



DESAFIOS - The Challenges of Globalization

São Paulo KOSMOS Workshop

Berlin meets São Paulo: Cities for All — Livable and Sustainable

Lecture 4: Waste to energy

Chances, Possibilities and Technologies on example of some Brazil and African Cities

Prof. Suani Teixeira Coelho, IEE-USP

.. and of some German, European and Iranian Cities

Prof. Frank Riesbeck, HU Berlin

Sao Paulo, 9 April 2015





General overview



- CENBIO's presentation
- Traditional biomass vs Modern biomass
- Energy from residues
 - Brazilian experience
 - African experience
 - Cuban experience



CENBIO – THE BIOENERGY GROUP GRADUATE PROGRAM ON ENERGY

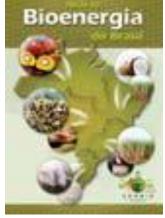


- CENBIO the Brazilian Reference Center on Biomass – created in 1996 at USP (agreement with the Ministry of Science and Technology, the State Secretariat of Energy of São Paulo and the (NGO) Biomass Users Network
- Nowadays CENBIO Bioenergy Research Group at Graduation Program on Energy (PPGE)/Institute of Energy and Environment/ USP



 Studies/projects on Biofuels and Bioenergy
 Bioenergy sustainability









CENBIO'S TEAM



- Coordination: prof Suani Coelho
- Special contribution: prof J. Goldemberg
- 12 PPGE' Students in 2015
 - 1 pos doc Alessandro S. Pereira
 - 1 PhD Vanessa Pecora
 - 4 PhD candidates Javier Escobar; Adriano Violante; Manuel Moreno; Luis G. Tudeschini
 - 4 MSc candidates Fernando Oliveira; Naraisa Coluna; Dafne P. Silva; Thaisa Waiss
 - 2 undergraduate students Pedro Germani; Brunno Boyadjian









Energy Access



- The United
 Nations Secretary
 General Advisory
 group on energy
 and climate
 change (AGECC)
 - 1.5 billion people without electricity access worldwide
 - 3 billion people using traditional biomass for cooking and heating

Energy for a
Sustainable Future

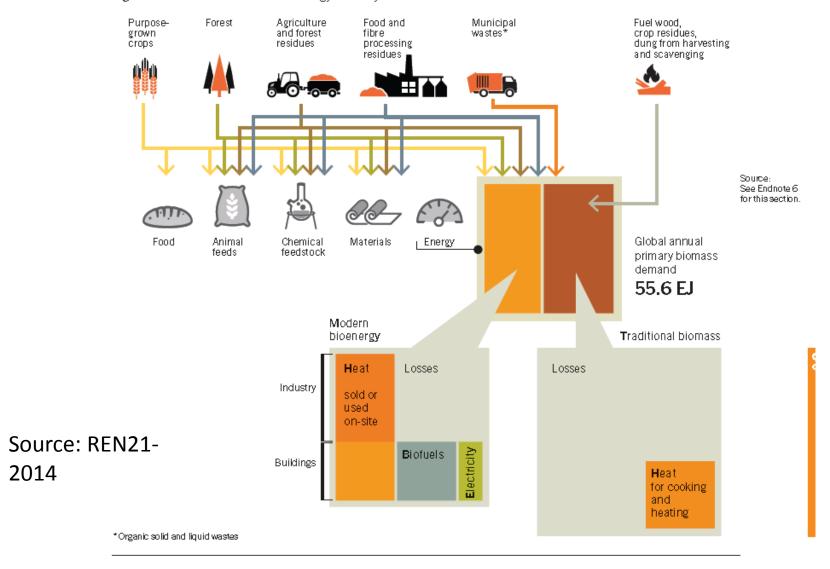
THE SECRETARY-GENERAL'S
ADVISORY GROUP ON
ENERGY AND CLIMATE
CHANGE (AGECC)
SUMMARY REPORT AND
RECOMMENDATIONS
28 April 2010
New York







Figure 5. Biomass Resources and Energy Pathways





General overview



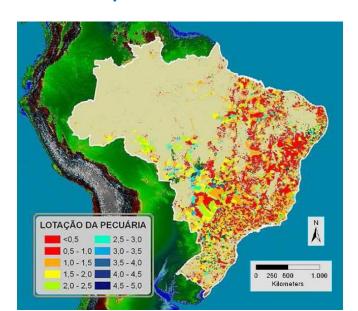
- CENBIO's presentation
- Traditional biomass vs Modern biomass
- Energy from residues
 - Brazilian experience (and CENBIO's projects)
 - African experience
 - Cuban experience



Wood pellets

Javier F. Escobar – PhD candidate

Possibilities of sustainable wood production, increase in sustainably produced wood energy and the impact on developing and emerging countries – Study case Brazil









CCH - Congress Center Hamburg, Germany

23 - 26 June 2014



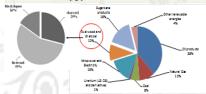
Abstract

Brazil is a country with several advantages to act as a leader in agro-industrial and sixhalture sectors, particularly those declicated to energy, featuring sustainable biomass production with significant potential for exploitation, as discussed in this paper. Its natural and geographical conditions are quite favorable and there are available areas with adequate characteristics of soil and dimate conditions, making it the country's largest gathering of quantitative comparative advantages to lead the sustainable production and use of biomass energy on a largescale, without competitionwith other corps such as food crops.

troduction

According to the National Energy Balance 2013, biomass currently represents about 27% of primary energy supply, and wood is an important source of energy with more than 10% of the primary energy used in the county.

Wood bioenergy is in fact a form of energy not so well understood and presenting great potential gains in the near future. It is estimated that wood energy has been responsible in 2012 for the production of 30,4 Mtoe, same order of magnitude as other renewable sources [112]

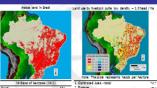


| Mase | Source | Sou

The consumption shares are 34% charcoal (for iron/steel sector), 28% industrial (mainly for heat/power in pulp and paper sector) and 28 % residential sector (cooking purposes) and 10% in agriculture (mainly for heat purposes) [2]

Methods & Material

According to this study, from these 70 million ha, it is predicted that 10 million housed be occupied by sophean and other grains, 5 million to meet family farmers needs and 25 million for crops for energy purposes (sugar 30 million has subject to occupation with other cultures, for example, forest plantation, which has seven million tomes to meet the productive wood sectors of the ountry. If successful in institutional advancements, we can expect Brazil to accelerate the sustainable expansion of forest plantations, reaching an average growth off imilion halyes. In fact it must be considered that there is still a high deficitor forest plantations compared to careful for a supply (charcest) plantations can be careful for a supply charced to careful for supply charced to



(2012) 1. Cultivated Awa - total
(51) 2. Famus
(54) 3. Available Awa (total avable land)

103



Wood Pellets



Energy production from residues from the prunning of urban trees. Case study Campus of USP – São Paulo - Master candidate Dafne Pereira da Silva

Objective:

To evaluate the potential for energy production from residues from urban prunning through densification process. A case study for the São Paulo Campus of USP





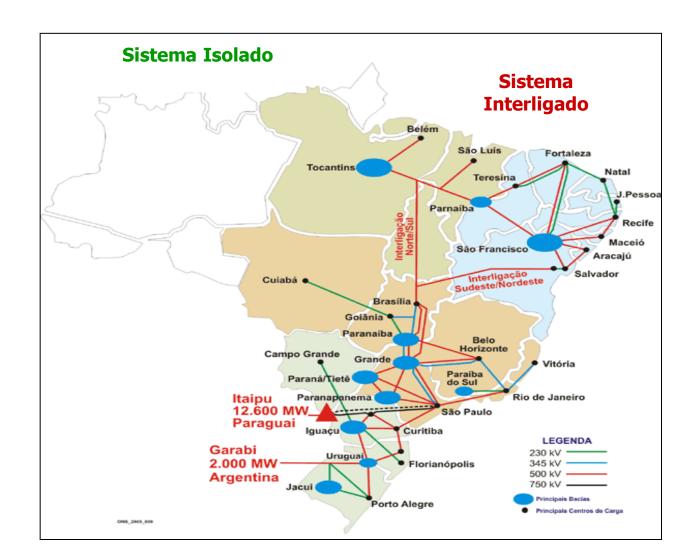


- Moagem
- Secagem





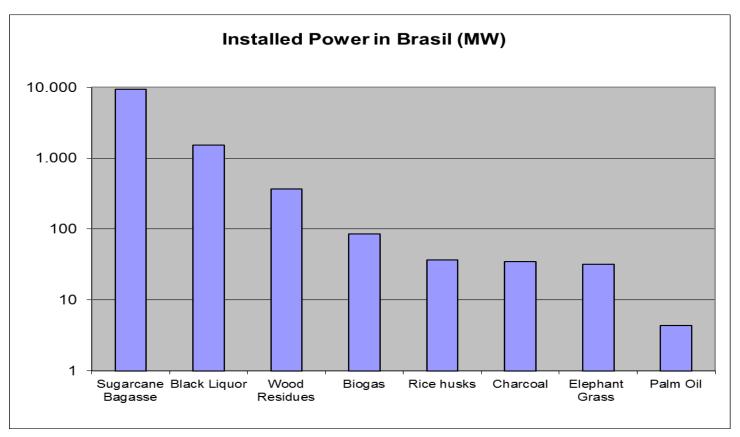
Brazilian Electric System





Biomass for power production in Brazil (2013)





Biomass – 7% of the electricity generated by thermoelectric power plants

Source: ANEEL, 2014

Bagasse from sugarcane - 80% of this power.

Forest-based biomass - 15.8%

Other types - 1.8%.



Electricity surplus from sugarcane bagasse cogeneration

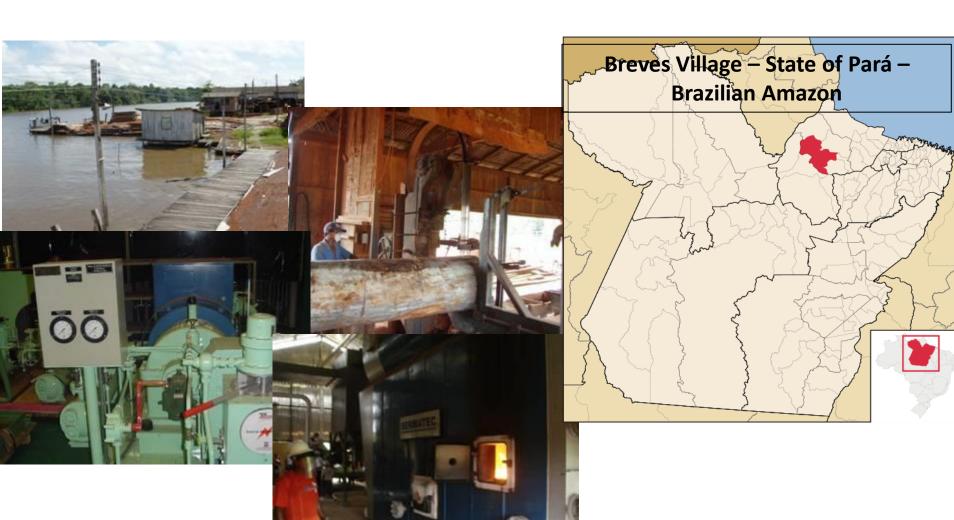






Brazilian Isolated System Energy production from wood residues Enermad Project – 200 kW







Brazilian Isolated System Energy production from agricultural residues Small scale biomass gasification system



Joint Project Brazil (CENBIO-IPT/USP) – India (IISc) Sandra Apolinario (Master thesis)



- 700 people 180 households;
- Cupuassu crops 100 ha;
- Before the power plant cupuassu fruits sold *in natura* (low added value)
- Need to improve economic activities
- 20 kWe installed power for freezing systems
 - Agricultural residues: cupuassu husks

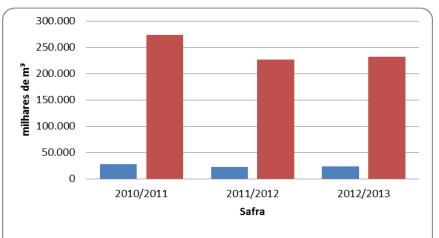


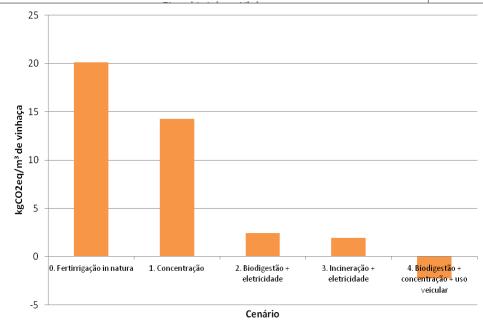
Biogas Energy Conversion



Technical, Economic and Environmental Analysis of Biogas from Sugarcane Vinasse

Manuel Moreno R. Poveda (Master Thesis)











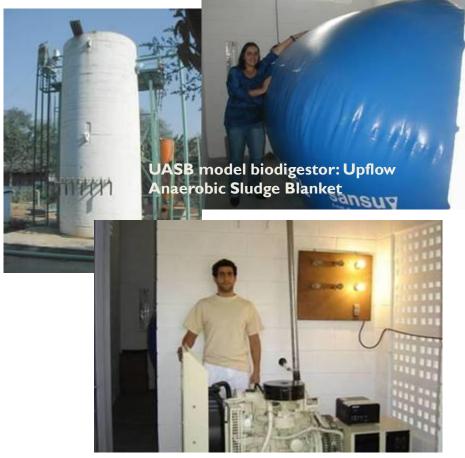
Biogas Energy Conversion from Sewage Treatment



Biogas-fired Microturbine – Biogas from Sewage Treatment at SABESP Sewage Treatment Station, São Paulo (first one in LA) – Master thesis (D.F. Costa)



Biodigestor for Sewage from Guest House at USP - Master thesis (V. Pecora)



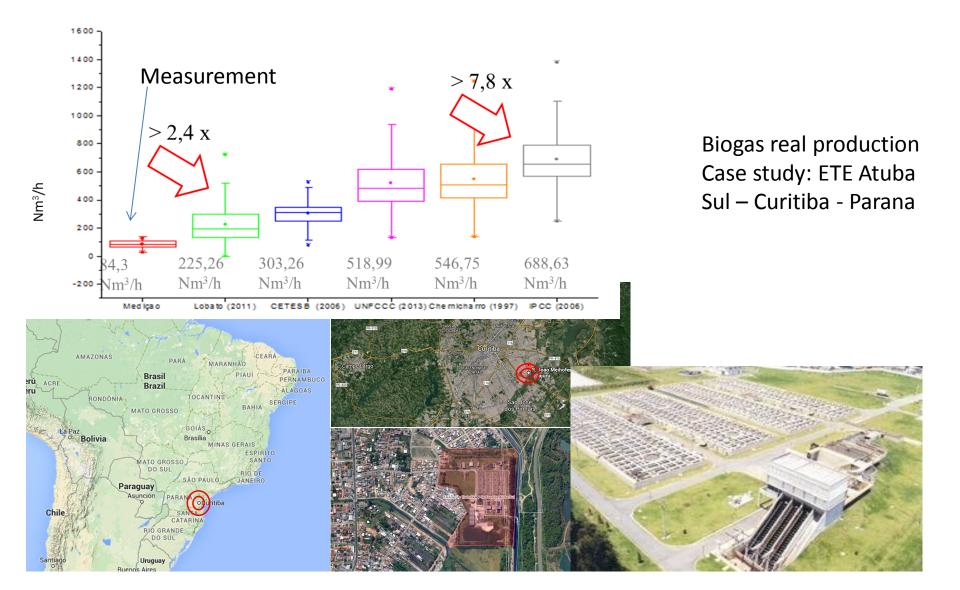
Engine and control system



Biogas Energy Conversion from Sewage Treatment

Use of biogas from sewage treatment for energy purposes (Thaisa Waiss - Master thesis)







Biogas Energy Conversion from Sewage Treatment





Sewage Treatment Plant Arrudas - COPASA

Belo Horizonte - Minas Gerais / Brazil

Installed power: 2.4 MW (12 microturbines - 200 kW each)

Exhaust gases - thermal energy for heating the digesters





- 33 local farmers;
- Effluents average daily flow rate: 48.43 m³
- Biogas average daily production: 821.8 m³;
- Thermal use of biogas for gain dryers/cooking;
- Electricity average daily production of 1.15 MWh (power engine);

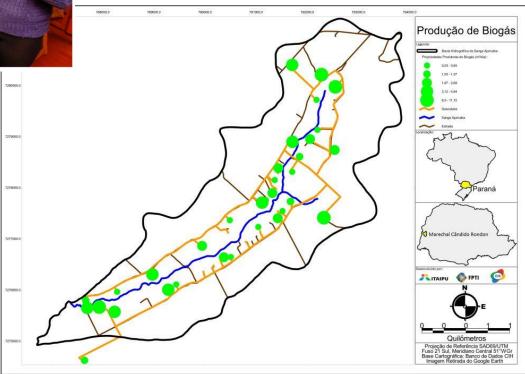
https://www.cibiogas.org/

Biogas from pig manure

Ajuricaba Agroenergy for Family Farming – Parana State

Itaipu Binational and Municipality of Rondon

International Centre for Renewable Energy - Biogás / CIBiogás-ER







National Policy for Solid Residues



RESIDUE

FINAL DESTINATION

WASTE

FINAL DISPOSAL

- reutilization
- recycling
- composing
- recovering
- energy conversion

3,000 municipalities, with less than 10,000 inhabitants with inadequate disposal (42% of the residues collected have no adequate disposal in landfills)

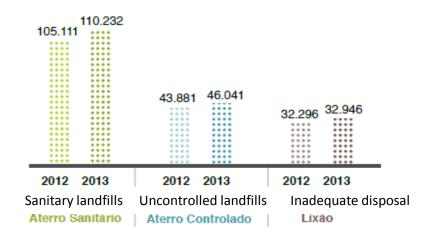
IEE USP

FINAL DESTINATION OF USW IN BRAZIL



I.1.4 Destinação Final de RSU

igura 4.1.4.1 - Destinação final de RSU (t/dia)



Fonte: Pesquisa ABRELPE

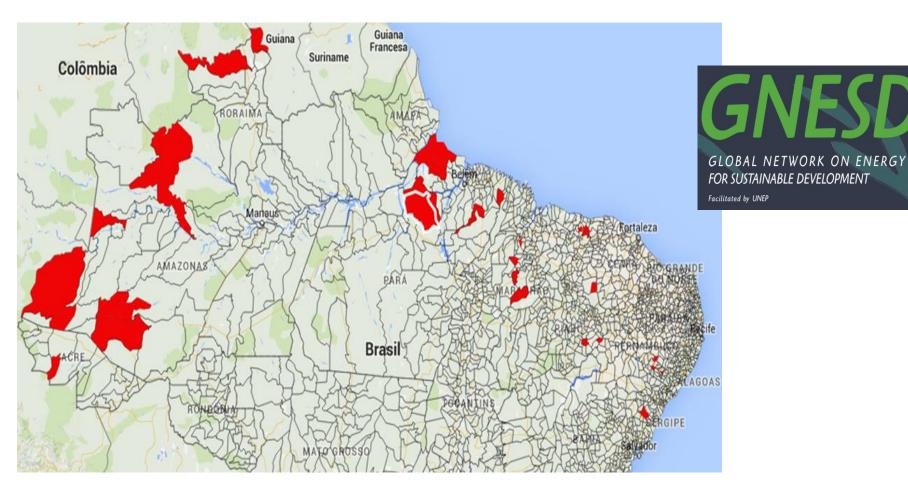
Tabela 4.1.4.2 – Quantidade de Municípios por Tipo de Destinação Adotada – 2013

BRASIL	450	1.794	407	1.008	1.191	5.570		
Inadequate disposal	247	837	158	206	121	1.569		
Uncotrolled landfills	111	504	148	645	367	1.775		
Sanitary landfills	92	453	161	817	703	2.226		
Destinação Final	Norte	Nordeste	Centro-Oeste	Sudeste	Sul	BRASIL		
Doctingoão Final	2013 - Regiões e Brasil							



Urban waste x Energy access x HDI in N/NE Brazil





Project: Biomass Residues as Energy Source to Improve Energy Access and Local Economic Activity in low HDI regions in Brazil and Colombia

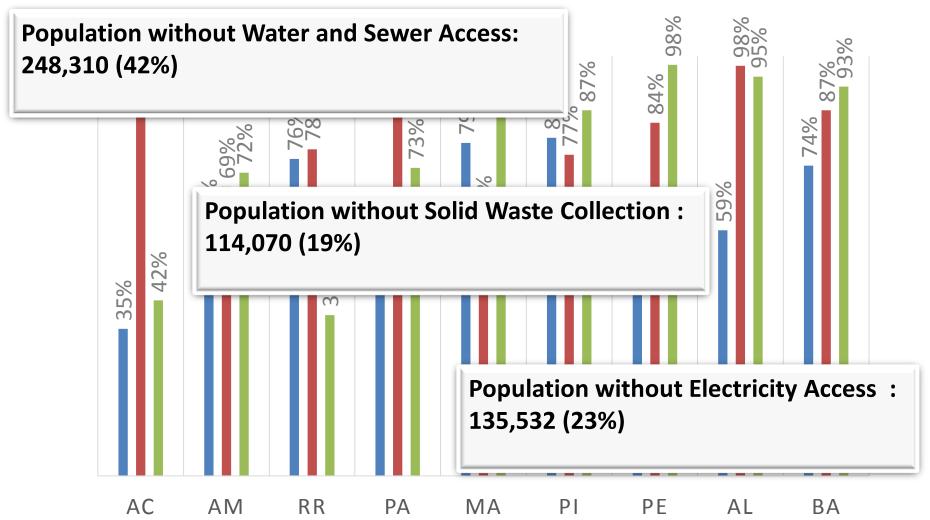


Project: Biomass Residues as Energy Source to Improve Energy Access and Local Economic Activity in low HDI regions in Brazil and Colombia











Energy from Urban Solid Waste

Comparison between Solid Waste Energy Recovery Technologies using Life Cycle Assessment



Objective: a comparative study thought the Life Cycle Assessment (LCA), of power generation from municipal solid waste and sludge of sewage treatment plant, using tree different treatment technologies

Mechanic – Biologic Treatment

Landfill

Incineration

The study considers Barbarian technology



Energy from Urban Solid Waste



Comparison between Solid Waste Energy Recovery Technologies using Life Cycle Assessment

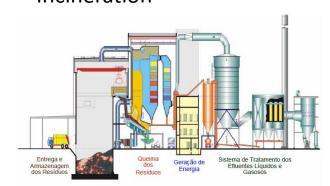


Baixada Santista Coastal Area 1200 t/d 90% USW - 10% sludge

Scenario I – No recycling

Scenario II – Recycling (catadores)





Landfill





TMB

Coelho et al, 2014 - 22nd European Bioenergy Conference, Hamburg, June, 2014 - http://www.etaflorence.it/proceedings/







http://www.gasnet.com.br/conteudo/4578/Biogas-gera-eletricidade-e-creditos-de-carbono-a-partir-do-lixo









Bandeirantes Landfill – São Paulo



"Baixada Santista" - North Coast - São Paulo State MSW transportation





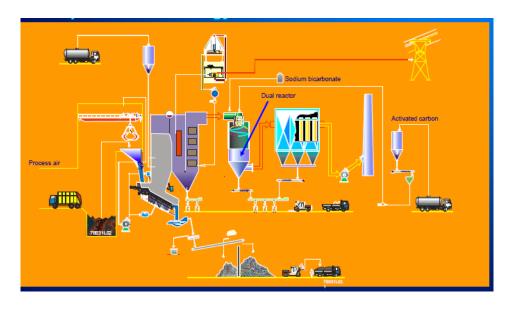


Incineration





Valorsul incineration plant – Lisbon (photo - CENBIO, 2012)





Incineration – Existing Difficulties in Brazil



- Strong rejection of civil society (lack of information):
 - Toxicity of exhaust gases (dioxines and furanes): lack of information about the existing cleaning technologies;
 - Possible impacts of jobs for recycling workers (catadores workers): lack of information about the benefits of recycling before waste-to-energy processes.
- High initial investment.
- High generation costs Electricity production cost: BRL 300/MWh – EUR 85/MWh – 0.85cents/kWh
- Lack of policies to incentivate waste-toenergy technologies.









Waste to energy - USW plants BAVARIA/SÃO PAULO JOINT PROJECT



Resolution SMA 079/Nov, 2009 Emissions standards for Sao Paulo (based on European Community standards)

	сот	co	HCI	HF	502	NOx	MP	Dioxinas Dioxins
Limites Legais - Indústria Legal limits - Industry	50	-	30	3	350	350	20	0,1
Limites Legais – URE Legal limits – WTE plant	10	50	10	1	50	200	10	0,1
Emissões Usuais - URE Usual limits – WTE plant	1	10	1	0,1	1,5	150	1	0,005

Tabela 4 - Limites de Emissão e Emissões Usuais na Alemanha Table 4 - Limits of emission and usual emissions in Germany

Fonte: São Paulo, 2010

Res. CONAMA 382 (26/12/2006) MP < 730mg/Nm³, NOx não se aplica



Incineration plant in São Bernardo do Campo municipality – São Paulo State Start-up 2016



São Bernardo do Campo queima lixo para gerar energia

19 de Julho de 2013 . Atualizado às 14h46

Curtin (201) f Compartilhar



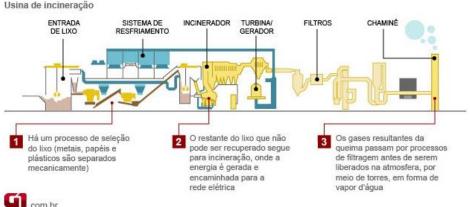
A incineração será capaz de suprir a metade da A incineração será capaz de suprir a metad demanda de energia de São Bernardo.

A cidade de São Bernardo do Campo receberá a primeira instalação de aproveitamento da incineração lixo entre o final de 2015 e o início de 2016. O projeto conta com o orcamento de R\$ 600 milhões, v disponível para colocar a usina em prática.

O lixo é queimado e o vapor gerado é usado para movimentar as turbinas. Nesse processo, a inciner será capaz de suprir a metade da demanda de energia de São Bernardo, cidade que possui cerca de mil habitantes. A usina vai gerar até 22 megawatts/hora.

Estima-se que seiam produzidas 11 bilhões de toneladas de lixo diariamente no mundo, e, por conta sticine/conharmancers/20 hunicacy ina





http://ciclovivo.com.br/noticia/sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-para-gerar-http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-bernardo-do-campo-queima-lixo-de-sao-bernardo-denergia bernardo-do-campo



Gasification of Urban Solid Waste Carbogás plant - Maua, Sao Paulo, 2014









Electricity conversion technologies for USW

AMOUNT OF USW	ELECTRICITY PRODUCTION POTENTIAL
1200 t/d (large municipalities)	20 MW (incineration)
60 t/d (60 000 people)	1 MW
5 t/d (5 000 people)	75 kW (gasification)

Tabela 21 - Classificação quanto ao porte do município em relação ao número da população residente - Brasil – 2000.

Classificação de ac	Número de	Relação ao Total	
Pegueno Porte I	até 20 000	4.074	73,26%
Pequeno Porte II	De 20 00 i até 50 000	963	17,32%
Médio Porte	De 50 001 até 100 000	299	5,38%
Grande Porte	Mais de 100 001	225	4,05%
	Total	5.561	100,00%

Fonte: Elaborado pelo autor com base no IBGE, 2000.







MBA thesis – Luiz H. T. G. Miranda

ITANHAEM MUNICIPALITY



Figura 42 - Trajeto da destinação dos resíduos do município de Itanhaém -

Fonte: Google Mapas.

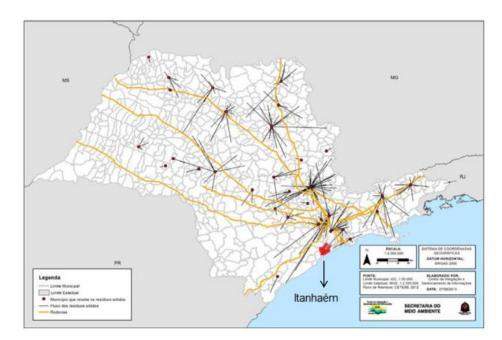


Figura 9 - Mapa de fluxo de resíduos sólidos urbanos no Estado de São Paulo. Fonte: SMA/CPLA (2013).



General overview



- CENBIO's presentation
- Traditional biomass vs Modern biomass
- Energy from residues
 - Brazilian experience
 - African experience Second Bioenergy Week
 - Cuban experience







Zoneamento Agroecológico

Resultados do País, excepto Maputo



MOZAMBIQUE

Apresentação de la Agrifinal 2(1)(1) le Bioenergia Maputo, 06 Maio de 2014

Example - Zoning





Agroclimatic Zoning Edaphic Zoning Edaphoclimatic Zoning Water deficit Evapotranspiration Avarage tem Protec





EGYPT

2- Solid fuel produced from rice straw

With capacity reaches 50 Thousands ton/year















Dissemination of Biogas Units in Minia

June 2008– Dec. 2009
Abdullah El-Nadim Foundation in Minia



The GEF Small Grants Programme





Prof . Dr. Ahmed Abd El-Ati Ahmed
Egypt - GBEP Focal Point

Cogen for Africa Project



Cogen for Africa Project Energy supply for households around the plant















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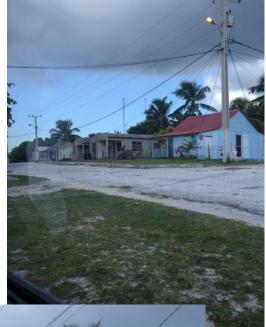
UNIDO/UNEP/GEF Project

Generation and Delivery of Renewable Energy Based Modern Services in Cuba - The case of Isla de la Juventud

Wood gasification for power production



Source: S. Coelho, Project Technical Reviewer -2014





UNIDO/UNEP/GEF Project

Generation and Delivery of Renewable Energy Based Modern Services in Cuba - The case of Isla de la Juventud

Cocodrillo Power Plant – Isla de la Juventud

Wood fixed bed gasifier

- 50 kW installed
- Indian Institute of Science (India)
- Different types of wood
- Local grid small community



Source: S. Coelho, Project Technical Reviewer - 2014



UNIDO/UNEP/GEF Project

Generation and Delivery of Renewable Energy Based Modern Services in Cuba - The case of Isla de la Juventud

La Melvis Power Plant – Nueva Gerona - Isla de la Juventud

Wood fixed bed gasifier

- 2 x 250 kW
- Ankur (India)
- Different types of wood
- Local main grid



Source: S. Coelho, Project Technical Reviewer - 2014

















CENBIO – PPGE/IEE/University of Sao Paulo

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