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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

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MINISTRY OF ENVIRONMENT, FINLAND

Final Report

LNWT IN BRAZIL

CASE STUDY ON WASTE MANAGEMENT

By

Yehia ElMahgary	VTT-Energy, Finland
Diogo Dominguez	PROMON, Brazil
Jan Teir	AVICON, Finland
André Luiz Castello	PROMON, Brazil
Kari Salo	TAMPELLA OY
Matti Puhakka	AHLSTRÖM OY

Keywords: LNWT, clean technology, energy production, developing countries

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E. TAMPELLA OY's IGCC PROCESS DEVELOPMENT FOR BRAZIL

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 Study on Waste Management in Brazil was undertaken by VTT - Energy in cooperation with PROMON in Brazil and AVECON OY in Finland. At the time of undertaking the present case mstudy on Brazil, the two Finnish consulting firms Ahlström Oy and Tampella Oy were involved in undertaking other prefeasibility studies for the use of biomass in power generation by means of the LNWT introduced in Finland at the Workshop and Study Tour. Accordingly, no seperate case study could be ubdertaken on the same subject by these firms. However, it was possible to obtain the summaries of their studies for publication in this report. These are given in D and E.

A. PROSPECTS OF LNWT IN ENERGY PRODUCTION IN BRAZIL

1 INTRODUCTION

At the beginning of the nineties, Brazil was at a very special situation concerning its future development in terms of energy production, particularly electric energy. In fact, the Federal Government and the power public utility companies were behind the investments leading to the creation of the electricity generation grid in Brazil (about 56000 MW), with a large predominance of hydro power (94 %). Since privatization is starting, the situation is changing and the share of thermal plants is expected to increase. This new scenario is creating several new possibilities for energy production in Brazil, including more use of clean fuel as natural gas and bagasse and the development of new technologies as energy forests, fluidized bed combustors and energy from urban wastes.

The fast economic growth which took place until the end of the seventies was supported by a steady growth of electric power supply, largely based on hydro power. Today, the possibility of expansion of this form of electricity production is subject to number of restrictions; most important of which are the decreasing potentials of hydro power and the shortage of funds for new large investment projects. As a matter of fact, hydro power potential has almost been depleted in the highly industrialized south and southeast regions, where the Itaipu hydro electric power plant was built (12000 MW) in association with Paraguay.

In the case of São Paulo, the most industrialized in the country and the highly energy consuming state in Brazil - which consumes about 50 % of all electric energy produced in Brazil - CESP, the utility company responsible of electric power generation in the state, will exhaust its hydro power potential after the conclusion of the Porto Primavera power plant [11.1]. Currently, CESP is seeking options in the thermal power plant area. The same situation is met in the region covered by the Companhia Hidrelétrica de São Francisco - CHESF, which is the utility responsible for the northeast region, as its hydro power potential will be completely depleted by 94/95, when the commercial operation of Xingó hydro power plant (5000 MW) starts. New hydro power potentials are still available in Brazil, specially in the north region, but the long distance to the industrialized areas increases the charge rate because of the cost associated with electricity transmission. On the other hand, the fact that about 94 % of electric energy generation is based on hydro power is worrisome causing some anxiety because of the risk of an eventual drought and its effect on the system stability.

In the case of a normal G.D.P. growth rate of 4 % to 5 % per year, which is considered to be the minimum growth necessary to maintain its current stage of development, the electric system would need every year about 2400 MW. Even for a slow economic growth of 2 %/year, an additional power of about 1200 MW should be added to the electric system every year.

In addition, energy prices in Brazil have been systematically used for inflation control, e.g., they reached the extremely low price of US$ 4/kWh at the beginning of 1993 and recovered just to the level of US$ 6/kWh by October 1993; these are to be compared to the normal international charge rate which is around US$ 8-9/kWh. These figures would indicate a de-capitalization on the side of electric utility companies without funds for the necessary investments. Foreign loans are also difficult to obtain because international banks are aware of the frequent underpricing of energy prices, which does not guarantee the recovery of investments made in electric energy generation.

The prospects of using clean fuels and energy resources in Brazil to meat the energy needs of the country during the remaining years of the nineties and beginning of the next century will be considered below.

2. PROSPECTS OF USING NATURAL GAS

Natural gas contribution in the Brazilian energy production system is currently only 2 % of the country primary energy consumption. However, there are indications that it will play an important role in energy production in Brazil for the coming 10/15 years. The average daily production natural gas in 1993 was 8,6 millions m^3/day, 44 % of which is distributed and sold by Petrobrás, the state owned Brazilian oil company, mainly for use as fuel in the industry. Practically, natural gas is not used for the production of electricity with the exception of a cogeneration plant at a petrochemical company in the state of Bahia. Petrobrás is planning to enlarge the distribution and sales of natural gas to reach a daily consumption rate of 16 millions m^3/day before the year 2000. Import of natural gas from Bolivia is expected to start by the end of 1995 at a rate of 8,0 millions of m^3/day, increasing to 16.0 millions m^3/day by 2005. A 3400 km long gas pipeline which will be constructed for that reason and routed through the country regions that consume 80 % of the Brazilian energy production.

In view of accumulated large debt by Brazilian power utilities since the Federal Government started controlling the utilities rates, and the consequent shortage of financial resources for new investments, natural gas is being planned as a fuel for further production of energy, specially cogeneration systems for production of electricity and heat in combined cycles. The Federal Government and the utilities are now encouraging the private enterprise to invest in the development of natural gas installations for energy production, specially for cogeneration. However, the development of this new path for the country energy development will depend heavily on the government policy for energy and fuel oil prices which should be implement in a way to make the investments in cogeneration systems economically attractive.

The first studies dealing with natural gas import from Bolivia to produce electrical energy are already being undertaken by some Brazilian utilities as CESP, CPFL and ELETROSUL. This is summarized in the followings:

* Carioba Power Station: retrofit to burn natural gas and to increase power consumption from 32 MW to 350 MW (state of São Paulo)
* Piratininga Power Station: retrofit to burn natural gas and to increase power consumption from 420 MW to 1200 MW (state of São Paulo)
* Installation of two 75 MW units to be fuelled with natural gas (state of Mato Grosso do Sul).

An important market for natural gas has been identified in the private sector. This may reach 1000 MW in about 15 to 20 years, and will include cogeneration systems for small scale industries with a power consumption between 5 and 10 MW of energy and 8 to 10 tonnes per hour of steam [11.4]. In the glass and ceramic industries, a large consumption of natural gas is also foreseen as natural gas utilization improves products quality and reduces fuel consumption.

There are also several potential applications of natural gas in Brazil chemical and petrochemical industries, e.g., in COPENE - a large petrochemical company in the state of Bahia. COPENE will be the first Brazilian company to install a cogeneration system with combined cycle using natural gas as fuel. Cogeneration systems are also being designed for the Petrobrás oil refineries and the first one will be installed at a plant located in the state of Ceará, where natural gas is already available [1]. Studies performed in Rio de Janeiro identified about 500 (five hundred) opportunities for independent electrical energy production in the cities of São Paulo and Rio de Janeiro, including hotels, supermarkets, shopping centres and industries [11.5]. In many cases the utilization of the natural gas will be through retrofitting of existing systems, as for houses, commercial buildings, large companies, bank organizations, etc.

If the above plans materialize, the contribution of natural gas in the Brazilian energy production may increase from the current value of 2 % to reach 10 % around the year 2000 [11.3].

3. PROSPECTS OF PRODUCING ELECTRICITY FROM BAGASSE - COGENERATION IN SUGAR AND ALCOHOL MILLS

Bagasse of sugar cane is one of the most promising clean and indigenous energy sources in Brazil, and it is already attracting the attention of private sector for investments. The cogeneration of electricity and heat using bagasse along with sale of surplus energy to the national grid is a common practice in sugar mills around the world [9], but it is still in its early stages in Brazil, as Brazilian sugar mills have yet to consider seriously the efficiency factor in their energy generation systems following many years' traditional practice of disposal of bagasse after each season [8]. Thus, most of the sugar mills still burn the bagasse in low pressure boilers (2130 kPa) for operating steam turbines without thinking to improve the efficiency. In fact, there was no need for investing in more efficient systems, as energy has been rather cheap. From the government side, there has been no need to provide incentives for self generation of energy because of the low cost of the hydro power electricity and the availability of foreign investments and loans to develop the infrastructure in the country.

Silva Walter [8] points out that the above scenario has changed starting from 1985, when the Brazilian government realized that financial resources for new investments in the energy sector were becoming scarce; and consequently decided to encourage the private companies to invest in energy production.

In case of São Paulo, the most industrialized state in the country, energy supply problem is not only financial, as hydroelectric sources, as mentioned before, are no longer available in the state. On the other hand, the state produces two thirds of the alcohol of the country, having thus an enormous potential for self generation of energy in the alcohol - sugar industry and for employing cogeneration in combined cycles. A similar situation exists in the northeast of Brazil, where also the hydro power sources are exhausted by 1994, when the Xingó hydroelectric plant goes into operation. Self generation of power in the alcohol - sugar industry will be necessary to meet their own needs. The governments of the states producing sugar and alcohol are thus seeking to provide incentives for self generation of power in this sector. São Paulo state, for example, signed an agreement with the producers of sugar and alcohol in early 1993, to buy all the surplus energy generated in their sector. This will push their energy production from the present level of 200 MW to 6000 MW[1]. This level of energy production from bagasse will require investments in research in the field of bagasse gasification to permit in the near future the utilization combined gas/steam turbines in cogeneration plants of high efficiency.

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[1] This number must be considered as an upper limit, as the technology of gasification of bagasse is still in the process of development.

Indeed, CPFL, a utility company in the State of São Paulo, has presented in December 1992 evidences on the viability of producing 200 - 300 MW surplus power in their sugar and alcohol industry in a period of two to three years [8].

In the light of the facts and considerations presented above, it is clear that the government, the sugar - alcohol industries and the public have become aware that generation of electricity in the sugar - alcohol industry for sale to the utilities is in the interest of the country. However, it is essential that industries should be assured that the return on their investments is guaranteed; and the first step towards this shall be the recovery of the energy prices. It is believed that if a rate of increasing electricity tariff is maintained independent of anti-inflationary controls and if a climate of mutual trust exists between the industry and the Government, energy production within the alcohol - sugar industry will turn to be a reality during the coming years.

A few possible scenarios of implementing a national policy on the use of bagasse for generation of electricity, especially in the southeast and the northeast regions of Brazil, are described below:

1. In the short term, the sugar and alcohol industry would invest in their existing facilities, mostly equipped with low pressure boilers (in the range 2310 kPa), in order to improve their efficiency and to achieve self sufficiency in energy. In this case, only a limited energy surplus for commercialization will be available since these installations are not cost effective for large scale production of electricity [5].

2. If remuneration is attractive and economic situation is stable, the current equipment could be replaced with high pressure boilers, which will permit generation of surplus energy for commercialization, but are still using steam turbines (a good example is given in reference [7], where investments were made for the purpose of energy sale). There are no technical barriers in Brazil that would hinder the implementation of this step.

3. In a third step, bagasse will be used in a high efficiency Integrated Gasification Combined Cycle (IGCC) with cogeneration possibility. As gasification of bagasse involves a new technology and since the corresponding research program started only in 1992, this option may be available for commercial application only by the end of the current decade.

STIG option is also being studied to improve the efficiency of gas turbine plant in conjunction with the biomass gasification (BIG/STIG) [4]. A substantial efficiency increase in converting biomass into electrical energy is expected when the IGCC and/or the BIG/STIG technology are available. This potential increase in the efficiency may even transfer energy production into a source of principal revenue for the Brazilian sugar mills and alcohol distilleries.

Recent studies performed by COPERSUCAR - ELETROBRAS in 1991 indicate a potential for generation of 2 to 3 GW of electrical energy in the sugar - alcohol industry within a period of five years, through the use of cogeneration technology already available in Brazil. With the use combined cycles with bagasse gasification (IGCC) mentioned above, the potential is estimated at 5.2 to 10.5 GW[2] for the whole country, to be attained in a period of fifteen years [8][3]

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[2] This figure, when compared to the total installed capacity of 56 GW in 1993, shows the importance of this source of energy to Brazil.

[3] Additional information about the bagasse potential to produce electricity in Brazil can be found in a report issued by ELETROBRAS, October 1992, which provides a detailed analysis of the subject.

The use of bagasse for electricity generation in Brazil is an option that is also environmentally sound because of the following reasons [2, 10]:

1. In addition to being a large sugar producer since 1975, Brazil plants sugar cane also for producing ethanol for vehicle fuel. Bagasse is thus a byproduct which is and will be available in large quantities.

2. Continuous renewable of bagasse establishes an equilibrium between the carbon dioxide generated during its combustion and that absorbed by the plant during its plantation. Hence its is a zero CO_2-producing energy source.

3. Revenue from the sale of energy produced from bagasse will be an incentive for the production of more alcohol for vehicles. Bigger cities will benefit from the use of alcohol as fuel, as it is far less polluting than gasoline.

4. Sugar cane bagasse does not contain sulphur.

4. PROSPECTS OF ENERGY FORESTS

The utilization of energy forests as primary sources for electricity production is one of the possible alternatives that are being considered in Brazil, with the objective of increasing the contribution of the biomass in electricity generation. The utility responsible for the generation of electricity in the northeastern region of Brazil, CHESF, is directing its attention to wood gasification following the exhaustion of hydro power by 1994/95. Studies conducted by CHESF show that in the northeastern states of Brazil there is a potential to produce about 19 GWh/year of electricity if 5 % of the states land is planted with forests exclusively meant for the purpose of energy production [3]. As there is no commercial installation of this nature in Brazil, it is difficult to establish parameters on costs and competitiveness, but studies conducted by CHESF indicate that a production cost between US$ 3.2 and 6.7/kWh could be achieved [6]. Thus one of the proposals is to attract funds from international organizations for installing an experimental unit in order to obtain reliable data on costs.

In the southeast region, where the energy consumption is the highest in the country, reforestation is primarily geared for generating charcoal for the steel industry. Hence, electricity generation from forests is not very probable in this region. However, the studies conducted by CEMIG indicate a potential of producing as much as 3170 MW with cogeneration, systems associated with the current process of producing charcoal, through the recovery of heat from the gases generated in the combustion process of wood [3].

In terms of utilization of forests for electricity generation, recovery of heat from industrial wastes seems to be the most practical on a short term basis. Paper industry in Brazil is an example. In fact, paper and cellulose sector may be interested in retrofitting their systems for energy production and the sale of surplus energy.

The studies under way in Brazil for the production of electrical energy from exclusively planted forests are primarily related to the gasification of wood in fluidized bed combustion and to the operation in the combined cycle (IGCC). Research and development on gasifiers are in progress since 1992, with the participation of international organizations, and prototypes would be ready in seven years [8].

As far as the environment is concerned, the studies accomplished in Brazil show that the energy forests presents several advantages compared to the non-renewable sources of energy, provided that the forests are planted exclusively for energy production. As it is the case for bagasse, there is an equilibrium between the carbonic gas produced in the combustion and absorbed during the plant growth. Also, forest biomass contains practically no sulphur - a positive option in terms of pollution control [3].

5. PROSPECTS OF CONVERSION OF URBAN WASTES TO ENERGY

In almost every big city in the developing world urban solid waste disposal is one of the major problems of municipalities in view of its sanitarian, social and environmental dimensions. Such problems are even more complicated in Brazil because of the pressure of the internal economic situation, the external debt and lack of new foreign investments. According to the National Secretary of Sanitation 8700 tonnes of municipal solid waste is produced in Brazil per day, most of which is disposed inadequately. Only in São Paulo, the biggest city in Brazil, 13000 tonnes of solid waste are produced daily. In the year 2000 this is predicted to be over 16000 tonnes. These figures show clearly that urgent steps must be taken to minimize the impact of municipal wastes on the environment and the population.

Since the beginning of the 70's, the city of São Paulo has been building Landfills and Composting Plants in order to face the pressing problems of population growth, environmental pollution and sanitary control. In 1979, an alternative was introduced to use landfills for energy production, but they were constructed and operated as normal sanitary landfills due to the economic difficulties in spite of the fact that they were designed using new technologies.

Historically, it has not been possible for the municipal waste management in São Paulo to make planning and take decisions, which would cope with the situation that current installed capacity will be exhausted in two years. In 1977 the so called Serete program was presented to the municipality which proposed to build sixteen landfills in the city over fifteen years. This program was not implemented at that time and now it is virtually impossible to implement it due to the cost of land and transport. This situation is not different in other cities in Brazil, even worse in some cases, since São Paulo has more resources compared to other cities.

Following this trend, CESP presented in 1981 the first technic-economic study to install a waste-to-energy facility in São Paulo. According to this study, a waste-to-energy facility with 1800 t/day capacity, in three modular plants of 600 t/day, could be built with the following characteristics:

- lower calorific value : 5650 kJ/kg (São Paulo data)
- annual energy capacity : 149000 MWh
- installed power : 20 MW
- life : 10 - 20 years
- total investment : US$ 97.000.000

Considering a cost of US$ 14.60 per tonne of incinerated waste, the resultant annual revenue of US$ 16,000,000 would allow an investment pay back period of 6.2 years.

Although the situation of the big cities in Brazil is becoming more and more critical in terms of municipal solid waste disposal, the way in which it has been treated so far does not offer a solution to sanitary health and environmental problems. The following questions should be addressed in order to implement the waste-to-energy option:

- Provision of political and administrative support, for any solution selected, giving priority to social, sanitary and environmental aspects.
- Provision of financial investments to install modular units, as proposed by CESP.
- Undertaking the necessary steps to guarantee adequate pollution control including emission monitoring.

Finally, similar to the case of natural gas and bagasse, it will be necessary to encourage investments from private sector to obtain full advantage of the business opportunities associated with the urban wastes problem in Brazil.

6. PROSPECTS OF FLUIDIZED BED COMBUSTORS

The utilization of this technology for boilers of thermal power plants is under investigation in southern Brazil, especially in the states of Rio Grande do Sul and Santa Catarina, where the coal reserves of the country are concentrated. The current researches are still in the pilot plant and engineering study stage, and there has not been any order for a thermal power plant using this technology so far. The fact that Brazilian coal has a high sulphur content makes fluidized bed combustors more attractive for application in Brazil because desulphurisation takes place in the combustors, according the installation of scrubbing equipment to clean the flue gases, from sulphur as would be required in conventional boilers, is not necessary. Lack of foreign investments and the reduction in local investments by the utility companies due to the control of electricity tariff have been the major obstacles in the way of development activities in this area. The presence of natural gas, which will be imported from Bolivia or Argentina in that region in the near future, also has discouraged the development of FBC technology. On a short term basis, natural gas should encourage installation of power plants within the industry without additional investments or environmental problems.

The renovation of the boiler and the rehabilitation of the thermal cycle of the Capivari thermal power station is one of the projects that has been suspended at the design stage due to lack of funds. This project would have been crucial for obtaining experimental data in actual operating conditions.

Nevertheless, perspectives for the development of fluidized bed combustion are good in view of the large coal reserves in southern Brazil and the interest of the coal producers in this technology. There are plans for installation of a 50 MW power plant with fluidized bed combustors in Santa Catarina state, through a private sector consortium. But the future availability of natural gas in the south region of Brazil will badly compete with any new investments in this technology, as already pointed out above.

7. CONCLUSIONS

It is now clearly understood in Brazil, that the Federal Government, without funds for investments and with serious deficiencies in the areas of housing, education and health, should allow the participation of private enterprises in the generation of electric energy. In fact, various agreements are under way for stimulating private investments in this direction. From now on, the thermal power generation should gradually increase its relevance in the mix of electric power generation through increasing the use of natural gas, sugar cane and municipal wastes and energy forests. Specifically for natural gas, which is today responsible for 1.8 % of the Brazilian energetic matrix, the demand is already considerably suppressed, with a growth potential which might take it to a participation of 10 % by the end of the century [11.3]. An important share of this increase in the consumption of natural gas is expected in cogeneration applications in the private sector which will require the development of new industrial facilities, expansion of existing facilities and replacement of ageing steam generation equipment. The same conclusions are also valid for cogeneration from sugar cane bagasse, accordingly, the development of these low and non-waste technologies in Brazil will depend basically on investments to be made by the private sector.

However, there are barriers to overcome and the most important one relates to the questions of the energy prices, since new fuels will not be competitive with the low values of electricity rates being currently used. On the other hand, it will also be necessary to change the Brazilian legislation to provide the potential cogenerators with firm regulations about the sale of power to the utilities to encourage the private companies participation in the electrical energy production.

B. THE CASE STUDY ON MUNICIPAL SOLID WASTES

In accordance with the 1988 Brazilian Constitution, in its article 30, the responsibility for the organization, collection system, transportation and final disposal of the urban **municipal solid waste** (hereinafter **MSW**) belongs exclusively to the municipalities.

However, as it is a subject directly related to the public health, the federal government retains the authority to define the laws and regulations to be followed by the cities of the country.

Meanwhile, there are organizations for each state, for instance, CETESB in Sao Paulo(SP) and FEEMA in Rio de Janeiro(RJ), which are responsible for the regulations and controls to be applied in their respective states.

The consequence of the political organization pictured above, is that the municipal waste management does not present an uniform approach around the country. For instance, currently waste-to-energy facilities do not exist in Brazil, although in many developed countries is already a common practice (in figures of 1992, the installed capacity of generators operating on landfill gas in USA was about 340 MW).

For the sake of this case study, two waste management situations will be considered, for two different cities of the state of São Paulo, as follows :

* The city of São Paulo , capital of the state of São Paulo , one of the biggest cities in the world , and that generates about **13,000 t/day of MSW.**

* The city of Mogi das Cruzes , which is a medium size city (300,000 inhabitants located near São Paulo and that generates about **120 t/day of MSW**

The reasons to justify the selection of these cities are as follows :

* Both cities are lacking area for landfills (please refer to items 1.1 and 1.2 below).

* Both cities want assistance to resolve their problems and are willing to provide UNIDO with all the required information.

The work to be done for both cities shall be an example for other cities of the country , since we have selected one state capital and one medium size interior city and , therefore, they are a good sample of the MSW problem in Brazil.

Developed countries use often incinerators to burn their solid wastes in order to reduce their volume and to generate energy. This tendency is indispensable because of sky rocketing disposal costs as the landfills are reaching their capacity.

1. CONSIDERATIONS ABOUT WASTE MANAGEMENT IN SAO PAULO

The existing sanitary landfills in the city of São Paulo are reaching their capacity and the city hall is working to implement new solutions, such as the installation of three incinerators in different regions of the city:

Two of them will have a capacity of 2,500 t/day each and shall be designed to produce 200 KWh per ton of waste burned. The contracts to purchase them are about to be signed , pending on final arrangements of the financing and they shall start-up in 1997;
One for 1,200 t/day ,which shall enter in operation only in 1988. As a by-product of the incineration process , there will be an amount of 3,000 tons per day of organic matter. The current plans are to handle them in a composting plant with a corresponding production of about 2,100 t/day of compost for agricultural use .

In the future it might be a problem the destination of this huge quantity of compost , since the cities around São Paulo are also willing to install their own composting plants and so they will be also producing compost , what may cause an over production of this product in the region of São Paulo.

It is agreed that one possible solution to be investigated is the anaerobic process with electrical energy production , specially when it is considered that the organic matter content in the São Paulo city waste is three times more than in Europe, thus leading to a larger production of fuel gases during the fermenting process (please refer to the news paper article in Annex A , where this option is discussed by the City Mayor assistant to the environment).This option could be enforced even more if noted that the electrical utility in São Paulo- CESP - is searching for thermal sources of electrical energy supply and it is considering waste-to-energy as one of the possibilities.

2. CONSIDERATIONS ABOUT WASTE MANAGEMENT IN MOGY DAS CRUZES

The existing landfill in Mogy das Cruzes is not sanitary ; is merely a site without any kind of protection to avoid spoiling the soil and the water sources and where every day 120 tons of MSW are discharged.

Part of the hospital wastes are incinerated in São Paulo but the remaining is also discharged to this site. This situation occurs not only in Mogy das Cruzes but also in many other cities of the state of São Paulo. Please refer to the attachment "B" for a news paper article recently published (July 05, 94) where it is shown that the public attorneys are now starting legal suits in the locations where waste management is not done properly .

The city of Mogy das Cruzes is already facing a legal suit against dumping trash in an improper landfills and this is forcing them to solve the problem (Annex B).The solution they are working on today refers to the installation of a composting plant in a site located close to the city .

This facility shall be purchased as soon as possible in view of the legal problems they are facing with. However, the following should be noted:

1.They need confirmation that the composting plant is an adequate solution ;in favour of it there is the fact that Mogy is an agricultural based city and so there is market for the compost ; against it is the fact that the city does not have space for landfills the compost in excess, since most of the city territory is located in a region protected by the ecological organisms (a kind of natural reserve)

2.They have not made characterization of the MSW, although they are requesting that the plant supplier shall provide mass balances for the installation. Also they have not made an economic evaluation of the waste management problem as a whole, and so they are lacking information on the costs of the adopted solution ;

3.The composting plant solution is not addressing also the industrial wastes, which is an important matter in a city with more than 50 industrial installations. Although the state company in charge of the industrial pollution (CETESB) is working hard to resolve this issue , the people of Mogy intends to accomplish a waste management plan including the industries;

Assistance, technical and financing, is required to clean the existing landfill. The waste should be removed to a proper place or burned in an incinerator. This may need the participation of experts from countries other than Brazil to define the solution, since there is no previous experience on how to perform this type of work .Considering the amount of trash already dumped in the landfill, it is necessary to make a study to find the best technical and economical option. This experience will be of great value for many other cities in the State of São Paulo facing the same problem (as cited in Annex B);

3. GENERAL CONSIDERATIONS

In terms of public health, MSW (municipal solid waste) is today in Brazil one of the most critical problems. For this reason it will receive priority in this case study. It is for this reason too that mention was made above of city mayors facing legal suits for continuing dumping trash in non-sanitary landfills.

In Sao Paulo (city and state) MSW is administered by Sao Paulo, whereas management of other residues and wastes is administered by the State of Sao Paulo. Consequently, it was decided in this study to deal with one public organization to avoid unnecessary delay due to bureaucracy and other complications. Also other organizations are working on non-solid wastes, as the de-pollution of the Tite River. Hence, MSW was selected to be the subject of the present study.

Based on earlier experience, MSW is the most important component in the waste-to-energy equation, particularly when taking about biogas; as it produces more than double the amount of biogas produced by the same weight of any other organic waste. On the other hand, the city of Sao Paulo needs desperately assistance to study the anaerobic digestion option, especially when it is known that the organic matter contents in the MSW of Sao Paulo is roughly three times its average value in Europe.

In the following items of this case study more detailed information will be given of the Waste Management situation of the Sao Paulo City than that of Mogi das Cruzes, because there is a general plan for MSW issued for the city of Sao Paulo, since 1990, while for Mogy das Cruzes, for the time being, there is no detailed information.

4. MUNICIPAL SOLID WASTE GENERATION IN SAO PAULO CITY

According to the Urban Cleaning Department of Sao Paulo (LIMPURB), it is generated, in average, 13,000 ton/day of Municipal Solid Waste (MSW) in the city. This MSW is composed basically by residence material, trees cutting, street sweeping and part of the industrial solid waste. To such amount it shall be added the non controlled industrial waste and other sources that are disposed in an inadequate way.

The MSW generated in the city has been classified historically by the municipality , on the collection point of view, in the following categories:

* Residence - waste collected from residences and open markets;

* Sweeping - waste from street sweeping

* Medical waste - waste from hospitals, clinics, laboratories of clinic analysis, medicine, prisons and airports;

* Miscellaneous - waste from trees cutting, animals, secret documents, rubble and debris collected by the municipality;

* Particular - Inert industrial solid waste, big commercial and/or residence centres, shopping centres and other places which have private waste collection system.

Table 1 and Fig. 1 show the current (1994) and expected MSW generation in Sao Paulo city.

Table 1. MSW production in tonnes/day in Sao Paulo City

TYPE	YEAR			
	1994	1997	1999	2001
DOMESTIC	8000	8200	8400	8600
INDUSTRIAL	1300	1500	1500	1550
INERT	2000	2150	2150	2200
SWEEPING	900	950	1000	1050
HEALTH	150	150	155	160
VARIOUS	800	850	900	950
TOTAL	13150	13800	14105	14510

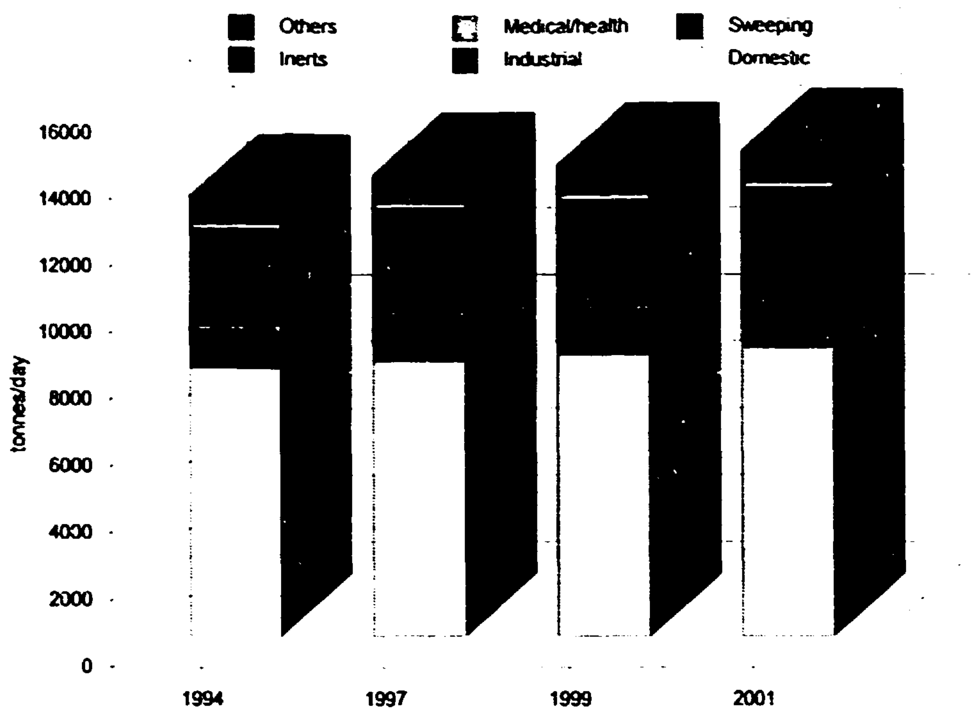


Fig.1. Expected growth of MSW in Sao Paulo City

Table 2 gives an idea about the situation in Sao Paulo State as far as the residential MSW generation is concerned in all the cities of the state.

Table 2. Residential MSW production in Sao Paulo State

Waste Production - City Classification	Number of Cities	Total Production (t/day)
up to 50 ton/day	526	3,098
50 to 100 ton/day	23	1,604
100 to 500 ton/day	19	3,694
over 500 ton/day	4	9,732
TOTAL	**534**	**18,128**

4.1. MSW composition

The MSW composition of any city vary according to many different parameters, usually linked to the population way of life and its topography. The main qualitative and quantitative characteristic of the MSW are deeply influenced by the population social and economical situation, its culture, local climate, area occupation and other features that modifies with the time.

The qualitative and quantitative characteristics growing tendencies, are given by the gravimetric composition of the MSW. Knowing the composition by weight of the MSW, it is possible to issue studies on the most adequate form to treat and dispose them, as well as to dimension correctly the best collection system.

It is interesting to note the evolution of the MSW composition from Fig. 2 and Table 3. The increase of the plastic part is due to the type of collection of the waste and the ever growing number of plastic packing. Meanwhile, it can be observed that the paper contribution is falling down in opposite to the organic matter. The MSW composition (e.g., of 1991) could be divided into the following three categories:

* Recycling materials - papers, plastics, glass and metals;
* Composting materials - organic matter;
* Others - not included in the above mentioned categories, as sand, stones,..

The percentage of each of these materials is shown in Figure 3.

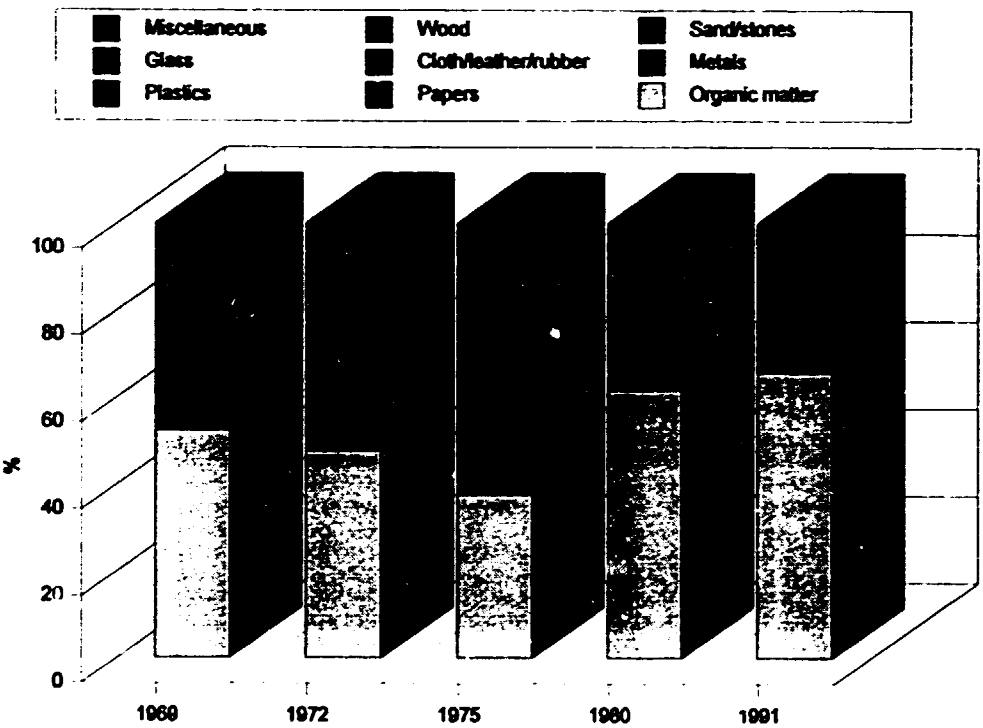


Figure 2. The evolution of the MSW composition in Sao Paulo.

Table 3. Composition (% by weight) of the MSW in Sao Paulo

	YEAR				
	1969	**1972**	**1975**	**1980**	**1991**
Organic matter	52.2	47.6	37.8	52.8	61.96
Papers	29.2	25.9	29.6	16.0	13.06
Plastics	1.9	4.3	9.0	7.75	11.15
Metals (ferric)	7.8	4.1	5.4	3.0	2.85
Metals (non ferric)	-	0.1	0.6	0.25	0,6
Cloth/leather/rubber	3.8	4.9	2.2	1.5	5.22
Glasses	2.6	2.1	5.0	1.5	1.65
Sand and Stones	-	9.0	9.6	2.95	-
Wood	2.4	1.9	0.8	-	0.78
Miscellaneous	-	-	0.5	-	0.5
Spec. weight (kg/m3)	230	215	173	235	231

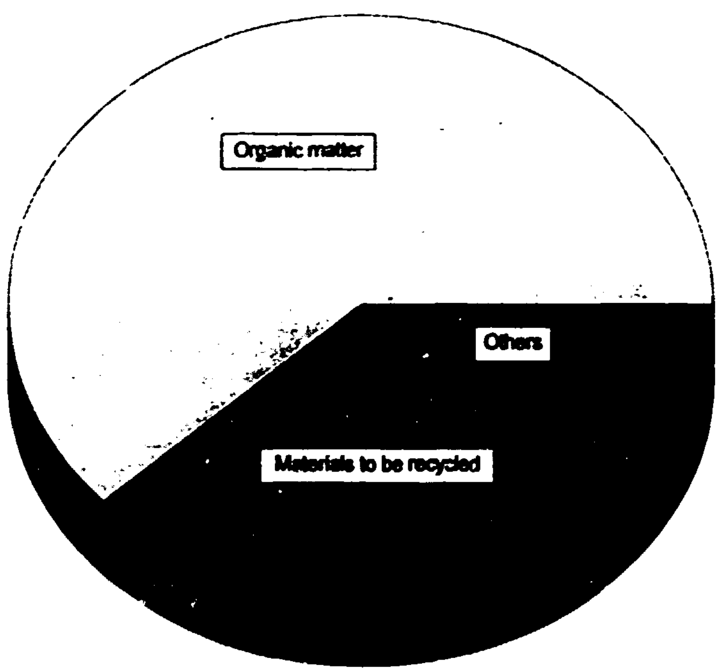


Figure 3 - Main Components of Wastes

It can be noted that recycling could influence the problem of waste treatment in general.

5. PRESENT MUNICIPAL SOLID WASTE COLLECTING SYSTEM IN SAO PAULO CITY

According to the Regional Public Administration of Sao Paulo City, the MSW being collected currently, is in the average of 2.5 Mt of MSW per year or , i.e., about 210 kt/month. This is the result of cleaning, in average, 3,600 km of streets per day.

Table 4 shows a summary of the services and costs referred to the municipal cleaning services, excluding destination costs.

Table 4 - Municipal Cleaning Costs in Sao Paulo

YEAR	WASTE COLLECTED (Mt)	COST (MUS$)	% OF MUNICIPAL BUDGET
1988	4.657	68	2.4
1989	3.694	193	3.9
1990	3.858	160	4.4
1991	4.239	172	3.2

To undertake this job there are approx. 9,000 employees and 730 transport trucks, that are being used by private companies contracted by the municipality. Currently, there are three companies contracted to collect the MSW of Sao Paulo.

The solid waste collection system can be divided into three different types, as follows:

* from **residencies** - including are all municipal areas. It is performed by trucks with compacting system, which have 7 t/trip capacity. Depending on the area characteristics the collection can be made daily or in each two days.

* from **sweeping** - normally done once a week. In some specific areas of the city it can be done daily. The waste is collected in plastic bags and transported by the same trucks as for the residential waste.

* from **slums**, due to access difficulties, the waste collection in the slums is performed by using big containers, which are placed in specific places.

6. MUNICIPAL SOLID WASTE DESTINATION IN SAO PAULO CITY

6.1. Present Situation

Sao Paulo has the best MSW destination system in Brazil. Nevertheless, there are still some non controlled landfills for MSW destination. This situation is much more worst in other cities in Brazil, where the MSW is placed in complete inadequate places, source of insects and rats that may cause epidemics.

The present MSW destination system in Sao Paulo consists of three sanitary landfills, two composting plants, two medical waste incinerators and one recycling centre.

6.2. Composting Plants

There are two aerobic composting plants in the city treating approximately 1.000 t/day of MSW. One of plants (Vila Albertina Plant) was considered for long time the largest plant of its type in the world. The organic compost produced in those plants is sold to small farmers near Sao Paulo.

As the producing capacity of those plants is greater than the present consumption of compost, the facilities operate sometimes with part load, or store the waste for long times in open areas, causing a lot of problems to the community because of the **mau cheiro.**

6.3. Sanitary Landfills

If properly managed, sanitary landfills are still economic and environmentally sound solution to the MSW.
There are three sanitary landfills in operation in Sao Paulo, reaching the capacity of approx. 12,000 t/day of MSW. One of them, Sao Joao landfill, is actually considered the best in South America. Table 5 above shows the present landfills and their capacities in Sao Paulo city.

Table 5. Current landfills in Sao Paulo city

Landfill	Capacity (t/day)
Itatinga	2.000
Bandeirantes	5.000
Sao Joao	5.000

Apart from Sao Joao landfill which started operation end of 1992, the others are nearly full. The present and forecasted situation of sanitary landfills in Sao Paulo city are shown in Fig. 4.

So far, the possibility of using the landfills as source of energy has not been yet considered. This is the subject of the following section

6.4. Medical Waste Incinerators

This type of incinerator is mainly used to burn wastes from hospitals and health services in general. Meanwhile, they are also used to burn confidential documents, waste from prisons and others. Such incinerators do not produce energy, since their concept and capacity do not allow it. Due to their operational problems they are operating presently in reduced capacity. The average capacity of the incinerators is 180 t/day.

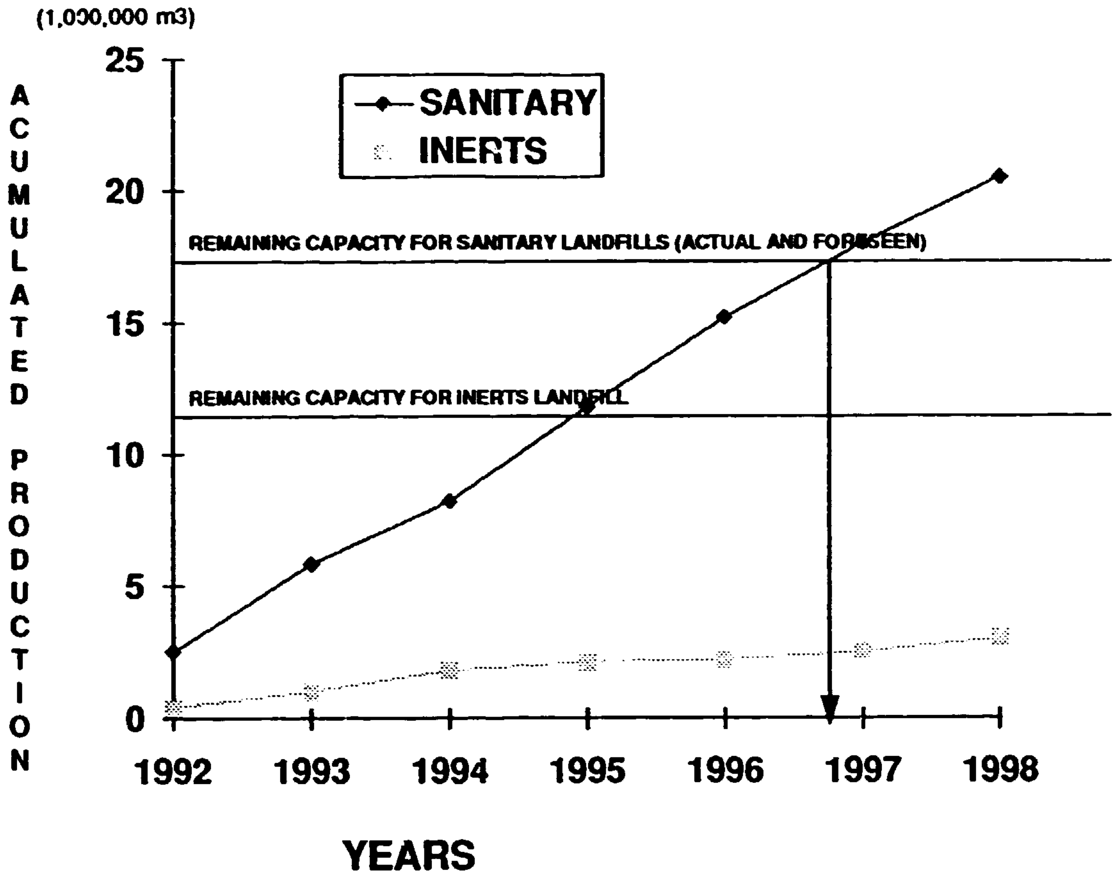


Figure 4. Sanitary Landfills Service Life

6.5. Recycling

Despite the potential capacity to recycling, only a very little part of the MSW (2 ton/day) is recycled in Sao Paulo, through the selective collection system implemented in Sao Paulo at the end of 1989.

In Brazil, Curitiba capital of Parana State, has the best recycling program with educational programs and covering almost all city. In Sao Paulo the present administration is not following the same approach, despite there is a written program to increase recycling up to 10% of the MSW generated in Sao Paulo.

Figure 5 outlines the present situation of the MSW destination in Sao Paulo

6.6. Foreseen Situation

In order to solve the present problem that the present landfills are reaching their capacities, Sao Paulo municipality has already ordered two MSW incinerators 2,500 t/day each, to be in operation by mid 1997. Moreover, it is expected by the end of 1994 to bid for another incinerator, with 1,500 t/day capacity, to enter in operation in 1998/1999.

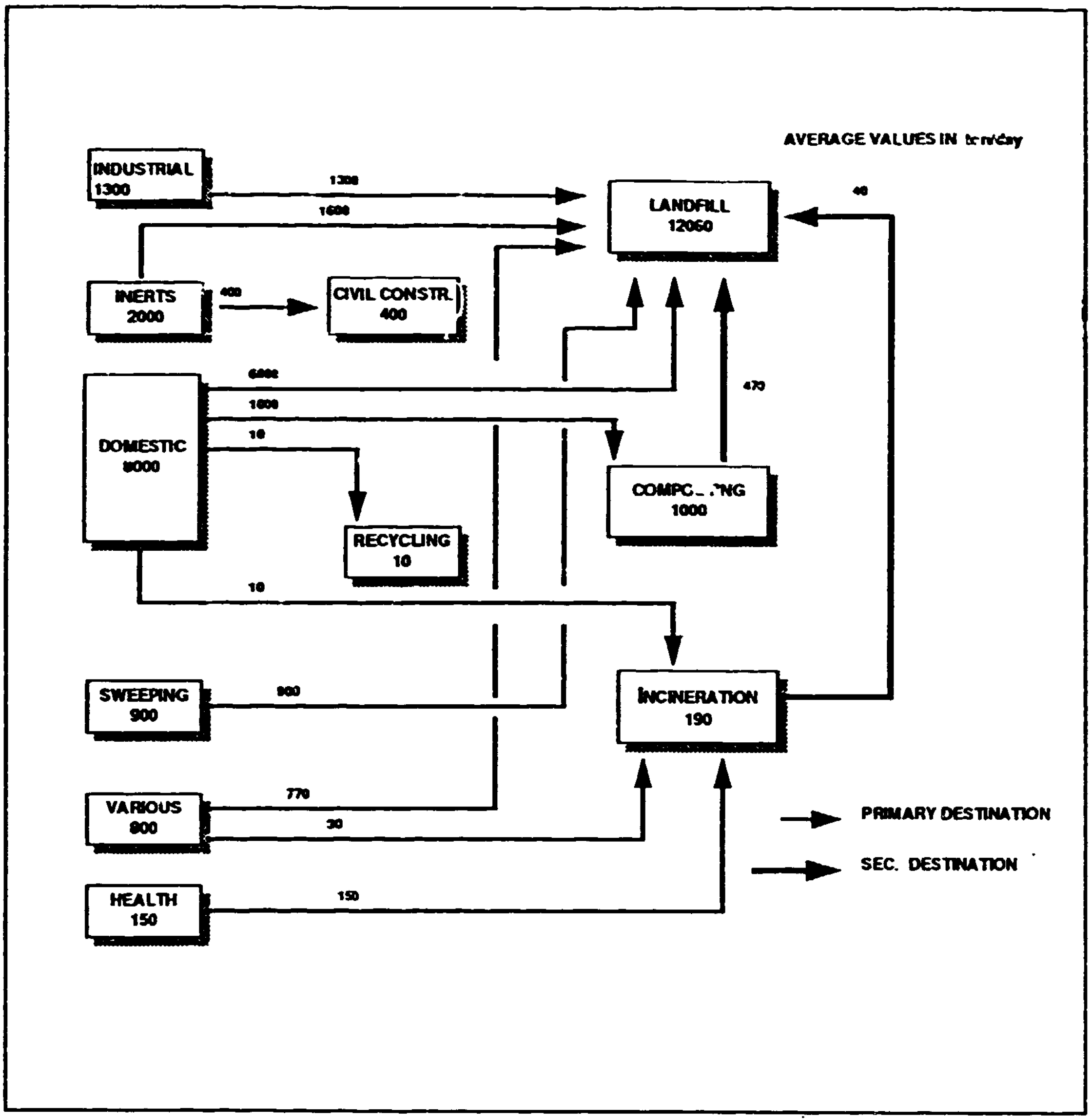


Figure 5. MSW Destination in Sao Paulo - Present Situation

Figure 6 shows the foreseen situation for MSW destination from 1997 on.

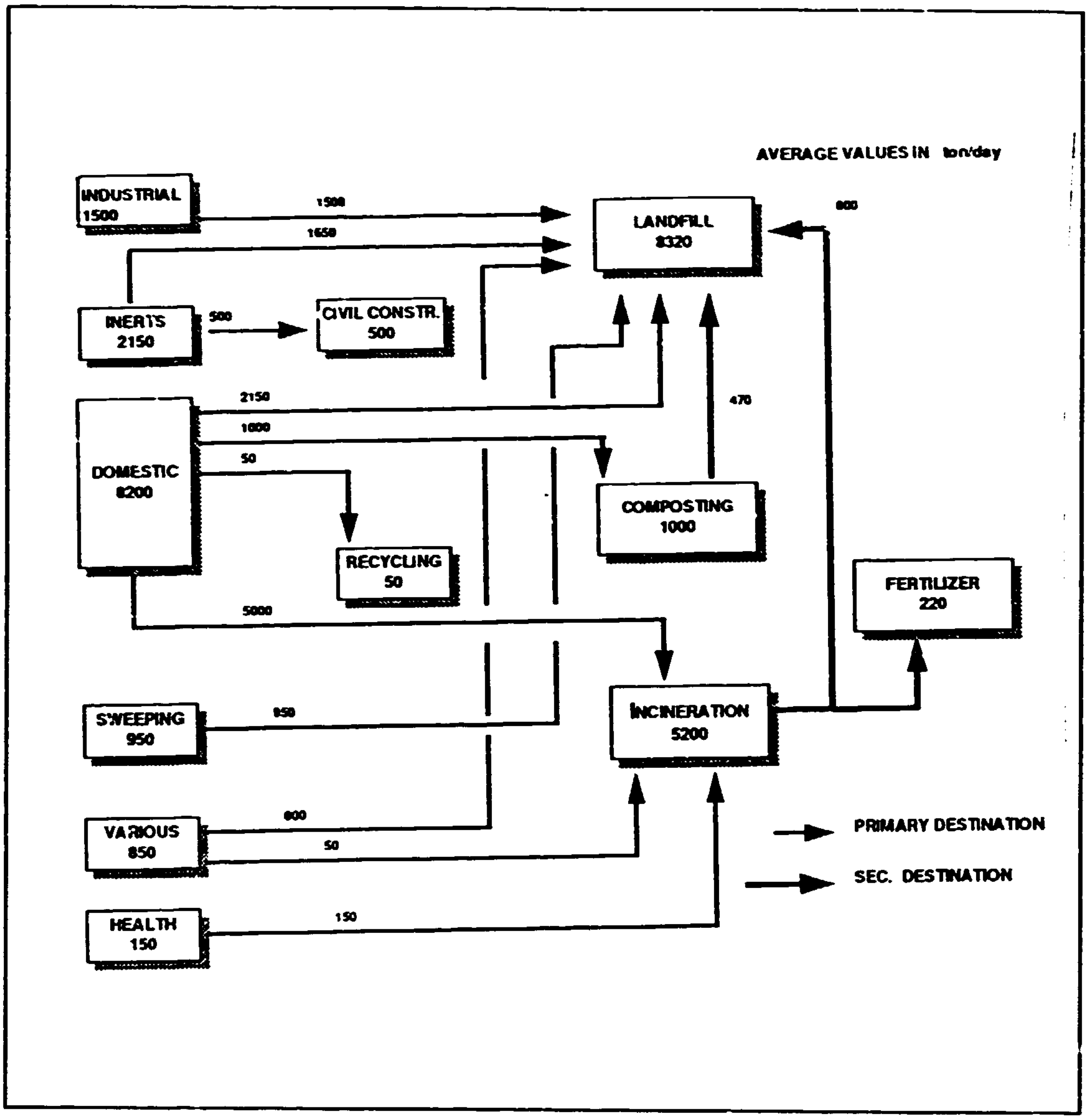


Figure 6. MSW destination in Sao Paulo - Foreseen Situation

It is predicted to built a MSW treatment centre, in order to receive approximately 8,000 t/day of waste, which will burn 5,000 t/day producing electric energy and steam. In this centre the organic matter of the MSW will be separated, increasing heating capacity of the waste to be burned up to 8400 kJ/kg.

Up to now it is not decided what to do with the separated organic matter. The present tendency is to built in the same MSW treatment centre an aerobic composting plant, using the same technology as the already existing plants.

As the municipality has already problems in putting the compost to the market, when such new plant enter in operation it is predictable to say that they will not succeed to sell all of it. Therefore, it is a good alternative to think on aerobic composting plants, because the energy produced in this facility could subsidy the transport of the compost to distant places.

In relation to recycling its degree that will take place during the next years remains to be seen. In fact the actual administration is not thinking to upgrade this way of MSW treatment.

7. CONCLUSIONS

In 1994 the management of municipal solid waste (MSW) became an important issue and perhaps the most critical threat to public health.

Even in the case of São Paulo, the wealthiest state in the country with a per capita income comparable to European countries, the management of MSW is still a challenge to almost all cities. The article included in attachment B states that merely dumping the trash in sites without any kind of sanitary protection is still common practice in many cities of the State of São Paulo.

In the past few years, however, the situation has been going through dramatic changes due to increasing worldwide concern for environmental preservation leading to international pressures on Brazil. Legal actions are increasingly being used to force municipal governments to review improper waste management.

In the other hand, as a consequence of rural exodus and migratory mobility, the most important state capitals are becoming densely populated areas, which contribute to limit the availability of areas for sanitary dumping. This is the typical case of São Paulo, which is trying to solve its MSW problems using the best engineering and environmental protection solutions (as shown in attachment A), even recurring to "waste-to-energy" technology.

The fundamental purpose of the work to be developed is to provide judgement elements for the decision of which international experience, especially that of more technologically advanced countries, can be best applied to Brazilian reality.

Even though it may be early to provide details of the work to be done, the leading idea to be followed will be the waste-to-energy approach with the following main principles;

* anaerobic digestion with electrical energy production for treating the organic matter which will be rejected by the incinerators of the city of São Paulo. Analysis of the installation of a pilot plant, to obtain operational data on the anaerobic process, in the city of Novo Horizonte, where a composting plant is already in operation.

* electrical energy production in the sanitary landfills in operation, with eventual steam production for process industries (to be confirmed)

* for the case of Mogi das Cruzes, development of a master plan for the management of MSW, also taking into consideration the hospital and industrial waste.

During the work development, the execution of technical-economic viability study, will be analysed, for the creation of an incineration plant with energy recuperation for the urban and industrial solid waste for the region of Mogi das Cruzes, including neighbouring cities.

C. SUGGESTIONS OF A WASTE MANAGEMENT PROGRAMME FOR THE SAO PAULO DISTRICT

1. INTRODUCTION

The waste treatment in the Sao Paulo district relays heavily on landfills up till today. Due to environmental impacts from 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) and thus gives possibilities to recover energy from this type of waste. This process is one solution to decrease the load on landfills/ disposal places, extract energy, fertilizer and usable end products from waste and improve the environmental conditions. Fig. 7 is a block diagram summarizing the waste treatment system of the Vaasa process.

2. START VALUES

The plant is sized to treat a fraction of the waste generated in the region and can also receive some dewatered sewage sludge or other industrial organic wastes. Since the amount of waste is so enormous it has been found more practical and convenient to build smaller units of approx. 45,000 t/a capacity with 2-shift operation in a suitable number of places in the district under consideration. This solution has the advantages of short transportation distances, better working environment, better operation of the plant as well as more access to the market of end products, viz: fertilizer, compost, biogas and/or electricity/heat. The start values used in the present case study are given in Table 6.This composition gives a treatment capacity of 45,000 tonne per year for the waste fraction.

Table 6. Waste composition

Material	Percentage	Amount t/year
Organic kitchen waste	64 %	28800
Paper	13 %	5850
Plastics	11 %	4950
Metals	3 %	1350
Stones	3 %	1350
Glass	3 %	1350
Sand	3 %	1350

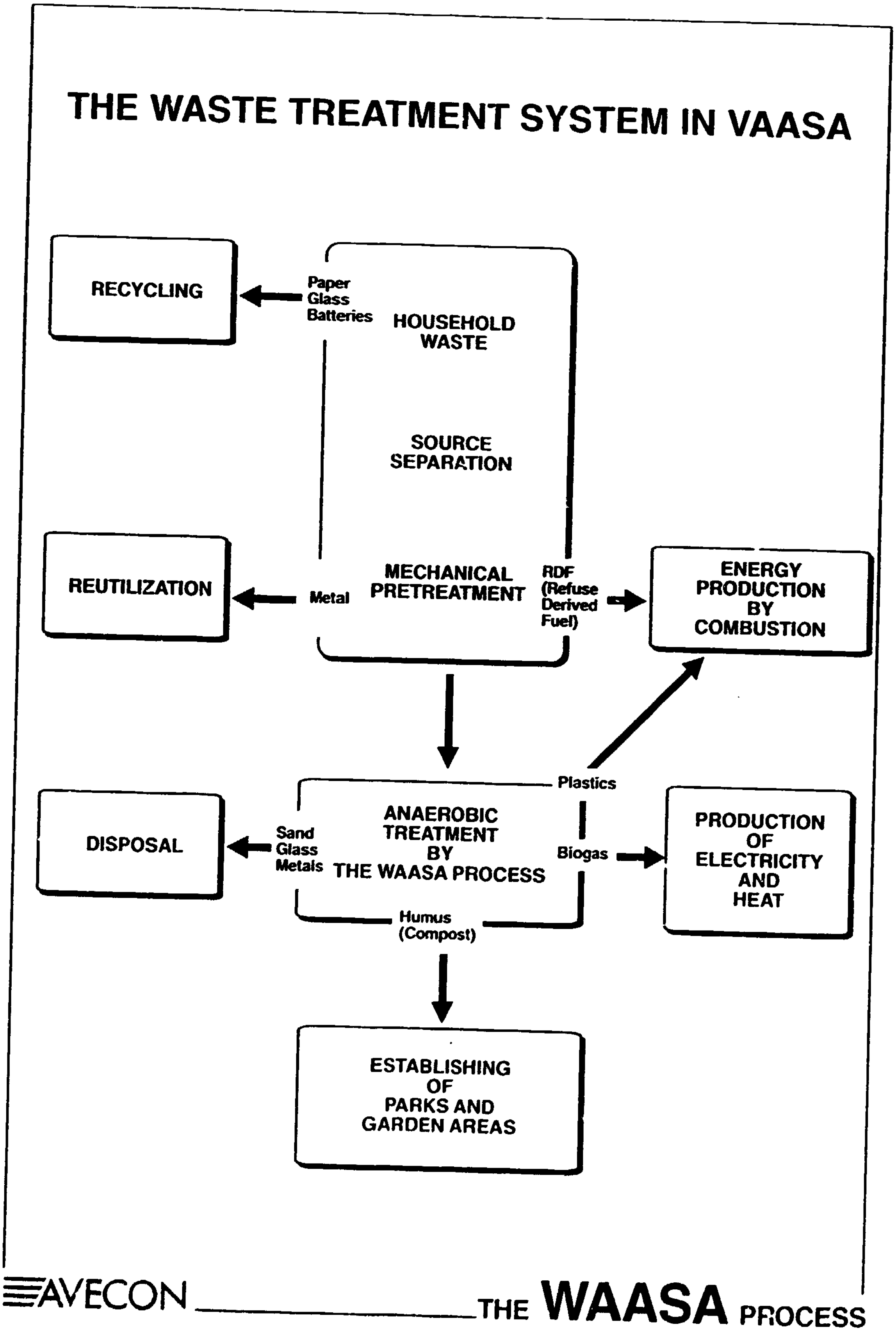


Fig. 7 Block Diagram of the Waste Treatment System in Vaasa

3. THE WASTE TREATMENT PLANT

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

3.1. Pretreatment Plant:

The components of the pretreatment plant are shown in Fig. 8. It consists of the following items:

- receiving silo
- screen
- crusher
- magnetic separator
- conveyor belts
- control room

3.2 Biological Treatment Plant

The main components of the biological plant are shown in Fig. 9. These are:

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

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. Accordingly, the dewatered digested sludge is of a higher quality compared to conventional composting end products and can be used directly in the agriculture. However, the anaerobic process will not remove heavy metals which leaves consumers with a responsibility to separate non-wanted materials.

4. 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	5,9 x 10^6 m^3/a	CH_4 58 %
Digested sludge	26,400 t/a	TS 35 %
Surplus water	1,300 t/a	
Disposable products	9,800 t/a	

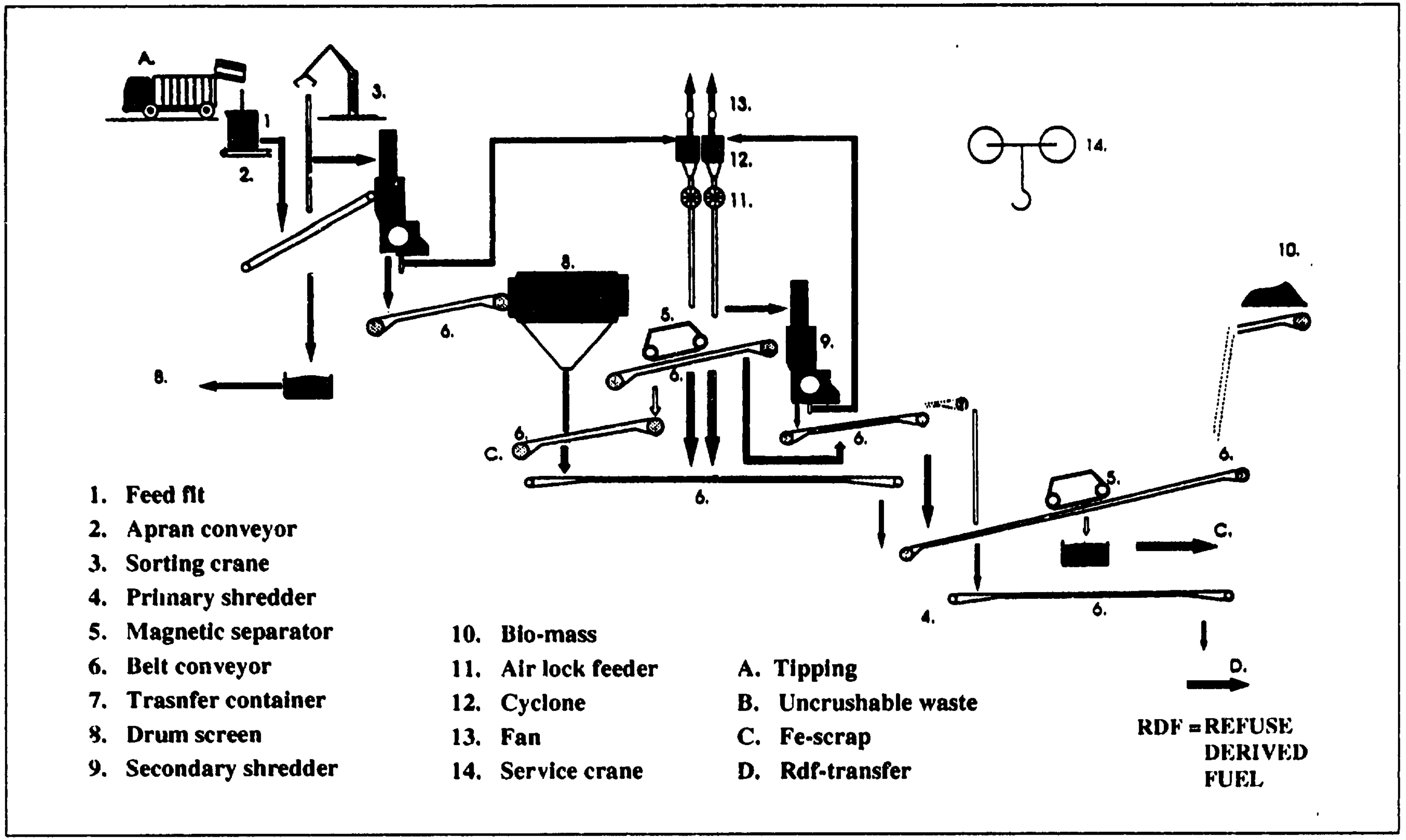


Fig. 4. Components of Pretreatment Plant

4.1. Biogas

The biogas can be used in a power generation plant, producing electricity a total of approx. 12 GWh/a and heat 19 GWh/a. The internal electricity consumption of the plant is approx. 1.8 GWh/a and the heat consumption is approx. 3.5 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 can 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 34 GWh/a.

If the plant operator wishes to produce electricity and heat at the plant, one biogas engine, with an consumption of about 800 Nm^3 biogas per hour is recommended. This equals to 6 MW gross power generator set with a net power of approx. 2.4 MW electricity and a maximum of 2.7 MW heat. The cost of such biogas generator sets is roughly be FIM 7,000,000 (about US$ 1.3 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.

4.2. Digested Sludge

The sludge digested is a good fertilizer which can replace imported fertilizers in the agriculture. The amount of which will be 26.4 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, which will make the use of the sludge interesting for the agriculture.

4.3. Surplus water

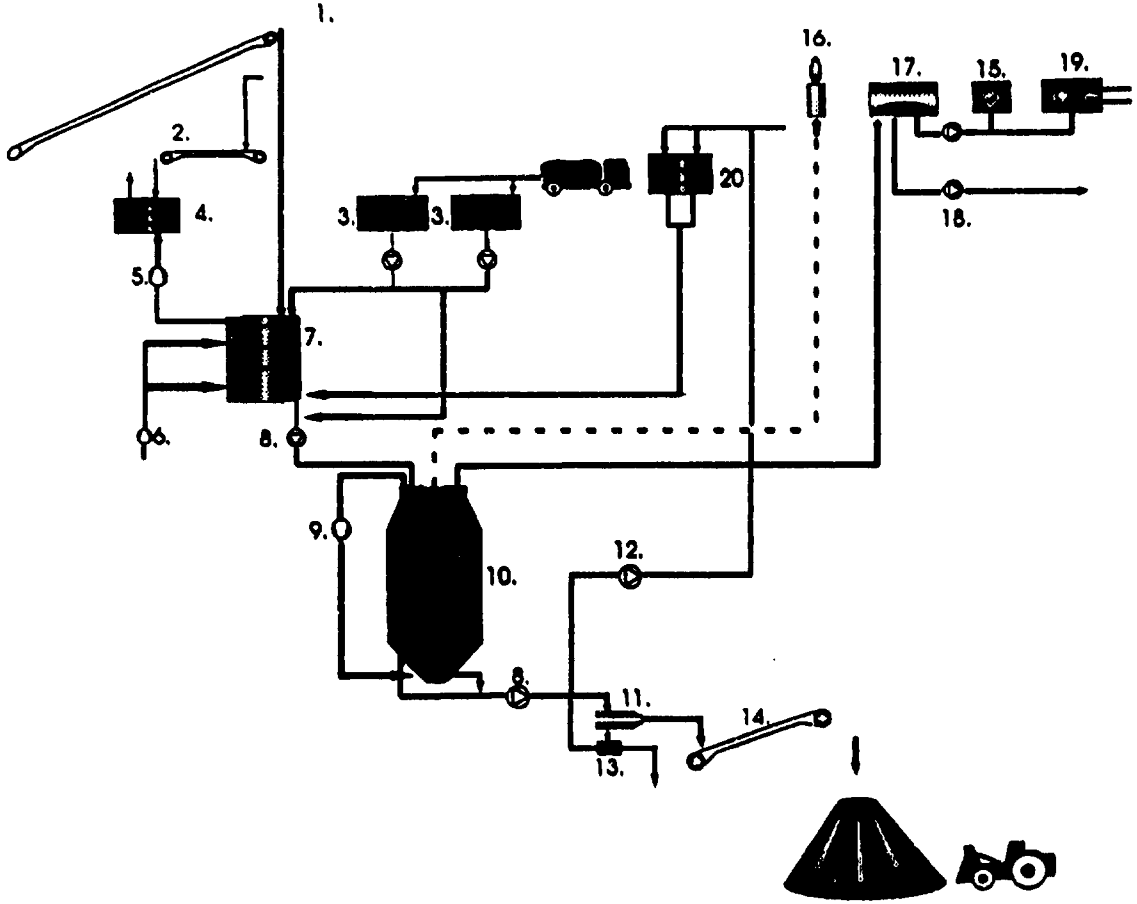
The surplus water may also be used in the agriculture as a liquid fertilizer, amount approx. 1.300 t/a. If local restrictions don't allow the spreading of liquid fertilizers on fields the water should be treated in a waste water treatment plant.

4.4. 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. 10.000 t/a.

4.5. 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 this price estimate does not contain the equipment for sludge treatment.



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

5. OPERATIONAL PERSONNEL NEEDED

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

6. STAFF TRAINING

The plant in Vaasa, Finland which has been in operation since 1990 is involved in training new operators. On site practical training could be thus be carried out at the Vaasa plant before the commissioning of the new plants.

7. INVESTMENTS NEEDED

It is extremely difficult to give an estimation of the investment for the above mentioned plant with a capacity of 45 Mt/a to be built in Brazil, 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 Brazil, where the environmental problems caused by waste management are much more sever.

D. BRAZILIAN BIOMASS POWER DEMONSTRATION PROJECT SUGGESTED BY AHLSTRÖM OY, FINLAND.

Broader commercialisation of biomass power requires a more favourable combination of power plant efficiency and specific investment cost.

The Biomass Integrated Gasification-Gas Turbine (BIG-GT) cycles appear promising in this respect and a number of commercial gasifiers exist which could be developed for gas turbine applications. However, the concept is only now approaching the stage of demonstration in an integrated system in Brazil.

Amongst the emerging renewable energy options, biomass power appears particularly well positioned to contribute to commercial energy supply of Brazil early in the 21st century, both in terms of cost and scale. With careful management, it could also offer considerable social and environmental benefits.

The following is the main outcomes of a recent study undertaken recently by Ahlström Oy/Bioflow, Finland.

1. BACKGROUND LEADING TO THE BRAZILIAN STUDY

Over the past two years, several factors have converged to create a framework for a commercial demonstration of BIG-GT technology in Brazil, and both Shell Brazil and the Renewable Energy Section of Shell International Petroleum Company (SIPC) have been active in the process.

BIG-GT technology could have a positive impact on the carbon cycle, whilst at the same time being potentially competitive with conventional, fossil-based electricity.

Brazil, as mentioned earlier, is a leading producer of renewable energy - more than 90 % of its electricity is based on hydro resources and biomass accounts for almost a third of total primary energy. A successful demonstration of BIG-GT technology would expand the potential of biomass, most notably in the sugar/alcohol industry where considerable quantities of bagasse are incinerated in inefficient energy recovery systems. Indeed, the integration of BIG-GT power technology with high efficiency distilleries could substantially improve the economic performance of the fuel alcohol sector. In addition, sustainable managed fuelwood plantations - established, for example, on degraded grasslands - have the potential to become a major source of primary energy if the economics of BIG-GT plants live up to expectations. The Brazilian government has therefore shown a keen interest in promoting a commercial demonstration.

2. TECHNOLOGY DEVELOPMENT

The scheme included development of the gasifier/gas clean-up train; integration of the gas turbine and steam bottoming cycle; the overall system control; and the provision of process guarantees.

Bioflow - a joint venture involving Ahlström and Sydkraft - was responsible for the high pressure system development and TSP Termiska Processor for development of the low pressure technology (Fig. 10). Both project teams worked with General Electric who adapted the LM2500 gas turbine for use in BIG-GT cycles.

A. Ahlström Corporation is a diversified, multinational, privately-owned Finnish company with group net sales of approximately US$ 2 billion. The company operates in four sectors: Ahlström Machinery; Ahlström Paper; Ahlström General Products; and Ahlström Pyropower.

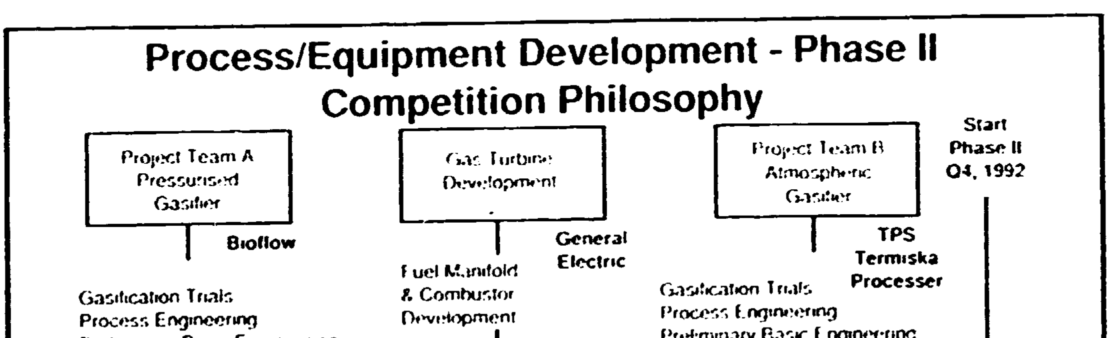


Fig. 10 Process Selection Strategy

a. Ahlström Pyropower is responsible for energy-related products and processes. Headquartered in San Diego, USA, the global operations of the sector comprise Ahlström Boilers in Varkaus, Finland; Pyropower and Ahlström Development Corporation in San Diego; and Pyropower Japan Ltd in Kobe, Japan. In total, Ahlström has supplied more than 300 industrial and utility boilers over the last 50 years, with a combined capacity of 20,000 MW thermal (MW_{th}).

Close collaboration with the Finnish pulp and paper industry has formed the base for Ahlström's expertise in the use of biomass and wood waste material for energy production. The first "Pyroflow" circulating fluidised bed (CFB) unit was built to burn biomass and of more than 110 units sold to date (12,000 MW_{th}), more than 30 operate on biomass.

Based on Pyroflow CFB combustor technology, a gasifier was developed in the early 80s. Four atmospheric gasifiers are now in operation, fuelling lime kilns in kraft pulp mills. The first unit of capacity 35 MW_{th} was started up in 1983 and continues to operate with high availability.

In 1989, Ahlström built a Pressurised Circulating Fluid Bed (PCFB) combustion test facility of capacity 10 MW_{th} at the Hans Ahlström Laboratory located in Karhula, Finland. Building on this R&D experience, the world's first commercial demonstration of PCFB technology is in the construction phase. This plant, of 78 MW_{th} capacity, is built in Des Moines, Iowa.

The combination of experience with atmospheric biomass gasification and pressurised (PCFB) coal combustion forms a strong base from which to develop pressurised CFB gasification technology. In 1990, Sydkraft AB of Sweden joined Ahlström to develop pressurised CFB gasification for biomass applications. At the Karhula laboratory, a 7 MW_{th} pilot plant is under construction to further develop pressurised CFB gasification technology for both biomass and coal.

b. Sydkraft AB:

The Sydkraft Group consists of some 50 wholly or partially owned companies, most of which operate in the electricity sector. It is the largest private energy group in Sweden and is the second largest power company after the state-owned utility Vattenfall. It owns and operates nuclear, fossil and hydroelectric power plants with a combined capacity of around 5 GW. Sydkraft is also active in other energy-related areas such as natural gas, LPG, solid fuels and uranium. The group operating revenues in 1991 were around US$ 1.4 billion. Sydkraft has a tradition of technological innovation and invest around 3 % of turnover in R&D. These investments include the world's first biomass power plant incorporating pressurised BIG-GT technology at Värnamo.

c. The Värnamo plant:

Construction of Sydkraft's BIG-GT demonstration plant began in September 1991 at the town of Värnamo in central Sweden and the unit was commissioned in stages during the course of 1993. Full commissioning was followed by a research programme spanning a period of several years although contracts are in place to supply electricity to the grid and heat to the local district heating system from the outset. The Värnamo plant is a component of a bioenergy programme pursued by Sydkraft with the aim of commercialising heat and power production from fuels based on agriculture and forestry. The Värnamo plant will deliver 6 MW of electricity together with 9 MW_{th} to the district heating system. Sydkraft selected Ahlström Pyropower to supply the gasifier/gas cleanup system following a world-wide screening of the available technology.

Bioflow is using the Värnamo plant for gasification tests on eucalyptus chips shipped from Brazil; and as a basis for optimising the design of their high pressure BIG-GT system (Fig. 11).

3. IGCC PRESSURIZED GASIFICATION

The Värnamo demonstration plant is giving an excellent opportunity to further de· elop the technology in order to increase efficiency, optimize process perfonnance, improve hardware and process design as well as monitor plant reliability. This work in addition to other work such as the Brazilian Wood BIG-GT Demonstration Project (30 MW_e), development of Äänekoski IGCC power plant (60 MW_e) and other projects will further develop the technology in order to commercialize it during the second half of this decade.

IGCC systems in themselves bring advantages compared to conventional technologies. In the co-generation concept it offers a total efficiency in excess of 85 % with a ratio between electricity and produced process heat ranging from 0.8 to 1.2. This means 2 - 3 times as much electricity based on the same amount of back pressure heat compared to conventional technology. In condensing mode the power production efficiency is 45 - 50 %. Absolute emissions per generated kWh_e are only 50 - 80 % of those of conventional technology.

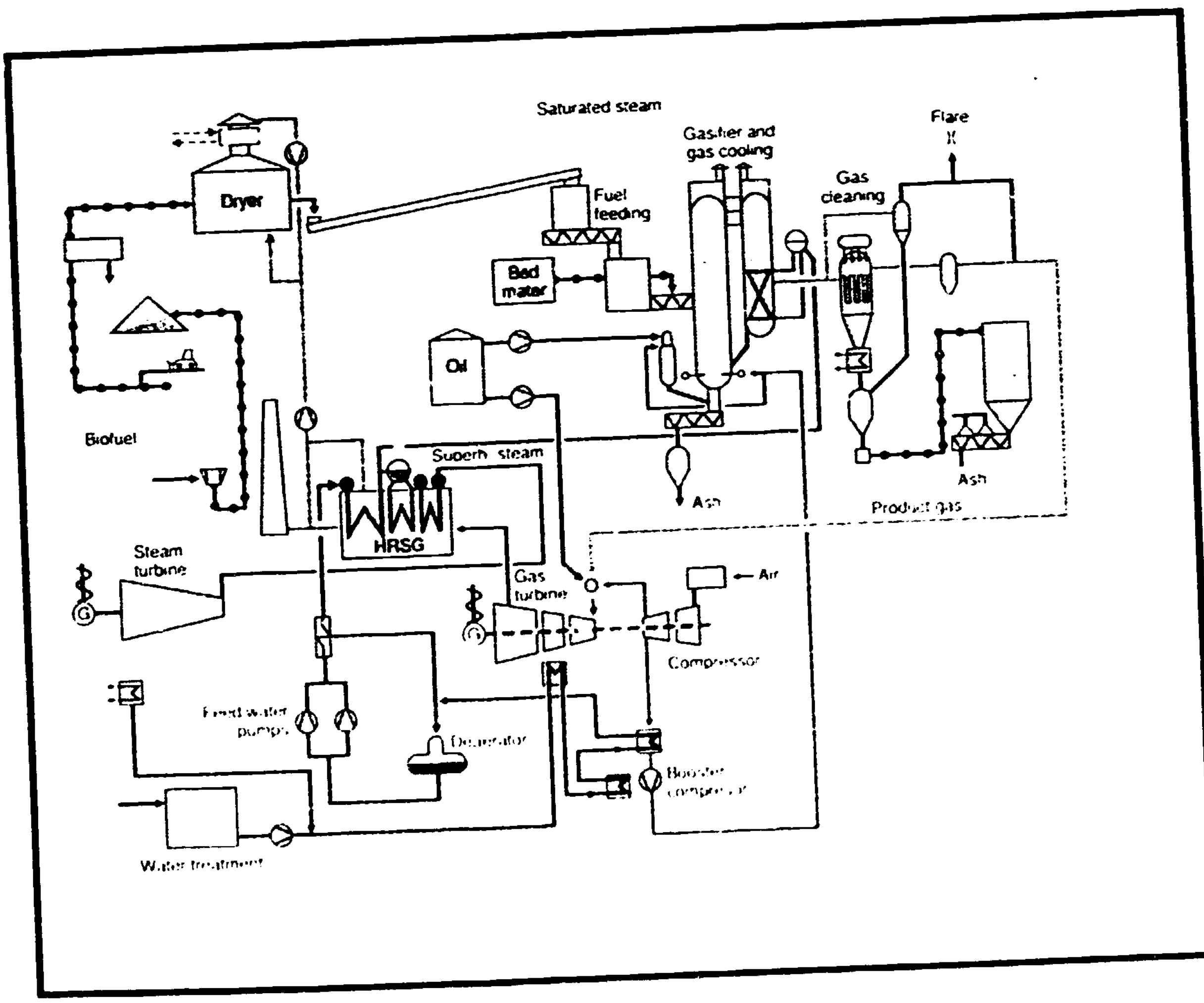


Fig. 11 Bioflow BOG-GT Process Schematic

4. TYPICAL PROCESS AND ENVIRONMENTAL DATA OF THE BRAZILIAN PLANT

a. Process Data

Dry solids of fuel	35...65%
Gasification pressure	25 bar
LHV of product gas	5 MJ/m^3
Total net efficiency (LHV)	85...90%
Net electric efficiency	40...50%
Electricity to heat ratio	0.6...1.2
Typical size	30...150 MW

b. Environmental Data

NO_x	< 50 mg NO_2/MJ
SO_x	< 25 mg SO_2/MJ
Dust	< 10 mg/m^3

5. EQUITY PARTICIPANTS

Under the terms of the Memorandum of Understanding, CIENTEC, CHESF, CVRD, ELETROBRAS and Shell Brazil have options for Phase III (started in 1995) equity roles. No restrictions have been placed on third party equity participation, for example by:

Utilities. The Brazilian power industry (CHESF and ELETROBRAS) is already committed to the project. Independent power producers internationally and in Brazil may also be attracted by privileged access to the experience generated by the world's first commercial BIG-GT demonstration.

Portfolio Investors. Leveraged by the GEF's Phase III grant, the project has good commercial prospects and it is an archetype for sustainable development in the power sector. Some investors are committed to place a proportion of their funds in environment-oriented ventures.

Biomass Producers. The project is of interest to a number of companies in the forestry and sugar cane sectors. COPERSUCAR, an association of Sao Paulo state sugar cane growers, is planning a complementary project involving bagasse gasification trials at the facilities of both TPS and Bioflow. BIG-GT technology could unlock the potential for 6,000 MW of generating capacity based on cane residues in the State of Sao Paulo where special incentives are already in place to promote independent power production.

Equipment Manufacturers. The gasifier process developers have already expressed informal interest in equity participation.

CO_2 Producers. Applied Energy Services (AES), a major US Independent Power Producer has committed "to substantially offset CO_2 emissions from any few AES fossil fuel power facilities by supporting appropriate greenhouse gas mitigation or offset projects". Assisted by the World Resources Institute, AES has donated substantial funds to carbon sequestration projects, most notably in Guatemala. Afforestation for power generation could have an impact on the carbon cycle substantially larger than afforestation solely for carbon sequestration.

E. TAMPELLA OY's IGCC PROCESS DEVELOPMENT FOR BRAZIL

Enviropower's goal is to develop a simplified Integrated Gasification Combined Cycle (IGCC) process. This concept incorporates the pressurized fluidized-bed gasification of different solid fossil fuels, combined with air-blown gasification and hot gas clean-up, integrated into a combined cycle process.

The IGCC process includes three major subsystems:

* gasification plant, including fuel preparation and feeding, gasifier and hot gas clean-up
* gas turbine plant, including the gas turbine, the booster compressor and heat exchanger system for the gasifier air supply
* steam cycle, including the heat recovery steam generator, steam turbine and conventional parts of a steam cycle.

The gasification system is a single-stage, pressurized fluidized-bed gasifier, which produces a low heating value gas to fuel the gas turbine.

1. IGCC PERFORMANCE AND SIZE

The IGCC process has the advantage of high power generation efficiency. The efficiency of natural gas-fired combined-cycle processes is between 50 % and 60 %. This is reduced by the efficiency of the solid/gas conversion process to 42 - 47 % in the IGCC applications. Based on the general trends in power plant development, better process and operating parameters are expected in the future.

The size of an IGCC power plant is determined by the size of the gas turbines available. The fuel input of the gasification plant is determined by the fuel demand of the gas turbine unit used, while the heat of the gas turbine exhaust gases determines the capacity of the steam cycle. The advantage of the IGCC process compared to other pressurized technologies lies in the opportunity it offers for using commercially available gas turbines with only minor modifications. Since the emphasis of Enviropower is currently on a gasification plant size range of 100 - 400 MJ/s (300 - 1500 MBtu/h), medium-size gas turbines in the range of 25 - 150 MW fall in the main area of interest.

2. GASIFICATION PLANT

The technology licensed by Enviropower has been developed by the Institute of Gas Technology (IT) and is based on a single-stage, pressurized fluidized-bed coal gasification process, known as the U-Gas gasifier. This has been modified by Enviropower also for biomass gasification. The multifuel gasification (coal mixed with biomass or biomass mixed with another biomass) concept is unique among the range of gasification technologies currently under development.

The Gasification Plant includes two main subprocesses:

* gasification process, including the gasifier, fuel feeding, ash removal and air/steam supply system
* product gas conditioning system, including gas cooling and hot gas clean up.

Air-blown gasification of coal and other solid fuels, such as biomass generates a gas with a low heating value of between 4 (1719) and 6 (2579) MJ/kg (Btu/lb). Some gas compositions are presented in Table 8.

Table 8. Typical Product Gas Compositions

FUEL	COAL	COAL	LIGNITE	WOOD
moisture (af), %	5	25	20	20
gas composition:				
CO, % b.v.	24	18	17	16
CO_2, % b.v.	5	8	9	12
CH_4, % b.v.	2	2	3	7
H_2, % b.v.	14	12	12	12
H_2O, % b.v.	5	11	10	14
N_2, % b.v.	50	49	49	39
LHV, MJ/m^3	5.0-5.5	4.0-5.0	4.0-5.0	5.0-6.0
LHV, (Btu/scf)	125-140	110-125	110-125	135-150

3. GAS CONDITIONING

High-temperature, high-pressure (HTHP) gas clean-up is a key component of the simplified IGCC system. Product gas contaminants vary, depending on the feedstock that is gasified. Generally in coal gasification, sulphur and nitrogen compounds and in biomass gasification tars and nitrogen are the main contaminants to be treated. Solid particulates have to be removed from the gas in all cases. Attention has to be paid to heavy metals, alkali metals and different trace elements.

IGCC technology will incorporate advanced control systems capable of significantly reducing the emission level of different pollutants. The higher efficiency of the IGCC process compared to conventional and competing technologies will also reduce emissions (CO_2) because of the lower feedstock levels required to generate equal amounts of power. The anticipated gas, solid and liquid emissions from a simplified IGCC process will be well below the limits set for energy production from solid fuels.

4. SULPHUR REMOVAL

The sulphur removal options in Enviropower's IGCC process can be seen in Fig.12. Novel zinc titanate sorbents suitable for fluidized bed application have been tested at the pilot plant. The regenerable sulphur removal system after sufficient development will be the preferred method of sulphur removal in the future. This will reduce the bulk of solid waste from the gasifier and improve the system performance and economy.

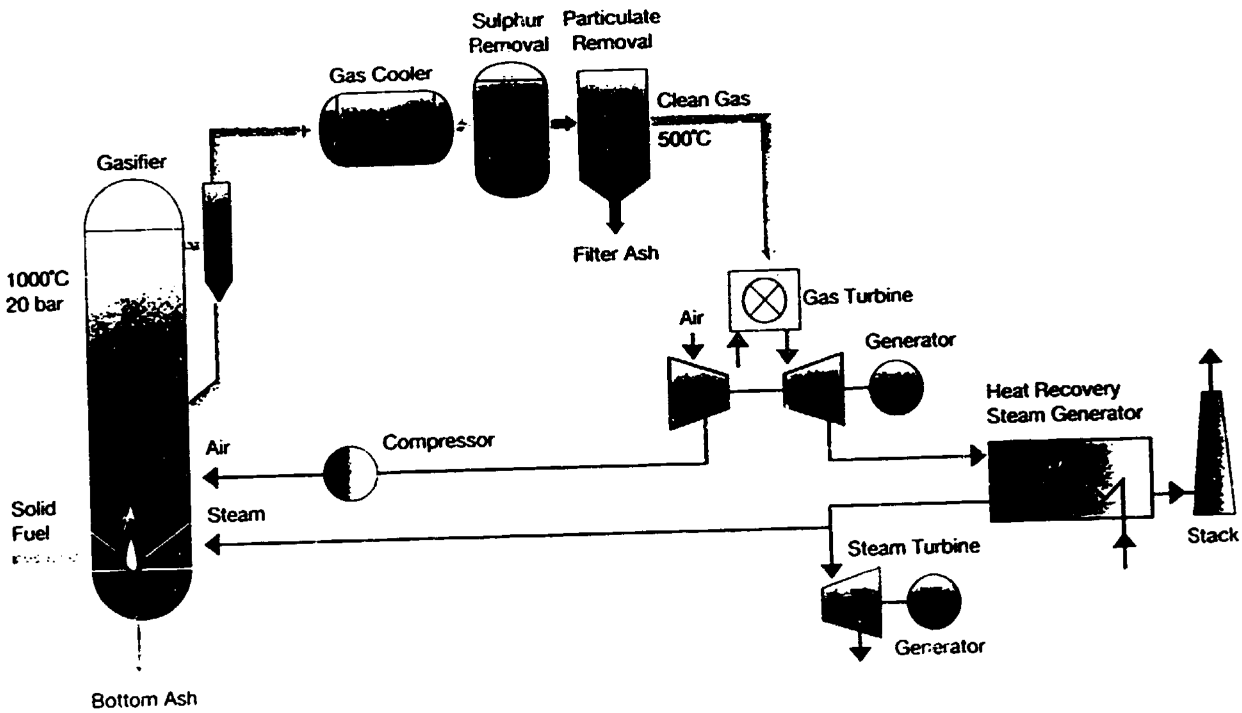


Fig. 12 Schematic layout of the Enviropower IGCC process

Cyclic sulphidation and regeneration tests with zinc titanate have been carried out in a 3-inch. I.D. batch fluidized bed reactor which is located at the Institute of Gas Technology in Chicago. The reactor is capable of operating at temperatures up to 1000 °C (1832 F) and pressures up to 30 bar (435 psi) with synthetic gas mixtures containing all the gaseous components for sulphidation and regeneration reactions. Testing has been performed mainly using sorbents produced by United Catalyst Inc. and The Research Triangle Institute (RTI).

Full-scale pilot plant testing of the sorbents was carried out in Finland, using a pressurized fluidized bed absorber and regenerator. The sulphur removal efficiency and long term durability of the sorbent was evaluated in these tests. Sorbent samples from the pilot plant will be analyzed by Enviropower, IT and METC/RTI.

Enviropower's external sulphur removal system consists of HTHP fluidized bed type desulphuriser and regenerator reactors and equipment for continuous feeding of fresh sorbent and sorbent transportation between the reactors. In February 1994, the operational shake-down of the pilot at actual process conditions was carried out with the objective of testing the mechanical integrity of the system as part of the pilot plant. The tests confirmed that the sorbent feeding and transportation systems could be operated as designed, and the automation and control systems were working well.

In March 1994, two tons of zinc titanate sorbent produced by the United Catalysts Inc. was received from the USA. Another batch of zinc titanate sorbent (ZT-4) with about the same fluidization properties has been ordered by DOE to be shipped to Finland by September 1994.

In May 1994, the commissioning of the process was accomplished with the first zinc titanate sorbent at actual process conditions with coal gas. Bituminous (Polish) coal with 1 % sulphur was used as gasifier feedstock. The test run was successful and several operation test points were achieved. The desulphuriser temperature was kept at around 550 °C (1022 F) level.

5. COMMERCIALIZING OF GASIFICATION TECHNOLOGY

Enviropower's work on gasification has been successfully demonstrated at the pilot plant scale at the company's own facilities, and is entering the demonstration phase to commercialize IGCC technology.

The short-term target is to start at least two demonstration projects: one in the USA for coal under Clean Coal IV program and one in Europe, based on biomass and multifuel gasification. The aim is to make the technology commercially available before the end of the decade.

The base technology has already been applied in gasification demonstration projects by IT in Hawaii, and in China. The Hawaiian project uses a local biomass, bagasse, while eight gasifiers under construction in Shanghai, China will use coal to produce fuel gas for coke ovens.

6. BIOMASS IGCC PROCESS DEVELOPMENT

A test programme has been carried out by Vattenfall, Sweden, with three different dryer manufacturers to clarify the performance of steam dryers when drying biomass. All dryers were tested with the same type of biomass, forest residues including bark and green parts, with a moisture content of 50 %. The fuel was dried to a moisture content of 10 - 15 %. All three types of dryers worked well for drying of biomass. The low content of organic material and impurities in the condensed water from the dryer indicates that only a biological waste water treatment is necessary for this kind of plant.

Enviropower's biomass feeding system was developed to feed large variety of biomass into the 15 MWth capacity pilot plant in Tampere, Finland. The development work combined experiences from the coal feeding system of the pilot and biomass related specific data generated in conventional combustion system. The biomass feeding system has been tested successfully with forest residue, dry/wet lignite, dried/wet coal & straw mixture as well as with paper mill residue consisting of bark, sludge and paper.

The biomass gasification test programme to demonstrate the IGCC technology for biomass fuels using air blown gasification and hot gas cleanup. The main objective of test runs was to verify and demonstrate the ability of the gasifier and the hot gas cleanup system. Combustion of low calorific value gas in a gas turbine combustor was also tested in the programme. General Electric testes it's combustor with a gas similar to the product gas produced in Enviropower's pilot plant. The test programme verified that the modified combustor is well suited for biomass applications.

7. BIOMASS GASIFICATION TESTS

The biomass gasification test programme in 1993 was a part of the joint development project of Vattenfall and Enviropower to demonstrate the IGCC technology for biomass fuels using air blown gasification and hot gas cleanup. The test programme for the demonstration plant in Finland started in the beginning of 1995.

Enviropower's pressurized fluidized bed gasification pilot plant is located in Tampere, Finland. The pilot plant includes all essential modules for research, component testing and completion of the development of the gasification process for IGCC applications. The pilot plant converts 15 MW thermal input of fuel to product gas suitable for combustion in a gas turbine. The gasifier operates at pressure and temperature up to 30 bar(a) and 1100 °C respectively. The process flow diagram of the pilot plant was shown in Fig. 12.

The plant is equipped with separate coal and biomass feeding lines which allow testing of a variety of feedstock like biomass, coal, lignite and straw. Bed materials can be fed into the gasifier through a separate lock hopper system or through fuel lock hoppers.

The gasifier is an air-blown, single stage pressurized fluidized bed gasifier. Gasification agents, which are air and if needed steam, are fed through the bottom of the fluidized bed to maintain proper conditions for simultaneous fluidization and ash removal. Freeboard temperature can be controlled by air injection. Gasification steam is produced in gas coolers and it is superheated in the heat recovery boiler. The bottom ash is removed through the bottom of the gasifier through a cooling screw and a lock hopper system.

The bulk of entrained fines from the gasifier is separated from the product gas in an external cyclone. The fines are returned from the cyclone to the fluidized bed. The product gas leaving the cyclone is cooled in two steps: first to 400 - 650 °C and after hot gas cleanup to 200 - 350 °C. After the first gas cooling stage, the dust particles are removed from the gas stream by ceramic candle filters cleaned by gas pulsing. Sulphur compounds (in coal case) can be cleaned in the post gasification desulphurisation system. Pressure of the cooled product gas is reduced before the burner of the heat recovery boiler that is connected to the district heating system of the city of Tampere. The flue gas of the boiler is directed to the stack.

The pilot plant is equipped with a state-of-art data acquisition and control system. More than 1000 positions are measured continuously, product gas and flue gas quality is analyzed on-line and all solid flows are sampled.

Total of 3000 tons of wood based biomass (as received) was gasified during 900 test hours during 1993. Long, stable set points were achieved under demo plant operating conditions. Testing conditions and fuels/amounts gasified are presented in Table 9. The first results are shown in Table 10.

Table 9. Biomass Pilot Test Runs

Operation pressure	14 - 18 - 22 bar
Operation temperature	800 - 950 °C
Plant capacity	15 - 17 MJ/s (MWth), 100 t/day
FUELS GASIFIED (1993 - 1995)	
	Amount/t
Wood chips	1630
Forest residue	1650
Paper mill waste (bark, paper, sludge)	460
Straw with coal	20 (+ 120 t coal)

Table 10. Biomass Gasification Pilot Test Program, Test Results

		Forest residue	Bark
Pilot plant fuel input	MJ/s	15	15
Product gas LHV (dry)	MJ/m^3	4.5 - 5.6	4.5 - 5.6
Fuel conversion	%	97 - 99	97 - 99
Product gas dust content after ceramic filter	mg/m^3	<5	<5
Alkaline (K + Na)	ppm (w)	0.01	0.01
Product gas H_2S content	mg/m^3	15 - 50	- 200
Product gas NH_3 content	mg/m^3	500 - 1500	- 2200

8. FEASIBILITY OF POWER PRODUCTION FROM BIOMASS

The economical feasibility of a power production method should be calculated case by case because of different conditions in each country and case. The following examination gives trends for the formation of power generation price at Finnish conditions. Fuel and electricity prices are low in countries like Finland where biomass is available in large quantities and power is produced from many sources. Higher prices would give further advantage for the IGCC process.

The prices in Brazil are expected to be less, however, the ratio between the IGCC and FBC plants is expected to remain unchanged or to change slightly in favour of IGCC.

The relative specific investment costs of Enviropower's IGCC and conventional fluidized bed (CFB) combustion technology are presented in Fig. 13.

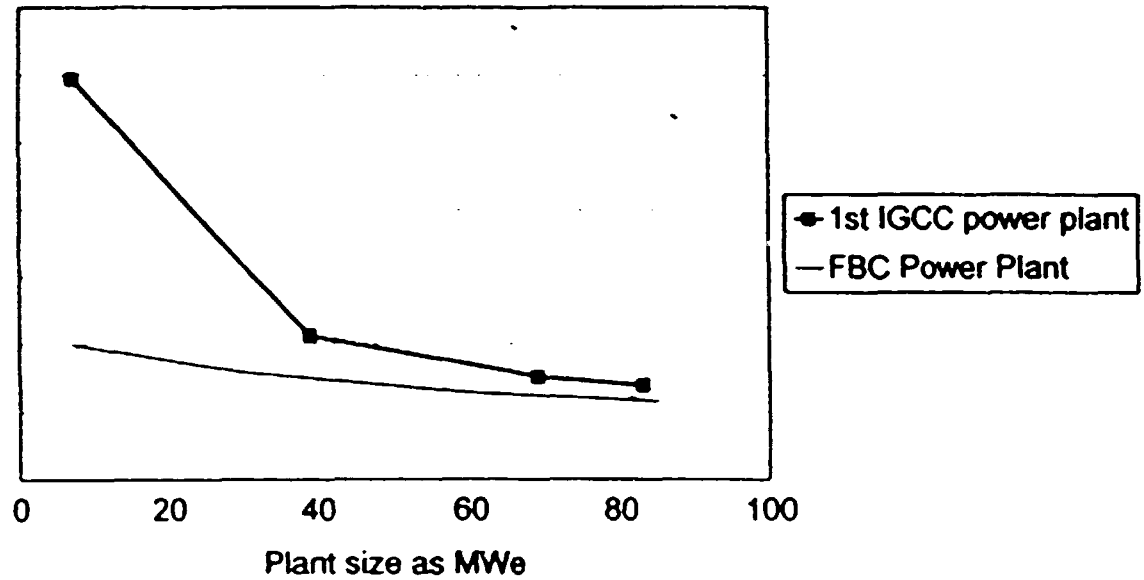


Fig. 13. Investment costs of IGCC and FBC power plants

Fig. 13 shows that the specific investment cost of an IGCC plant declines much more rapidly than that of a conventional plant when the power plant size is increased. The investment cost of an IGCC "demo-plant" is expected to decrease by 15 - 20 % when ten plants have been built.

Results of electricity production cost calculations for two cases - condensing power and process heat generation in pulp and paper industry - are presented below. The calculation basis is: Operating time per year 8000 h, 20 years life time, similar fuel price and Internal Rate of Return (IRR) is expected for each project. Typical efficiencies, availabilities and operation costs for each plant are considered.

Fig. 14 shows the cost of electricity (COE) production of both IGCC and fluidized bed combustion (FBC) power plants as if these were condensing power plants. The power plant size is shown as megawatts of electricity production. Separate IGCC plants up to 80 MWe are marked on COE curves. COEs of IGCC plants decrease more rapidly than those of FBC plants as the power plant size increases. Results from calculations predict that the COE of the first of the kind IGCC power plant will be equal to the COE of a fluidized bed power plant at 35 MWe plant size. In case of Brazil, the break-even point is expected to take place at smaller plant sizes in view of cheaper biomass prices.

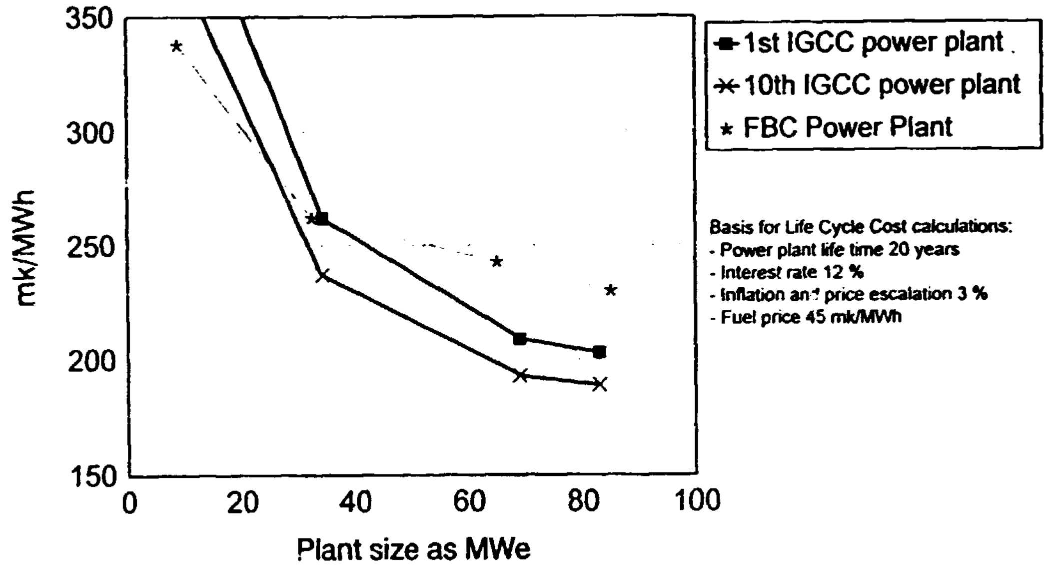


Figure 14. The Cost of Electricity from Condensing IGCC and FBC Power Plants

Most of the power plant projects, especially in industrial applications, are based on heat demand. Fig. 15 shows COE curves as if power plants were supplying process steam to a paper mill with typical process conditions of a Finnish paper mill. Existing steam cycle of power plants is designed to produce 2.8 bar(a) and 5 bar(a) process steam. The excess steam is used for power generation in a condensing steam turbine. These conditions are rather similar to those of Champions Paper Mill by Sao Paulo in Brazil.

Power plant size is shown as a function of heat production. Electricity production is shown as an area in the figure. IGCC power plants will be more feasible than FBC plants at larger than 20 MJ/s power plant size and produce more than twice as much electricity as FBC plants.

9. IGCC DEMONSTRATION IN FINLAND

The development of the biomass fuelled simplified IGCC process has achieved the maturity for demonstration in full scale. Enviropower plans to demonstrate this technology on a fast schedule participating in the initiation of demonstration projects both in Europe and the USA.

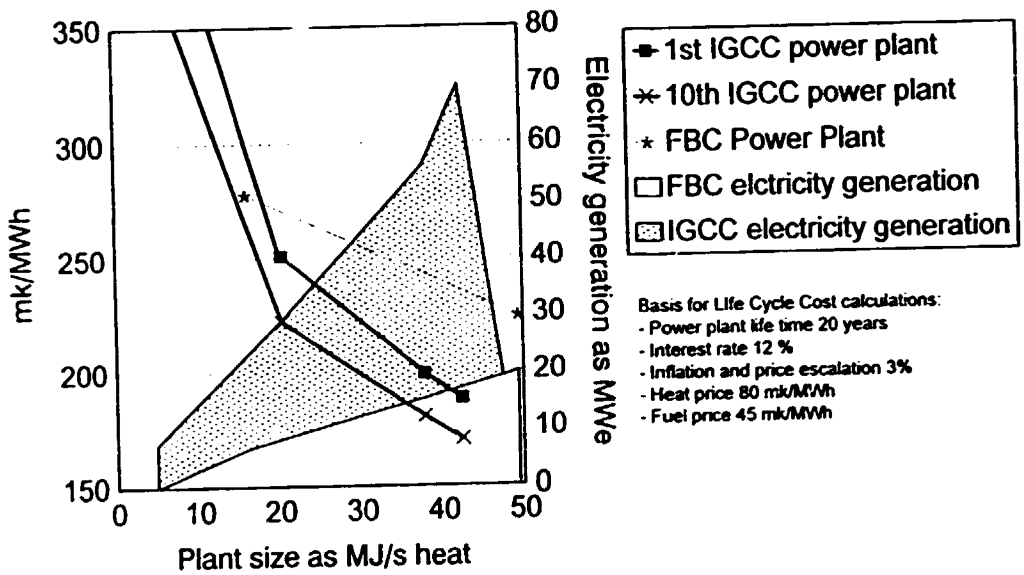


Figure 15. Process Heat Generation in Pulp and Paper Industry

In Finland the pulp and paper industry typically utilizes all the in house wood waste (black liquor, bark, etc.). Thus the re-powering of a paper mill power plant gives an excellent opportunity for the demonstration of the biomass fuelled IGCC process like in the case of the Summa IGCC Demonstration Proje :t where the steam turbines of the existing power plant are utilized. The IGCC plant of 60 - 70 MW power generation will supply about 30 MJ/s heat for the paper mill. However, the amount of available biomass, waste from the mill, is not enough to provide the total fuel input of the IGCC plant thus the feedstock is made up of 40 % biomass waste from the mill and the rest from forest residues. The 120 MUSD project is co-funded by the Finnish government. The engineering of the project was started at the end of 1994 and the construction work is scheduled to start during 1996.The IGCC plant placed in the paper mill environment is shown in Figure 16.

10. POTENTIAL OF BIOMASS IGCC POWER PRODUCTION IN BRAZIL

A rough estimate of biomass availability and the potential IGCC market share can be predicted by using the information from World Energy Council (3), Commission of the European Communities (4) and the U.S. Department of Energy (5). In short term the most realistic potential seems to be in countries where biomass waste is generated by large industrial sites using biomass as raw material. The two major industries are pulp and paper and sugar industry (wood waste/bagasse). These are the two main industries in Brazil.

The conclusion is that about 10 % of biomass from the national potential estimates could be used as fuel for an IGCC plant(s) of size (30 - 80 MWe). The estimated biomass IGCC potential in short term potential areas by 2010 is presented in Figure 17. Brazil alone has potentials for the production of power from biomass roughly twice that of Europe, or the equivalent of five large nuclear power plants each about 1000 MW.

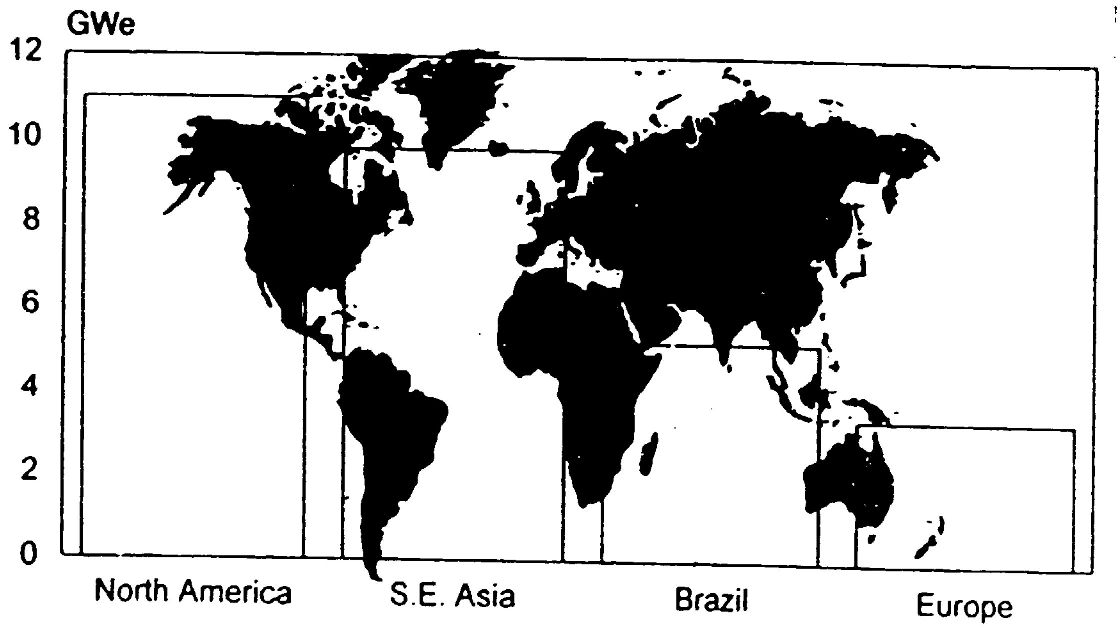


Figure 16. IGCC Plant at a Paper Mill

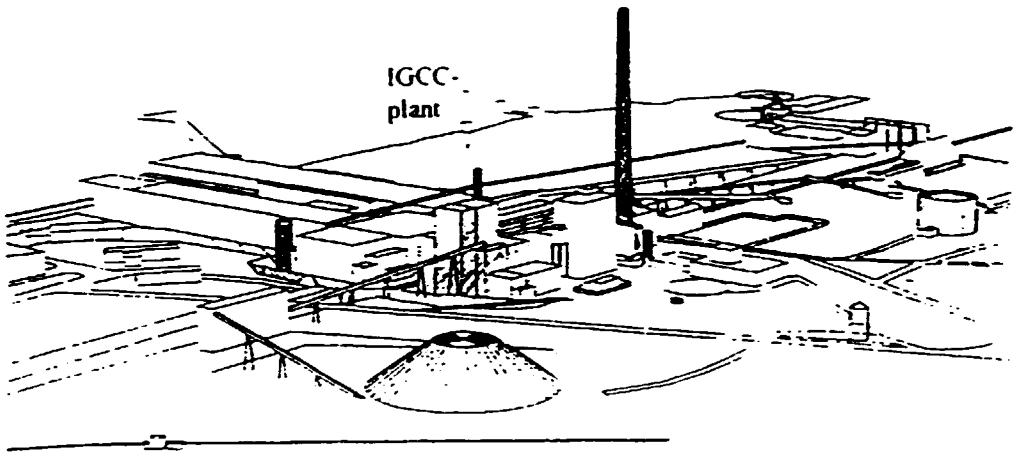


Figure 17. Estimated Biomass IGCC Potentials by 2010

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Annex A

ENVIRONMENT

The Energy from Trash

WERNER EUGÊNIO ZULAUF (São Paulo city mayor assistant for the environment)

The large urban areas are still the largest polutant generators, which result in a health hazard for the population and degradation of the urban and suburban environment.

In every large city of the world, the automobile continues to be the main contributor for the air quality degradation , which is one of the components of the above mentioned problem.

The *ecomarket* has detected this demand and developed the necessary technology. Among other resources of the new technology are the liquefation of gases at low temperatures, such as metanol (-160ºC) or hydrogen (-200ºC), both environmentally friendly fuels (*umweltfreuntlich*, in German) and having a potential to substitute part of the petroleum fuels.

The technology of liquefation and storage is already stabilished; no sensible heat exchange with the environment is noticed. The natural gas has been stored this way during the summer, to provide for the excess demand during the winter in temperate climates. With respect to automotive use, there are conversion kits and prototipes in use.

The liquefied gas is the modern, safe and light weight alternative to compressed gas, since the latter requires extremely heavy and bulky reservoirs.

With respect to gases generated in the process of organic trash treatment, in sanitary landfills and in composting plants, they are an energy source still to be conveniently explored.The trash of the City of São Paulo, when fermenting its extraordinary organic fraction (60% in Brazil against 20% in Europe), is an example of this huge potential.

In the core of the courageous and definite solution for the trash, currently underway in São Paulo, a form of *duplo-eco* appropriation (economic + ecologic) of the energetic component of the organic part of the trash, will be developed.

The metane, which today dissipates in the atmosphere, generating the *greenhouse effect,* shall be used as clean energy source substituting the gasoline and diesel in a considerable part of the vehicles of the City.

This substitution has been made in São Paulo and other Brazilian cities, in a small scale, using compressed natural gas. The two new solutions shall be the use of trash gas as a source of metanol and the storage in the criogenic liquid form. Both are technological steps to be made simultaneously.

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free translation of an article printed in news-paper " Folha de São Paulo " in 02.07.94

Annex B

LAW SUITS AND HEARINGS ARE FORCING CITIES TO PROVIDE A BETTER DESTINATION FOR TRASH *

A diagnosis provided in 1989 by the São Paulo state environmental agency (CETESB) showed that, for almost all the 39 counties of the region named " Great São Paulo ", trash is deposited in inadequate places, thus spoiling water resources and soil. In fact the scenario in 1994 is almost the same. But there is one indication that the solutions are begining to move faster.

With no exceptions, public attorneys know the municipal solid waste situation in detail and many have proposed legal suits against the city to force them to stop dumping trash in inadequate places and to demand them to pay for damages already made to the environment.

Legal suits are also under way for the investigation of the situation in 15 counties. Preparatory procedures have been implemented in 10 counties to schedule hearings.

This number of actions is the result of the first joint action of the Public Attorneys of the state of São Paulo,thus facing an environmental macro-problem. From now on, the tendency is to act in the same integrated joint effort according to Daniel Fink, who is one of the Public Attorneys who coordinates the efforts of the State Environment Curate.

The Public Attorneys of the various state counties will be oriented to concentrate efforts on the large hazard focus to the environment. The next target will be river polluters which are part of the *Piracicaba* river basin. After that, the joint efforts shall be concentrated in other river basins, according to Fink.

The applicable regulations in the environmental legislation allow the Justice to rule that cities should stop dumping trash in inadequate places, such as city dumps close to water resources and those that do not have soil impermeabilization. The concerning rule may also determine the appropriate dumping places and enforce economic sanctions , such as a reimbursement for damages.

Fink considers these economic sanctions inefective since the tax payer is the one who will bear the burden for the sanction. But he considers the court ruling will submit the Mayor to a strong political pressure, enough to persuade him to solve the problem. The prosecutor is also aware that the Public Ministry knows the difficult financial situation of many counties. "Nevertheless, this should not be an excuse for them not to do anything about such an enormous problem", he says.

The situation of trash destination in small counties and in the " Great São Paulo ", acccording to the latest inventory made by the Public Ministry is as follows:

-After preliminary investigations in *Arujá, Cajamar, Embu, Guararema Jandira , Santa Isabel São Bernardo do Campo, Francisco Morato, Poá, Ribeirão Pires.*

- After civil hearings for the investigation of eventual misdoings in *Barueri, Caieiras, Cotia, Embu-Guaçu, Ferraz de Vasconcelos, Franco da Rocha, Itapecirica da Serra, Itaquaquecetuba, Juquitiba, Mauá, Osasco, Pirapora do Bom Jesus, Santana do Parnaíba, Vargem Grande Paulista e São Lourenço da Serra.*
- After proposing public civil suits against *Carapicuiba, Diadema, Guarulhos (two suits), Itapevi, Mairiporã and Mogi das Cruzes. In Salesópolis,* where the *Tietê* river begins, *the* suit it was ruled procedent, thus condemning the City not to dump trash in two neighboring counties, *Santa Branca and João Lemos da Cruz.*
- A group of five counties are in "peculiar situation", according to an evaluation of the Public Ministry. They are: *Rio Grande da Serra e São Caetano do Sul,* which dump their trash in the *Mauá* county; *Taboão da Serra* dumps its trash in São Paulo; and, at last, São Paulo with a complex solution, which is being studied by the Environmental Justice Department.

- After the balance closing the coordination of Environmental Curators did not have precise information abouth the situation in the *Santo André* and *Suzano* counties.

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* *free translation of an article printed in news- paper " Gazeta Mercantil " in 05.07.94*