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Brazilian recycling potential: Energy consumption and Green House Gases reduction

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ABSTRACT

The present article seeks to quantify the potential energy saving as well as the reduction on carbon dioxide emissions by package recycling through the implementation of the National Solid Waste Policy (NSWP) in Brazil. The applied methodology is based on the Green House Gasses (GHG) Protocol guidelines. Thus, The objective of this article is to determine the energy saving and CO_2 emissions reduction according to recyclable material. The result shows that, from 2015 until 2031, the potential CO_2 emission reduction was 42,18CO_2 Mt and it showed a reduction of 63,72CO_2 Mt within the NSWP goals. The energy savings were estimated to be 1,078,745 TJ for current recycle indexes and 1,529,718 TJ according to National Solid Waste Policy goals.

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1. Introduction

The National Solid Waste Policy (NSWP) is a Brazilian Law (Law 12,305/2010) which led to the formulation of the National Solid Waste Program by the Brazilian Ministry of Environment which established guidelines to solid waste management in the country. This legislation foresees integrated management improvements for several wastes and considers landfills usage as a last resort for the waste generated. The program also presents several strategies and guidelines in order to fulfill those goals with an emphasis on recycling. The Center of Packaging Technology and Food Technology Institute (CETEA/ITAL) [7], with support from the Business Commitment for Recycling (CEMPRE) revealed a 74% potential reduction on carbon emissions made by solid urban wastes with the implementation of the National Solid Waste Policy.

According to Pimenteira [20], recycling is an effective way of decrease CO_2 human-induced emissions. Thus it helps achieving

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the United Nations Framework Convention on Climate Change and the Kyoto Protocol's goals. Morris [19] showed that recycling solid waste materials saves more energy than to recover the heat potential in the waste by generating heat or electricity with the incineration or gasification of the waste.

The aim of this article is to quantify the energy saving potential and reduction of CO_2 emissions that would arise from the package recycling within the National Solid Waste Policy implementation in Brazil.

2. Methodology and data

This study used the Pimenteira et al. [20] methodology to quantify the energy saving and the CO_2 emission reduction derived from materials recycling. It consists of quantifying the available recyclable solid wastes and determining the economy saving and the emissions reductions by material recycled. This is supported by improvements concerning the energetic matrix used. The following section presents the steps of the methodology.

2.1. Quantification of MSW – municipal solid waste recycling in the period 2015–2031

Data with annual recycled quantity was obtained from Business Commitment for Recycling (CEMPRE). This data included the annual production and recycle rates recycled quantity/total quantity (CEMPRE [6]) of the following materials: aluminum cans, tins, steel, plastics, PET bottles, paper, cardboard and glass.

It was assumed that the quantity of packages for recycling occurs in the same rate of municipal solid waste (MSW) generation and the European Topic Center on Resource and Waste Management (ETC/RWM, 2008) model was adopted in order to estimate the MSW generation during the studied periods. The ETC/RWM model takes into consideration the per capita Gross Domestic Product's (GDP PPP) effects on the variation of the annual MSW rate and quality produced by inhabitant/day.

The GDP PPP and annual population data before 2012 were taken from the Time Series Management System from the Brazilian Central Bank [3] and input to the ETC/RWM model. Projections of GDP and of population from 2012 forward were obtained from the Energy National Plan 2030 (EPE [8]), in which it was estimated four growth rates to the GDP (5.1%, 4.1%, 3.2% and 2.2%) that corresponds to different scenarios from 2007 forward. Population growth was estimated to be 1.10% from 2010 to 2020 and 0.80% from 2020 to 2030. The resulting MSW generation growth rate during the 2015 to 2031 period fluctuated between 2.35% and 4.57% with a 3.44% average. This average was assumed as the MSW generation growth rate in this study.

The recycling indexes' projection are shown in Tables 1 and 2. They show the projection of recycled material in the reference year with the application of the recycle index.

Table 1
Recycling rates for attending the NSWP (National Solid Waste Policy)/2010.
Source: CEMPRE (Center of Packaging Technology), [6] and MMA (Brazilian Ministry of Environment), [16].

Material	Current recycling rate (%)	Year and NSWP (National Solid Waste Policy) Goals/10[a]				
		2015 22%	2019 28%	2023 34%	2027 40%	2031 45%
Aluminum cans	98.3	98.7%	98.8%	98.9%	99%	99%
Steel cans	47	58.7%	61.8%	65%	68.2%	70.9%
Plastics	21.7	38.9%	43.6%	48.3%	53%	57%
Bottles Poly-ethylene terephthalate	57.1	66.5%	69.1%	71.7%	74.3%	76%
Paper	29	44.6%	48.9%	53.1%	57.4%	61%
Paperboard	73.3	79.2%	80.8%	82.4%	84%	85.3%
Glass	47	58.7%	61.8%	65%	68.2%	70.9%

[a] Table prepared considering the emphasis on recycling 100% to meet the goals of NSWP (National Solid Waste Policy)/2010.

2.2. Determination of specific energy consumption

In order to determine the specific consumption of energy source in TJ/ton of produced material, the life cycle for the production of each material was studies in details. The energy consumption was then divided by the production of each material in the respective year. The electric consumption for producing each material was took into account electricity acquired from the National Grid or self-generated. All data were extracted from the industries which produce the respective material and were obtained in [9]. The power generation characteristics of each material can be observed in Tables 3 and 4.

2.2.1. Steel and paper/paper card

Regarding steel and paper production, it was adopted the energetic consumption matrices from the industrial sector of Pig Iron and Steel and Industrial Production of Paper and Celulose and Association Brazilian Paper (BRACELPA) [5].

2.2.2. Plastics and PET bottles

Concerning PET bottles there was some adjustments in order to make the electric energy consumption equal to 0,005T J/t. This specific consumption was obtained from information from the Swiss Agency for the Environment, Forest and Landscape [21] (Quoted by [12]). According to SAEFL's data, the thermic energy consumption was 0,0159T J/t resin. But after making the adjustment, the same consumption was 0,0135 TJ/t material.

Table 2
Annual amount of material to recycle (1000 t).
Source: CEMPRE (Center of Packaging Technology), [6] and MMA (Brazilian Ministry of Environment), [16].

Material	2013	Fulfillment of the NSWP (National Solid Waste Policy) Goals/ 2010					Maintenance of current recycling indexes				
		2015	2019	2023	2027	2031	2015	2019	2023	2027	2031
Aluminum cans	266	286	328	375	430	493	285	326	373	427	489
Steel cans	321	429	517	623	748	889	343	393	450	515	590
Plastics	1020	1957	2511	3184	4000	4918	1091	1249	1430	1637	1874
Bottles Polyethylene terephthalate	315	392	466	554	657	774	337	385	441	505	578
Paper	1022	1682	2110	2626	3247	3948	1093	1252	1433	1641	1878
Paperboard	3630	4196	4901	5722	6678	7767	3885	4447	5092	5829	6674
Glass	503	672	811	976	1172	1394	538	616	705	807	924