Barriers to Implementation of Waste-to-Energy (WTE) Technologies in Brazil

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There are many reasons why energy recovery technologies are not considered as a final treatment or disposal for Municipal Solid Waste (MSW) in Brazilian cities. Most important barriers can be listed as political, economic and technological. Such problems began in past, when, in order to solve first the critical situation of water supply and wastewater collection, solid waste management was neglected by federal and states policies, thus slowing sector development. Lack of funds, absence of consistent national policy and legislation as well as of detailed data collection and assessment are some of the difficulties facing implementation of modern waste treatment technologies' including waste-to-energy solutions. Analysis and discussion of such barriers may be useful towards planning the future insertion of this kind of technologies in Brazil, particularly considering the new, and maybe favorable, energy sector's perspectives in the country.

1. SANITATION SECTOR IN BRAZIL

1.1. Brief overview

In the colonial period sanitary situation was very critical in Brazil. From the end of 19th century up to third decade in 20th century, sanitation was delegated to private entrepreneurs. Government intervention in sanitation sector started in 1934, by enactment of the "Water Code", still in power.

From the fifties until the end of the eighties, relevant facts were:

- The 1960 census showed that water supply benefited less than 50% of population and wastewater collection, less than 30%. There was no wastewater treatment. Solid waste management was not surveyed.
- In middle of 60s, military government developed the first plan for sanitation establishing goals, mainly for water and wastewater. Relevant measures included a National Fund and a National Council for Sanitation. The Fund, directed exclusively to water and wastewater was partially successful. The Council, whose responsibilities included solid wastes, never worked.

- In early 70s, Federal Government through National Sanitation Plan, perhaps looking at economies of scale and scope, encouraged the States to establish Sanitation Public Utility Companies to benefit from Fund resources, restricted however towards water and wastewater. Cities, which legally still retained responsibility over sanitation were forced to either contract state utilities to execute its sanitation services or be denied access to resources.
- During the eighties, public services and goods tariffs and prices, although inflation was very high, were not adequately corrected for, supposedly in order not to feed back the inflationary process. As a consequence, public utilities were de-capitalized and stripped of re-investment resources.
- In 1985, when Brazil asked for a loan for the national sanitation improvement program, the World Bank demanded inclusion of solid wastes in the program.
- In 1991, for the first time, solid waste situation was included in the national demographic census.
- In 1992, after a period of crisis and failures, the National Plan of Sanitation was officially declared extinct and replaced by the Urban Nuclei Sanitation Program which is expected to improve the indicators of all sanitation sub sectors, specially solid wastes management.

Currently, federal government is proposing a National Sanitation Policy to promote sector reform, encompassing water, wastewater, solid waste and drainage services, following World Bank guidelines: regulatory framework with independent agencies, opening to private capital, commercial orientation, and technology modernization strongly relying on imports.

1.2. Funding for Solid Wastes Management

Investments in sanitary programs systematically have decreased since 1968. Resources allocated by National Budget for "general sanitation" sub-program, which includes solid waste management, were spent without control and subjected to political manipulations.

Possible funding sources for solid waste management investments are: municipal budgets, foreign loans; fiscal incentives, fees, tariff revenues, bonds and debentures.

Financial restrictions plaguing public cleansing services are generally caused by inadequate budgets and tariff structures, leading to non-equilibrated cash flows, insufficient revenues and absence of credit lines.

1.3. Legal Context and Institutional Framework

Solid waste management is, by Brazilian Constitution, municipal attribution. The most common organization forms are either a municipal "Public Cleansing Department", funded by public budget, or a public utility company living essentially on rate-based revenues**.**

In both cases severe deficiencies can be found, resulting in high costs and low quality services. Such deficiencies derive from discontinuity of administration plans and programs; inadequate definition of roles and responsibilities, diverting of operational resources and staff toward works not related to public cleansing, such as cemetery management, for example.

As opposed to water and wastewater services, in MSW private initiative has been welcome. In some cities, up to 100% of services are run by private enterprises. Nevertheless, extremely unskilled operational and even technical staff is a typical characteristic of solid wastes service companies. Furthermore, poor maintenance of vehicles, obsolete technologies, equipment and installations plague majority of service companies and cities.

Sanitation lacks specific policy and regulatory instruments to drive government actions. Superposition and conflicts among the various levels of existent legislation are common. Part of confusion is caused by unclear boundaries for legal responsibility, according to the kind of waste. Hazardous wastes, for example, must be collected, treated and disposed of by the producer, but that rarely occurs.

Environmental laws, when existing, are not always clear or coherent, and enforcement is very hard to ensure due to lack of institutional, human and material resources.

Sale of MSW plants' energy would be subject to the new regulatory framework, currently under development for Brazilian energy sector, which allows for such business, requiring however additional managerial capability.

1.4. Indicators

The National Survey on Sanitation, performed in 1991, provided the following data about solid waste collection and destination in Brazil (tables 1, 2):

Table 1

Waste Destination in Brazil (% of benefited households)

Area	Collected	Burned	Buried	Dumped	Other
Urban	80.04	7.68	0.83	10.73	4.67
Rural	5.56	27.03	4.56	39.09	23.75
Total	63.74	11.92	1.64	16.93	5.76

Source: Instituto Brasileiro de Geografia e Estatística, Censo Demográfico de 1991 apud Série Modernização do Setor de Saneamento, 1995

Table 2

Final Disposal of Collected MSW in Brazil (%)

Destination	Open Pit Dumping	Controlled Landfill	Sanitary Landfill	Composting Plants	Incineration
%	76	13	10	0.9	0.1

Source: Instituto Brasileiro de Geografia e Estatística, Censo Demográfico de 1991 apud Manual de Gerenciamento Integrado de Lixo, 1995

2. SOLID WASTES' ENERGY RECOVERY POTENTIAL

2.1. MSW Characteristics

Compilation of dispersed data on municipal solid waste, available for few Brazilian cities, is presented in tables 3 to 6. Data collecting methodologies vary strongly, from sampling to engineering calculations. Data amplitude and reliability are poor, thus establishment of Brazil-wide averages may not be accurate.

Table 3

Composition of Belo Horizonte (1), São Paulo (2) and Brazilian (3) Solid Wastes (%)

	Glass	Metal	Plastic	Paper	Organic	Others
B.Horizonte	2.50	2.50	12.00	12.00	65.00	6.00
São Paulo	1.1	3.24	12.08	14.43	-	69.15
Brazil	3.0	4.0	3.0	25.0	-	65.0

Source: (2) CETESB, 1998; (1) Mercedes, 1997; (3) IPT, 1995

Table 4
S. Paulo ABCD Metropolitan Area (1) and S. Paulo City (2) Solid Waste Physical-Chemical Parameters

	Per capita (kg/pc/d)	pH	h (%)	Vol. Solids (%)	Ashes (%)	Spec. Mass (kg/m^3)	H Heating Value (kcal/kg)
1	0.61	6.6	61.6	66.03	33.97	≅200.00	2965
2	-	-	-	-	-	-	4000

Source: (1) Lima, 1995; (2) CETESB, 1978

Table 5
São Paulo ABCD Metropolitan Region (1), B.Horizonte (2) MSW Chemical Parameters (%)

	C	N	K	P	Na	Ca	S	H	O
1	35.16	1.56	0.87	0.25	-	-	0.17	3.17	45.09
2	23.00	1.00	-	-	-	0.5	-	-	-

Source: (1) Lima, 1995; (2) Mercedes, 1997.

Table 6
Belo Horizonte MSW Chemical Parameters (ppm)

Zn	Cu	Pb	Cd	Hg	Ni	Md	Cr
65.0	13.0	21.0	0.1	0.3	9.0	-	12.0

Source: Mercedes, 1997

2.2. Estimated Potential for Energy Recovery

Some commercial designs and research assessments for energy recovery from MSW were developed for São Paulo region. From these works, following data were obtained:

- biogas generation from anaerobic digestion of a mixture of MSW and sewage sludge (55% of organic matter) : 665 m^3 (60% CH_4) / t MSW (Quaresma, 1992);
- electricity production potential for WTE plants ranges from 300 to 400 kWh/ton of Brazilian MSW with LHV varying from 1600 to 1900 kcal/kg (Farghaly, 1997);
- Brazilian net CH_4 emissions from MSW disposal and treatment – around 650 Gg CH_4 / year (Alves and Manso, 1998).
- Brazilian biogas fuel value ranging, approximately, from 6kWh/m^3 (crude biogas) to 9.5 kWh/m^3 (clean biogas) (Mines and Energy Ministry, 1981).

Brazil's methane generation of around 650 Gg (fuel value of 9.5 kWh/m^3, specific volume of 1.475 m^3/kg (60 F, 1 atm), could, in theory, substitute for up to 780 thousand of TOEs (1 GWh ≅ 86 toe). Considering a conversion efficiency of 25 to 50% it could allow for generation of 2.3 to 4.6 TWh of electric power per year, equivalent to 1 to 2% of national consumption.

Alternatively, considering the official numbers for total MSW generation in Brazil (50.000 to 90.000 tons. per day (Alves, 1998, IPT, 1995)) and the energy recovery average of 350 kWh/ton, if the whole generated MSW were incinerated in WTE plants, the correspondent amount of recovered energy could vary from 6.4 to 11.5 TWh per year (corresponding to 2.6% to 4.6% of total national electricity consumption.). Beyond substituting for other energy sources, this strategy would avoid methane emission to atmosphere. Of course, these are theoretical figures which do not consider specific economic feasibility assessment nor full-fledged institutional, political and technological barriers.

3. BARRIERS DISCUSSION

Following Reddy's (1991) systematization concerning energy efficiency, MSW to energy barriers may be grouped in categories:

1. Citizens

Citizens can react in negative way to waste-to-energy technology for many reasons: ignorance, indifference, and uncertainty, among others. However, the major problem normally confronted in Brazilian cities about solid waste disposal or treatment concerns to the recognized "not in my backyard" syndrome.

People consider that any kind of waste plant installed in neighborhood depreciates the whole region, attracting poverty, dirtiness and intense trucks' traffic. In truth, the common belief is that waste must be maintained as far from anyone's eyes as possible. Incineration, beyond facing dioxin and furan emission problem is aggravated by visual pollution of gases causing uncertainty, fear and sometimes panic.

Ignorance is a permanent obstacle to MSW technologies implementation whereas indifference which normally ends as soon as a plant is being located in the neighborhood.

Citizen opposition is also enhanced by increasing municipal taxes to pay for new technology. In general, citizens are not willing to pay more taxes or fees, even when it means improving life quality.

2. Technology Providers

Whenever possible, technology providers prefer to supply low tech at the highest prices rather than high tech. It has been a common practice in Brazilian MSW management, mainly because of authorities negligence, to acquire obsolete technologies. Currently waste-to-energy technology is well developed and complies with environmental restrictions. Higher direct investment costs still are accepted as arguments against WTE systems.

3. Competition from Recycling and Composting Industry

Recycling industry improvement can be considered as recent in Brazil. Programs of sorting recyclable materials from waste are still difficult to implement in face of citizens' resistance. The major part of work is done by scavengers, exploited by an established "industry structure" allows for considerable profits to a little group of people.

In the entire recycling chain, the implementation of WTE plants is treated as direct threat. In addition, some sector researchers voice the opinion that incineration menaces the social role of recycling, while eliminating scavengers work opportunities.

Although composting could not be considered as an industry, cultural resistance let people to believe that WTE is worst than composting.

4. Government

As in Reddy's view regarding energy efficiency, new MSW technologies are destined to fail because government's disinterest, lack of technical and managerial skills, of adequate training facilities and of access to hardware and software, as well as to sales-promoting regulatory behavior, the cost-blind price-fixing behavior, the fragmented decision making and the large-is-lucrative sponsoring.

Lack of clear policy, legislation and information, constitute also major barriers.

5. Costs / Funding

WTE in Brazil is still more expensive than any other solution. Few cities could pay for WTE plants or would choose to install and maintain biogas plants, when it is cheaper and well accepted by public opinion and environmental legislation to plainly dump wastes in landfills.

The international pressure on greenhouse gases emissions, among them MSW methane, mitigation doesn't seem to make substantial difference in the near future, in face of other problems and priorities. Costs amounting to US$ 400.000.000,00 – for two São Paulo WTE plants – and managing and operating biodigesters or landfill gas plants, which includes selling of electricity, just seem way-off Brazilian cities priorities and capabilities. Funding is too difficult to obtain and when resources become available, there are too many other urgent needs to be taken care of.

In conclusion, MSW management in Brazil requires extensive changes before being able to benefit from WTE technologies, starting by collecting, assessing and spreading of reliable data and information. Institutional and legal reforms, R&D, training and public education programs, financing and funding mechanisms, modernization of technical, managerial and operational structures are also in order.

4. REFERENCES

1. Brazil. Ministério do Planejamento e Orçamento, Diagnóstico do Setor de Saneamento: Estudo Econômico e Financeiro (1995).
2. Instituto de Pesquisas Tecnológicas. Manual de Gerenciamento Integrado de Lixo (1995).
3. Mercedes, S.S.P., Perfil de Geração de Resíduos Sólidos para o Município de Belo Horizonte no Ano de 1995, Foz do Iguaçu (1997).
4. Lima, A.X., Estudo de Viabilidade Técnico-Ecnonômica de Uma Usina de Incineração de Resíduos Sólidos Urbanos no ABCD, São Paulo (1994).
5. CETESB, Determinação do Poder Calorífico Inferior dos Resíduos Sólidos Urbanos do Município de São Paulo (1978).
6. Quaresma, M.Y.V., Avaliação da Eficiência e da Qualidade dos Resíduos Gerados em Biodigestores Anaeróbios Operados com Cargas Orgânicas Crescentes e Diferentes Granulometrias de Resíduos Sólidos Domésticos, São Paulo (1992)
7. Farghaly, M., Combustão de Resíduos Sólidos Urbanos In Tecnologias de Geração de Energia Elétrica, São Paulo (1997).
8. Alves, J.W., Manso, S.M.V, Inverntário Nacional de Emissões de Metano pelo Manejo de Resíduos, São Paulo (1998).
9. Tenessee Valey Authority, The Handbook of Biogas Utilization. Atlanta, Georgia (1996).
10. Ministério das Minas e Energia, Balanço Energético Nacional, Brasília (1998).
11. Reddy, A.K.N., Barriers to Improvements in Energy Efficiency, Energy Policy (1991)