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Data Article

Data supporting the assessment of biomass based electricity and reduced GHG emissions in Cuba

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ABSTRACT

Assessing the biomass based electricity potential of developing nations like Cuba can help to reduce the fossil fuels dependency and the greenhouse gas emissions. The data included in this study present the evolution of electricity production and greenhouse gas emissions in Cuba. Additionally, the potentialities to produce biomass based electricity by using the most significant biomass sources in Cuba are estimated. Furthermore, estimations of the potential reductions of greenhouse gas emissions, resulting from implementing the biomass based electricity potential of the different sources discussed in the study, are included. Results point to the most promising biomass sources for electricity generation and their potential to reduce GHG emissions.

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Specifications table

Subject area	*Renewable energy, environment*
More specific subject area	*Carbon dioxide emissions.*
Type of data	*Table*
How data was acquired	*From documents and own calculations.*
Data format	*Raw, filtered, analyzed, etc.*
Data source location	*Cuba*
Data accessibility	*Data is available at* www.one.cu *Complementary data is available in literature (see reference list)*
Related research article	*The current potential of low-carbon economy and biomass-based electricity in Cuba. The case of sugarcane, energy cane and marabu (dichrostachys cinerea) as biomass sources "in press".*

Value of the data

- This data contains key information for the biomass production and the GHG emissions in Cuba.
- This data can be used to estimate the biomass based electricity potential of Cuba.
- This data can be used to estimate the reduction of GHG emissions that could result from implementing the different biomass based electricity potentialities existing in Cuba.
- This data permits to focus on the largest biomass sources for energy production in Cuba.

1. Data

The data presented in the article is related to the research article: *The current potential of low-carbon economy and biomass-based electricity in Cuba. The case of sugarcane, energy cane and marabu (dichrostachys cinerea) as biomass sources* [1]. The data corresponds to the evolution of the electricity production and of the GHG emissions in Cuba, and includes the biomass potential of the largest sources and the estimation of the associated biomass based electricity generation and greenhouse gas (GHG) emissions potential. The data of the evolution of the electricity production and of the GHG emissions was collected from the National Statistics Office of Cuba, when needed complemented with information from literature and databases. The estimations of the potentialities of biomass based electricity production and GHG emissions reduction in Cuba are calculated to highlight the main features.

2. Materials and methods

Based on the available biomass sources (between 2011 and 2016) estimations of the biomass based electricity potential and the possibilities to reduce GHG are developed. The biomass based electricity potential was calculated as:

$$E = LHV_{\mathrm{w}} \cdot \eta_{\mathrm{elect}} \quad (1)$$

where:

E – Electricity potential (kWh/t)

Table 1
Biomass production factors.

Biomass	Sugarcane (t)	Paddy rice (t)	Poultry (head)	Pig (head)	Pig manure (t)	Ref.
Filter cake (kg)	33	–	–	–	–	[5]
Rice husk (t)	–	0.22	–	–	–	[6]
Drying wastes (t)	–	0.04	–	–	–	[6]
Poultry manure kg)	–	–	0.12	–	–	[7]
Pig manure (kg)	–	–	–	794.7	–	[8]
Biogas (m^3)	–	–	–	–	14	[9]

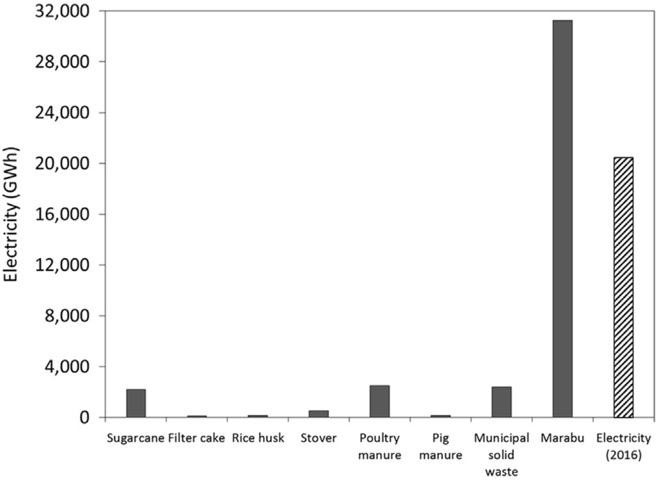

Fig. 1. Biomass based electricity potential of the biomass sources vs electricity generation in Cuba (2016).

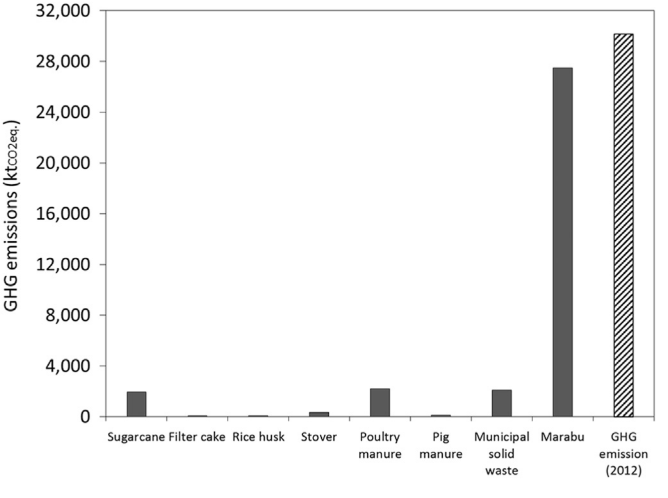

Fig. 2. Potential of GHG emission reductions of the biomass sources vs GHG emissions in Cuba (2012).

Table 2
Evolution of power generation and GHG emissions in Cuba. (Source: [10–12]).

Year	Power (MW)	Electricity (GWh)	FBE (GWh)	SBE (GWh)	HP (GWh)	GHG.W ($kt_{CO2eq.}$)
1959	475.6	2348.4	1956.4	392.0	5.9	–
1960	472.6	2492.7	2105.7	387.0	13.0	13,700
1961	509.1	2521.9	2086.9	435.0	8.5	12,182
1962	534.1	2552.5	2257.5	295.0	8.6	14,169
1963	532.1	2597.0	2345.0	252.0	49.8	13,040
1964	566.1	2811.4	2494.6	316.8	100.5	14,294
1965	564.1	2954.5	2954.5	–	56.7	14,609
1966	658.6	3157.4	3157.4	–	131.4	15,185
1967	758.6	3453.6	3453.6	–	109.2	15,750
1968	861.5	3615.4	3615.4	–	80.7	16,036
1969	913.5	3782.3	3782.3	–	102.9	17,261
1970	908.0	4888.5	4008.0	880.5	90.7	18,672
1971	985.0	5020.5	4203.5	817.0	110.2	19,607
1972	1466.2	5269.0	4624.0	645.0	74.0	20,799
1973	1531.8	5707.9	4989.0	718.9	62.0	22,398
1974	1644.6	6019.6	5283.4	736.2	89.4	22,911
1975	1677.3	6588.9	5831.8	756.2	62.5	27,066
1976	1704.6	7195.9	6422.6	773.3	53.2	27,224
1977	1858.0	7705.0	6868.9	836.1	72.8	29,402
1978	2288.3	8482.7	7527.0	955.7	83.2	30,689
1979	2560.7	9403.1	8445.0	958.1	104.3	31,712
1980	2731.4	9989.6	9035.4	954.2	97.1	31,401
1981	2751.8	10,575.5	9600.1	975.4	59.8	32,750
1982	2974.5	11,071.4	10,025.9	1045.5	42.7	34,554
1983	2999.9	11,551.4	10,466.6	1084.8	62.7	30,843
1984	3111.2	12,292.0	11,167.3	1124.7	70.4	32,603
1985	3249.0	12,199.4	11,068.0	1131.4	54.3	32,578
1986	3419.2	13,176.4	11,991.7	1184.7	59.3	33,568
1987	3532.0	13,594.0	12,388.8	1204.7	43.9	33,953

Year	Power (MW)	Electricity (GWh)	FBE (GWh)	SBE (GWh)	HP (GWh)	ESPE (GWh)	GHG.C ($kt_{CO2eq.}$)	GHG.W ($kt_{CO2eq.}$)
1988	3841.3	14,542.3	13,225.0	1317.3	72.8	0.0	–	35,636
1989	3998.9	15,239.8	13,959.7	1280.1	82.0	0.0	–	35,739
1990	4077.9	15,024.7	13,575.6	1449.1	90.9	0.0	15,025	33,344
1991	4033.3	13,247.2	11,982.8	1264.4	104.7	0.0	–	29,710
1992	4032.2	11,538.0	10,200.8	1337.2	80.5	0.0	22,934	31,294
1993	4031.7	11,004.2	10,117.0	887.2	82.4	0.0	–	29,380
1994	4059.6	11,964.0	11,067.1	896.9	48.5	0.0	23,192	32,248
1995	3991.1	12,459.0	11,769.3	689.7	74.4	0.0	–	25,709
1996	4311.9	13,236.5	12,314.4	922.1	95.2	0.0	27,284	26,996
1997	4223.9	14,145.6	13,275.9	869.7	130.0	0.0	–	24,650
1998	4348.3	14,148.6	13,369.5	779.1	96.7	0.0	28,886	24,499
1999	4284.3	14,492.2	13,611.3	880.9	103.3	0.0	–	25,332
2000	4286.5	15,032.2	14,088.0	944.2	89.0	0.0	27,558	26,083
2001	4410.9	15,299.8	14,369.5	930.3	75.0	0.0	–	25,453
2002	3959.6	15,698.8	14,760.3	938.5	106.4	0.3	25,786	26,091
2003	3965.0	15,810.5	15,090.4	720.1	127.7	0.4	–	25,486
2004	3763.5	15,633.7	14,845.1	788.6	87.6	0.4	25,266	25,005
2005	4275.1	15,341.1	14,921.6	419.5	67.7	0.1	–	26,006
2006	5176.0	16,468.5	16,062.4	406.1	93.5	0.3	28,829	27,407
2007	5429.4	17,622.5	17,209.7	412.8	121.4	0.2	–	26,795
2008	5396.4	17,661.8	17,127.6	553.7	138.3	8.2	32,216	30,443
2009	5550.0	17,727.1	17,037.9	534.8	150.8	3.6	–	29,897
2010	5852.6	17,395.5	16,832.3	446.2	96.6	11.7	30,378	38,375
2011	5913.9	17,754.1	17,186.6	453.8	99.2	19.8	–	35,988
2012	5699.1	18,427.9	17,744.3	551.0	110.9	21.7	30,173	36,157
2013	6054.8	19,139.6	18,306.9	696.6	127.3	25.6	–	34,800
2014	6168.6	19,366.1	18,588.3	636.5	104.1	37.2	–	34,837
2015	6280.0	20,288.0	19,585.3	702.7	48.3	50.1	–	–
2016	6453.9	20,458.6	19,648.0	686.3	64.2	–	–	–

* FBE – Fossil based electricity, SBE – Sugarcane based electricity, HE – Hydroelectricity, ESPE – Eolic + Solar photovoltaic, GHG.C – Net GHG emissions reported by the Cuban government, GHG.W – Net GHG emissions reported by the World Bank.

Table 3
Evolution of sugarcane production and its use of agricultural land in Cuba. (Source: [11,13]).

Year	Harvested surface (ha)	Yield (t)	Production (t)	Bagasse (t)	Year	Harvested surface (ha)	Yield (t)	Production (t)	Bagasse (t)
1959	1,070,000	41.9	44,800,000	12,960,000	**1988**	1,297,300	56.8	76,714,080	21,819,600
1960	1,160,000	40.9	47,500,000	12,203,300	**1989**	1,350,600	60.0	85,218,000	23,022,700
1961	1,260,000	43.1	54,300,000	14,002,700	**1990**	1,420,300	57.6	83,646,720	23,261,900
1962	1,130,000	32.5	36,700,000	9,724,600	**1991**	1,452,200	54.9	79,698,330	19,473,800
1963	1,070,000	29.3	31,400,000	8,386,100	**1992**	1,451,700	45.6	55,253,520	10,093,300
1964	1,000,000	37.2	37,200,000	9,880,200	**1993**	1,211,700	36.0	44,960,400	12,921,200
1965	1,060,000	47.8	50,700,000	13,344,100	**1994**	1,248,900	34.6	40,738,040	12,902,700
1966	980,000	37.0	36,800,000	9,874,900	**1995**	1,177,400	28.5	35,468,250	10,208,100
1967	1,040,000	35.0	50,500,000	13,950,300	**1996**	1,244,500	33.2	41,377,160	12,423,200
1968	1,010,000	42.4	42,800,000	11,869,000	**1997**	1,246,300	31.2	32,713,200	11,859,500
1969	940,000	44.4	41,700,000	11,551,400	**1998**	1,048,500	31.3	31,168,540	10,070,300
1970	1,460,000	55.8	81,500,000	23,274,100	**1999**	995,800	34.1	35,494,690	10,673,300
1971	1,250,000	41.7	52,200,000	15,836,700	**2000**	1,040,900	35.6	35,852,760	11,038,700
1972	1,180,000	37.5	44,300,000	13,369,100	**2001**	1,007,100	31.4	32,693,680	11,599,000
1973	1,070,000	45.0	48,200,000	14,254,000	**2002**	1,041,200	33.3	21,438,540	8,952,000
1974	1,100,000	45.8	50,400,000	14,779,200	**2003**	643,800	34.3	22,672,300	7,100,700
1975	1,180,000	44.4	52,400,000	15,153,300	**2004**	661,000	36.0	18,619,200	6,950,500
1976	1,220,000	44.1	53,800,000	15,275,800	**2005**	517,200	22.4	8,895,040	4,787,300
1977	1,140,000	53.0	60,400,000	16,073,200	**2006**	397,100	28.0	9,226,000	3,605,800
1978	1,240,000	56.1	69,600,000	18,678,800	**2007**	329,500	36.1	13,728,830	3,415,100
1979	1,310,000	59.0	77,300,000	19,585,100	**2008**	380,300	41.3	17,953,110	3,863,300
1980	1,390,000	46.0	64,000,000	17,108,000	**2009**	434,700	34.3	14,797,020	3,719,000
1981	1,210,000	55.0	66,600,000	19,147,000	**2010**	431,400	26.7	13,512,870	3,027,300
1982	1,330,000	55.0	73,100,000	19,075,000	**2011**	506,100	31.2	11,272,560	3,949,600
1983	1,200,000	58.1	67,400,000	19,149,000	**2012**	361,300	39.9	15,971,970	3,959,900
1984	1,350,000	57.3	77,400,000	19,635,000	**2013**	400,300	40.3	16,329,560	3,637,100
1985	1,347,800	50.0	67,400,000	18,315,000	**2014**	405,200	44.10	19,300,000	4,604,200
1986	1,328,600	51.6	70,088,280	19,584,000	**2015**	435,600	44.30	19,297,080	4,942,000
1987	1,358,300	52.1	67,589,330	19,969,000	**2016**	–	–	15,806,667	3,793,600

Table 4
Biomass properties and electric potential.

Biomass	Moisture (%)	HHV_d (MJ/kg)	LHV_w (MJ/kg)	Electricity potential (kWh/t)	Ref.
Bagasse	50.0%	17.30	7.43	577.6	[3]
Filter cake	40.0%	14.50	7.72	600.5	[3]
Marabu	19.0%	20.70	16.30	1267.9	[3]
Rice husk	9.0%	16.50	14.79	1150.7	[14]
Maize	6.1%	–	15.68	1219.6	[15]
Poultry manure	39.7%	–	8.54	664.2	[15]
Pig manure	92.1%	–	– 1.24	0	[15]
Biogas from pig manure	–	–	18	51.7	[9]
Municipal solid waste	44.0%	–	7.15	556	[16]

η_{elect} – Electricity efficiency of the generation technology (understand as the % of the $LHV_{W.B.}$ transformed into electricity)

An electricity production efficiency of 28% was considered for biomass incineration [1,3]. Moreover, to assess the potentialities of pig manure, where the use of the biogas resulting from manure rather than directly incinerating manure (because of its high moisture content) is considered, an electricity production efficiency of 35% was used [2].

Table 5
Production of the main crops, livestock and municipal solid wastes in Cuba: 2011–2016. (Source [11]).

Year	Sugarcane (t)	Maize (t)	Paddy rice (t)	Poultry (heads)	Pig (heads)	Municipal solid waste (m^3)
2011	11,272,560	304,800	3,256,100	33,663,300	3,256,100	23,390,400
2012	15,971,970	324,463	3,036,100	30,182,000	3,036,100	27,817,400
2013	16,329,560	354,000	3,366,700	32,415,500	3,366,700	26,521,000
2014	19,300,000	360,400	3,379,600	32,285,800	3,379,600	27,221,300
2015	19,297,080	426,200	3,492,800	31,963,900	3,492,800	28,007,800
2016	15,806,667	427,295	3,600,800	31,336,200	3,600,800	28,796,400

Table 6
Estimation of the biomass production from the more significant sources in Cuba: 2011–2016.

Year	Bagasse (t)	Filter cake (t)	Rice husk (t)[a]	Stover (t)	Poultry manure (t)	Pig manure (t)	Municipal solid waste (t)[b]	Total (t)
2011	3,949,600	371,994	147,264	304,800	4,039,596	2,587,623	3,508,560	14,909,437
2012	3,959,900	527,075	166,816	324,463	3,621,840	2,412,789	4,172,610	15,185,493
2013	3,637,100	538,875	174,876	354,000	3,889,860	2,675,516	3,978,150	15,248,378
2014	4,604,200	636,900	152,048	360,400	3,874,296	2,685,768	4,083,195	16,396,807
2015	4,942,000	636,804	108,690	426,200	3,835,668	2,775,728	4,201,170	16,926,259
2016	3,793,600	521,620	133,652	427,295	3,760,344	2,861,556	4,319,460	15,817,526

[a] Includes rice husk and drying wastes.
[b] A density of 150 kg/m^3 is considered for Municipal Solid Waste.

Table 7
Estimation of the marabu (dichrostachys cinerea) biomass stock in Cuba: 2011–2016.

Year	Surface (ha)	Biomass (t)
2011	1,500,000	55,500,000
2012	1,600,000	59,200,000
2013	1,700,000	62,900,000
2014	1,800,000	66,600,000
2015	1,900,000	70,300,000
2016	2,000,000	74,000,000

Table 8
Calculation of biomass based electricity potential in Cuba: 2011–2016.

Year	Sugarcane (GWh)	Rice husk (GWh)	Stover (GWh)	Poultry manure (GWh)	Pig manure (GWh)	Municipal solid waste (GWh)	Marabu (GWh)	Total (GWh)
2011	1578	169	372	2683	134	1951	70,371	77,336
2012	2236	192	396	2406	125	2320	75,062	82,848
2013	2286	201	432	2584	138	2212	79,753	87,720
2014	2702	175	440	2573	139	2271	84,445	92,878
2015	2702	125	520	2548	144	2336	89,136	97,644
2016	2213	154	521	2498	148	2402	93,827	101,873

The factors used to estimate the biomass resulting from the production of different crops and livestock in Cuba are included in Table 1. For the estimations of dichrostachys cinerea (kwon as marabu, is a non-indigenous bush tree that is widely available and considered a fast spreading plague,

Table 9
Calculation of the biomass based GHG reduction potential in Cuba: 2011–2016.

Year	Sugarcane ($kt_{CO2.eq}$)	Rice husk ($kt_{CO2.eq}$)	Stover ($kt_{CO2.eq}$)	Poultry manure ($kt_{CO2.eq}$)	Pig manure ($kt_{CO2.eq}$)	Municipal solid waste ($kt_{CO2.eq}$)	Marabu ($kt_{CO2.eq}$)	Total ($kt_{CO2.eq}$)
2011	1387	112	245	2359	118	1715	61,856	67,860
2012	1966	126	261	2115	110	2040	65,979	72,694
2013	2010	133	285	2271	122	1945	70,103	76,967
2014	2375	115	290	2262	122	1996	74,227	81,505
2015	2375	82	343	2239	126	2054	78,351	85,687
2016	1945	101	343	2195	130	2111	82,474	89,398

occupying between 1.5 and 2 million ha) it is considered that between 2011 and 2016 its area increased from 1.5 to 2 million ha (at a rate of 100,000 ha/year). Marabu yields 37 t/ha with a re-grow period of three years [3]. Based on re-grow period, the yearly marabu based electricity potential is estimated as 33.3% of the overall potential of the marabu stock.

To assess the potential reductions of the GHG emissions, it is considered that the GHG emissions of producing the different crops and livestock are allocated to the production of the product (e.g. rice, maize grain, meat, eggs, sugar, etc.). This is not entirely true since biomass is not carbon neutral. However, it serves as a first approximation. Thus, it is considered that biomass based electricity can save 100% of the GHG emissions resulting from generating the same amount of fossil based electricity. In Cuba, the greenhouse gas emission factor for electricity generation is 0.879 t_{CO2}eq./MWh [4] (Figs. 1 and 2, Tables 2–9).

Transparency document. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2018.01.071.

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