expected treatment in 2000	
	Mt dry waste	TJ	TJ	efficiency %	out-putTJ	effic-iency %	out-pu TJ
Agriculture	9	135	68	8	5.44	15	10.2
Livestock	12	86	43	8	3.44	15	6.45
Paultry	1.5	22	11	0	0.00	15	1.65
Municipal	7.77	78	39	0	0.00	10	3.90
Sewage	5.18	16	9.3	0	0.00	10	0.93
Total	35.45	337	170.3		8.88		23.13

1.3 Problem

Organic waste is not properly treated or utilized in Egypt. Many different sources of organic waste exists : municipal solid waste, sewage waste, industrial waste, animal waste, agricultural waste and sewage waste. The organic waste is often drained to lakes, sea or other water streams. Part of the waste is used directly as fertilizer or burned under poor efficiency & bad conditions.

1.4 Effects

Some of the unfortunate effects are a pollution of the water sources and soil of Egypt and an increased risk of epidemic diseases, The pollution of air due to inefficient burning and emission of greenhouse gases due to bad treatment. The poor utilization of waste causes large economic loses, environment pollution and health hazards.

1.5 Suggestion of demonstration project

It is believed that once the proper solution for the organic waste problem is introduced in a pre-selected locations and the advantages are recognized in Egypt, dissemination and adoption of technologies applied will happened by itself. The solution must have the technical feasibility and economic attractiveness to encourage private sector to take part with minimum governmental help.

1.6 Locations

Three locations will be presented as a suitable cases for waste management in Egypt. However, a complete plant will be described for only one of these cases.

1.6.1 Port Said City

1.6.1.1 Waste Management in the City

This is one of the Egyptian cities representing the problem of municipal waste, particularly that of sewage & animal wastes.

Organic waste available in Port Said City can be estimated as :

municipal solid waste	t/day	150
sewage waste	tonnes of dry matter/day	60
animal waste	tonnes of fresh manure /day	50
Industrial organic waste	t/day	5
		----
total	t/day	215

Other information:

Population (annual rate of growth 2.8%)	300,000
Housing units	70,000

The present situation of waste management at Port Said is illustrated in Fig. 5, in which the following disadvantages can be observed :-

1- Municipal waste is improperly stored and burned in open fires leading to pollution of the environment and severe health hazards.

2- The 'Zabbalin' (garbage collectors) community has a miserable situation leading to bad social situations.

3- The industrial organic waste and sewage waste is improperly treated leading to:

a) Sea & lake water pollution affecting both beach environment and fishing possibilities.

b) Health hazards.

c) The secondary energy (waste) is completely unutilized.

4- Animal waste is used directly as a fertilizers after poor storing this leads to loss of nutrients, crop contamination & health hazards.

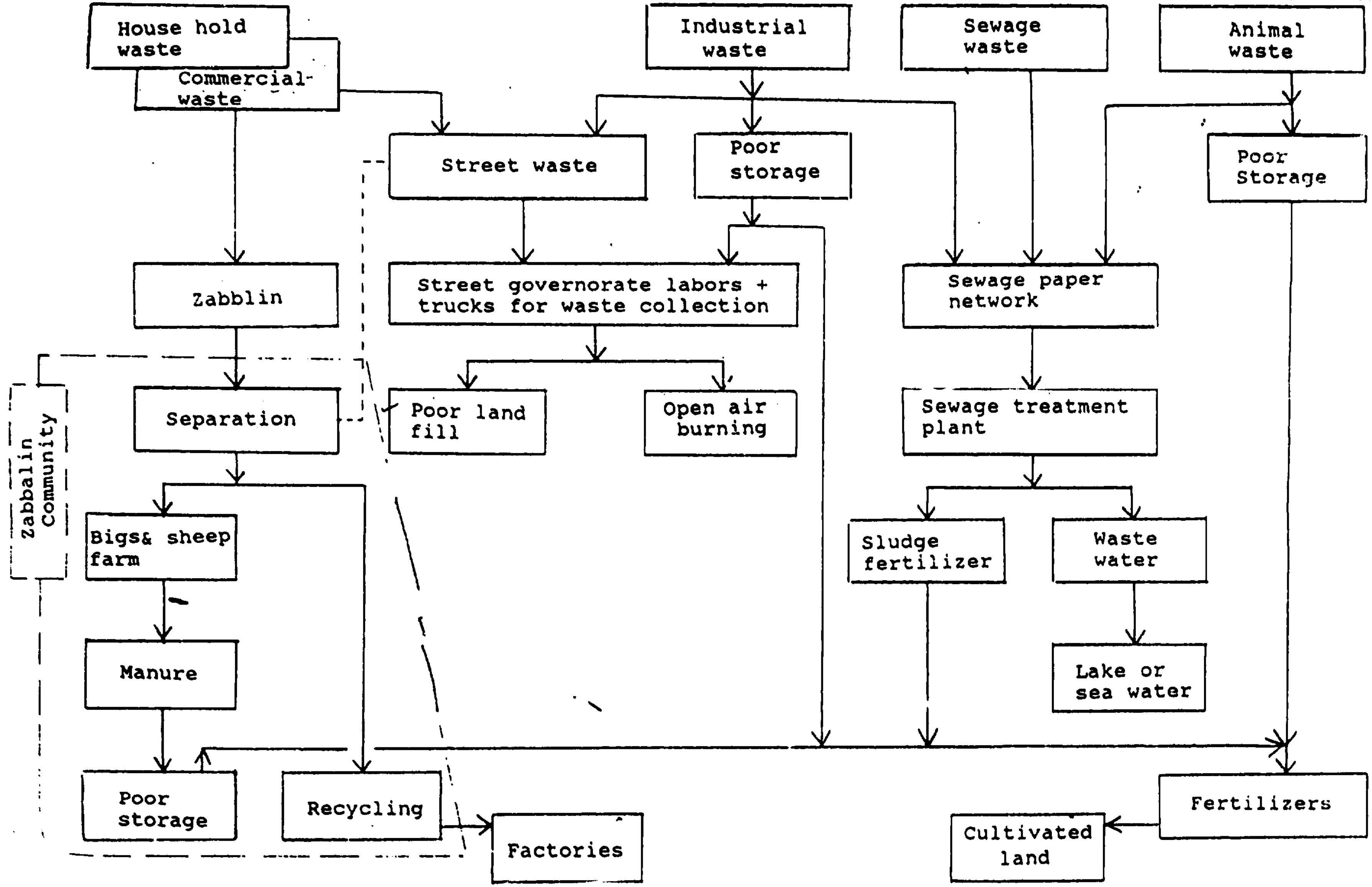

Fig. 5 Present Waste Management Scheme of Port Saïd City

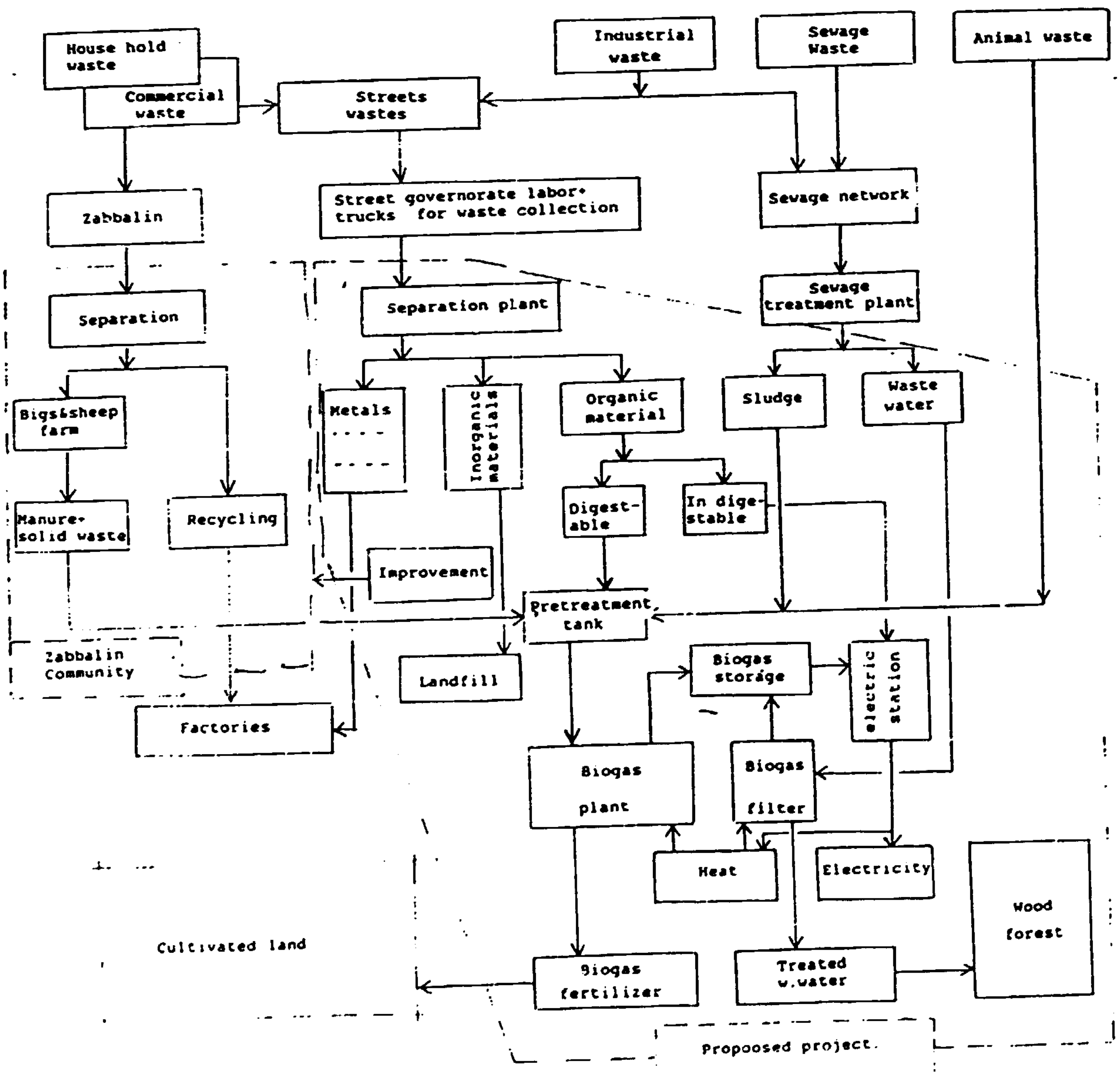

Fig. 6 Proposed Waste Management Scheme for Port Saïd City

5- The bad treatment & utilization causes considerable economic loss.

A new waste management programme is suggested in Fig. 6. The proposed waste management programme based on the flow diagram illustrated has the following advantages :

1- Proper treatment with minimum impact on the environment.

2- Helping the 'Zabbalin' community to better social situation

3- Efficient recycling of organic waste especially potential energy production wastes .

4-& Technically feasible and economically attractive.

1.6.1.2 Waste Management Plant

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) and thus gives possibilities to recover energy from this type of waste. This process is one solution to decrease the amounts on the disposal places, extract energy and usable end products from waste and improve the environmental conditions.

a. Start values

The plant is sized to treat a fraction of the waste generated in Port Saïd City and can also receive some dewatered sewage sludge or other industrial type organic waste. Since the amount of municipal solid waste is about 60,000 t/a it has been seen to be suitable to build smaller plants of approximately 30,000 t/a capacity with 2-shift operation in two suitable places with possiblity of extension, or building a third one if needed in the future.This solution will also result in shorter transportation distances, better working environment and better operation of the plant as well as better possibilities to market the end products: compost, biogas/alternative and electricity/heat.

The start values used assumned for the plant are given below:

Table 6. Waste composition

Material	Percentage	Amount tonnes/year
Organic kitchen waste	64 %	19200
Paper	13 %	3900
Plastics	11 %	3300
Metals	3 %	900
Stones	3 %	900
Glass	3 %	900
Sand	3 %	900

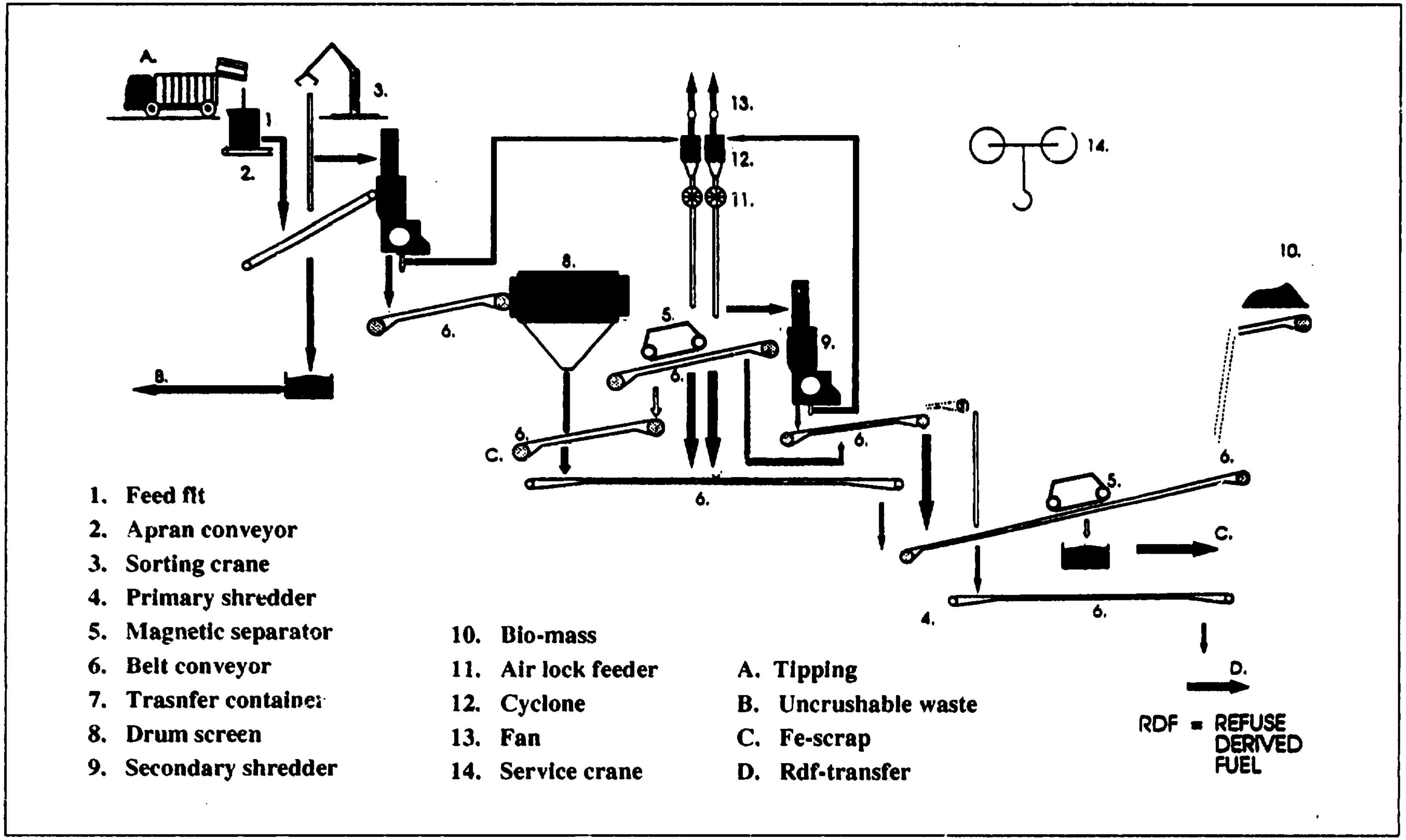

Fig. 7. Components of Pretreatment Plant

This composition gives a treatment capacity of 30,000 tonnes per year for the waste fraction.

b.Plant components

Waste treatment consists of the following main plants:

i. Pretreatment Plant:

The pretreatment plant (Fig. 7) consists of the following items.
- receiving silo
- screen
- crusher
- magnetic separator
- conveyor belts
- control room

ii. Biological Treatment Plant

The biological treatment plant (Fig. 8) consists of the following items:

- Mix-separators
- Biomass pumps
- digesters
- Gas cleaning system
- Heating system
- Process water system
- Mechanical dewatering equipment
- Bio-filter

c. End products

With the input mentioned in Table 6 the plant will produce the end products given in Table 7.

Table 7. End products

	Amount	Remarks
Biogas	$3.9 \times 10^6 Nm^3/a$	CH_4 58 %
Digested sludge	17600 t/a	TS 35 %
Surplus water	870 t/a	
Disposable products	6500 t/a	

The Vaasa 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 dewatered digested sludge is of a higher quality compared to conventional composting end products, and may be used in agriculture. However, the anaerobic process will not remove heavy metals which is the responsibility of the consumers.

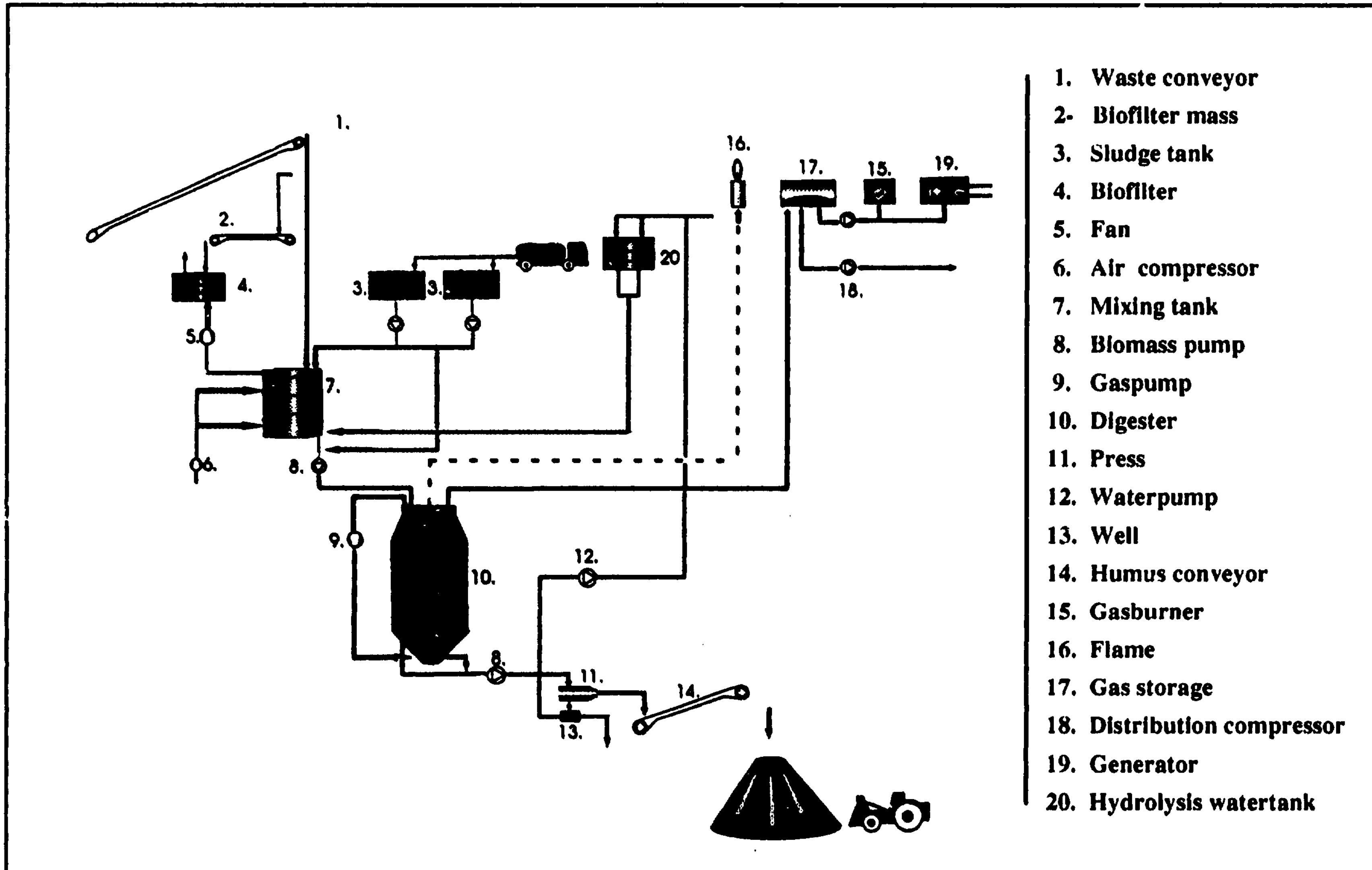

Fig. 8. Main Components of Biological Treatment Plant

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d. Biogas

The biogas can be used in a power generation plant, producing electricity a total of approx. 8 GWh/a and heat 13 GWh/a. The internal electricity consumption of the plant is approx. 1.2 GWh/a and the heat consumption is approx. 2.3 GWh. Another alternative is to use the biogas as a fuel in industrial facilities, if they exist in the neighbourhood. In this way some fossil fuels could be saved for the future and the facilities will use domestic, renewable fuel in their production. The total gross energy content of the biogas would be 23 GWh/a.

If the plant operator wishes to produce electricity and heat at the plant, one biogas engine, with consumption of about 550 m^3 biogas per hour is recommended. This equals to 4 MW gross power generator set with a net power of approx. 1.6 MW electricity and a maximum of 1.8 MW heat. The cost of such biogas generator sets is roughly be FIM 5,000,000 (about US$ 1 million).

The reason for over sizing the engine slightly is an expectation of higher biogas yields in the future and the fact that daytime energy is more valuable than nighttime energy.

e. Digested sludge

The sludge digested is a good fertilizer which can replace imported fertilizers in the agriculture. The amount of which will be 17.6 Mt/a. The final usage of the sludge will, however, depend on the local restrictions for fields and the heavy metal content in the digested sludge. Analysis carried out in the Agricultural University of Umeå, Sweden, indicate that the nutrient content of anaerobic digested sludge is considerably better that for aerobic compost. This will make the use of the sludge more interesting in agriculture.

f. Surplus water

The surplus water may also be used in the agriculture as a liquid fertilizer, amount approx. 900 t/a. If local restrictions do not allow the spreading of liquid fertilizers on fields the water should be treated in a waste water treatment plant.

g. Disposable products

Since the waste is assumed to contain more than 20% 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. 7.000 t/a.

h. Sewage sludge and other organic waste

The plant may also treat some 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. However, the above price estimate does not contain the equipment for sludge treatment.

1.6.1.3 Operational personnel needed

A plant of this size can be operated during 5 days week, 16 hour per day (2-shift operation) by 4 - 5 operators, not including administrative personnel.

1.6.1.4 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.

1.6.1.5 Investments needed

It is extremely difficult to give an estimation of the investment for the above mentioned plant with a capacity of 30 Mt/a to be built in Egypt, as this has to be estimated in a pre-feasibility study. The plant has, however, proven its economic cost-effectiveness and environmental edge in all the countries it has been built (Finland, the Netherlands and Sweden), hence little doubt would exist in connection with its success in Egypt, where the environmental problems caused by waste management are much more sever. A very approximate figure of the investments needed for such plant of 30,000 tonnes per year, based on current information, would be in the range of 45 million Fmk (US$ 8..10 million).

1.6.2 Cairo slaughter house

This is the largest slaughter house in Egypt which represents the problem of waste management, especially that of animal waste. The organic waste available in this slaughter house is given in Table 8.

Table 8 Organic Waste Available in the Slaughter house

Kind of animal	Capacity heads /day	manure (50% solids) m^3/day	Washing water (2..3%) blood+organic waste m^3/day	Condemned meat kg / day
Camel	85	17	70	
Cow	350	35	140	
Sheep	850	13	50	
Big	150	0.6	15	
Stable		20		
Total	**1435**	**85.6**	**275**	**500**

- The present situation of waste management in the slaughter house is illustrated in Fig. 9 where the following features can be observed:

1- Washing water is drained directly to sewage network

2- Part of manure is used as a fertilizer and the rest is dumped in landfills

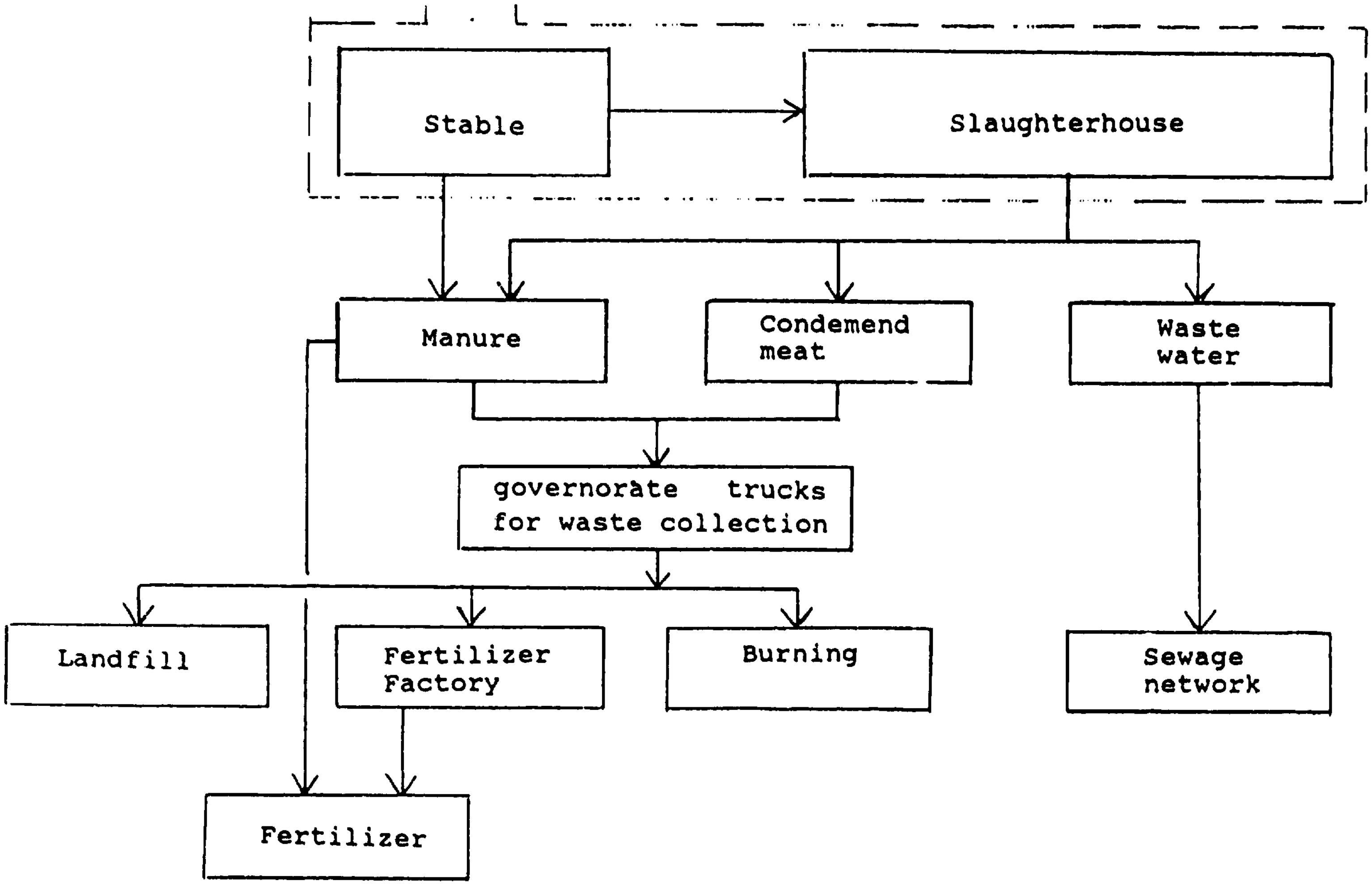


Fig. 9 Present situation of waste disposal in Cairo's Slaughter House

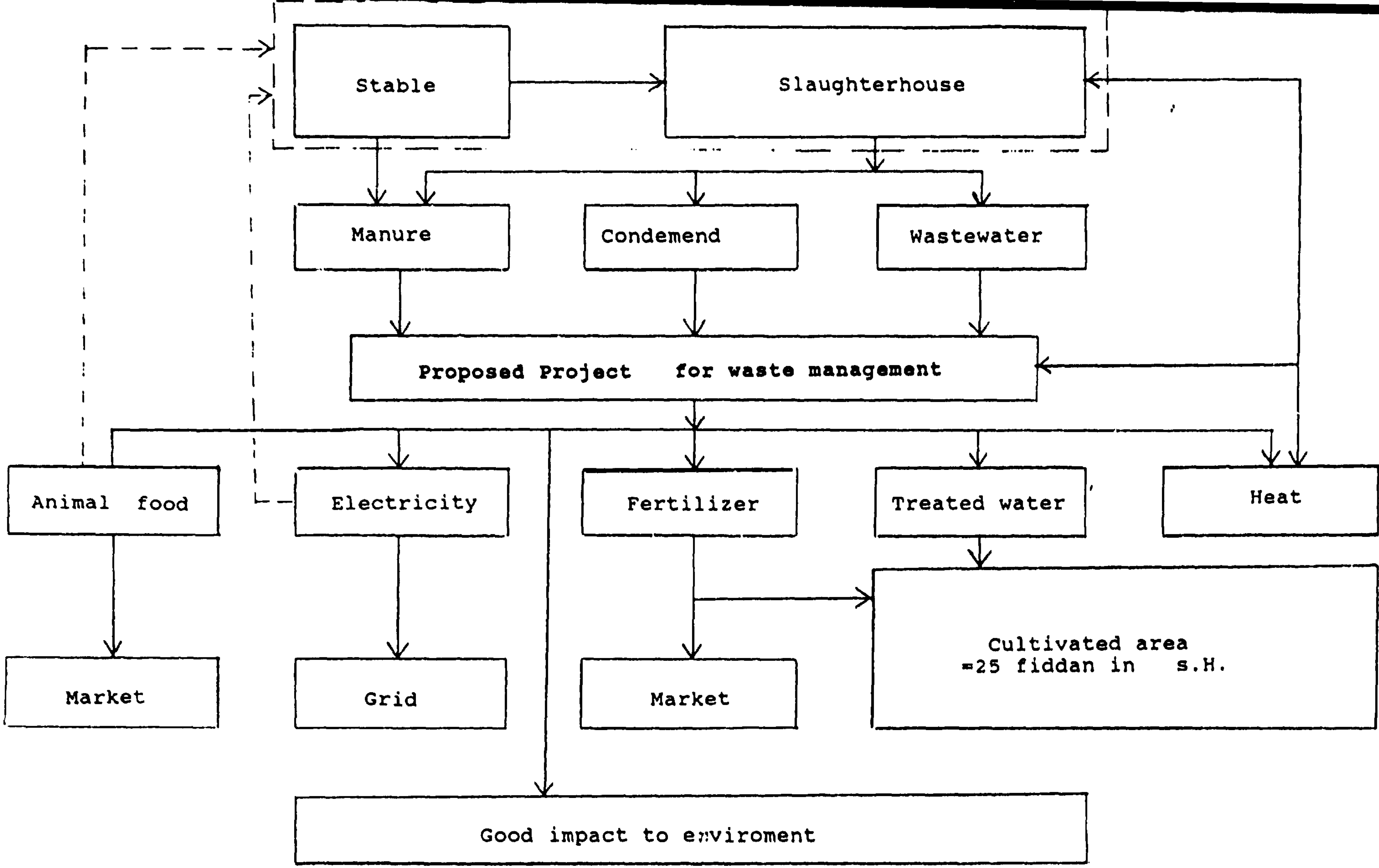


Fig. 10 Improved Waste Management Scheme suggested for Cairo Slaughter House

3- Condemned meat is burned or dumped in landfills

(There is a facility for treatment of condemned meat which is out of order and in need repair)

The improved waste management scheme suggested is shown in Fig. 10. It makes proper use of the wastes and accordingly has the following advantages:

1- Proper treatment of all kind of waste with good impact to the environment.

2- Efficiency recycling of all waste available

3- Production of energy

4- Technically feasible and economically attractive.

c) Food processing factory

- Most of food processing factories have large amount of organic refuses. This refuses is improperly treated & great share is drained to the water streams around these factories, whereas the remaining share is usually burned. Another sort of waste in these factories is heat lost during food processing.

Organic waste available in one selected factory for the study is as follows:

- Digestible organic waste	(t/day)	6.65
- Indigestible organic waste	(t/day)	2.75
- Total organic waste	(t/day)	9.40
- Working days / year	(day)	365

- The present situation of waste management in the factory is shown in Fig. 11, where the following drawbacks could be noticed:

1- Hot waste water have concentration of 0.5% of organic matter, and is directly drained to the nearest water stream.

2- The digestible organic waste and most of the indigestible organic waste are dumped into the landfills or burned in open fire.

- The improved waste management project proposed based on Fig. 12, has the following main features:

1- Proper treatment of all kind of waste with minimum impact on the environment.

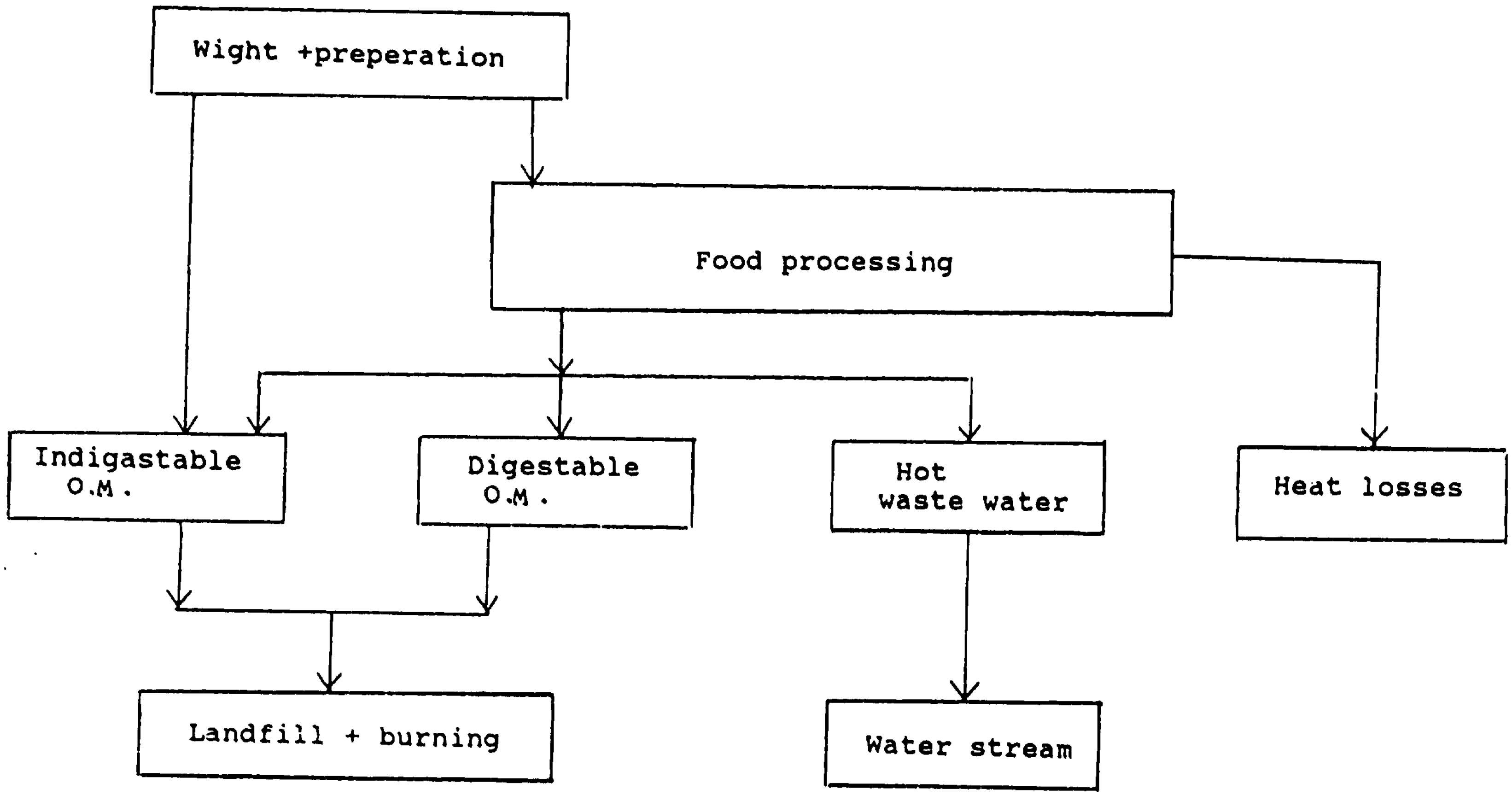


Fig. 11 The present situation of waste disposal at the Food Processing Factory

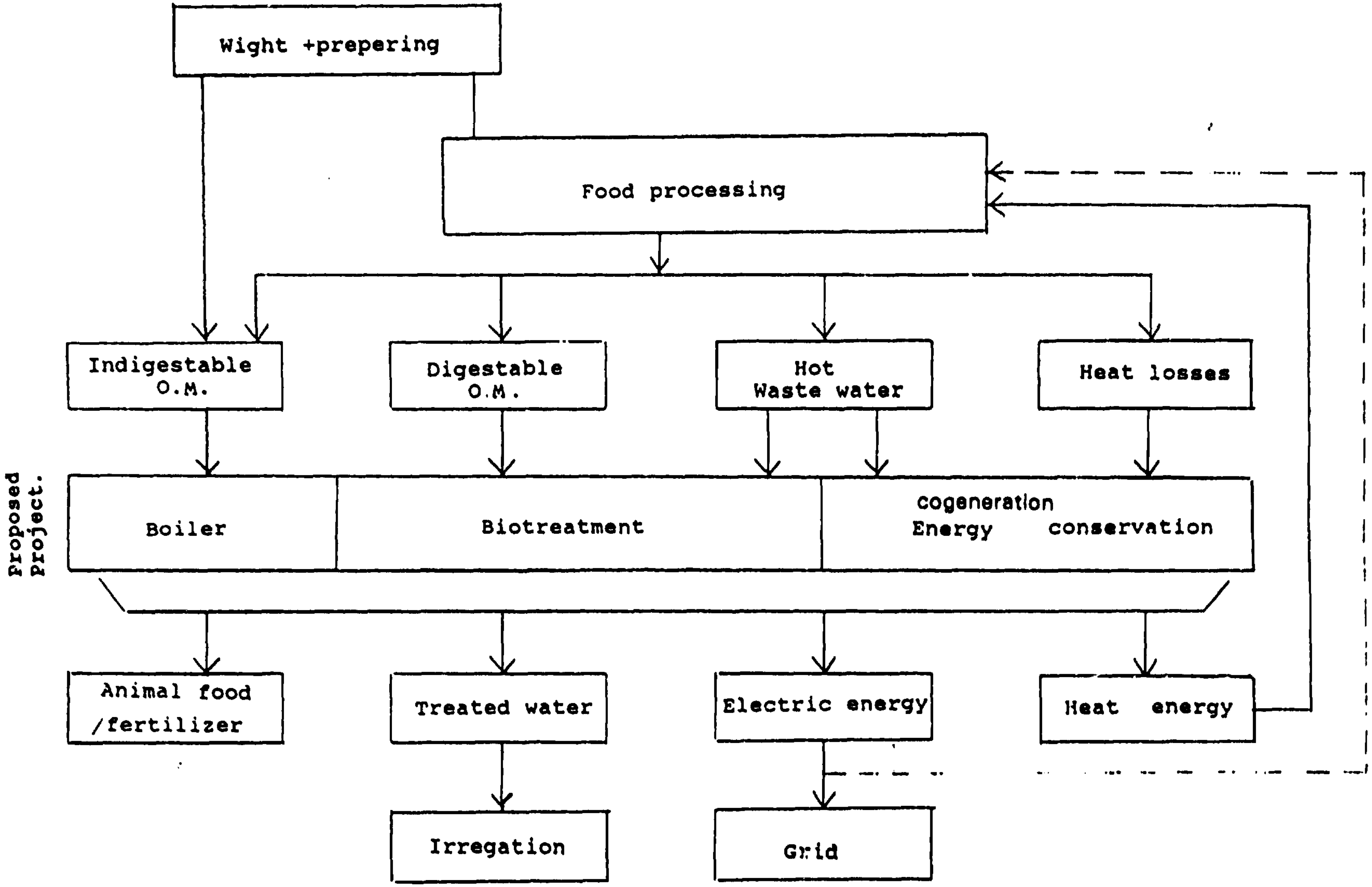


Fig. 12 The improved Waste Management Scheme proposed for the Food Processing Factory

2- Efficient recycling of all waste included

3- Production of energy

4- Energy conservation

5- Technically feasible and economically attractive.

6- Can be duplicated at other similar factories.

2. WASTE HEAT RECOVERY THROUGH COGENERATION

In addition to the cogeneration and waste heat recovery schemes in the proposed projects for the slaughter house & the food processing factory given above, a case study of tourist villages is presented in the following.

2.1 Tourist villages on the Red Sea & South Sinai

The tourism industry in Egypt is growing rapidly. In addition to the ancient sites, Egypt is rich of its vast coastal areas with pristine beaches, clear water, coral reefs, a broad variety of fish and aquatic plants and a year-round pleasant climate. Hundreds of thousands of Egyptian and foreign tourists arrive to the Red Sea and South Sinai coasts every year, prompting significant investments into tourist developments, especially for the purpose of establishing new settlements.

To be successful, a tourist village must attract and keep a steady stream of customers. Villages may need to supply their own power, water, and provide sewage treatment facilities. These major systems can play a pivotal role in the success or failure of the tourist village and therefore deserve special attention. Systems with improper designer, installation or operation can ruin the area's major tourist attraction, viz, the environment. These villages will appreciate projects for clean energy production and treatment of the village waste to keep nice environment around them and to improve the economics of the project.

2.1.1 Electricity Supply

Electricity is used throughout the tourist village for a broad range of tasks. In fact, many existing villages are "all electric" using electricity for all applications including lighting, cooking, water heating, air conditioning, pumping operations, and desalination.

The option of supplying electricity to the tourist village from the national grid, if available, is appropriate for the entire range of applications. A gas turbine generator, on the other hand, does not become appropriate until the application size increases to a group of tourist villages. Other technologies, such as diesel and photovoltaic are to be appropriately sized for the single, stand alone tourist village.

The changes in energy prices during the years 1960 to 1992 is illustrated in Fig. 13.

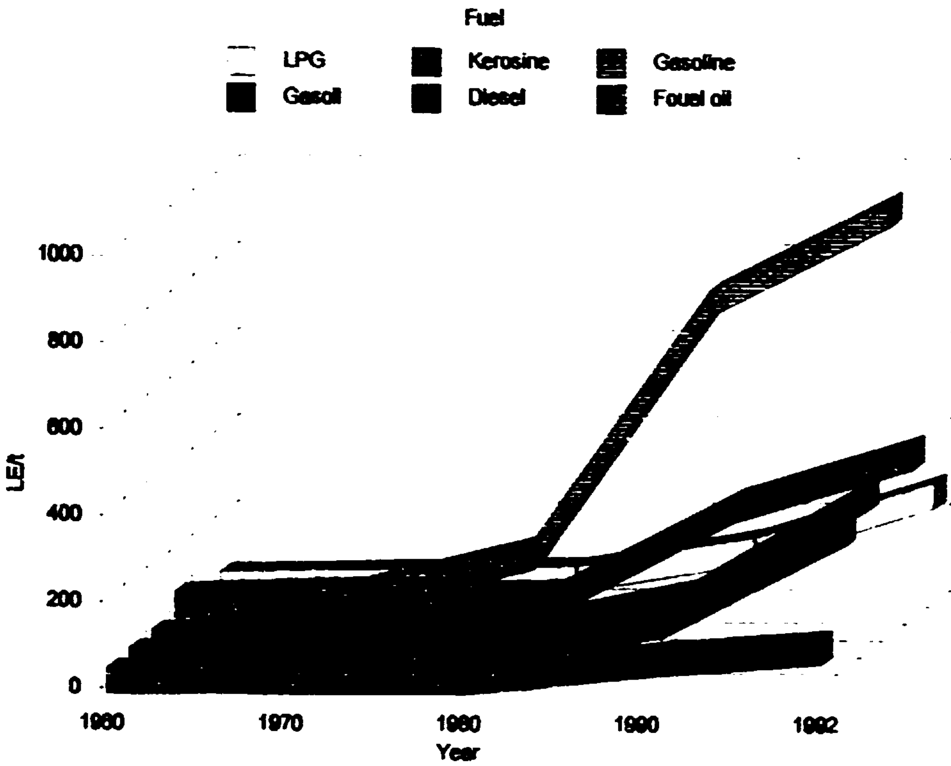


Fig. 13 Escalxtion of fuel prices in Egypt from 1960 to 1992

2.1.2 Electricity requirement

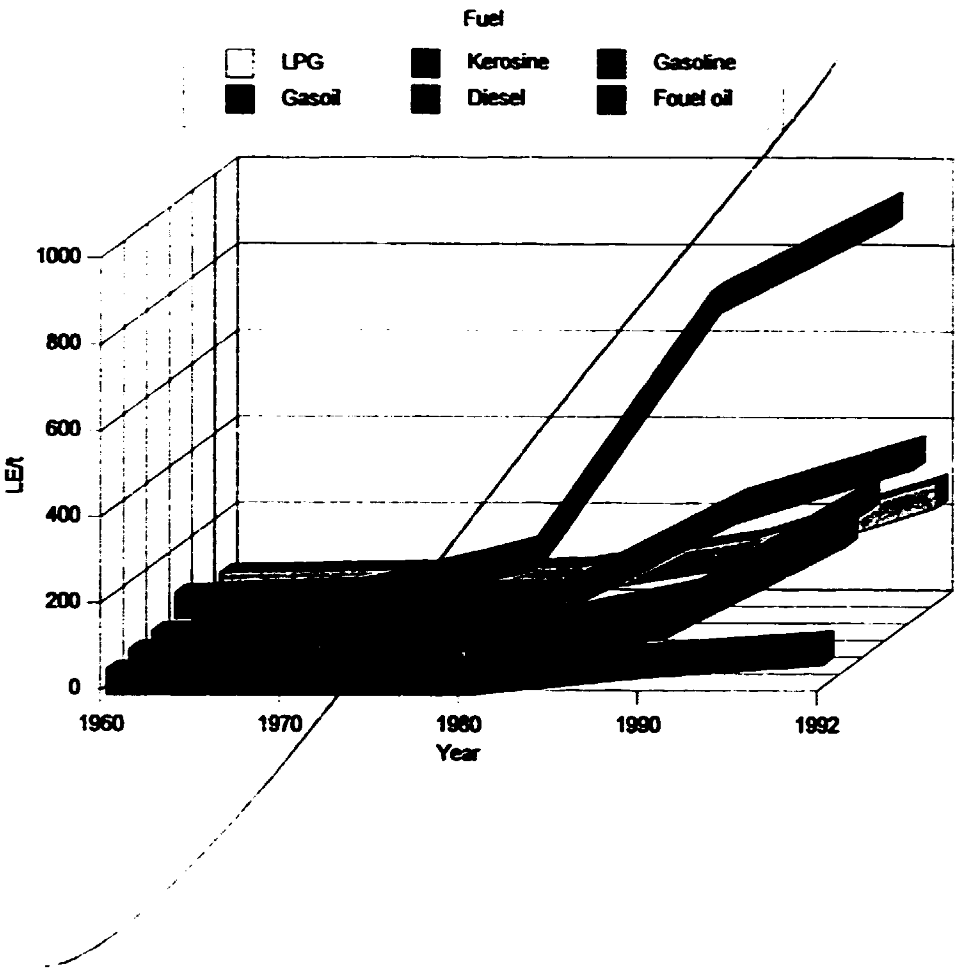
In a typical tourist village, electricity requirements are governed by the need to feed the following areas :

- Support services
  Water heating, kitchen, laundry, lighting and pumps

- Building space heating/cooling (air conditioning or heating)
- Water production, desalination (if applicable)

- Waste water / sewage treatment

Even-though the analysis of hourly electricity consumption data might indicate that a generating capacity of 1 kW/room is sufficient for design purposes, the actual value needed is considerably greater. Egyptian authorities have indicated that 4 to 6 kW per guest room is an appropriate rule of thumb for estimating the total required electrical generating capacity, while a higher figure of 10 kW per guest room suggested to have been used for some facilities in the area. In comparison, a standard rule of thumb used by many electrical engineer is that a 10-to-1 instantaneous-to- average power. Peak loads can be greatly reduced by careful load management.


Fuel
LPG
Kerosine
Gasoline
Gasoil
Diesel
Fouel oil
1000
800
600
400
200
0
LE/t
1960
1970
1980
1990
1992
Year

Energy management and control systems can be installed that prevent simultaneous restarts and cycle equipment on and off to prevent an overload. Such systems can reduce peak power requirements by a factor of two or three.

2.1.3 Diesel Generator option for electricity supply

Diesel generator represent a mature technology that is used extensively for remote, off-grid power applications in Egypt and worldwide. In remote areas where stationary power needs are in the range of 2.5 kW to several hundred kilo Watts, diesel generators are commonly the power source of choice. Diesel generators of 1.2 MW and larger are suitable for large and remote load demands. Widespread use has established a strong capability for maintenance and repair and an international network of engines, spare parts, and expertise

A diesel generator used to supply primary (continuous) power should be sized at 110 percent of the full load demand. This will assure adequate power to meet the steady load and provide enough safety margin to handle transient power surges.

2.1.4 Cogeneration

Cogeneration systems are electrical generation systems equipped with heat exchangers/waste heat boilers that recover waste heat to make hot water or steam. Such systems can therefore provide both electrical and thermal energy for tourist village applications. With internal combustion engines such as diesel and spark ignition engines, heat is obtained from two sources: the cooling jacket and the engine exhaust. Diesel exhaust is available at about 450-500°C. Exhaust heat can be used to make high or low pressure steam for space heating or other uses such as domestic hot water, steam absorbtion chillers, steam cookers, steam dishwashers, etc. The diesel engine is also cooled by a water-filled jacket. This heat is available at about 85-90°C and is predominantly used for water or space heating.

A diesel cogeneration system can provide approximately 3.6 MJ of exhaust heat and an equal amount of jacket heat for each kWh of electricity produced. Each kWh of electricity produced by a diesel-powered electric generation system can produce about 66 kg of 60°C water, 25 kg of 100°C water, 3.3 kg of low pressure steam, or about 1.5 kg of 205°C steam, or a combination of the above.

For tourist villages which are grid connected and use diesels only for emergency or back-up, cogeneration can not be economically feasible. The economic viability of a cogeneration package is closed linked to the operating schedule of the unit and the thermal loads which are serviced by the system. The operating schedule is almost always dictated by electricity demand. If the thermal load profile does not closely match the electrical profile, which is usually the case, thermal storage is required to take maximum advantage of the heat energy available from the cogeneration system. Use the cogeneration option may also change the entire configuration of the tourist village's mechanical design.

The availability of large amounts of hot water from a cogeneration system, for example may lead to the installation of a centralized hot water system rather than individual hot water tanks for each room or group of rooms. So cogeneration systems suitability to tourist villages depends only on the diesel generators of electricity production.

2.1.5 Integrated Systems

The review of the major operating systems for potential integration with one another is a major element of the design review process. Engineers reviewing the design will look for opportunities for reducing energy consumption without affecting the services provided. Fig. 14 illustrates a portion of the energy flow through the tourist village. In this figure, energy is used to produce electricity and desalination water; in addition, energy is used to heat water, and air conditioning the left hand side of the figure shows a "conventional" approach to energy use.

Diesel fuel is used to produce electricity and a separate diesel supply is used for the thermal input to the desalination plant. Electricity is used to heat water and for air conditioning, while more than 60% of the input heat from the diesel fuel is rejected as "waste" heat. The "integrated" configuration, shown on the left side of the figure demonstrates how the heat rejected from the diesel generator can be used for the thermal requirements of the desalination system and air conditioning systems work on the use of absorbtion adsorption method. Heat rejected from the desalination process is used for water heating. ***The "integrated" system uses less than half of the fuel required by the "conventional" system with no loss of service.***

2.1.6 System integration with cogeneration and multi systems for power generation and waste treatment

The major operating systems in a tourist village are, as mentioned earlier, the water supply, waste water treatment, solid waste treatment and disposal, electricity supply, thermal energy supply and building climate control, and general services' systems.

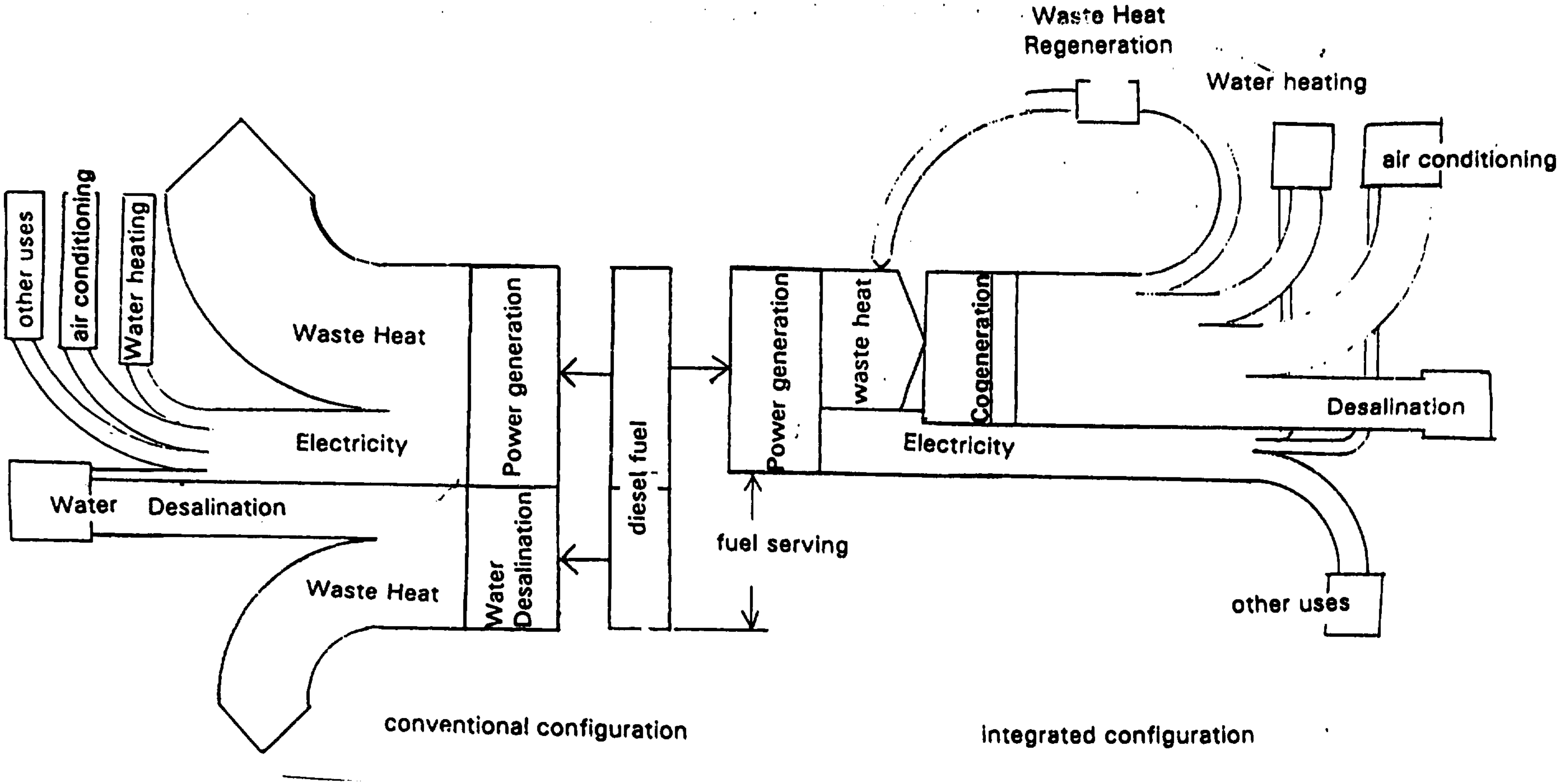


Fig. 14 Energy flow diagram for a tourist village showing the benefits of integrated systems

Fig. 15 shows, on the other hand, the proposed system for the proper utilization of waste heat through cogeneration and, the suitable system for waste treatment to prcduce energy, fertilizer and treated waste water f or promoting the village green area.

2.1.7 Wärtsilä Diesel Cogeneration Plant for Tourist Village in Egypt

The poiwer and heat needs of a tourist village in Egypt could be easily met, as was mentioned earlier, by one or more Diesel Cogeneration Plant, e.g., of the Wärtsilä type. This cogeneration plant described below, is based on one unit of 6R32 diesel engine. The engine can be runned by heavy fuel oil. Electricity production is 2046 kW at full load (max temperature 30 °C, max altitude 100 m ASL).

The heat production is 1970 kW as warm water (85 °C). In this application the heat is recovered from lube oil, charge air, jacket water and exhaust gases. If this temperature is not enough for desalination and other heating and cooliong applications, it is possible to use other combinations of heat recovery to get higher temperature, for example by using exhaust gases directly.In this application the SCR NO_x-catalysator is included, anu the power plant's total efficiency is 79 %.

The prices assumptions are roughly as follows:

Electricity	500 mk/MWh
Heat	72 mk/MWh
H eavy fuel oil	60 mk/MWh

The power plant's full load operqation time per year is assumed 5000 h. In addition, the investment is assumed to be covered with 100 % own equity and not with bank loan.The power plant's investment costs are 12,5 Mmk (about US$ 2.6 millions). This price is for budgetary purposes and should not be consider as offer. The offer should be asked separately.

Using this figures, the power plant's profitability was calculated and looked good. The simple payback time is 3.6 years and project's internal rate of return is 27.6 %. These are given in details in Table 9 of the Economic Evaluation. whereas the Plant Performance Data is given in Table 10.

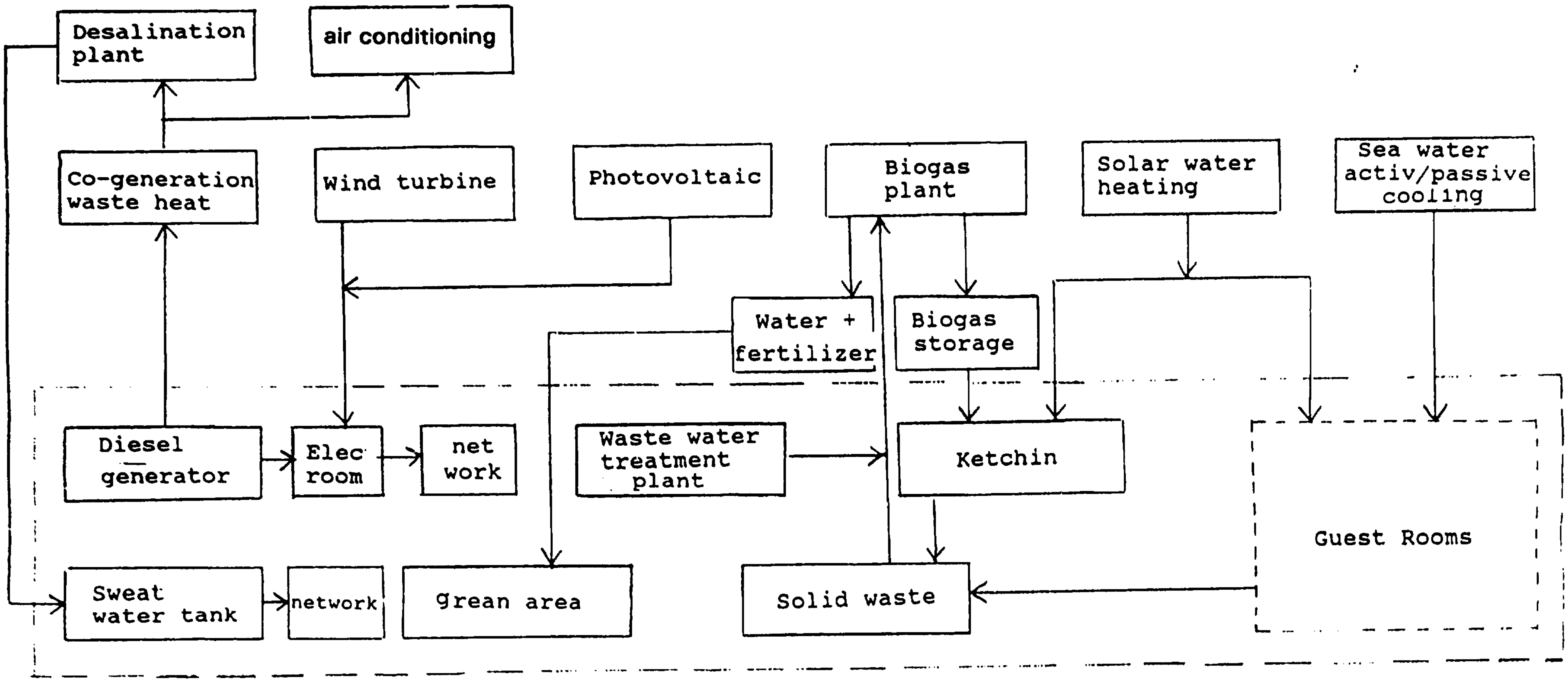


Fig.15 Proposed integrated system for cogeneration of electricity and heat and for waste management

Table 9 Economic Evaluation

Refer. Egypt
Date 5.12.1994

Project 6R32,HFO
Customer VTT/NREA

1. Plant Performance

Production	**kW**	**3976**
Electrical	kW	2005
Heat	kW	1970
Fuel Input	**kW**	**5032**
Main fuel	kW	5032
Pilot fuel	kW	0

2. Annual Operational Production

Full Power Hours		
Electrical	h	5000
Heat	h	5000
Operational Losses	%	0.5
Production	**MWh**	**19879**
Electrical	MWh	10027
Heat	MWh	9852
Fuel Input	**MWh**	**25287**
Main fuel	MWh	25287
Pilot	MWh	0
Annual Net Efficiencies	%	78.6
Electrical	%	39.7
Heat	%	39.0

3. Power Plant Profitability

Investment Data			
Total Investment	Mill. FIM	12.5	
Equity Investment	Mill. FIM	12.5	
Residual Value	Mill. FIM	0.0	
Net Investment	Mill. FIM	12.5	
Annual Economic Data			
Incomes	Mill. FIM/year	5.7	
Costs	Mill. FIM/year	-2.3	
Operational Margin	Mill. FIM/year	3.5	
Capital Costs	Mill. FIM/year	0.0	
Net Income	Mill. FIM/year	3.5	
Income Taxes	Mill. FIM/year	0.0	0 %
Operating Cash-Flow	Mill. FIM/year	3.5	

(Table 9. cont.)

Profitability		
Project IRR	**%**	**27.6**
Simple Pay-Back Time	**years**	**3.6**
Equity IRR	**%**	**27.4**
Debt Coverage Ratio		
4. Annual Operational Margin		
a. Annual Operational Margin	**Mill. FIM**	**3.5**
Incomes (D2)	Mill. FIM	5.7
Costs (D3...D5)	Mill. FIM	2.3
b. Annual Incomes	**Mill. FIM**	**5.7**
Electricity	**Mill. FIM**	**5.0**
Energy Payment	Mill. FIM	5.0
Tariff	FIM/MWh	500.0
Capacity Payment	Mill. FIM	0.0
Tariff	FIM/kWh	0.0
Heat	**Mill. FIM**	**0.7**
Energy Payment	Mill. FIM	0.7
Tariff	FIM/MW	72.0
Capacity Payment	Mill. FIM	0.0
Tariff	FIM/kW	0.0
c. *Annual Fuel Costs*	**Mill. FIM**	**1.5**
Main Fuel Costs	**Mill. FIM**	**1.5**
Energy Payment	Mill. FIM	1.5
Price	FIM/MWh	60.0
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
d. *Annual Operation and Maintenance Costs*	**Mill. FIM**	**0.5**
Operation Costs	**Mill. FIM**	**0.2**
Price	FIM/kWe/year	110.0
Maintenance Costs	**Mill. FIM**	**0.3**
Price	FIM/MWh el	25.0
Lube Oil Costs		**0.1**
Price	FIM/liter	5.0
Consumption	kg/year	10027
e. *Annual Costs for DeNox Reduction*	**Mill. FIM**	**0.2**
Catalysator Costs	**Mill. FIM**	**0.1**
Price	FIM/MWh	5.0

(Table 9 cont,)

Ammonia Water (25/75 %)				
	Costs		**Mill. FIM**	**0.2**
		Price	FIM/kg	0.8
		Consumption	kg/year	217975.7
5.	***Investment Costs***			
i.	***Investment Costs***		**Mill. FIM**	**12.5**
	a	Power Plant	Mill. FIM	12.0
	b	Infrastructure	Mill. FIM	0.5
	c	Indirect Costs	Mill. FIM	0.0
	d	Allowances	Mill. FIM	0.0
	e	Fees	Mill. FIM	0.0
	f	IDC	Mill. FIM	0.0
	g	Land	Mill. FIM	0.0
	h	Reserves	Mill. FIM	0.0
	Basic Investment Costs (a...c)		Mill. FIM	12.5
	Construction Costs (a...f)		Mill. FIM	12.5
ii	*Investment Fees*		**Mill. FIM**	**0.0**
	Commitment Fees		**Mill. FIM**	**0.0**
			%	0.0
	Development Fees		**Mill. FIM**	**0.0**
			%	0.0
iii. Interest During Construction, IDC			**Mill. FIM**	**0.0**
	Construction Time		months	8
	Construction Loan		Mill. FIM	0.0
	Interest Rate		%	10.0
iv. Annual Capital Costs			**Mill. FIM**	**0.0**
	Loan		Mill. FIM	0.0
		Equity Share	%	100.0
		Total Investment	Mill. FIM	12.5
	Interest Rate		%	10
	Amortization		years	20
v.	*Reserves*		**Mill. FIM**	**0.0**
	Fuel Reserves		**Mill. FIM**	**0.0**
		Fuel Effect	MW	5.0
		Reserve Fuel Price	FIM/MWh	0
		Reserve Days	days	0
	Debt Fund Reserves		**Mill. FIM**	**0.0**
		Debt Costs	Mill. FIM	0.0
		Reserve Days	days	0
	Cash Reserves		**Mill. FIM**	**0.0**
		Annual Running Costs	Mill. FIM	2.3
		Annual Full Power Hours	h	5000
		Reserve Days	days	0

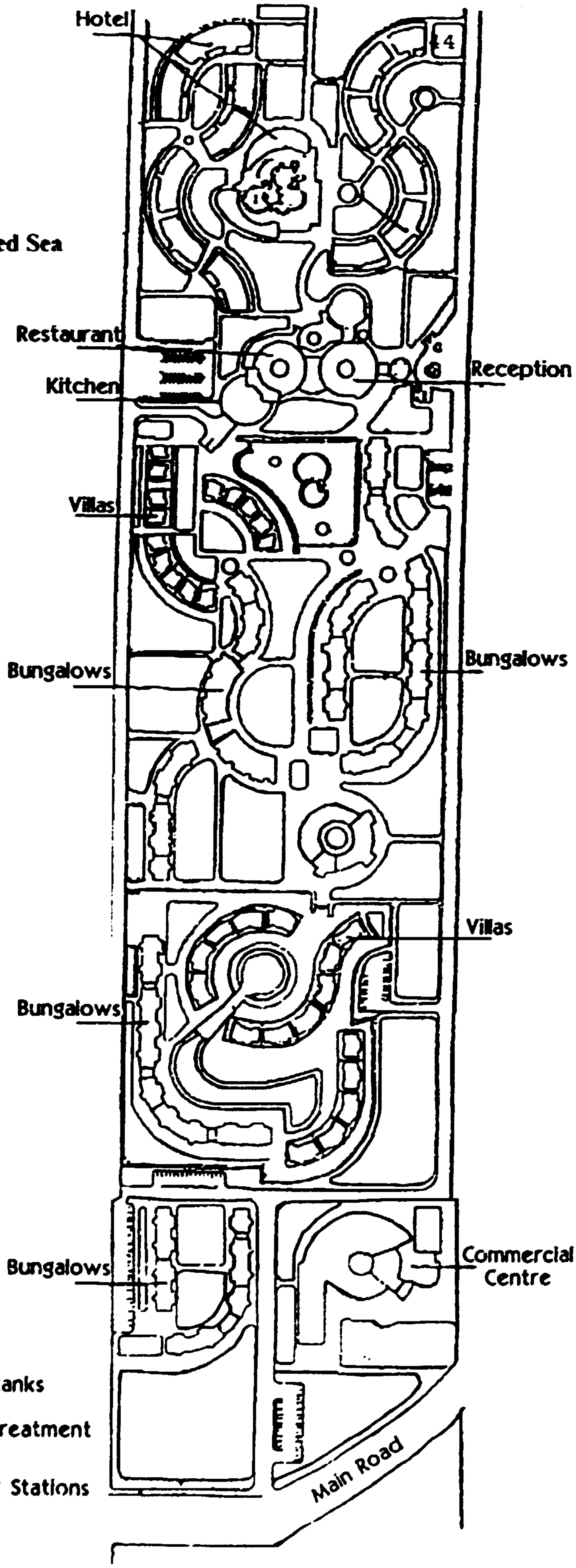
Table 10 Plant Performance Data

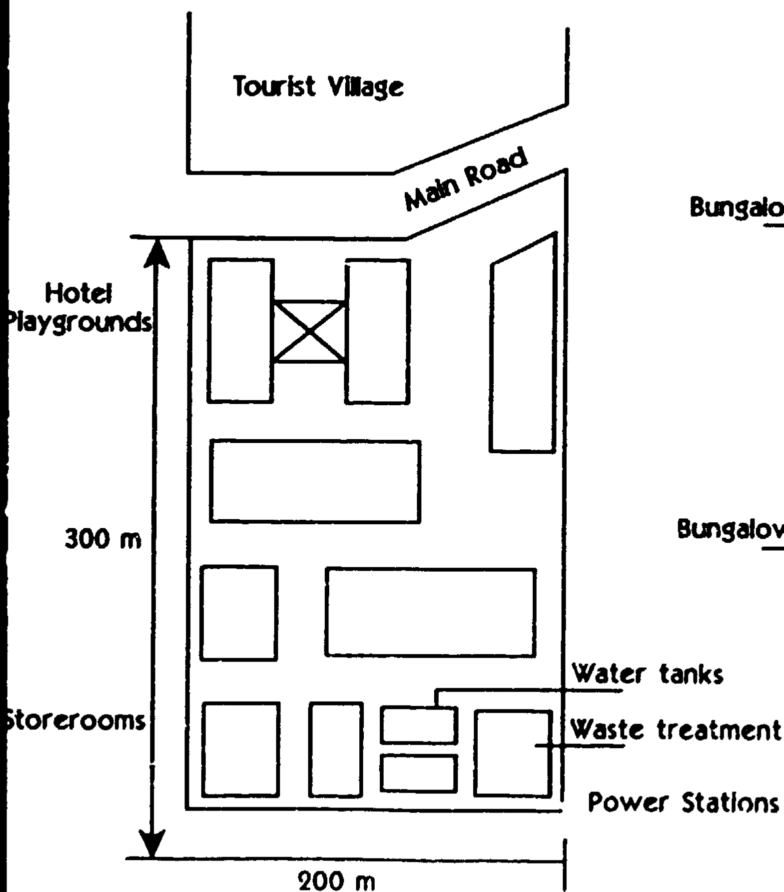
			Refer.	**Egypt**	
			Date	**5.12.1994**	
1.	***Project***		6R32,HFO		
	Customer		VTT/NREA		
2.	***Plant Specification***				
	Number of Engines	pcs	1		
	Engine Type		WV W6R32,HFO		
	Engine Speed/Frequency	rpm	750	50 Hz	
	Main Fuel		Heavy Fuel Oil		
	Lower Heat Value	kJ/kg	41000		
	Viscosity at 50 C	cSt	230		
	Heat Recovery Type		District Heating		
	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	30		
	0	0	0		
4.	***Plant Peformance***	DG-set	Plant Efficiency		
	Electrical Production	**kW, net**		**2005**	**39.9 %**
	DG-set	kW	2046	2046	
	Steam Turbine	kW		0	
	Paracitics	kW		-41	
	Heat Production	**kW, net**	**1970**	**1970**	**39.2 %**
	District Heating, boiler	kW	1970		
	...return water	C	45		
	...supply water	C	85		
	Total Production	**kW**		**3976**	**79.0 %**
	Fuel Consumption	**kW**	**5032**	**5032**	
		kJ/kWhe		9034	
5.	***Emissions***	**mg/MJf**	**ppm-v**	**mg/m3(n)**	**mg/m3(n)**
	O_2-content		13.0 %	5.0 %	15.0 %
	NO_x (calculated as NO_2)	207	150	620	230
	CO			80	

(Table 10 cont.)

6	***Consumables***		
	Lube oil consumption	g/kWhe	1.0
	Ammonia-Water (25/75 %)	g/kWhe	21.7

Fig. 16 Plan of a new tourist village at the Red Sea





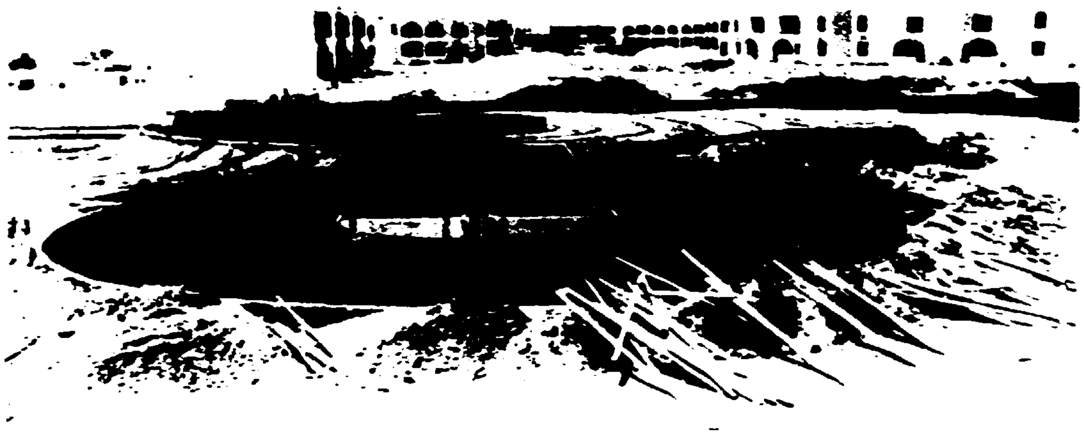


Fig. 17 The village under construction; hotel buildings can be seen in the background

Fig. 18 Models for the Bungalows

قرية ريمفرا السياحية

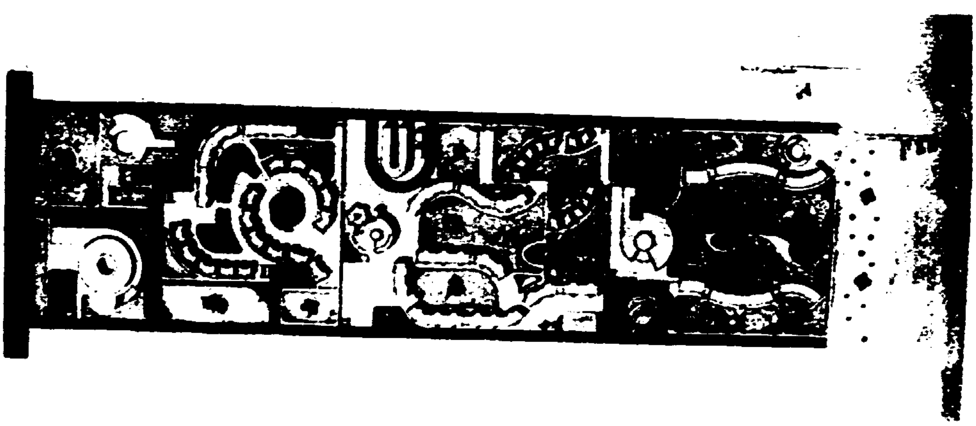


Fig. 17 Artistic Drawings of the Remiviera Touristic Village

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