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ENERGY RECOVERY FROM MUNICIPAL SOLID WASTES IN ITALY: ACTUAL STATE AND PERSPECTIVE FOR FUTURE

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Summary

Matter and energy recovery from MSW and assimilable wastes, and their reuse is one of strong points of nowday regulations and tendencies, both at national and at community level in Europe. In Italy, the interest in energy recovery from renewable sources has been encouraged by an energy-saving law which included capital-prize and subsidies for thermal plant building if low grade fuels, as MSW, were employed. New electrical power prices imposed by Italian Electric Power Authority ENEL, encourage energy recovery from waste burners. This paper aims to point out present state of energy recovery from wastes in Italy, trends and prospects to satisfy, by new plants, the need for waste thermal destruction and part of the demand for energy in the different italian regions: at present only about 10% of MSW are burned and just a small percentage of the estimated amount of recoverable energy (2 MTOE/y) is recuperated. Different technological cycles are discussed:

- incineration of untreated wastes and energy recovery;
- incineration (or gasification) of RDF and heat-electricity co-generation;
- burning of RDF in industrial plants in addition to other fuels.

Introduction

Disposal of municipal solid waste (MSW) and assimilable wastes is in Italy a relevant problem of enormous importance from the economic, energetic side but also for its environmental implications.

The most recent data on municipal waste production refer that twenty millions of tons of MSW are produced each year(Table 1). Eighteen of them are correctly disposed mostly by landfilling. Daily average pro capite production is about 0.9 kg and calorific value is now stable on a value between 1600 and 1700 kCal/kg .

Recent national data show that the organic fraction present in MSW has decreased in Italy steadly from 1976 (43%) to 1986 (32%).(Table 2)

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Table 1
MSW and assimilable production in Italy: 1991 estimation

	Wastes(t/y*1000)	
MSW	Assimilable	Sludge
20033	3166	3428

While differentiate collection at the origin and separation of organic fraction shall be improved, it may be foreseen that:

- the percentage of the organic fraction of MSW will decrease;
- paper, plastics, rubber and wood fraction shall increase from 30% to about 40%;
- the lower calorific value (LCV) of the untreated refuse tends to grow up to values of 1600 kCal/kg;
- quality MSW to incineration improves along with the improv and diffusion of the separate collection of danger refuse.

Table 2

Estimated Typical Percentage Composition of MSW for the years 1976 and 1986.

Composition	1976	1986	%
Underflow	17,8	18,5	+0,7
Paper and paperboard	19,5	21,5	+2,0
Textiles and Wood	3,2	6,3	+3,6
Plastics-Rubber	6,7	9,8	+3,1
Metals	2,9	3,2	+0,2
Glass	6,8	8,0	+1,2
Food wastes	43,1	32,3	-10,8
Humidity (%)	45	38	-7,0
Calorific value (kCal/kg	1266	1686	+420

It is possible to say that municipal refuses in Italy follow the tendency stable in industrialized countries with respect to constituent composition and, as a result, to the calorific value.

From the energetic point of view MSW (Table 3) are therefore a potentially relevant source, equivalent to more than two million tons of oil per year (2 MTOE/y), or even three if assimilable refuses are considered. It must be outlined that MSW are in part made up of renewable materials: paper, wood, cloths, vegetal residues; the remaining part (i.e. plastics) is formed by materials whose destiny has, almost with no other choice, to be landfilled since, even in the case of advanced practice of separated collection and recycle, only a limited fraction of them could be recovered.

Table 3

Energetic characteristics of solid fuels.

Solid fuels	Humidity Weight %	Calorific value MWh/t	Ash average weight %
Untreated MSW	40	2,3	28
RDF fluff	25	3,4	18
RDF pelletised	6	4,7	18
RDF densified	10	4,4	18
Wood	25	3,6	[illegible]
Lignite	30-40	3-3,5	2-8
Coal	5-15	7-9	7-15

MSW can be considered a convenient energy recovery and, as well, they are a domestic resource, locally produced and ready to use. This fact is relevant for Italy, as a country with scarce energy resources and strong dependence for energy supplies.

1. MSW energy recovery technologies

Several options exist for energy recovery from MSW, each at different development stage and technical maturity (fig. 1):

-recovery through "mass combustion" (with no or minimal preprocessing of the MSW);

-mechanical processing to separate a fraction of higher calorific value which can be used as a solid fuel (refuse derived fuel, or RDF);

-extraction and utilisation of landfill gas;

-anaerobic digestion of the readily degradable fraction of MSW within a process digester plant to produce (as in an active landfill) a methane-rich gas;

-thermal processing of MSW (or selected fractions) to generate gaseus or liquid fuel products.

This paper aims to examine the most important technologies available and to point out the combustion options that, nowadays, have reached, or are about to reach, a satisfactory development level and a good commercial availability.

1.1 Incineration of MSW

Burning refuses has nowadays an important part in the number of refuse-disposal processes, still beeing the best way to reduce their volume. Volume and weighth of municipal refuses may be reduced respectively to one tenth and to one third of their initial values; if it is taken into consideration the possibility of use the solid residuals (i.e. road construction), the ashes for which landfilling is needed may be reduced to a fraction of 2 or 3% . This is the feature that makes incineration the solution for refuse disposal in urban high density population areas where there is scarcity of land for landfilling.

Despite all these good reasons, in our country nowadays only 10% of the total ammount of municipal solid wastes are incinerated (Table 4). Only few plants are equipped with heat recovery system , and only a fraction of these produces electicity. The majority of them use the recovered energy for plant use only (Table 5).

Table 4

Municipal waste incineration plants in EC Member States.

Country	Plants n.	Total incinerated (t/y*1000)	Percentage (%)	Energy recovery (%)
Belgium	28	2123	23,4	30
Denmark	48	1577	65	100
Germany	44	7997	40	40
Greece	1	17		
Spain	9	672	6,4	59
France	293	7335	35	67 plants
Ireland				
Italy	51	2000	10	19 plants
Luxemburg	1	100		
Netherland	11	2323	32	50
Portugal				
United Kingdom	39	2758	17,6	

The interest for materials and energy recovery from refuses stands not only on social interest, but also on economical advantage. In Italy recovery of energy from renewable sources has been encouraged by three acts: Legge 308/ 82 , Legge 9/91 and Legge 10/91; they act giving finantial contributions and subsidies for the construction of plants capable of energy recovery from low grade fuels, as an alternative to hydrocarbon fuels.

The italian electric power authority ENEL, has estabilished an encouraging prize for the energy sold by producers who run "alternative-fuel-fired-power-plants", among which waste burners are included.

Many technical-economic studies say that it may be found a minimum size threshold over which the construction of an energy recovery plant is economically justified and reasonable. This threshold expressed in terms of year capacity is assessed to be close to 60.000 t/y, corresponding to a region of about 200.000 inhabitants.

It is commonly believed that small size plants (lower than 100 t/d) don't make economic and practical sense, and must not be licenced, mainly because of the high cost of the pollution control system.

Taking into account that the whole production of MSW in Italy is 20 million t/y and that we should construct a number of incineration plants which we may figure out according with the average of EEC countries, the energy recovered from MSW may be assessed to be about 2 MTOE/y. Waste derived electric power installed could be increased by a factor of 10, changing from the actual 30 to the possible 300 MWe.

In the large size plants, the moving grate is widely employed; the grate is commonly sloping, formed by steps alternately stationary and movable, or by tilting fire bar, or by a series of rotating rod, or by still different elements, capable to cause wastes to advance and to mix, in order to accomplish uniform and complete combustion.

1.2 Production and use of RDF

In many countries combustion of RDF has been tested in plants based on different processes.

Incinerators designed to burn untreated wastes, when used to burn RDF had problems in the feeding fase, and also heat transfer problems and combustion efficency, i.e. reduction in grate life, and increase of carbon oxide concentration in the flue gas.

With respect to untreated MSW, RDF has from 30% to 50% less metal and this reduces metallic compounds emmission of a fraction of 20% up to 40%. In correspondence it may not be noted a reduction in hydrogen chloride concentration in the flue gas.

We should have the same quality of emissions, with the exeption of mercury, also in the case of incineration of untreated refuses by means of the improvement of flue gas pollution control system equipment.

The optimum use of RDF is achievable by means of specific technologies:

- fluidized-bed incinerators (excess of air) or gasifiers (air controlled);
- fixed-bed gasification (up-draught or down-draught);
- co-combustion in coal fired power plants.

1.2.1 Fluidized-bed systems

These systems refer, at least in our country, to pilot and demonstration experiences. Among them it is relevant the plant made by Italimpianti at the ACCAM facility in Busto Arsizio designed to incinerate RDF within a research project in which ENEA is involved, having as main purpose the improvement and demonstration of a disposal process based on fluidized bed incineration.

The furnace is a fluidized boiling bed at atmospheric pressure capable of RDF maximum design inlet flow of 0.5 t/h, while operating temperature of the bed may range between 790°C and 875°C.

Another installation that has to be mentioned is the ABI-2000 test facility plant: this plant is expecially designed for the accomplishment of testing campaigns, aimed at the solution of problems related to operation and design of RDF (i.e. post-combustion chamber) and dangerous refuse thermal treatment.

The fluidized bed is of recirculating type with a capacity of 0.2 t/h and working at a temperature of 850°C.

1.2.2 Systems based on gasification technology

Gasification is based on the idea that heat content of the solid fuel may be converted to a gaseous vector. One of the main points of interest for this technology stands on the fact that the gas fuel produced is ready to be used without many restrictions (motor engines, turbines, burners).

The main demonstrations of gasification technology to waste disposal were accomplished in Italy in the following plants:

- Bioneer gasifier (a finnish technology) runned by Daneco in Tolmezzo (Udine);
- Studsvick gasifier runned by Aerimpianti in Greve in Chianti (Firenze).

The Daneco installation is an up-draught fixed-bed plant; it has been tested for many years in Finland and in other countries, and it is expecially designed to test gasification of biomasses, peat, and preselected and thickened municipal solid wastes.

The potential thermal output of the gasifier is about 2 MW, the mechanical output power may raise up to 600 kW and it is fed continously by RDF (500 kg/h) in the thickned form or in the form of brickettes and pellets.

The Greve in Chianti Aerimpianti gasifier plant is based on the fluidized bed technology; it is capable of an inlet waste flow rate of 200 t/d. In the case all the gas produced is used for electric power generation the output could be over 6 MWe. The normal practice is to send part of the gas to feed a cement kiln closed to the plant. Also this technology has been tested for a long time with regard to different organic waste fuels: wood, peat and RDF.

1.2.3 Utilization of RDF in industrial burners

We consider last the use of selected refuses (RDF) in industrial kilns in conjunction with ordinary fuels (coal).

The possible disadvantages connected with the use of RDF in industrial burners are:

- the introduction of additional pollution problems;
- increase or introduction of corrosion problems;
- discontinuity and disomogeneity of the inlet fuel flow rate;
- licencing and authorization problems due to regulation specification regarding waste use for energy production purpose;
- problems of acceptance by local community.

A very interesting possibility is to burn refuses in cement burners, because combustion in long rotating kilns is able to reduce disadvantages and to minimize the problem: a large axperience has been acquired by means of several testings and much practice by Italian firms in the cement sector.

Long residence times at high temperatures, both for waste mixtures and flue gas, create ideal conditions for thermodestruction of organic substances.

The enormous avaibility of basic mixtures in cooking process causes the development of absorption of acid gasses.

Heavy metals fixed in the ashes or in the slag of the air cleaners have no possibility to be released to the environment because ashes are included in the clinker and slag is used in the production of concrete. Washing waters are then treated to eliminate metals.

The data regarding emissions from stack are reported in (Table 6): they refer to monitoring campaign accomplished during the two years 1987 and 1989 at Enichem Plant in Ravenna during both demonstration and first operating phases.

The use of RDF in a fraction of the whole fuel to furnish 20% of the heat content which is required for the production of clinker, doesn't imlpy relevant variations in flue gas emissions.

In the combustion tests of RDF-coal mixed fuel low variations in the emissions of heavy metals are observed.

With reguard to organic micro-pollutants, no differences between the two cases of feedindg with or without addition of RDF to the fuel are noticed.

In the three main outflows in the clinker production (dust collected in the electrostatic precipitators, flue gas washing waters, clinker) no significant variations in metals and organic chlorinated pollutants are observed.

1.3 Integrated systems for energy recovery fron MSW

Aiming to maximize energy recovery in many favorable situations it is possible to design plants that stand on an integrated concept with respect to many technologies. In this type of integrated plants is included the installation which is under construction in the town of Verona.

The plant has a capacity of 500 t/y and it is the integration of the following processes:
- selection of refuses over 3 lines each capable of 200 t/d refuse inlet flow rate;
- anaerobic digestion of organic fraction with 30.000 Ncm/d biogas production devoted to feed Otto cycle co-generation engine;
- processing line for the production of RDF fluff type;
- drying, pelletization and summer-stocking of RDF fluff;
- fluid bed burning system and recovery of thermal energy to be employed in a Rankine co-generation cycle for production of electric energy (15 MWe) and heat (20 millions of kCal/h). A simplifyed scheme of the plant is given in fig. 2.

1.4 Regulatory trend

In Italy refuse disposal is ruled by a low, the DPR 915/82. Afterwards another low (July 1984), has stated the trends to be followed, the general criteria and the technical rules to be respected for the disposal of refuses. Moreover this low estabilished the criteria for licensing plants and procedures for the disposal of dangerous refuses.

As a consequence of these lows, among other, it was necessary to update old disposal plants and refuse handling equipment by means of intervention often important and expensive.

With reguard to burning of wastes, the low introduces the obligation to install a secondary combustion chamber, and it fixes some operating parameters :
- minimal free oxigen in the wet flue gas = 6% vol. ;
- minimum gas speed = 10 m/s ;
- minimum residence time = 2 s ;
- minimum gas temperature = 950°C or 1200°C if incoming organic chlorine fraction lower or higher than 2% .

Italian regulatory corp of lows has to be enriched by new specifications and standards which have to introduce the new European Community directives regarding prevention of air pollution due to new plants.

Conclusions

Refuse combustion associated with energy recovery is considered, nowadays in Italy, an important form of valorization valid to encourage saving high grade primary fuels and reducing immission of pollutants in the atmosphere .

Recovery technologies has now reached sufficient maturity and reasonable avaibility.

The development of certain types of plants is conditioned by the evolution of the regulatory standards and by the economic benefits which are estabilished to encourage the thermodestruction of wastes.

It is not possible to give a set of criteria capable to guide to the choice of the best plant or the best technology: in effect the solution to waste disposal problem is so strongly dependent from the local conditions that it may be achieved only following an accurate study and analysis of the local territorial situation.

. References

1)N. Brunetti. Applicazione dei sistemi avanzati per il trattamento termico dei rifiuti nel contesto nazionale. Atti del convegno "Dai rifiuti combustibili alternativi", Firenze, 6-7 Aprile 1990.
2)N. Brunetti, C. De Cecco. Tendenze e nuovi sviluppi nella termodistruzione. E [illegible]tec '91, Forlì 25-28 Settembre 1991.
3)CNR (1980). Indagine sui Rifiuti Solidi Urbani in Italia. Progetto finalizzato energetica.
4)Ministero dell'Ambiente (1989). Relazione sullo stato dell'ambiente.
5)L. De Simone, R. Scialdoni, M.Zagaroli. Indagine sull'incenerimento di Rifiuti Solidi Urbani. Risparmio Energetico n.15 gennaio-marzo 87
6)Walpat J.J. Markets for RDF. Atti del Convegno "Valorisation des déchets". JSW-GPGD-AGHTM 22-24 Aprile 1986. Parigi.
7)P.N.Muscetta,L.Sabbato. Atti del Convegno "Recupero di risorse dai rifiuti". Imola 15-18 Maggio 1990.
8)C.G.Dent, A.A.Krol. Solid Waste Conversion to Energy. Biomass 22 (1990) 307-327
9)P.Comolli. Valutazioni economiche di costruzione ed esercizio degli impianti di termodistruzione dei RSU. RS-Rifiuti Solidi,vol.V,n.1,gennaio-febbraio 1991.
10)F.Cenerini. Recupero di energia dall'incenerimento dei rifiuti: stato dell'arte e tendenze. RS-Rifiuti solidi,vol.IV,n.5,settembre-ottobre 1990.
11)U.Ghezzi. Termodistruzione dei rifiuti e produzione di energia: piattaforme combinate. RS-Rifiuti Solidi,vol.V,n.2,marzo-aprile 1991.

Table 5

Main MSW incineration with energy recovery for electric and/or steam production in Italy.

Plants/locality	Potentiality t/d	Nominal power at alternator
AMNU Bergamo	150	
AMSA Milano	600	11,4 MWe
ACCAM Busto	180	
Schio	70	0,3 MWe
AMNIU Bologna	600	
Azienda Comasca S.M.	110	
AMIU Forlì	200	
AMIU Genova	600	3.0 MWe
AMSA Milano	480	7,5 MWe
AMIU Modena	290	
AMNIUP Padova	150	1,5 MWe
AMNU Parma	300	
AMNIU Potenza	50	
Serviz. città R.Emili	180	
AMNU Roma	80	
AMNIU Taranto	200	
Consorzio Desio	240	
Consorzio Rimini	200	2,76 MWe

Table 6

Analysis of heavy metals and organic micro-pollutants in the flue gas stack.

Pollutant	Without RDF	With RDF
Cr mg/Nmc	0,206	0,134
Pb "	0,424	0,509
Ni "	0,132	0,176
Cd "	0,008	0,026
V "	0,286	0,096
Hg "	0,087	0,034
Zn "	0,145	0,106
TCDD-TCDF µg/Nmc	0,05	0,05
PCDD-PCDF "	0,01	0,01
PCB "	0,1	0,1

FIG. 1 – Process Schemes for Different Systems of MSW Treatments

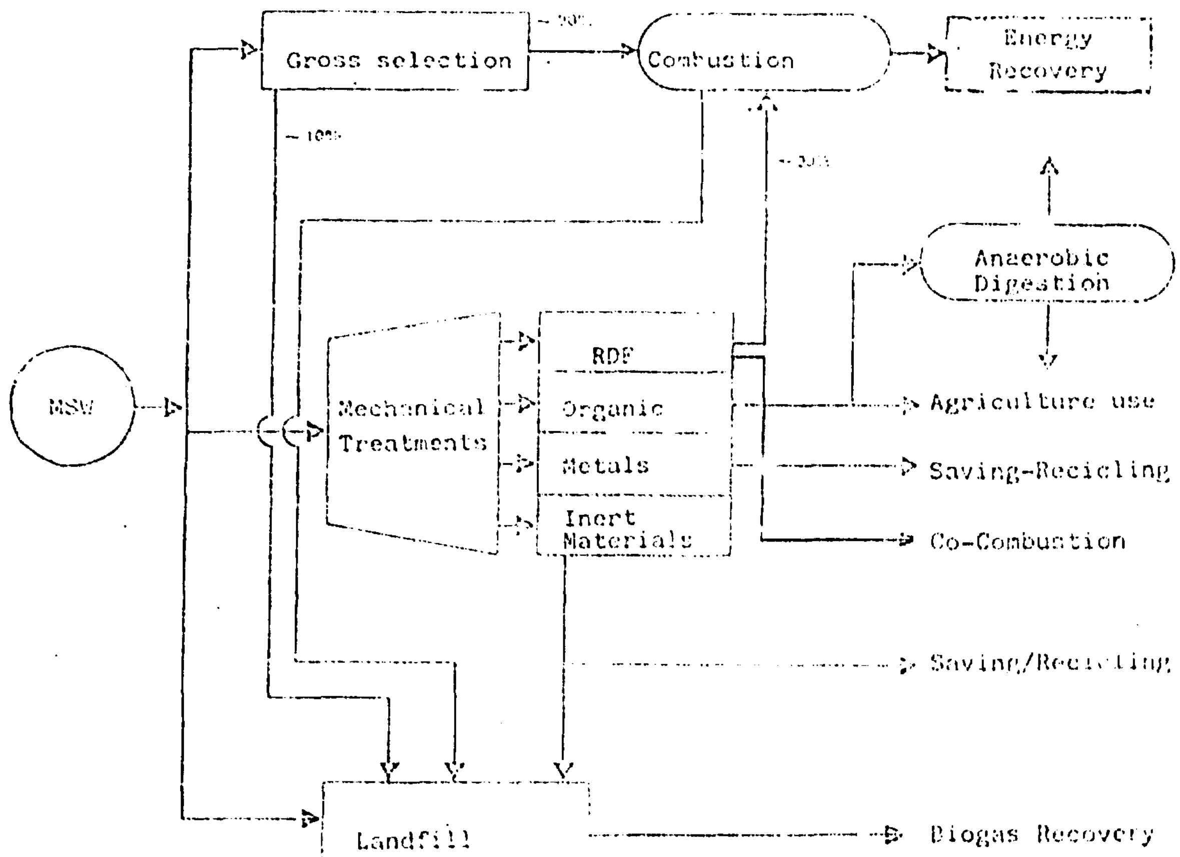
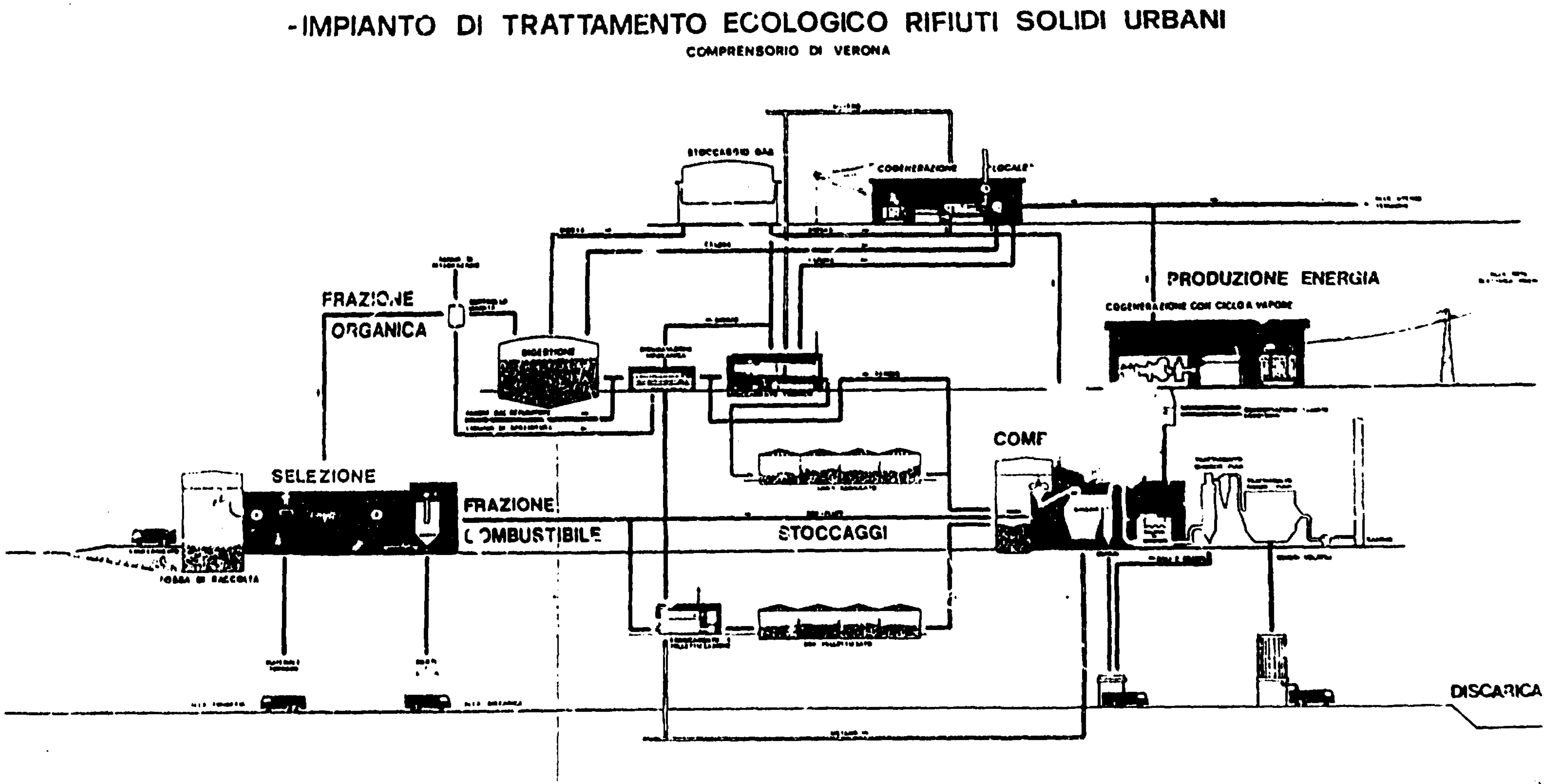
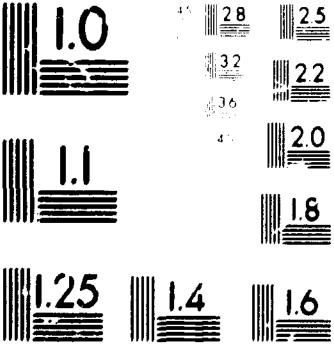


Fig.2 - Integrated Plant for MSW treatment in Verona city.





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