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Energy Planning: Brazilian Potential of Generation of Electric Power from Urban Solid Wastes—Under "*Waste Production Liturgy*" Point of View

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Abstract

The use of Urban Solid Waste (USW) as sources of energy has acquired rising importance in current discussions of alternative energy supplies, in particular in Brazil. This paper brings to these discussions an examination of the concept of solid wastes, including their historic origins and formation, taking their social, economic and cultural characteristics into account, including point view of *waste production liturgy*. Consequently, a spendthrift society slanted towards the decreasing marginal utility of assets must make efficient use of its USW in order to reduce excessive output. Besides that, this document presents the Brazilian potential of urban solid waste to produce electric power.

Keywords

Urban Solid Wastes, Renewable Energy, Energy Planning, Brazil

1. Introduction

From a systemic standpoint, the definition of solid wastes may be presented as the outcome of poorly balanced

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flows of certain elements in a specific ecological system, implying the instability of the system itself. However, once the orderly arrangements between the whole and the parts of an ecosystem have been taken into consideration through relations based on complementarity, with all the parts dependent on the life-cycles of the others, additional elements blur the definition of the concept of solid wastes, "as elements produced by the metabolisms of organisms or their life cycles could may be used as nutrients by other organisms, thus perpetrating the life of the system" [1].

Among all the many different ways of identifying an element distinguishing human beings from animals, Marx selects the capacity to produce their means of existence, a skill granted only to humans and the hallmark of this distinction [2]. Marx affirms:

"*by producing their means of existence*, *human beings indirectly produce their material lives*" [2].

However, the way in which human beings produce their "material lives" necessarily depends "*on the nature of the means of existence already found*, *and that they need to reproduce*" [2]. The human development process has always been closely linked to the expansion of mastery over the exploitation and use of the resources available in Nature. The imbalances imposed on the environment in the form of solid wastes are consequently the outcome of the choices made, the technological routes adopted and the speed of production and reproduction of goods.

The process of human occupancy of the land is spurred by a steadily expanding population, followed by an equally steady expansion of settled regions. Solid wastes generated as by-products of human activities soon outstrip the possibilities of dilution, regeneration and reintegration of the elements in the natural cycles of environmental change. As a result, the surrounding environment is unable to achieve satisfactory results in its attempts to absorb discarded elements into its original cycles.

During the XX century, visible alterations of a qualitative and quantitative order were imposed on urban arrangements and functions. These changes boosted the volumes of Urban Solid Wastes (USW) to a significant extent, as well as altering their composition. Prior to the XVIII and XX centuries, the world's population grew sevenfold, soaring from around one billion in the mid-XVIII century to some seven billion at the new millennium.

The problems caused by higher output of USW are not due only to population growth and concentration in major urban centers. The main culprits behind all the chaos caused by the imperative need to dispose of these solid wastes are life styles centered on the liturgy of consumption.

The development model adopted by modern society and the pace of its progress are reflected in an upsurge of the supply of goods and consequently energy consumption—which is in turn the basis of the production system. The consumption structure is shaped by life styles that define family arrangements, income levels and distribution, ownership and use of consumer goods, dissemination of heating/cooling equipment, transportation structure and housing expansion models, among other aspects.

Modern life styles have stepped up and concentrated family demands for goods through widespread use of household appliances, incentives for individual transportation, and endless appeals to squander, with new demands generated all the time, but without extending their marginal utility. Along these lines, Mészáros [3] affirms:

"*The notorious* '*planned obsolescence*' *of* '*consumer durables*' *that are mass produced*; *the replacement*, *junking or deliberate destruction of goods and services offering an intrinsically higher potential use* (*collective transportation*, *for example*), *substituted by those whose usage rate tend to be far lower or even minimal* (*such as private automobiles*) *and that absorb a considerable part of the purchasing power of society*; *the artificial imposition of a production capacity that is almost completely unusable*; *the upsurge in waste resulting from the introduction of a new technology*; *and the deliberate* '*elimination*' *of maintenance skills and services*. *All this belongs in this category*, *dominated by these imperatives and underlying determinations to heedlessly lower the practical usage rates*".

For Mészáros [3], the decreasing usage rate law is historically endowed with a civilizatory importance:

"*the movement that made two pairs of shoes available to workers instead of a single pair may certainly be rated as positive*, *regardless of the hidden agendas and motivations of the capitalist side*."

With this same approach, Marx [2], affirms:

"*Despite all* '*pious*', *discourses*, *he* [*the capitalist*] *seeks ways of encouraging* [*the workers*] *to consume*, *trying to endow his products with new charms*, *triggering new needs through non-stop advertising etc*. *It is exactly this aspect of the relationship between capital and labor that is at one time essentially civilizatory*, *and on which all historical justifications are supported*, *such as the contemporary power of capital*".

However, destructive repercussions are inherent to the decreasing use rate law—a trend driven strongly by the formation of the military-industrial complex—"*which appeared on the scene with dramatic emphasis during the XX century*, *particularly during its last four or five decades*. *As a result*, *the old socialist approach of warding off shortages by producing unimaginable abundance also requires radical re-examination*, *in the light of these same occurrences*" [3].

Within this context, it is noted that the possibilities of stepping up production, as a result of the civilizatory potential based on progress in science and technology, are distorted in terms of the adoption and consolidation of a capitalist practice whose bases are destructive and profligate. Pressured by the necessary expansion of the production segment, natural needs are thus constantly edged out by "historically created needs".

According to Mészáros [3] waste production liturgy can be defined:

"*the positive output of the dialectic interaction between production and consumption is far from being assured*, *as the capitalistic drive to expand production is not necessarily linked at all to human needs as such*, *but only to the abstract imperative of* '*capital achievement*'".

It is a known fact that consumption styles vary drastically between the more and less developed nations, with very marked differences also apparent between urban and rural consumption profiles. However, market appeals have extended these boundaries of action, spreading an ideal of rising consumption that is driven by technological progress but hobbled by economic and regional constraints.

In today's world, there are many enthusiasts urging the benefits of USW as an alternative energy source, particularly electricity and process heat. This paper discusses what society rates as solid wastes, assessing their formation and querying their role as energy sources. The concept adopted here is that producing all materials discarded as solid wastes requires amounts of energy far higher than the total energy that could be obtained from its use as a primary source by any technology designed to tap the energy contained in USW. Thus, in a society grounded on spendthrift consumption, shorter utility spans and shrinking margins, the most efficient way of making good use of USW lies in complex efforts reining in this profligate production, compatible with the concepts underpinning the concept of sustainable development[1].

This article is divided into five sections. In Section II, the theme of urban solid wastes and the waste production liturgy are presented. Section III discusses the use of USW to generate energy in Brazil considering the potential and stored. Finally, Section VI offers conclusions and recommendations.

2. Urban Solid Wastes and the Waste Production Liturgy

The human body houses the most complex energy conversion system used by humankind. Through digestion, the chemical energy found in foods is processed into heat, as well as muscle and brain energy. Outside their own bodies, human beings work with two basic forms of energy conversion: organic converters (the use of haulage animals to produce mechanical energy, fuelwood and others) and inorganic converters that use the energy stored in the environment (electrical machinery, internal combustion engines and others).

The hallmarks of energy resources and their uses are reflected in the freedom of movement they offer through extending the reach and strength of human beings. The earliest exteriorization processes expanded the use of muscle power and the heat generated in the human body [4].

For Freud [5], this exteriorization process—consisting of the development of knowledge used in the formation of transformation capacity and control of nature—proved to be a major civilizatory trend, together with the rules and actions regulating the distribution of these created values:

"*If we look back sufficiently far into the past*, *we discover that the earliest acts of civilization involved using*

[1]As used here, this term refers to the adoption of a type of development that guarantees at least the existence and quality of life of current social occupations and future societies. Consequently, it differs from concepts that deploy sustainable development as a tool underpinning the feasibility of entering a new capitalist expansion phase.

tools, learning to control fire, and building shelters. Among them, controlling fire stands out as an extraordinary and unprecedented accomplishment, as others opened up paths that human beings have been following since then. Through each tool, man recreates his own motor or sensory organs, extending the scope of his functions. Motor capacity places massive forces at his fingertips that he can deploy through his muscles: thanks to ships and aircraft, neither water nor air can hamper his movements".

For Marx [6], by exteriorizing his body, "*man turns something in Nature into an organ of his own activity, an organ added to his own body organs, extending his natural body, despite the Bible*".

During the process of building up a usage model for the resources available in nature, human beings were continually exteriorizing their bodies, replacing hard-to-handle organic converters (such as human and animal traction for transportation and generation mechanical energy, natural biomass for cooking and heating, etc.), by inorganic converters that reflect the creative spirit, backed by scientific and technical progress and opening up sources that were formerly unthinkable.

Consolidating the capitalistic production mode, the Industrial Revolution was a watershed in production relations, particularly through energy systems that were structured in earlier times and had to underpin the entire goods production and re-production framework. Ending the unchallenged supremacy of biological energy sources, the Industrial Revolution paved the way for the triumphant march of hegemonic fossil fuels.

"*The steam engine rearranged the relations between man and energy. The clock, the windmill and the watermill used forces within a context that left them intact; in contrast, the 'combustion engine' consumes the materials from which it draws energy. he new lines will require heavier investments, as well as the use of increasingly vast scientific and technical knowledge. Energy will become an independent and autonomous sector that will play a decisive role in economic regulation*" [7].

The driving force behind the Industrial Revolution is credited to the development of machinery that ratcheted up production scales to well beyond the capacities of individual workers and their tools. This approach to production was guided by increasing output and shorter production times, turning valueless resources into profitable products.

Within this context, the use of coal become more important worldwide, while energy production forged steadily ahead in response to rising demands spurred by the industrialization process.

"*For XXI century capitalism, energy production acquired an unprecedented elasticity through the widespread use of non-renewable fossil fuels and the progress of transportation: from this time onwards, energy supplies tended to stay a step ahead of demands. In fact, huge energy grids share the common characteristic of structuring a new energy market, based on technical systems that include important motor activities and consequently generate new energy needs. Thus, the primacy of production over demand was consolidated, characteristic of the capitalistic energy system*" [7].

Since the XIX century, the importance of re-using consumer goods has been discussed in society. It is known that certain goods (or parts of them) can be used in other products or to make new items. The economic system in effect at that time viewed the trend towards generating waste as no more than a "deviation" of "spirit of capitalism", in relation to idealized "sensible economic principles". Thus, rising production was viewed favorably, as some advantages could be assigned to the presence of machines and capitalistic manufacturing practices. Outstanding among them is the conversion of apparently common and valueless substances into profitable products, in parallel to savings in human time through manufacturing these goods.

The importance of time savings is assessed from a positivist viewpoint, and when analyzed from the viewpoint of capital, where a minimum time is a basic target to be attained, it becomes clear that human beings have become subordinate to this. "*The same trend is revealed as a force that degrades the human being, turning him into a 'time drudge' (Marx), while appearing as a measured objective from the standpoint of capital: the ideal solution for all possible lawful disputes between capital and labor*" [3].

The rising participation of machines in the means of production requires constant updating, in order to keep them as modern as possible. The outcome of this quest for the "new" is that they become obsolete, often before the end of their useful lives. The general trend is that large-scale production spurred by competition turns out goods that are less durable, meaning it may well cheaper to purchase a new item instead of re-using it.

Goods become viewed as old when the natural wear and tear caused by time occurs. Moreover, with no reduction in their usefulness, articles become considered as "obsolete" when improvements occur in their production processes, or because they no longer comply with current consumption standards. These discarded articles then become accessible to segments of society that lacks the purchasing power to acquire them new. In general, this generates a steady stream of fresh demands without extending the marginal utility of the goods.

It is important to note that this increase in productivity is not viewed askance, and is good and desirable, according to certain standards. However, gains in productivity trigger alterations in consumption standards in a throwaway society, making it hard to pinpoint the perfect balance point between production and consumption. Although society should ideally take steps to ensure that most of its resources are channeled to the production of re-usable goods, its resources are frittered away, under pressure from dropping usage rates.

> "*The dropping usage rate assumes a dominant position in the capitalist structure of the socio-economic metabolism, notwithstanding the fact that astronomical quantities of wastes must be now produced in order to impose some of their most disconcerting manifestations on society*" [3].

As human beings have countless needs, there are no limits on what will satisfy them, building up consumer markets that extend well beyond basic requirements. Reflection is required on the nature of these needs, as what was once a "luxury" (everything other than basic needs) is soon not rated even as a basic requirement today. As already shown, producing and scrapping goods create new demands in society, although without creating the corresponding uses. Thus, "*it does not matter how absurdly wasteful the production process may be, provided that its outcome can be imposed profitably on the market*" [3].

The generation of waste is consequently the outcome of a society with high consumption standards and dropping utilization rates, encouraging the ongoing production of goods that are (quasi) discardable. These lavish leftovers then become a burdensome nuisance for this same society (**Figure 1**).

One of the negative outcomes inherent to the development process based on the production of goods with a dropping utility rate is what society calls garbage. Within this context, the production of solid wastes necessarily arises from rising outputs of "luxury" goods. Consequently, solid wastes are the outcomes of basic human needs, compatible with the capacity of the planet to re-absorb them within an evenly-balanced population growth model. On the one hand, proper garbage recycling, treatment or disposal is a responsibility that cannot be ignored by

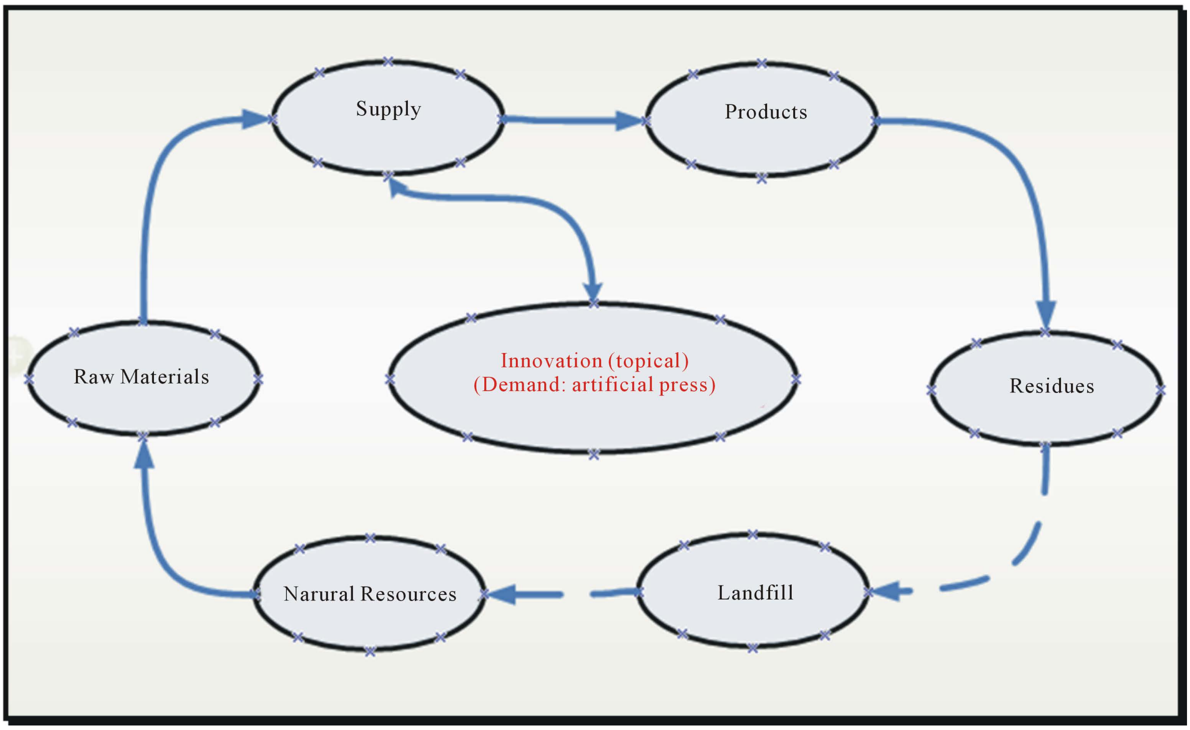

Figure 1. Schematic diagram of cycle process of the solid wastes in society. Source: own elaboration based on [3].

society, while on the other, it must find alternative ways of managing these solid wastes. This necessarily requires exploring ways of generating less USW.

According to its supporters, the use of USW to generate energy should be part of a drive to develop clean and abundant sources. For Illich [8] "*the promotion of clean techniques is almost the promotion of a luxury way of producing goods that meet basic necessities*" [8] in a throwaway society. Along these lines, a contradiction is noted in tagging USW as a clean source of energy, as the incentive for greater participation by this source may trigger efforts to step up USW production (or justify the *status quo* of production and consumption standards), which in turn exceeds the energy recovered by the generation plants.

The increase in USW volumes is intrinsically linked to wider social gaps, as affirmed by Illich [8] "*Believing in the possibility of high levels of clean energy as a solution to all evils is an error of judgment. This means imagining that equal shares in power and energy consumption can grow together*."

For Figueiredo [1] there are many doubts about the subliminal outcomes of adopting the concept of making direct use of USW as a clean source of energy:

> "*Along these lines, in addition to concerns over rising energy consumption in societies and the widespread effects on the natural environment, this concept prompts an additional concern, represented by the dependence of energy generation on consumption. This might offer an incentive for consumption, particularly energy-intensive fuel products, as solid wastes generated by consumption would contribute to energy generation. This absurd logic would be catastrophic from the environmental standpoint, through encouraging the extraction of natural elements*".

3. Using USW to Generate Energy: Brazil as a Case Study

3.1. Urban Solid Wastes in Brazil

Understanding the Brazilian solid waste generation structure is a basic requirement for adopting Government actions designed to shape the development of this approach and/or in other related areas, such as public health campaigns or job and income generations programs, energy use and the mitigation of poverty. This understanding requires an analysis of Brazil's urbanization process.

Similar to the processes noted in many poorer countries, urbanization in Brazil took place within a context of cities that were completely unprepared for this step, lacking the core service structures needed to provide transportation, healthcare, education, basic sanitation. To an even more marked extent, they also lacked infrastructures able to respond to the heavier demands imposed by rising volumes of USW.

A particularly noteworthy characteristic of the development of the distribution of the Brazilian population (shown in **Figure 2**) is a massive rural exodus that flooded into urban centers. In 1940, Brazil was still predominantly rural, with 68.8% of its entire population living in the countryside. In just four decades, its urban population rose from 31.2% in 1940 to 55.9% in 1970, topping 84% by the and first decade of the XXI century.

Brazil has continental dimensions, possessing an area of 8.5 mil-lion km^2, and a population of 191 million people. Per capita income is US$ 10,414 (Purchasing Power Parity—PPP 2010), the country is governed democratically and has friendly relations with its neigh-bors. There is not perspective of ethnic or religious conflict. It is the most industrialized and diverse country in Latin America with a GDP of 2.017 trillion (PPC). According to The Economist [10], the Brazilian economy is expected to expand from the ninth to the fifth largest in the world by 2025. Brazil also possesses major potential in terms of natural resources and the expansion of an agro-industry geared towards the external market as well as the potential of its renewable energy resource2 (solar, wind, biomass and hydraulic) and pre-salt fossil resources (destined primarily for export) [11].

Disorderly urban expansion made regional and social inequalities even worse, driven by the development process imposed by Brazil's political and economic system at the time. "*The lack of* '*social reforms*' *and the*

Year	1940	1950	1960	1970	1980	1985	1990	2000	2010
Total	41.2	51.9	70.2	93.1	121.3	135.5	150.3	179.5	190.7
Urban	12.9	18.8	31.3	52.1	82	97.6	112.7	134.1	160.9
Rural	28.3	33.1	38.9	41	39.3	37.9	37.6	36.4	29.8

Figure 2. Brazilian population (millions). Source: IBGE [9] and Figueiredo [1].

inability of the Brazilian bourgeoisie to introduce social standards that are compatible with level of economic diversification and growth has given rise to a deeply unequal society" [12]. Thus, the distribution of national wealth is concentrated in the South and Southeast, to the detriment of the States in the North and Northeast. This is mainly why the composition of solid wastes differs among regions, as well as States.

This shows that the South and Southwest are home to most of the Brazilian population, living mainly in urban areas, while also accounting for much of the formation of the nation's wealth. These influences are particularly significant when analyzing the composition of Brazil's USW, as this is intrinsically linked to income and location.

Sectors with higher purchasing power use products that are more industrialized with higher added values. In contrast, the less privileged classes use simpler products with higher organic content. With more packaging and less organic matter, the solid wastes discarded in wealthier areas have higher energy content than the USW produced in poorer areas. It is important to stress that, even in regions with better economic development, such as the South and Southeast, the USW composition differs among areas with varying purchasing power.

Keenly aware of all this diversity, the Technological Research Institute [13] drew up a conservative estimate showing that the average composition of Brazil's USW consists of 65% food wastes, 25% paper, 5% plastic, 2% glass and 3% metals.

The amounts of garbage generated every day in each municipality require careful observation. Only major cities producing vast amounts of garbage have this measurement equipment. According to data issued by the Brazilian Institute for Geography and Statistics (IBGE) in its National Basic Sanitation Survey [14], only 8.4% of Brazilian municipalities actually weigh collected garbage in scales, accounting for 64.7% of the garbage generated in Brazil. The remainder (35.3%) is based on an estimate drawn up by this Institute and based on the number of inhabitants in each municipality.

3.2. Energy Generation Potential

The USW volumes that might be recycled or reused for energy purposes are veiled by uncertainties, due to the difficulties of effectively measuring or even estimating these solid wastes. However, for the purpose of this exercise, the official data issued by the Brazilian Institute for Geography and Statistics [14] will be used, at around 160,000 tons/day. Additionally, selecting various ways of obtaining energy results in different possible values [15].

Among the technologies currently available, incineration is particularly noteworthy. This consists of using the calorie power stored in combustible materials found in garbage by burning it to generate steam. This naturally depends heavily on the calorie power of the USW being processed, with the use of solid wastes with higher calorie power being recommended, such as plastics, papers, etc.

The incinerator design technology currently available allows planned power generation of up to 0.7 MWh/t, [16]. Data issued by the EPA [17] show that incineration may produce up to 0.55 MWh/tons of solid waste.

For Brazil, looking at the amount of solid wastes mentioned above and taking an efficiency rate of 0.7 MWh/t, the amount of energy generated might well reach 45.44 TWh/year, as shown in **Figure 3**.

Produced through anaerobic decomposition of garbage in landfills, biogas offers another alternative way of using the energy stored in USW, possibly through open cycle plants. Once separated from the CO_2, it can be used in gas turbines, performing less well than combined cycle plants, but efficient enough for energy conversion purposes. The **Figure 4** summarizes the energy generation potential of this technical route in Brazil.

These findings indicate ample potential for generating electricity from solid wastes through anaerobic diges-

Item		Unit	Reference
(a) Urban Solid Waste	59.07	M t/ano	(IBGE 2000)
(b) Factor of Energy Produced	550.0	k Wh/t RSU	(EPA 2002)
(c) Factor of Energy Produced	769.2	k Wh/t RSU	(TOLMASQUIM 2003)
Potential Energy Estimated (a) × (b)	**32.49**	**T Wh/ano**	
Potential Energy Estimated (a) × (c)	**45.44**	**T Wh/ano**	

Figure 3. Recovery energy potential by incineration. Source: Henriques [15].

Item		Unit	Reference
(a) Urban Solid Waste	59.07	G kg/year	(IBGE 2000)
(b) Factor of Methane Produced (tCH4/tRSU)	6.5	%	(IPCC 1996)
(c) Density	1.40	m^3/kg	(PERRY 1999)
(d) Conversion Factor	10.76	k Wh/m^3	(MME 2003)
(e) Capacity Factor of Power Station	95	%	(MUYLAERT 2000)
(f) Efficient of Power Station (Open Cycle)	35	%	(GASNET 2004)
(g) Efficient of Power Station (Combined Cycle)	45	%	(GASNET 2004)
Potential Energy Estimated Open Cycle (a) × (b) × (c) × (d) × (e) × (f)	**19.18**	**T Wh/ano**	
Potential Energy Estimated Combined Cycle (a) × (b) × (c) × (d) × (e) × (g)	**24.67**	**T Wh/ano**	

Figure 4. Energy recovery potential with landfill gas. Source: Henriques [15].

tion, from 19.18 TWh/year from Garbage Gas at its lowest open cycle yield to incineration at 45.44 TWh/year. This clearly shows the significant energy generation potential of these technologies on the Brazilian energy scenario.

3.3. Energy Stored in Solid Wastes

The energy required to produce a ton of plastic in Brazil hovers around 6.74 MWh/t; 4.98 MWh/t for a ton of paper; 4.83 MWh/t for a ton of glass and 6.84 MWh/t for a ton of metal [18]. Taking into account the gravimetric composition of garbage in Brazil as described above [16], each ton of garbage produced contains 250 kg of paper, 50 kg of plastic, 20 kg of glass and 30 kg of metals, as well as 650 kg of organic matter. The energy required to produce the paper, plastic, glass and metal contained in a ton of garbage dumped in Brazil is presented in **Figure 5**.

With the energy content required to produce a ton of garbage totaling 1.9 MWh, a demand of 110 TWh may be estimated for the total amount of USW dumped each year in Brazil.

As a ton of garbage generates 0.55 MWh [14] and 0.7 MWh [16] through incineration technology, the energy generation potential of the amounts of garbage (59.07 Mt) produced in Brazil each year reaches 32.49 TWh/year for the former possibility and 45.44 TWh/year for the latter. Garbage Gas technology also has the potential to generate energy from USW in Brazil, reaching 19.18 TWh/year (Open Cycle) and 24.67 TWh/year (Combined Cycle).

4. Conclusions

The development of technologies generating energy from USW, specifically through heat conversion and/or gas production, is receiving steadily increasing amounts of attention. However, an entire cluster of concerns surrounds this discussion, related mainly to the sustainability of the planet.

Among the issues under discussion, this paper focuses on criticisms of what is known as the throwaway society, stressing that generating energy from USW can and should be planned in order to avoid dumping high-energy solid wastes in landfills. It also presents the concern that this practice may nourish and encourage a type of production based on meeting “artificial needs” and resulting in social and environmental degradation.

The development model adopted by modern society and the pace of its progress are reflected in an upsurge of the supply of goods and consequently energy consumption—which is in turn the basis of the production system. The consumption structure is shaped by life styles that define family arrangements, income levels and distribution, ownership and use of consumer goods, dissemination of heating/cooling equipment, transportation structure and housing expansion models, among other aspects. It is important to advertise that this development model is not enough so as to reduce the inequality of income around the word, in other words this model to reinforce the liturgy waste production liturgy.

This case study indicates that generating electricity from USW would avoid 41% of the energy expenditures needed to produce this volume of garbage, taking the highest possible USW energy recovery value (using incineration technology at the rates presented by the EPA).

Garbage	Energy Requeride to Produce MWh/t	Participation of Waste per ton Mwh
Metal	6.84	205.2
Vidro	4.83	96.6
Papel	4.98	1245
Plástico	6.74	337

Figure 5. Energy required and participation of waste per ton. Source: Author's calculation sbased on Calderoni [18].

It is important to stress that the energy required to produce the organic fraction of the USW was not considered. Moreover, the calculations for the share held by metal in energy expenditures took the steel value as a reference (6.84 MWh/t). This results in a conservative analysis, as aluminum holds a significant share in the metal fraction and its production is far more energy-intensive (17.6 MWh/t).

According to the 2013 National Energy Balance, the electricity generated in Brazil reached 552 TWh, 3.9% more than in 2012. The Brazil presents an electricity matrix predominantly renewable, and the domestic hydraulic generation accounts for 70.1% of the supply. Adding imports, which are also mainly from renewable sources, it can be stated that 85% of electricity in Brazil comes from renewable sources [19].

When assessing the use of USW as an energy source, it was assumed that all solid wastes contain more potential energy than the energy that could be converted through the conversion technologies that are currently available. This means that energy conversion based on USW falls below the energy required to produce the goods, with this gap widening significantly if including the energy required to ship the finished products.

This paper is not intended to challenge energy generation through USW, but rather attempts to highlight the fact that—in a society structured on the appeal of spendthrift consumption and slanted towards a steady drop in the marginal utility rate of goods—efficient use of USW should be encouraged while curbing profligate output, as an avoided ton of USW greatly exceeds the amount of energy that could be recovered by USW usage technologies.

The rising participation of machines in the means of production requires constant updating, in order to keep them as modern as possible. The outcome of this quest for the "new" is that they become obsolete, often before the end of their useful lives. The general trend is that large-scale production spurred by competition turns out goods that are less durable, meaning it may well cheaper to purchase a new item instead of re-using it. It is important to note that this increase in productivity is not viewed askance, and is good and desirable, according to certain standards. However, gains in productivity trigger alterations in consumption standards in a throwaway society, making it hard to pinpoint the perfect balance point between production and consumption. Although society should ideally take steps to ensure that most of its resources are channeled to the production of re-usable goods, its resources are frittered away, under pressure from dropping usage rates.

In actual fact, the most efficient way of making good use of USW involves moving away from the cult of the one-way pack, redefining the model that continuously generates "new needs" and integrating energy recovery processes into management practices.

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