Humboldt-Universität zu Berlin (HU Berlin)

FEAUSP FAUUSP

IEE USP INSTITUTO DE ENERGIA E AMBIENTE UNIVERSIDADE DE SÃO PAULO

iri

USP Universidade de Sao Paulo (USP)

USP CONFERÊNCIAS

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

CENBIO

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

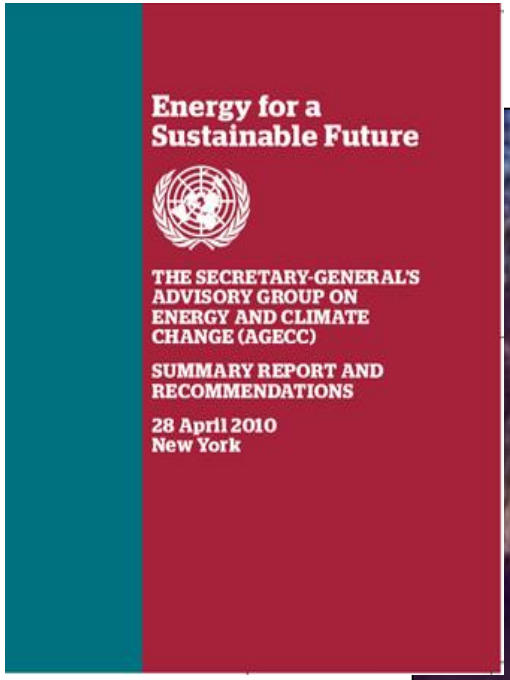
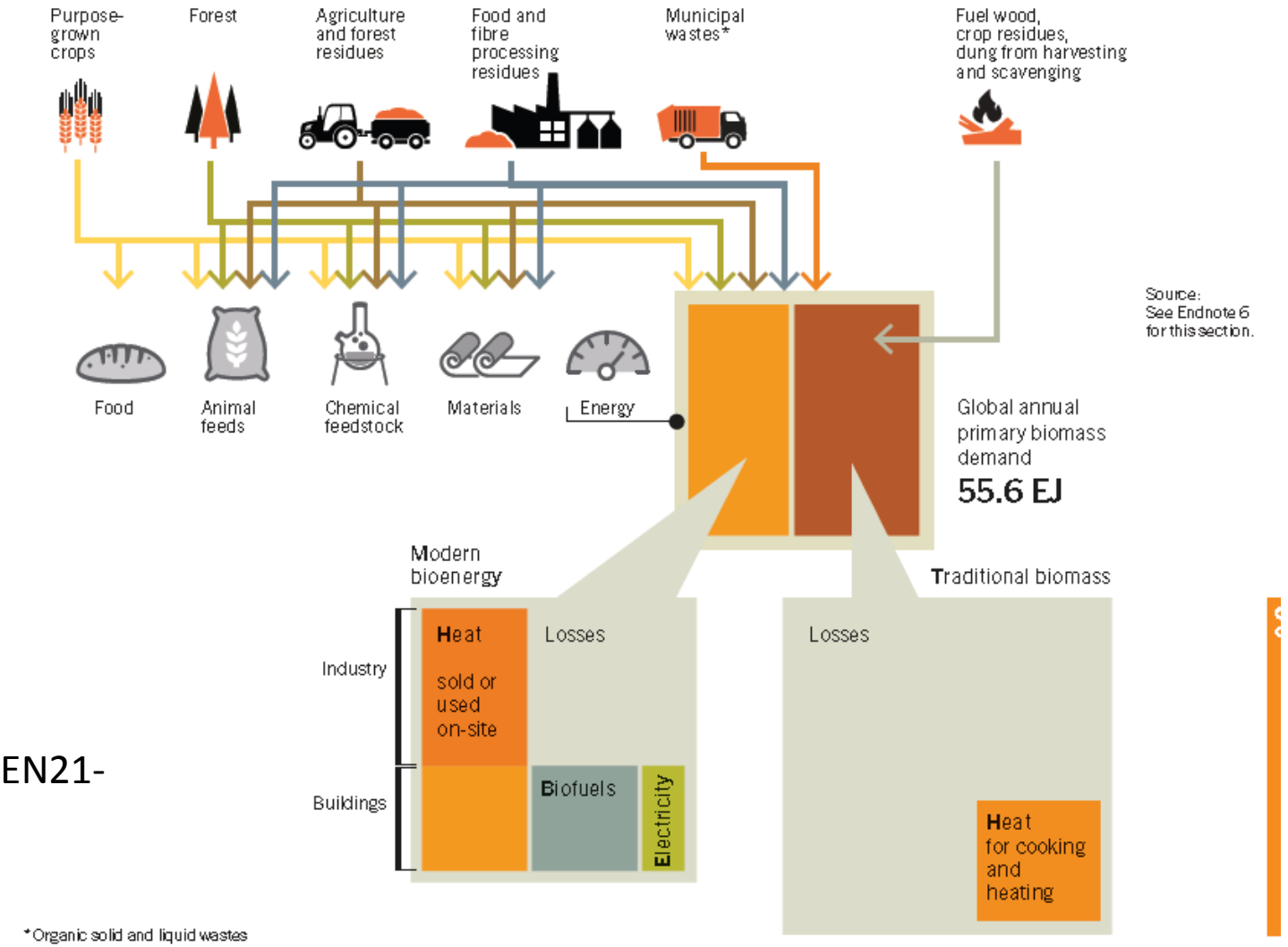


Figure 5. Biomass Resources and Energy Pathways



Source: REN21-2014

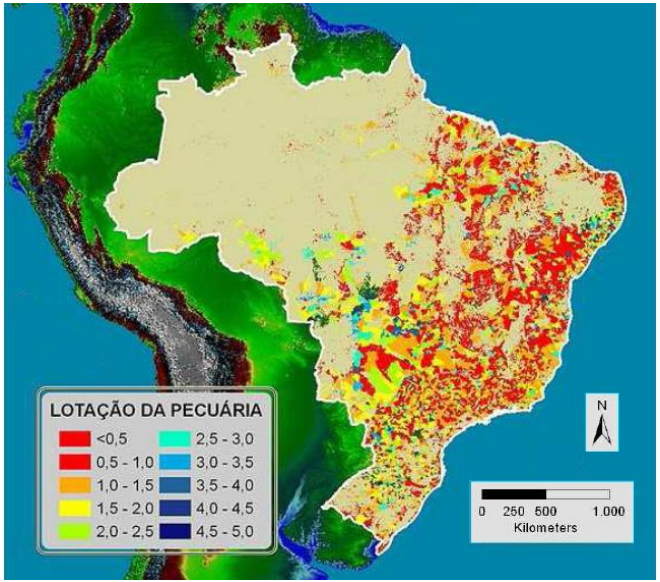
General overview

- 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



EU BC&E 2014
22nd European Biomass Conference and Exhibition
CCH - Congress Center Hamburg, Germany
23 - 26 June 2014

PERSPECTIVES FOR SUSTAINABLE WOOD PELLETS PRODUCTION IN BRAZIL

Javier F. Escobar, Suani T. Coelho, Uwe R. Fritsche, Laire Iriarte
Institute of Energy and Environment, University of São Paulo, Brazil
IINAS-International Institute for Sustainability Analysis and Strategy, Germany

Abstract

Brazil is a country with several advantages to act as a leader in agro-industrial and silviculture sectors, particularly those dedicated 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 climate conditions, making it the country's largest gathering of quantitative comparative advantages to lead the sustainable production and use of biomass energy on a large scale, without competition with other crops such as food crops.

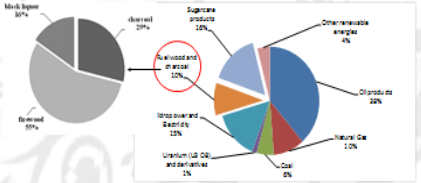
Introduction

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 country.
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.[1][2]

Wood participation in primary energy supply - Brazil

Source	Mtoe 2012
RENEWABLE	120,2
Hydropower and electricity	39,2
Sugar cane biomass	43,6
Fuelwood, Charcoal and Liquor	30,4
other renewable	7,1
NON-RENEWABLE	167,4
oil	111,2
natural gas	32,6
coal	15,3
Uranium (U3O8)	4,2

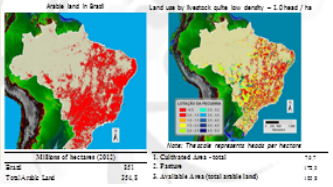
Source: Adapted from BEN (2012)



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 & Materials

According to this study, from these 70 million ha, it is predicted that 10 million would be occupied by soybean and other grains, 5 million to meet family farmers needs and 25 million for crops for energy purposes (sugar cane, oil palm, elephant grass, etc.). From this perspective, there are still 30 million ha subject to occupation with other cultures, for example, forest plantation, which has seven million tonnes to meet the productive wood sectors of the country. If successful in institutional advancements, we can expect Brazil to accelerate the sustainable expansion of forest plantations, reaching an average growth of 1 million ha/year. In fact it must be considered that there is still a high deficit of forest plantations to supply (charcoal + ceramic industry) in a sustainable way.

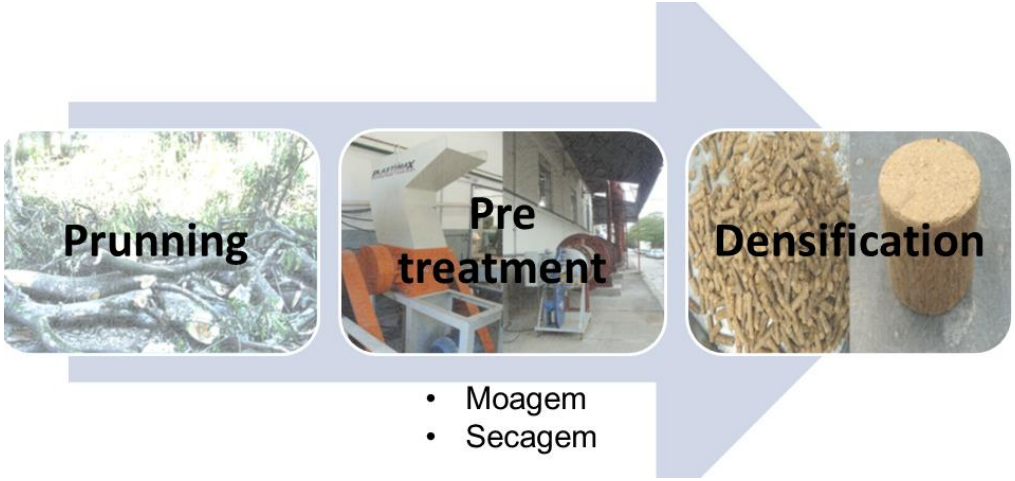


Wood Pellets

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

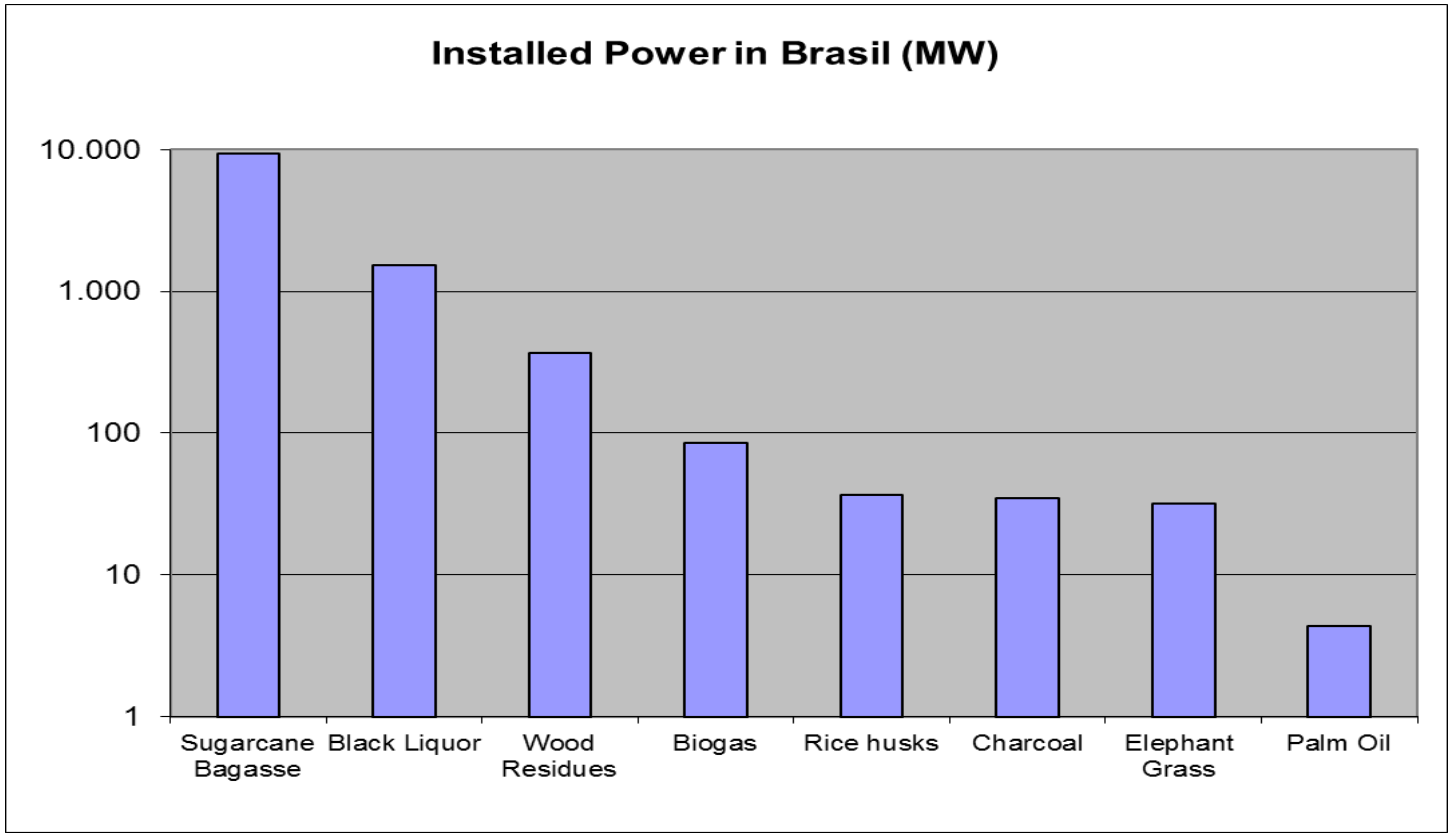
Objective:

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



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)

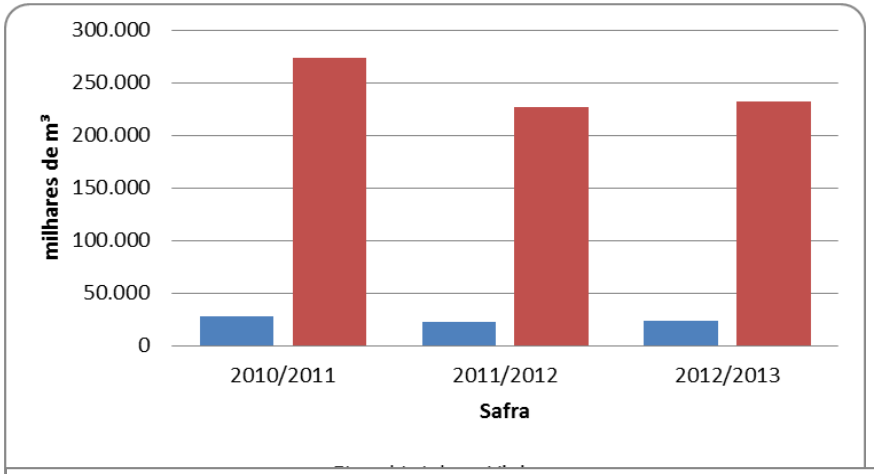
Brazilian Amazon
Aquidaban village

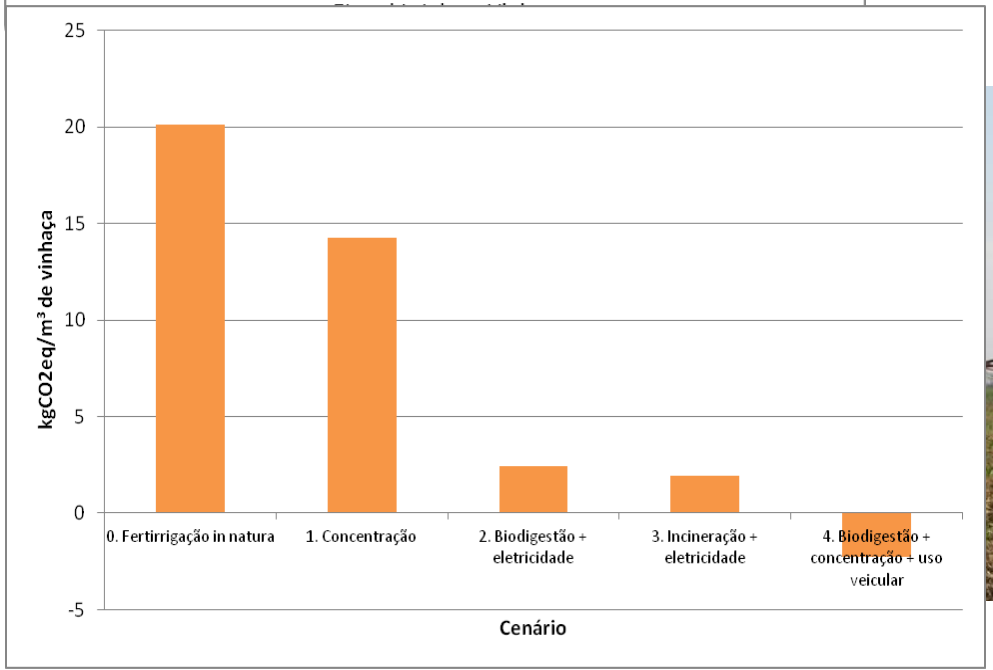
- 700 people - 180 households;
- Cupuassu crops 100 ha;
- Before the power plant - cupuassu fruits sold *in natura* (low added value)
- Need to improve economic activities
- 20 kWe installed power for freezing systems
- Agricultural residues: cupuassu husks

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

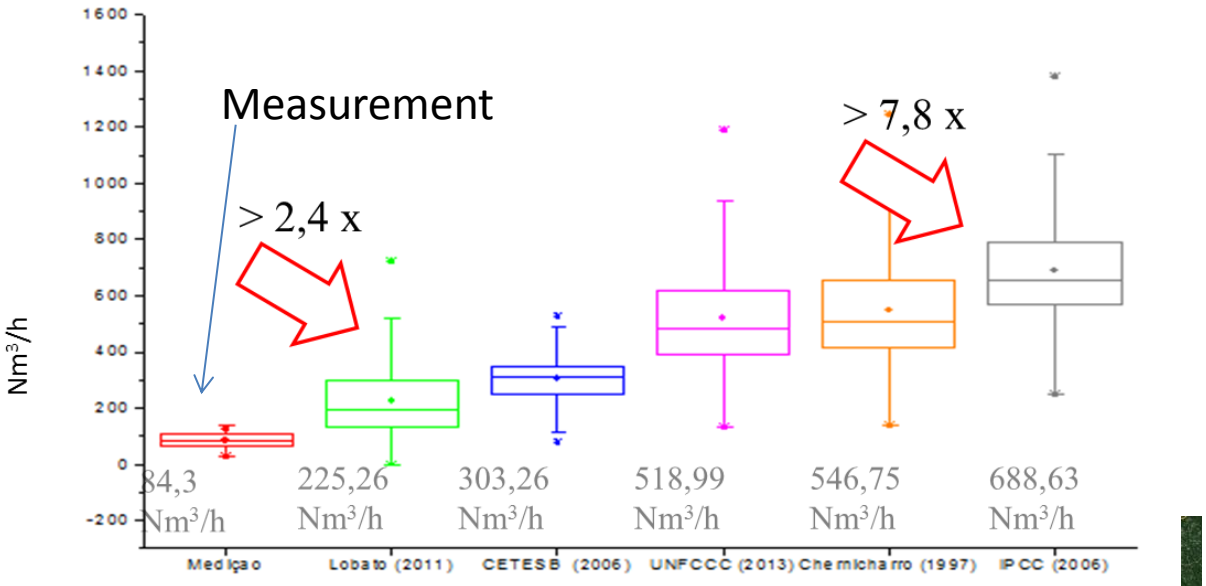
Biogas-fired Microturbine – Biogas from Sewage Treatment at SABESP Sewage Treatment Station, São Paulo (first one in LA) – Master thesis (D.F. Costa)

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 real production
Case study: ETE Atuba Sul – Curitiba - Parana

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

Biogas from pig manure

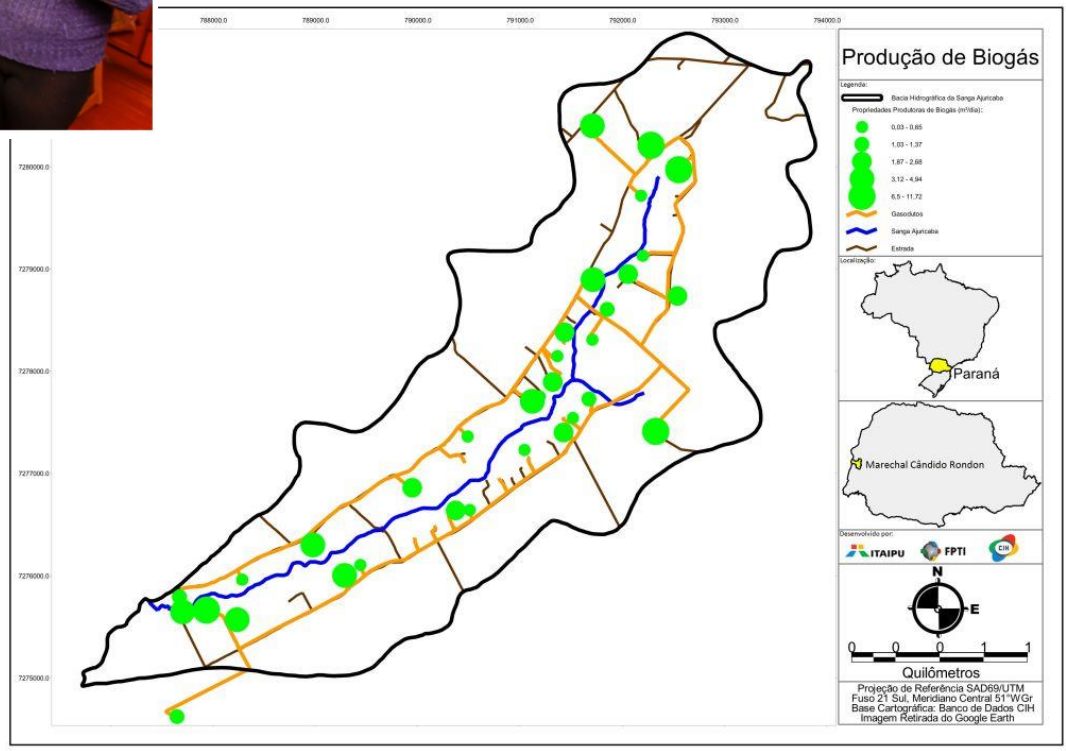
Ajuricaba Agroenergy for Family Farming – Parana State

Itaipu Binational and Municipality of Rondon

International Centre for Renewable Energy - Biogás / CIBiogás-ER

- 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/



National Policy for Solid Residues

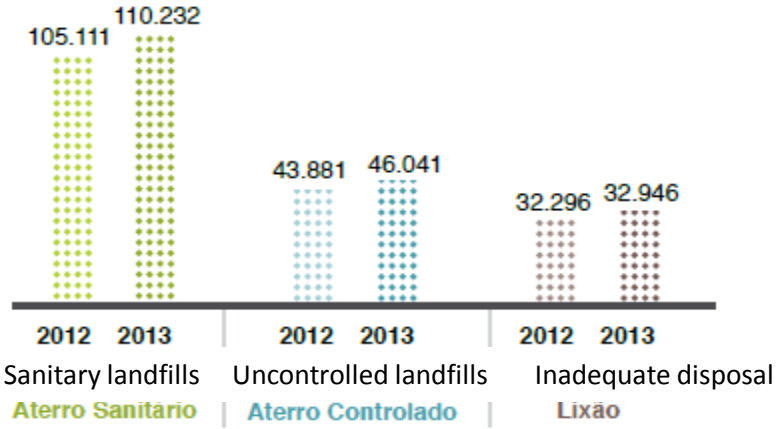
- reutilization
- recycling
- composing
- recovering
- energy conversion

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

FINAL DESTINATION OF USW IN BRAZIL

I.1.4 Destinação Final de RSU

Figura 4.1.4.1 – Destinação final de RSU (t/dia)

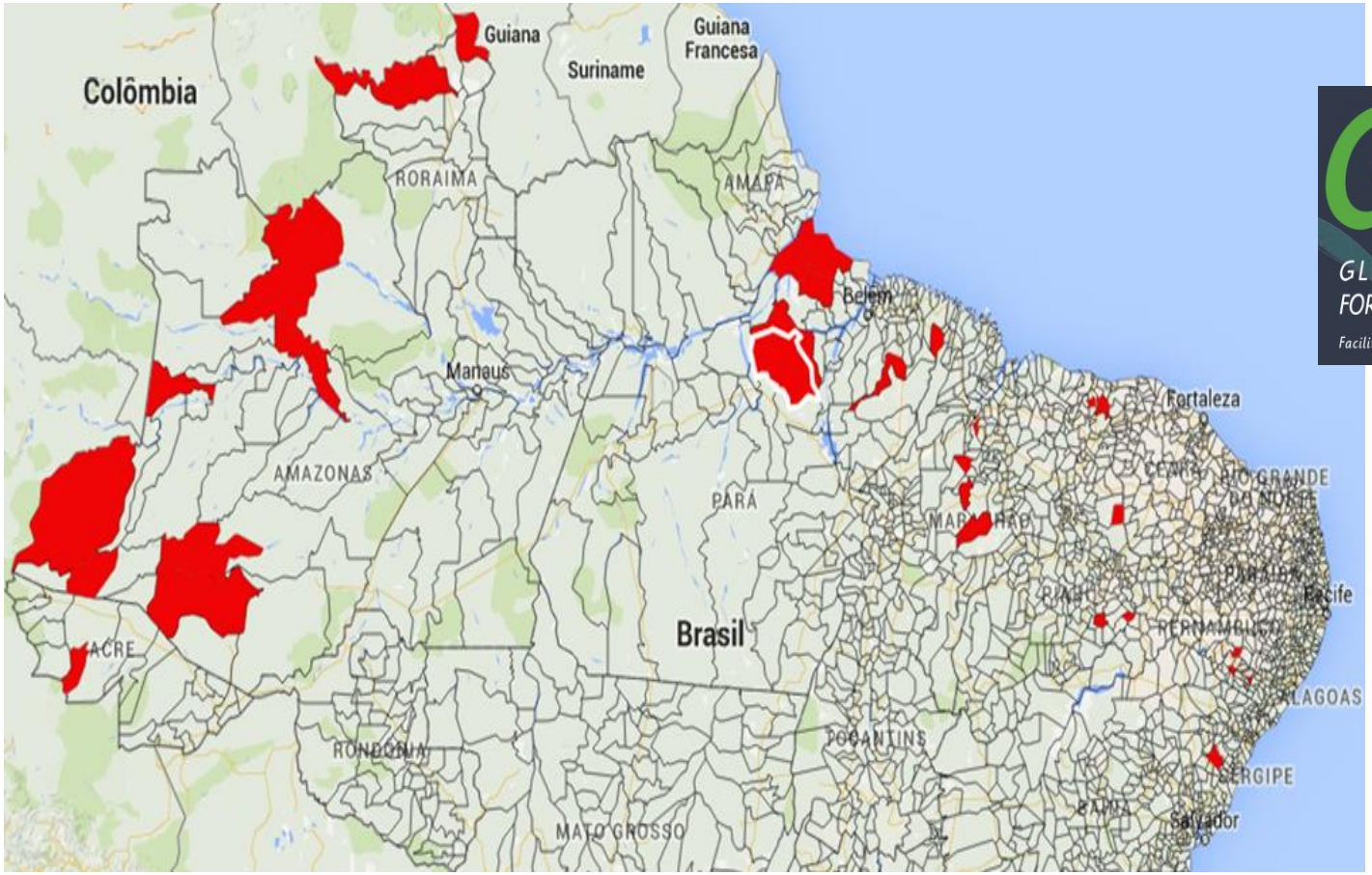


Fonte: Pesquisa ABRELPE

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

Destinação Final	2013 – Regiões e Brasil					
	Norte	Nordeste	Centro-Oeste	Sudeste	Sul	BRASIL
Sanitary landfills	92	453	161	817	703	2.226
Uncotrolled landfills	111	504	148	645	367	1.775
Inadequate disposal	247	837	158	206	121	1.569
BRASIL	**450**	**1.794**	**467**	**1.668**	**1.191**	**5.570**

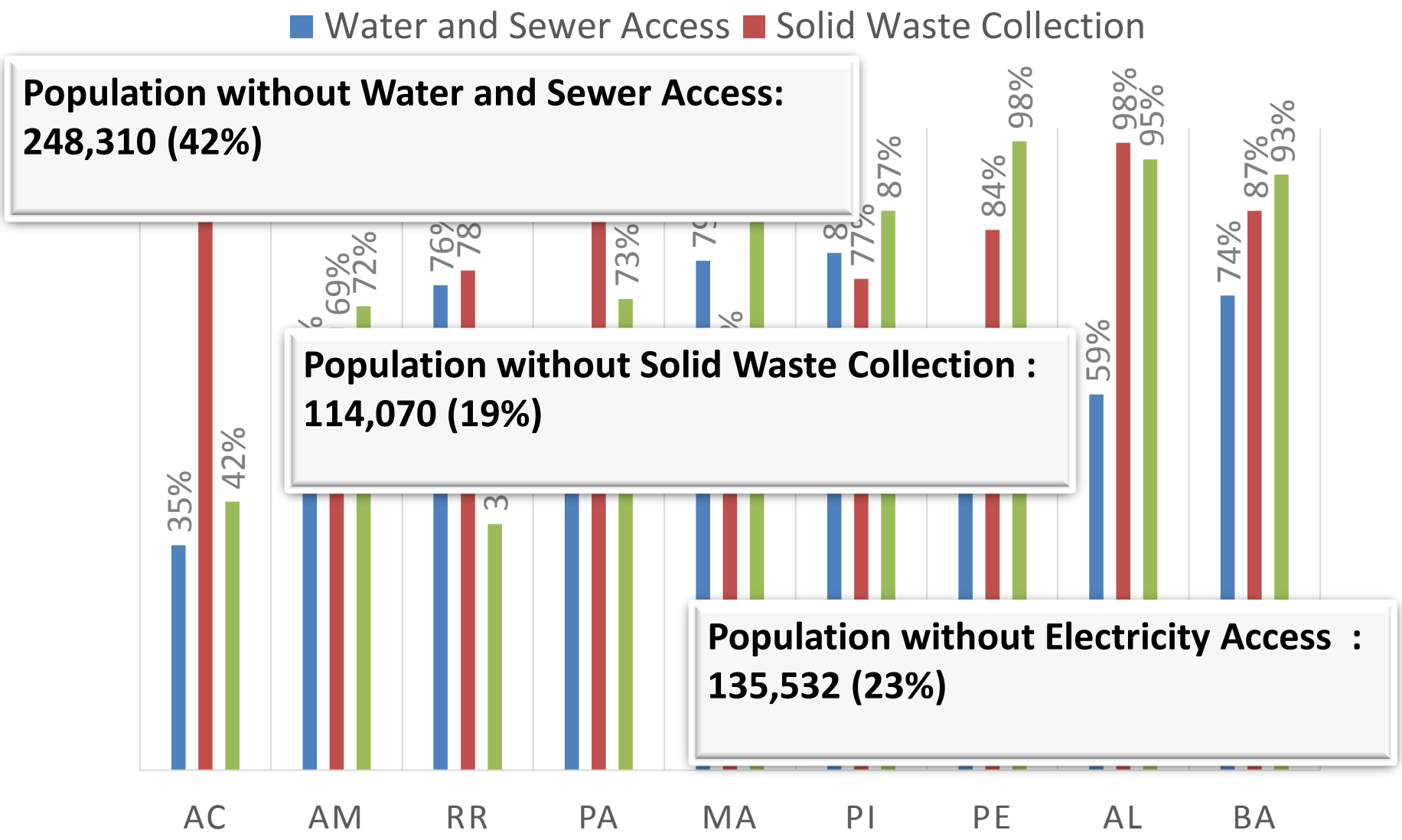
Urban waste x Energy access x HDI in N/NE Brazil



GNESD
GLOBAL NETWORK ON ENERGY FOR SUSTAINABLE DEVELOPMENT
Facilitated by UNEP

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

MARTIN GmbH
für Umwelt- und Energietechnik
seit 1925

Energy from Urban Solid Waste

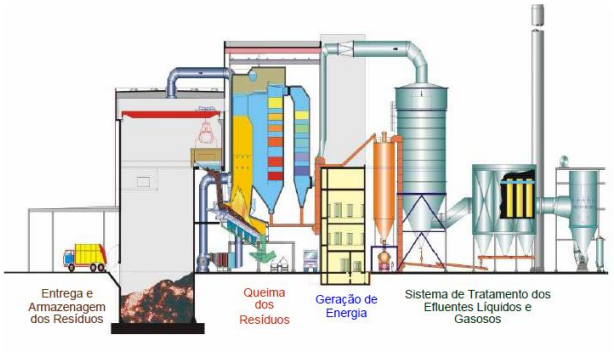
Comparison between Solid Waste Energy Recovery Technologies using Life Cycle Assessment

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

Scenario I – No recycling

Scenario II – Recycling *(catadores)*

Incineration



Landfill

TMB

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

São Joao Landfill – São Paulo

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

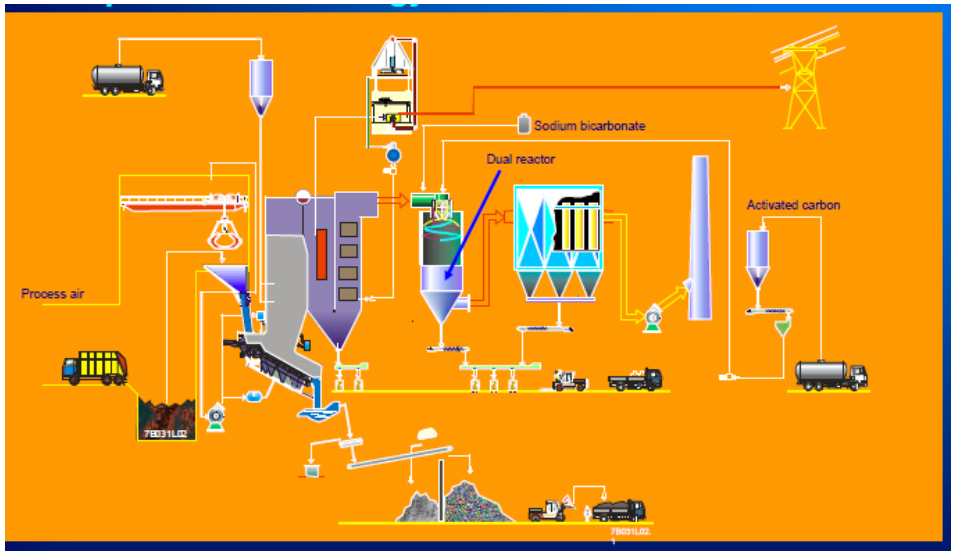
Bandeirantes Landfill – São Paulo

“Baixada Santista”- North Coast- São Paulo State
MSW transportation

EMAE, 2010

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-to-energy 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)

	COT	CO	HCl	HF	SO2	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/Nm^3 , 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

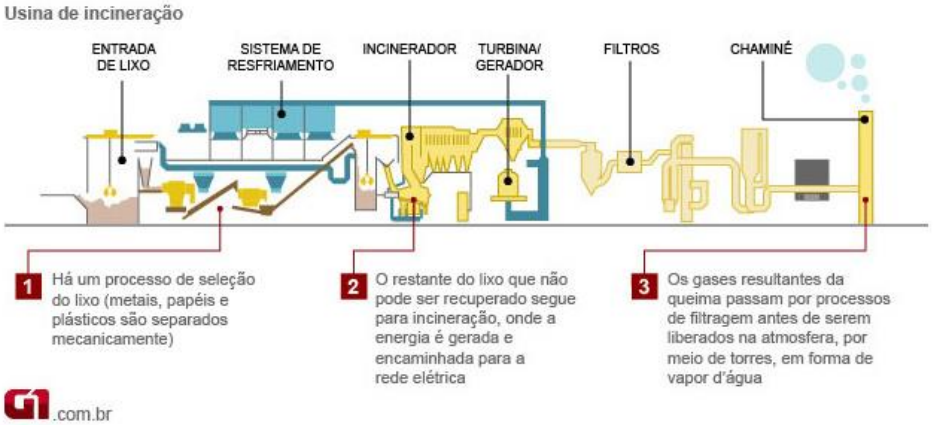
Curtir 201 Compartilhar Tweetar 19 +1 0

A cidade de São Bernardo do Campo receberá a primeira instalação de aproveitamento da incineraçã lixo entre o final de 2015 e o início de 2016. O projeto conta com o orçamento 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 sejam produzidas 11 bilhões de toneladas de lixo diariamente no mundo, e, por conta

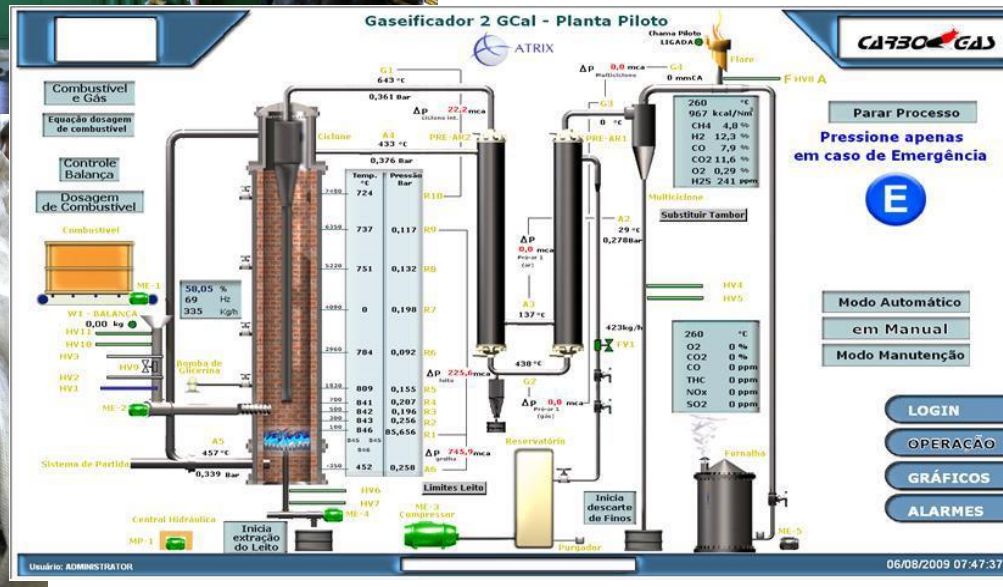
http://ciclovivo.com.br/noticia/sao-bernardo-do-campo-queima-lixo-para-gerar-energia



.com.br

http://jornalggn.com.br/blog/luisnassif/a-termoeletrica-a-lixo-de-sao-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 acordo com o tamanho da população		Número de municípios	Relação ao Total
Pequeno Porte I	até 20 000	4.074	73,26%
Pequeno Porte II	De 20 001 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.

ENERGY CONVERSION FROM USW IN ITANHAEM MUNICIPALITY – SÃO PAULO STATE

MBA thesis – Luiz H. T. G. Miranda

ITANHAEM MUNICIPALITY

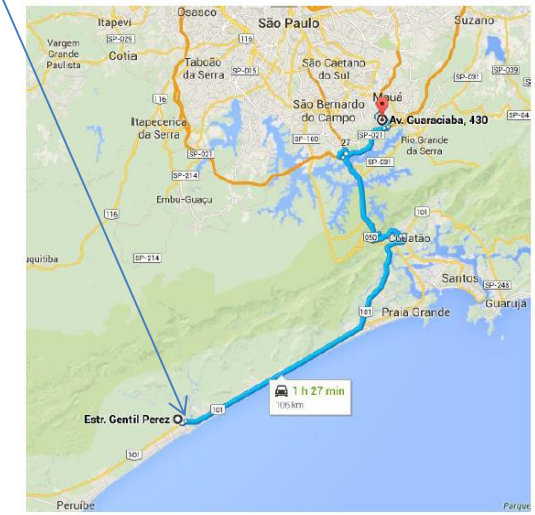


Figura 42 – Trajeto da destinação dos resíduos do município de Itanhaém – SP.

Fonte: Google Mapas.

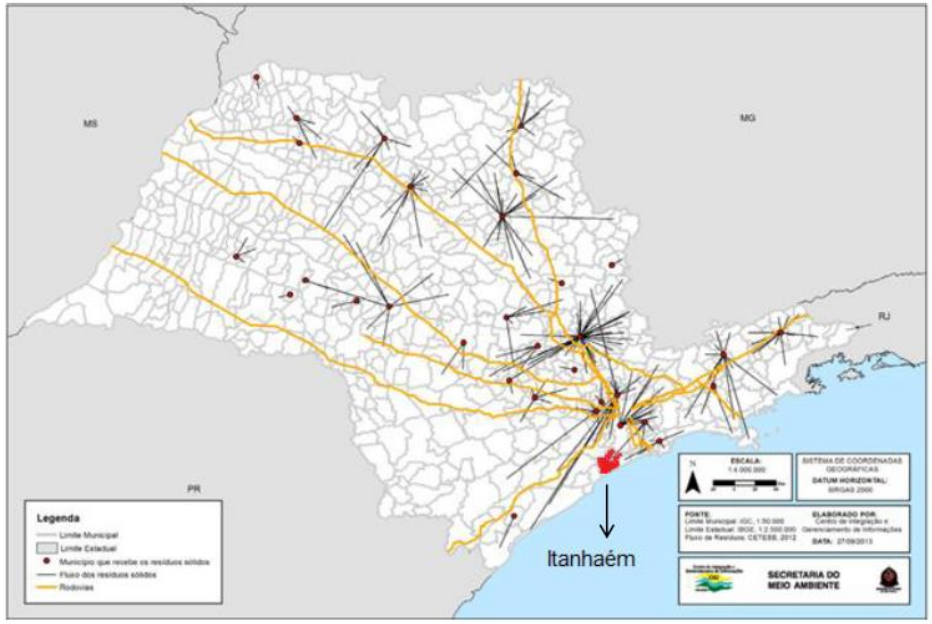


Figura 9 - Mapa de fluxo de resíduos sólidos urbanos no Estado de São Paulo.

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

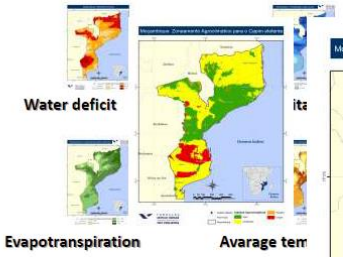
GBEP
Global Bioenergy Partnership

MOZAMBIQUE

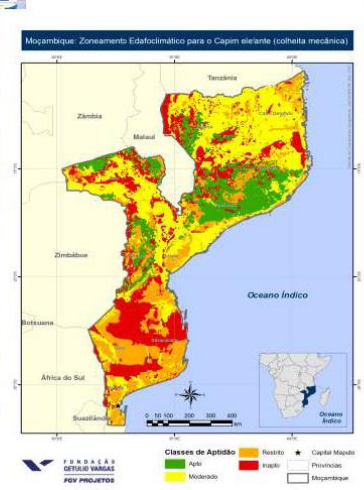
Example - Zoning

VALE FGV PROJETOS

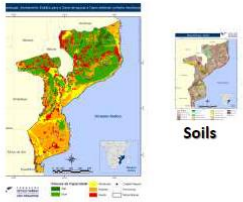
Agroclimatic Zoning



Edaphoclimatic Zoning

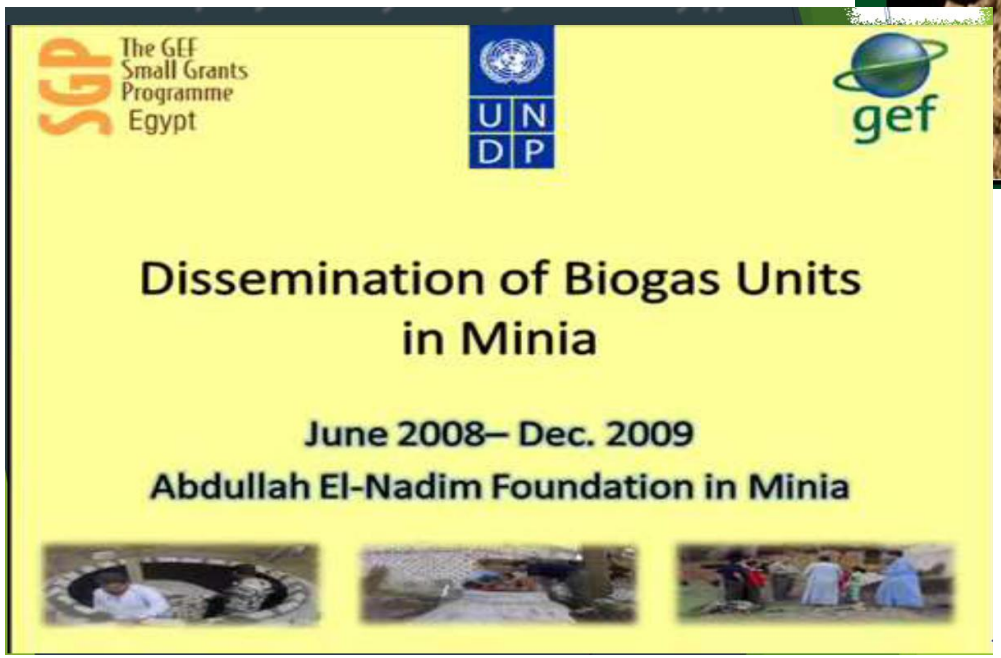


Edaphic Zoning



GBEP
Global Bioenergy Partnership

EGYPT



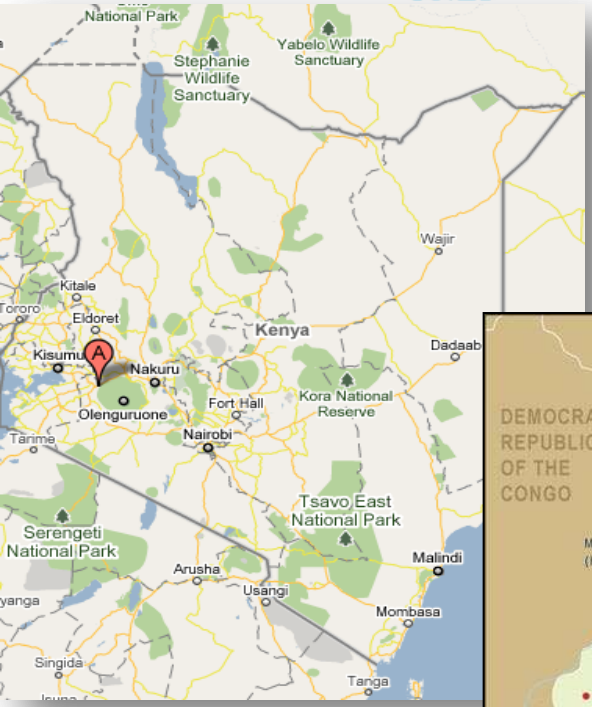
Prof . Dr. Ahmed Abd El-Ati Ahmed
Egypt - GBEP Focal Point

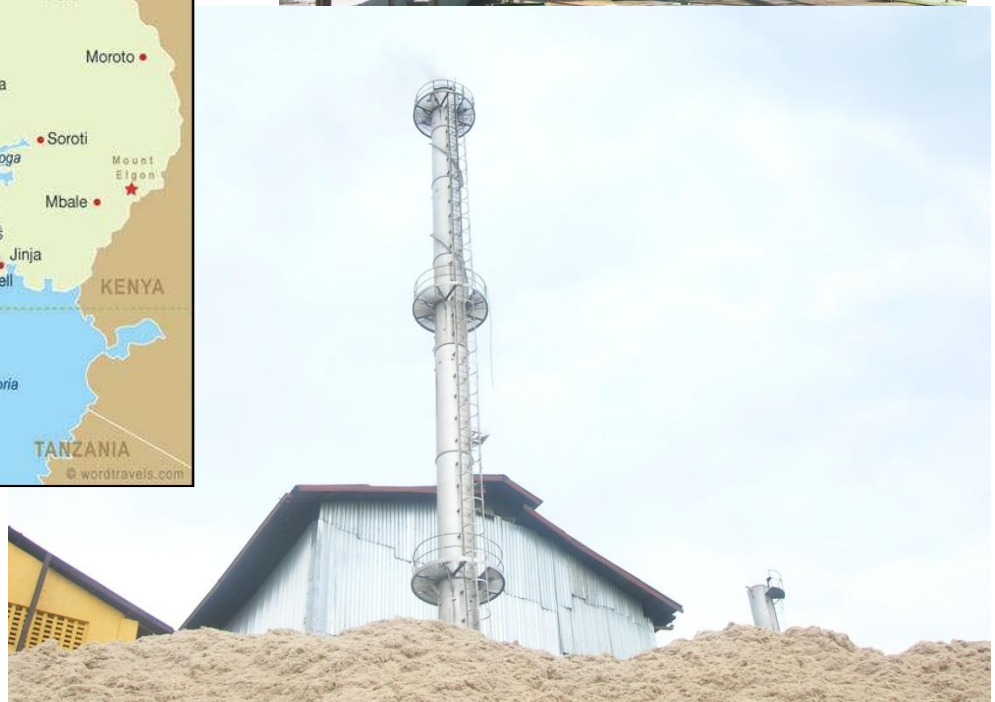
Cogen for Africa Project

UNEP GEF

reeep renewable energy & energy efficiency partnership

AFREPREN/FWD
Energy, Environment and Development Network for Africa





Source: Coelho, S.T., Project Mid Term Reviewer, 2011

Cogen for Africa Project

Energy supply for households around the plant

Source: Coelho, S.T., Project Mid Term Reviewer, 2011

General overview

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

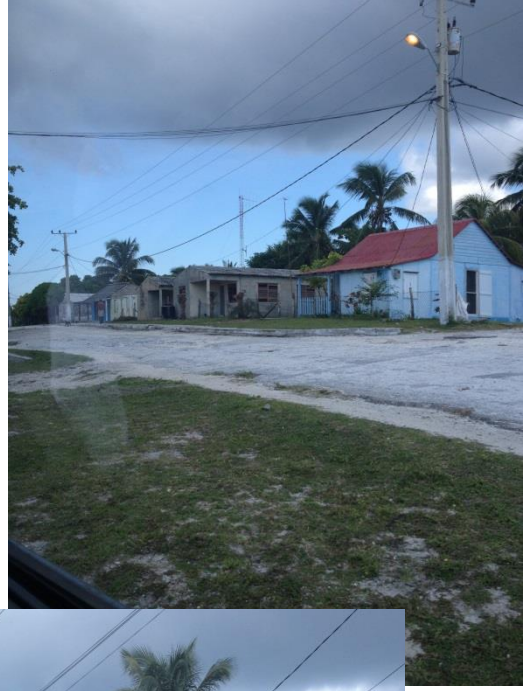
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
www.unido.org

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 UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION www.unido.org

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 UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION www.unido.org

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

10° Congresso
sobre Geração Distribuída e Energia no Meio Rural

GD 2015

09 a 11
de setembro de 2015

Universidade de São Paulo (USP)
São Paulo - Brasil

AGRENER

Informações: secretaria.agrener@workoutenergy.com.br
Tel.: +55 (11) 5531- 0847 (Cristina) - +55 (11) 3091-2652 (CENBIO)

Realização / Promoção

USP 80 1834 2014

IEE USP INSTITUTO DE ENERGIA E AMBIENTE UNIVERSIDADE DE SÃO PAULO

PPGE – PROGRAMA DE PÓS GRADUALÇÃO EM ENERGIA

CENBIO

Apoiadores

Biomassa BR energias renováveis

JORNAL BIOMASSA BR

Thanks !
Danke!
Obrigada!

CENBIO – PPGE/IEE/University of Sao Paulo

(suani@iee.usp.br)