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COGENERATION OF ELECTRICAL AND THERMAL ENERGY FROM BIOGAS IN WASTEWATER TREATMENT PLANTS
THE CASE OF BRAZIL

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Brazil and Latin America

Brazil

Area: 8,6 million km^2
Population: 187 million
Water Supply: ~ 95% *
Sewerage: ~ 51% *
Wastewater treatment: ~ 35% **

- * % of the urban population
- ** % of the sewer system = ~17% of the urban pop.

Sanitation in Brazil

Population →	Total - %	Urban - %
Water Supply	81.2	94.7
Sewerage	43.2	50.6
Wastewater Treatment		34.6 *

(*) = 17% of the urban pop., SNIS, 2008

Infant Mortality – Year 2010

Wealthy countries	Developing countries	Very poor countries
- Sweden - 2.7	- Cuba - - - - 5.2	-Chade - - 114.4
- Japan - - - 2.7	- Chile - - - - 6.5	- G.Bissau 158.6
- Italy - - - - 3.3	-Argentina -12.8	- Mali - - - 161.0
- Norway - - 3.4	- China - - - 15.4	- Nigeria - 168.7
- France - - 3.8	- Colombia- 15.3	- Angola - 180.2
- UK - - - - - - 5.3	- Mexico - - 16.5	
- USA - - - - 6.7	- Brazil - - - 19.9	

Health & Sanitation

Year	Infant Mortality in Brazil
1970	120,7 /1000 born, under 1 year old
1990	52,0
2010	19,9

- Brazil should meet the millenium goal

The Urban Challenge

Materials

Food

Energy

Water

Chemicals

Wastewater

Emissions CO_2 NO_x SO_2

Solid Wastes

The Urban Challenge

Materials

Food

Energy

Water

Chemicals

Wastewater

Emissions CO_2 NO_x SO_2

Solid Wastes

Recycle - Reuse – Treat

The Urban Challenge

Materials

Food

Energy

Water

Chemicals

Wastewater

Emissions CO_2 NO_x SO_2

Solid Wastes

Recycle - Reuse – Treat – Recover Energy

Challenge – Wastewater Treatment

- Enormous advancement in wastewater technology in Brazil
- Economical processes for wastewater treatment have been well stablished
- There is a good Brazilian experience with new and applicable technology
- How experts, federal and state agencies are facing the question ?

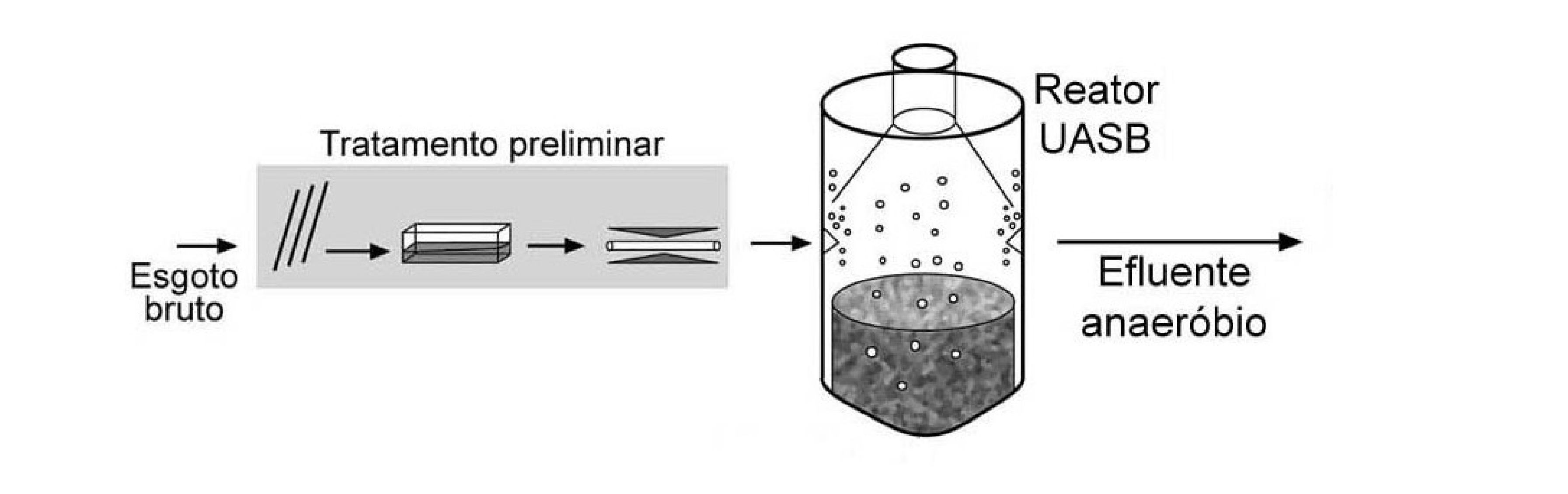
Investigation & Research Funding Water Utilities

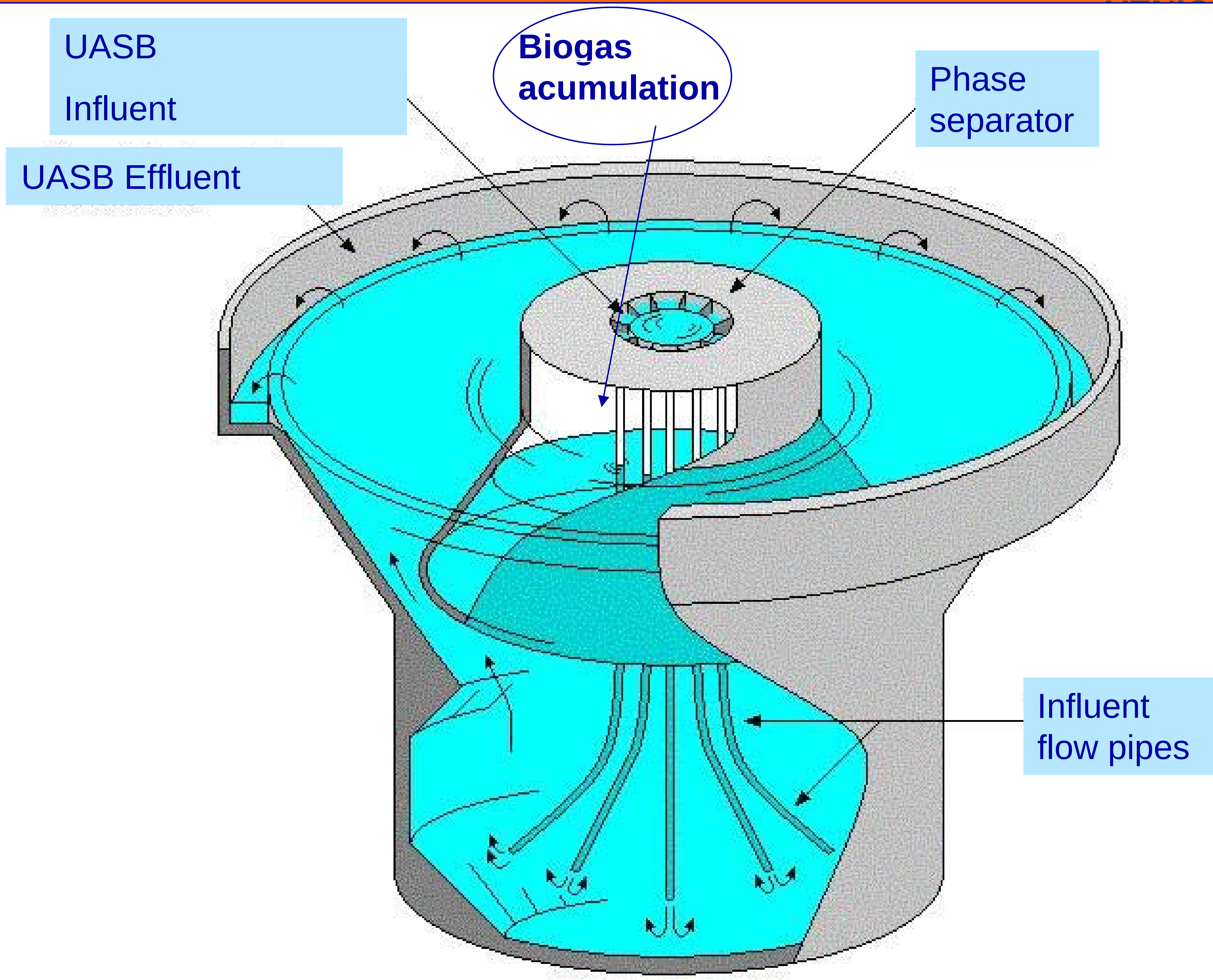
- ✓FINEP, a governmental organization, under Ministry of Science and Tecnlogy;
- ✓Has been financing a special research program on wastewater treatment since 1996; specially on anaerobic processes;
- ✓15 universities form the research network

Wastewater Treatment Research Center, UFRJ

UASB = Upflow Anaerobic Sludge Blanket Reactor

One of the new economical processes developed for WWTP.



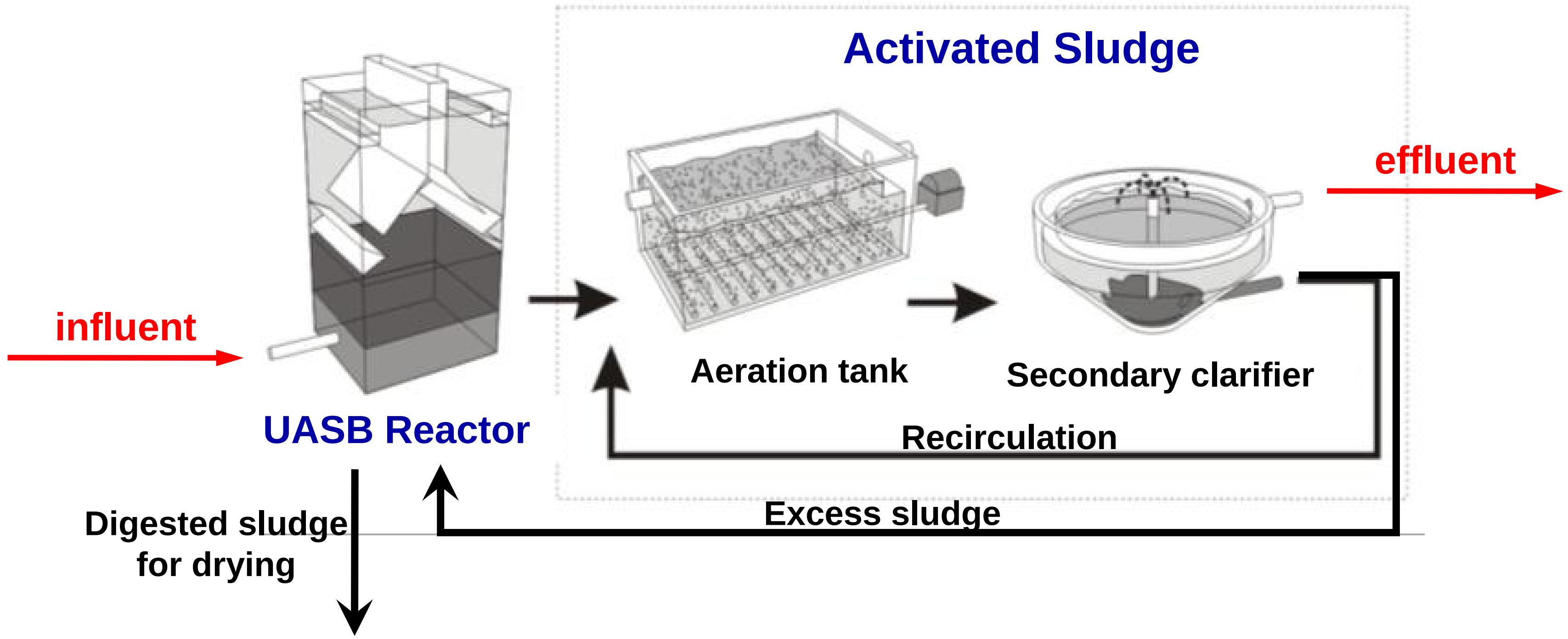

UASB
Influent
Biogas acumulation
Phase separator
UASB Effluent
Influent flow pipes

UASB

- **compact system, using a small surface area;**
- ✓ **practically no equipment in the anaerobic process, with low construction and operational costs;**
- ✓ **very low energy consumption;**
- ✓ **low excess sludge produced;**

- ✓ **INTENSE BIOGAS PRODUCTION.**

UASB + Activated Sludge

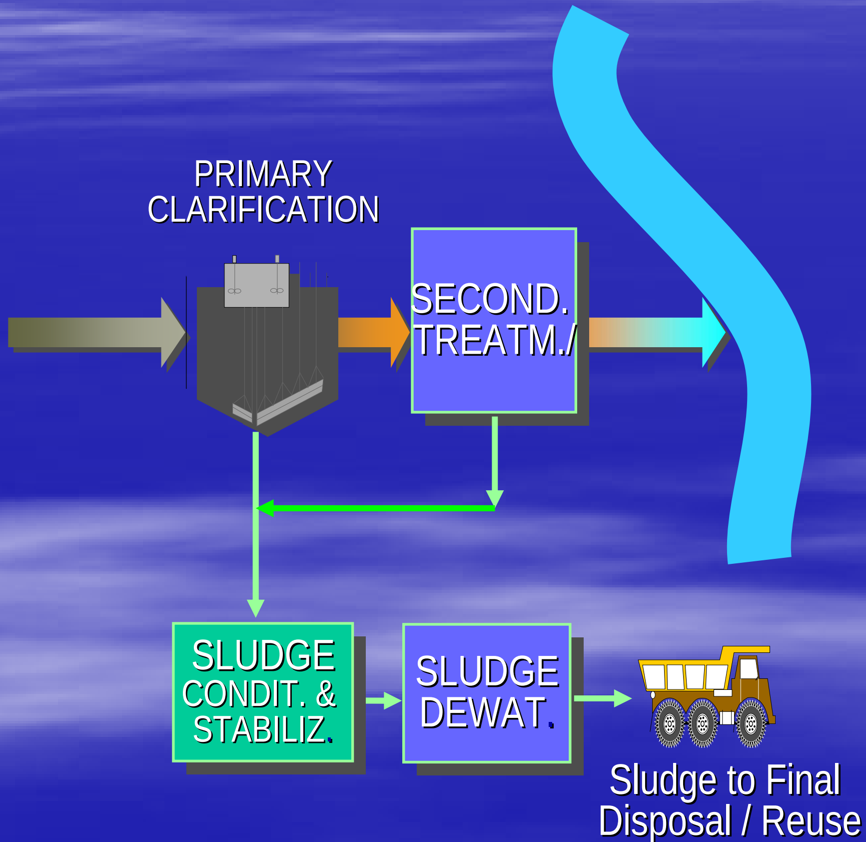


UASB Reactors + Postreatment

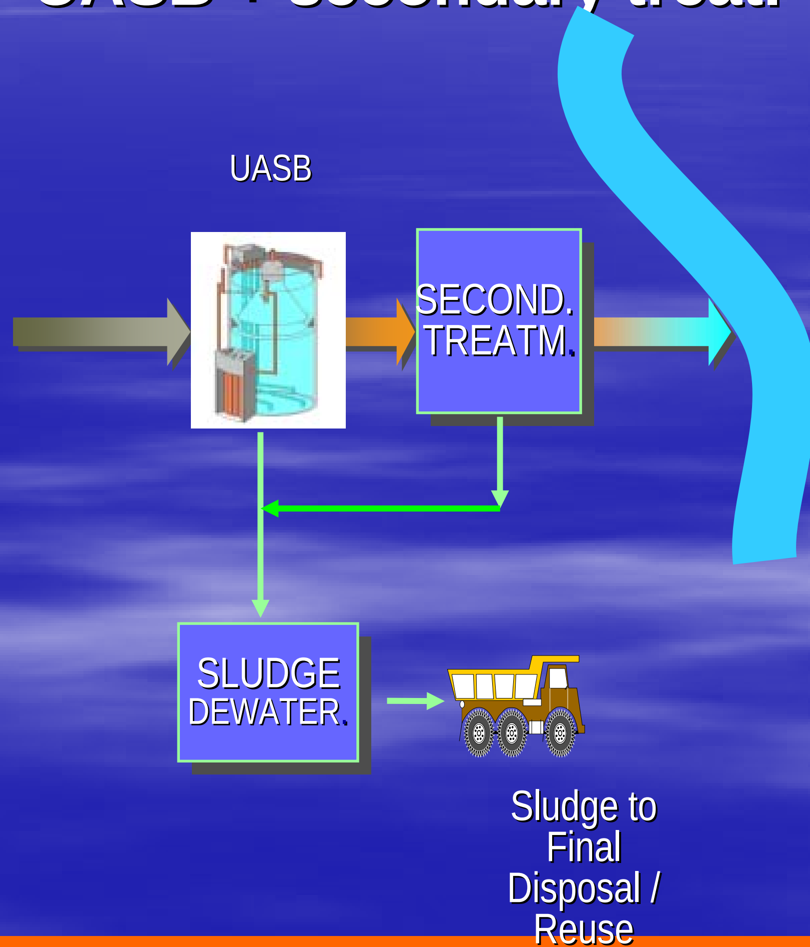
Possibility of Energy Recovery from the Biogas produced

A new design

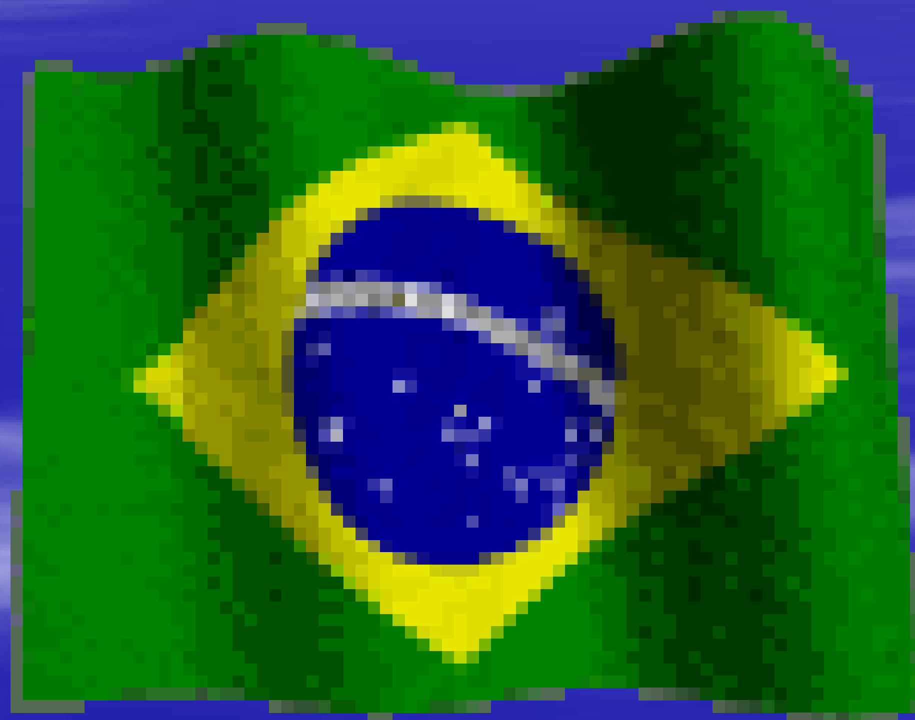
Clarifiers + second. treat.



UASB + secondary treat.



UASB IN BRAZIL



S.Jorge WWTP – Alm. Tamandaré 20,000 inhab.

Cambuí WWTP - Campo Largo, 30,000

Barreto WWTP – Niterói, 60,000

Rio das Ostras WWTP – 150,000

Sul WWTP – Londrina, 225,000

Piçarrão WWTP – Campinas, 250,000

Gama WWTP – Brasília, 300,000

Atuba Sul WWTP – Curitiba - 580,000

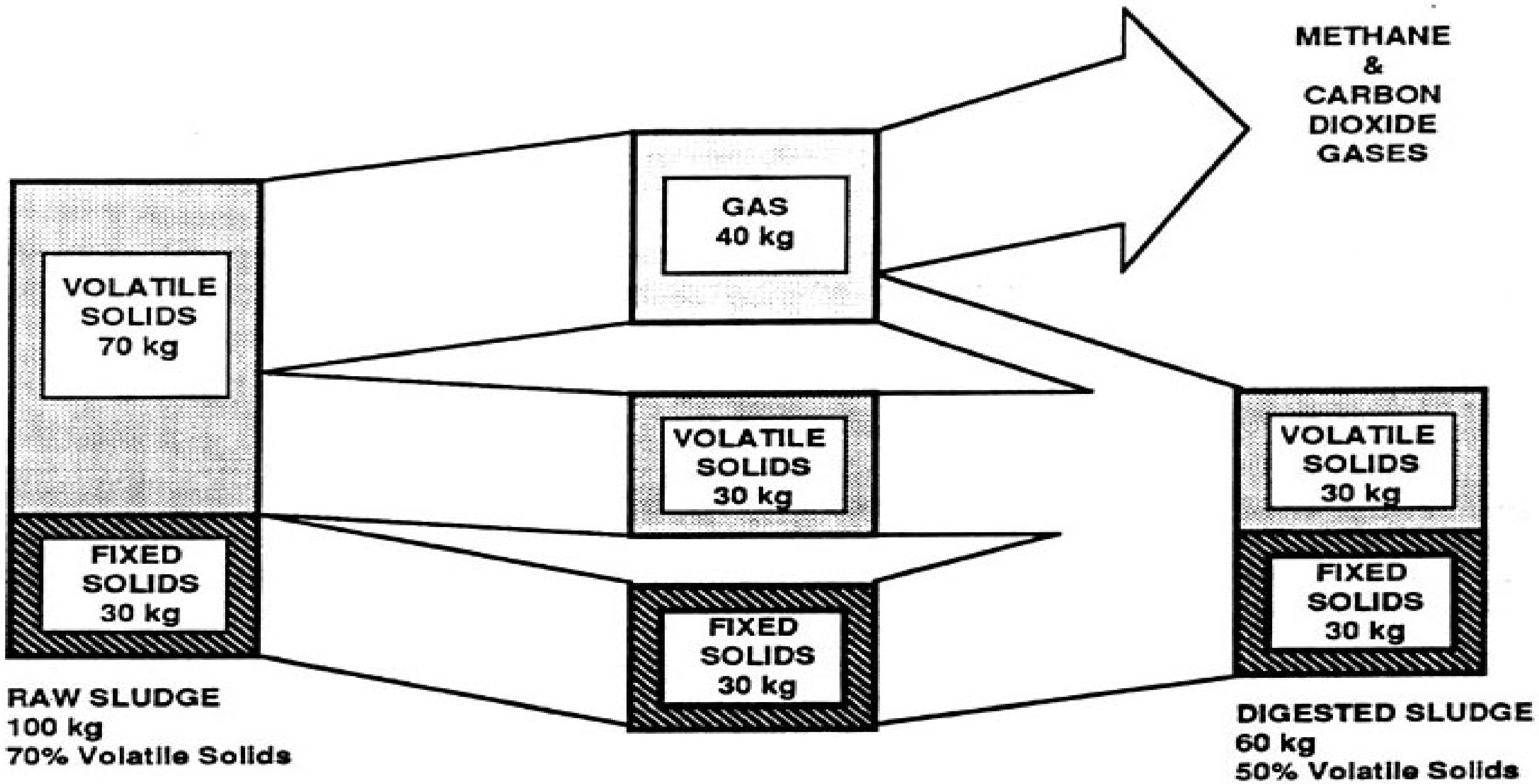
Onça WWTP – Belo Horizonte 1,500,000

Yes – we can !

- We can afford adjusting our technology for our own conditions
- We can afford buiding cost-effective WWTP
- We can win the challenge of poverty, of public health, of water management, of environmental protection
- We can produce biosolids for agriculture
- We can recover energy from our WWTP
- We can manage a sustainable sanitation program

Burning gas x Energy recovery

Conversion of Volatile Solids into Methane Gas



Energy Recovery

Gás	Heat Power, kJ/m^3
Propane (comercial)	45,800
Butane (comercial)	44,600
Natural gas	37,300
Methane	35,800
Digestion gas (*)	22,400

(*) For 65% methane in the biogas

Energy Recovery

- Heat power (biogas) = 22,400 kJ/m^3
- 5 to 20 L gas/person.day (conv. plant)

- For a 200,000 people Conv. Plant (*):
  - 0.020 x 200,000 = 2,000 m^3 biogas/day
  - 2,000 x 22,400 = 4.5 x 10^7 kJ/d = 1.6 x 10^{10} kJ/y

  = 4.6 x 10^6 kWh/y

(*) with the maximum gas production

Energy consumption at the WWTP

Typical WWTP uses ~ 1,200 kWh/MG treated

- Aeration = 52%
- Solids processing =30%
- Influent pumping = 12%
- Internal recycle pumping = 3%
- Nutrient removal generally increases overall energy costs

Energy consumption at the WWTP

- 200,000 people
- X 40 gal/hab.d = 8 MGD = 2,920 MGY
- Consumption Rate ~ 1,200 kWh/MG treated
- Energy Use~ 2920 x 1200 = 3.5 x 10^6 kWh/y
- Production, max.gas rate ~ 4.6 x 10^6 kWh/y
- Production, avg.gas rate ~ 2.3 x 10^6 kWh/y
- Production, min.gas rate ~ 1.2 x 10^6 kWh/y

Does it pay off ???

- Costs of
  - Investiments (Equipments & Construction)
  - Energy (Demand & Consumption)
- Feasibility
- Plant flow, local aspects

Energy recovery at conventional WWTP

- Electrical energy
- Thermal energy
- Heat exchangers
- Fuel for thermal sludge driers

San Fernando WWTP
Medellin, Colombia

San Fernando WWTP, energy recovery

Energy from biogás 2,081 kWh/h

Energy for other equipments 510 kWh/h

Eléctrical energy generated 710 kWh/h

Thermal energy generated 661 kWh/h

Lost 414 kWh/h

Used 247 kWh/h

Equipment Operatión 200 kWh/h

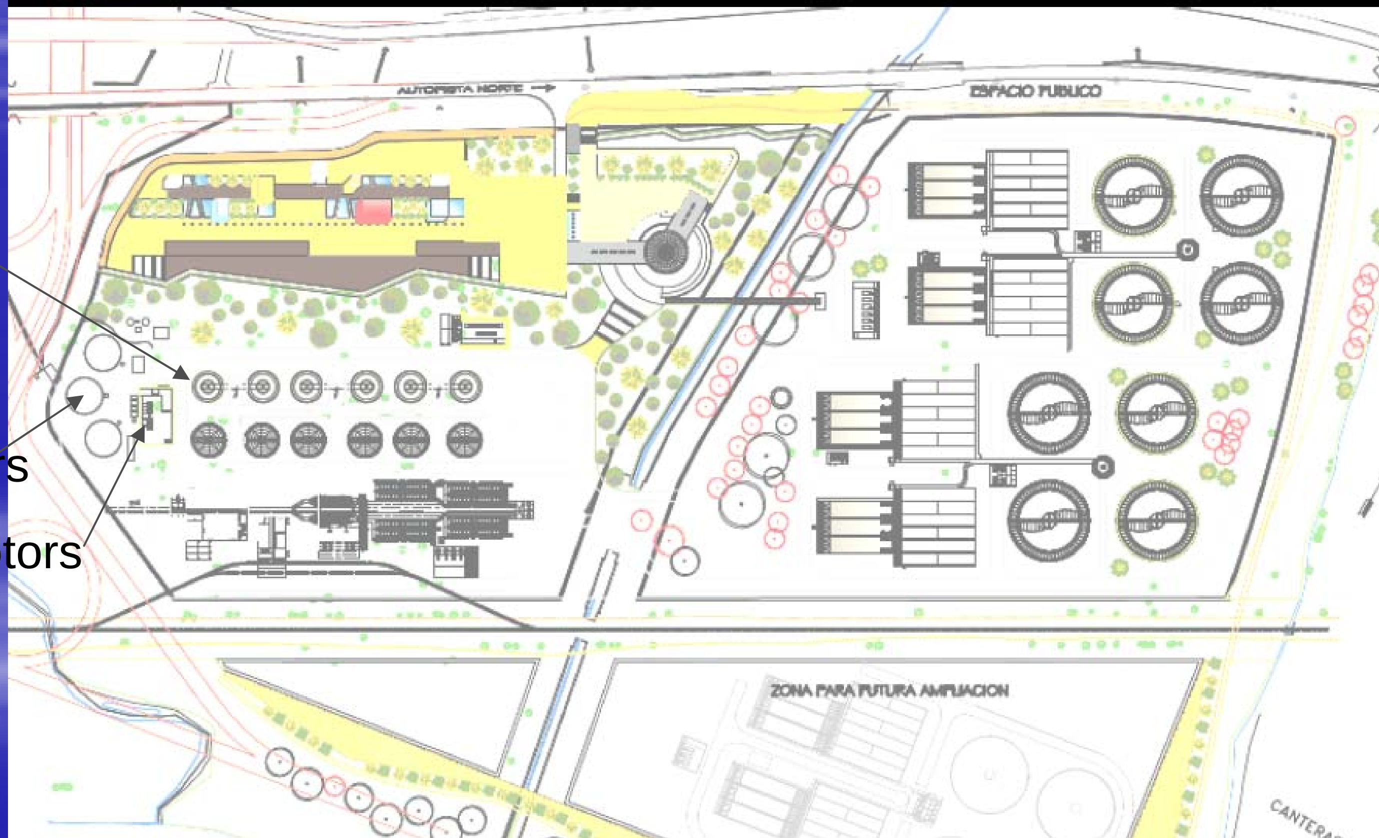
Along the 7 first years of operation the San Fernando WWTP produced 25,000,000 m^3 biogás (65% CH_4 y 33% CO_2), or 52,000 ton CO_2 e/year

Bello WWTP, Medellin, Colombia

Digestors

Gas holders

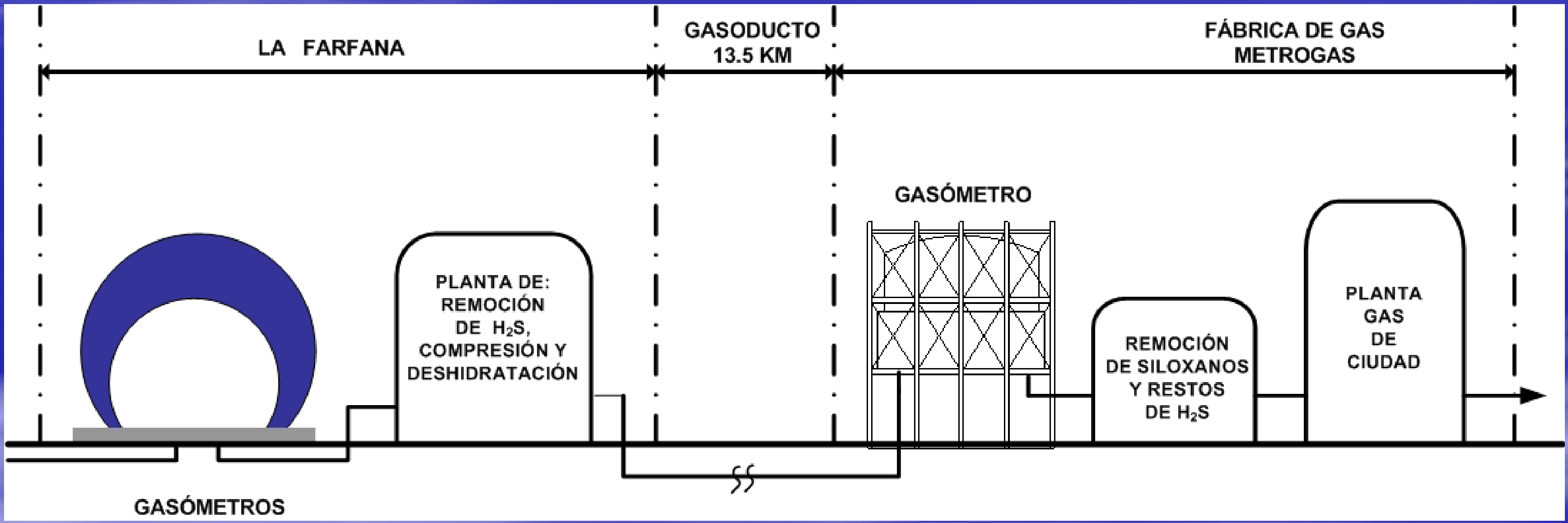
Energy motors



Huge experience in Chile

- La Farfana , 9 m^3/s
- Santiago, Chile
- 30 – 40 MM^3/year
- Energy for the plant
- Heat for digestors
- Gas to the city Metrogas Company

Metrogas - La Farfana project (US$ 5 million)

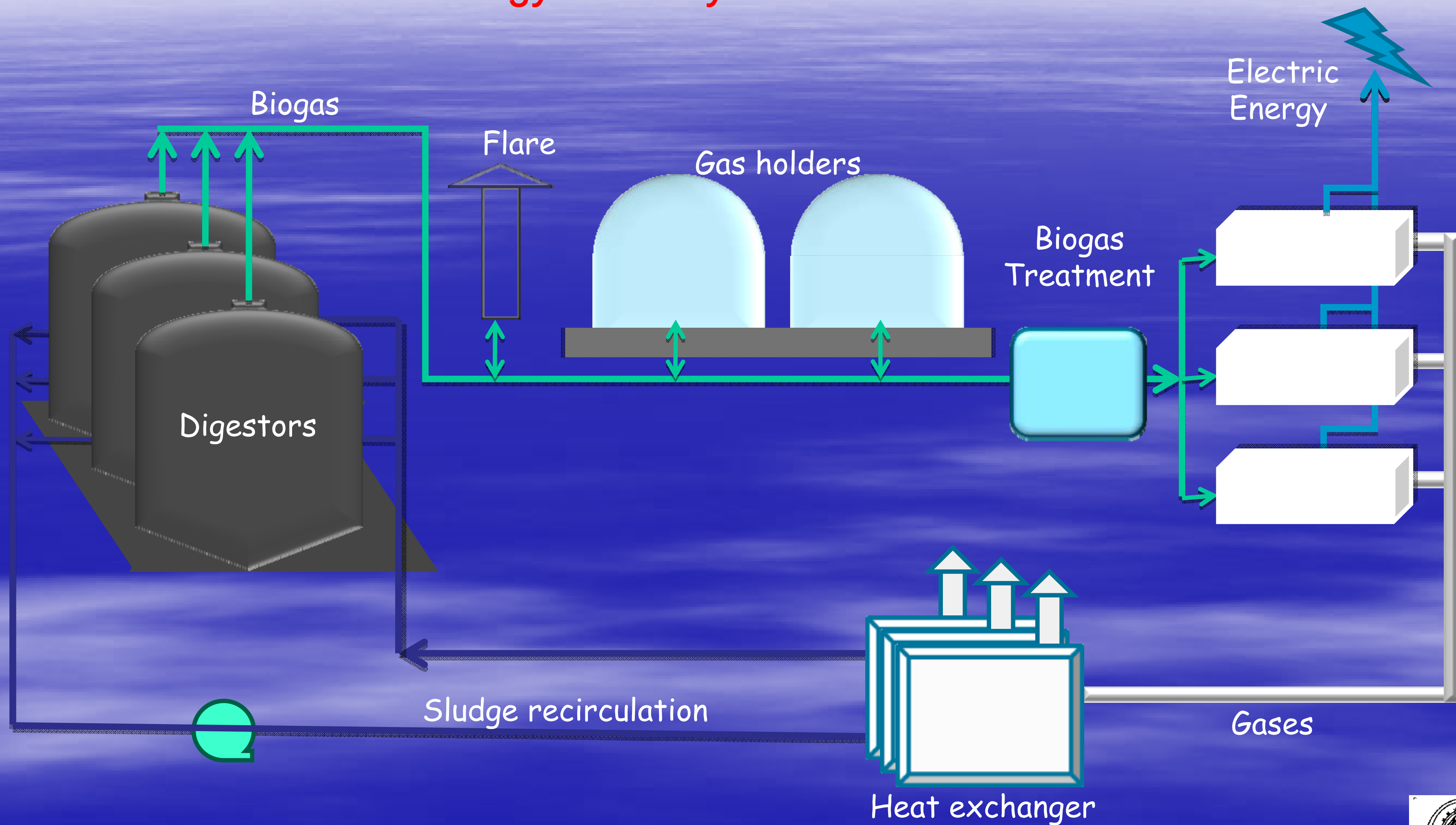


Energy recovery: from UASB reactors and from convencional WWTP digestors

- Arrudas WWTP, Belo Horizonte, Brasil – Activated Sludge with energy recovery from the digestors biogas.

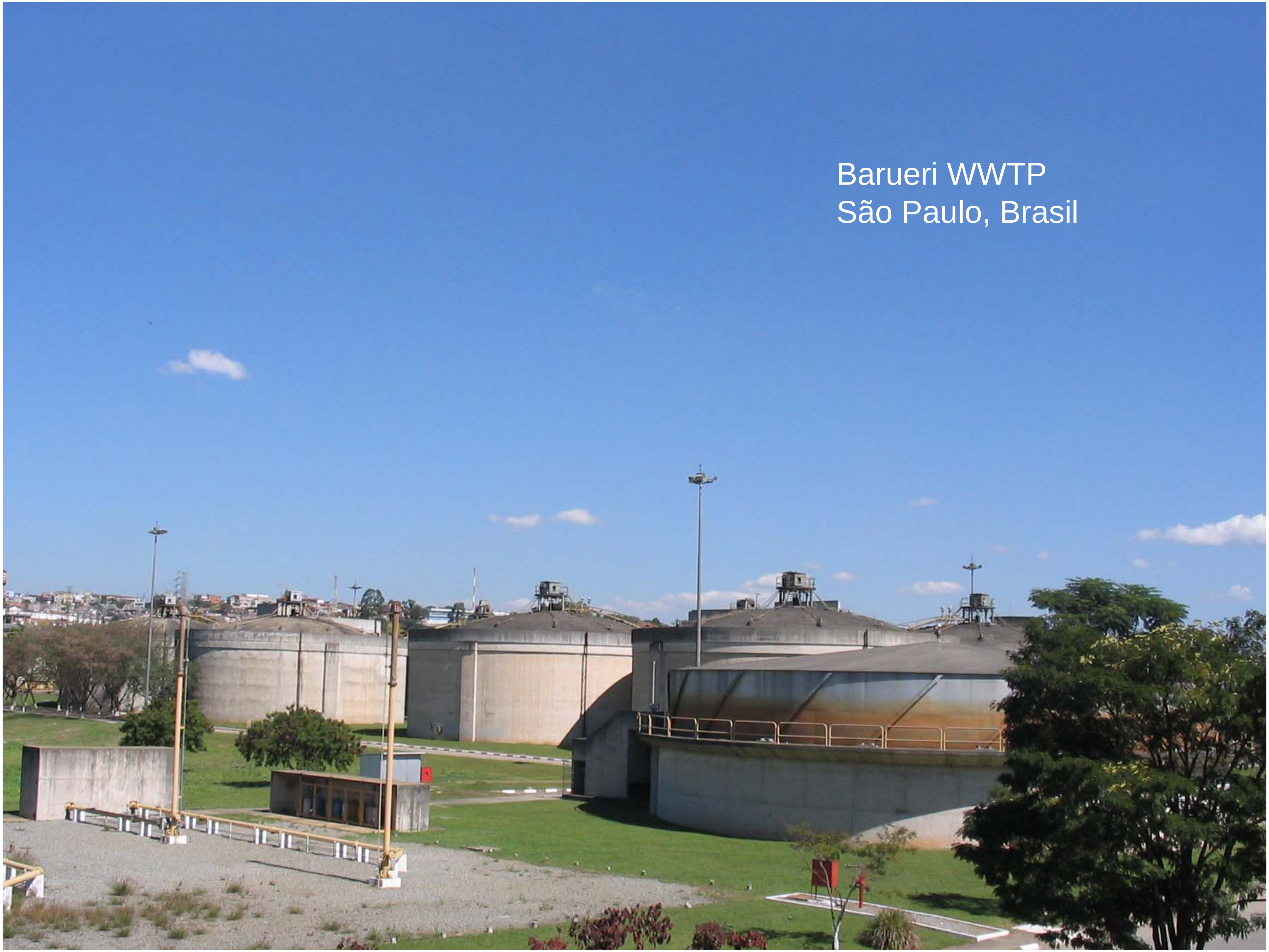

Arrudas WWTP
Belo Horizonte, Brasil

Energy recovery at Arrudas WWTP



Energy recovery at Arrudas WWTP

- Gas purification
- Microturbines


Barueri WWTP
São Paulo, Brasil

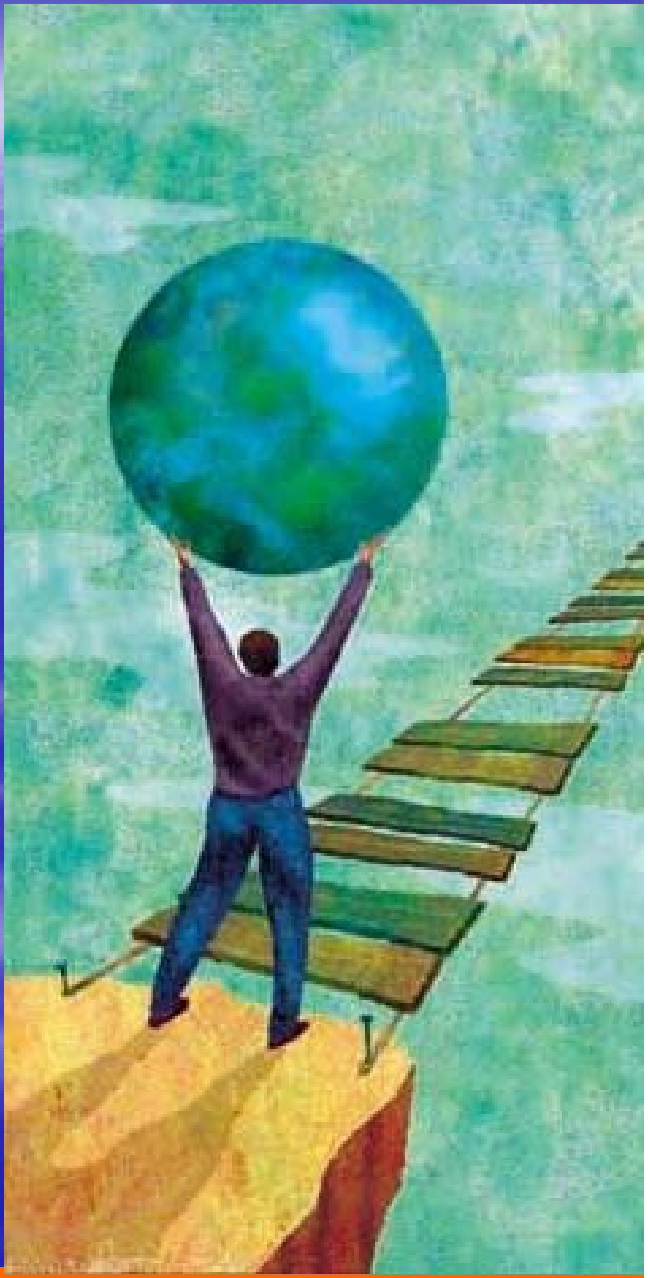

Alegria WWTP
Rio de Janeiro

Think big: can we make sanitation sustainable?

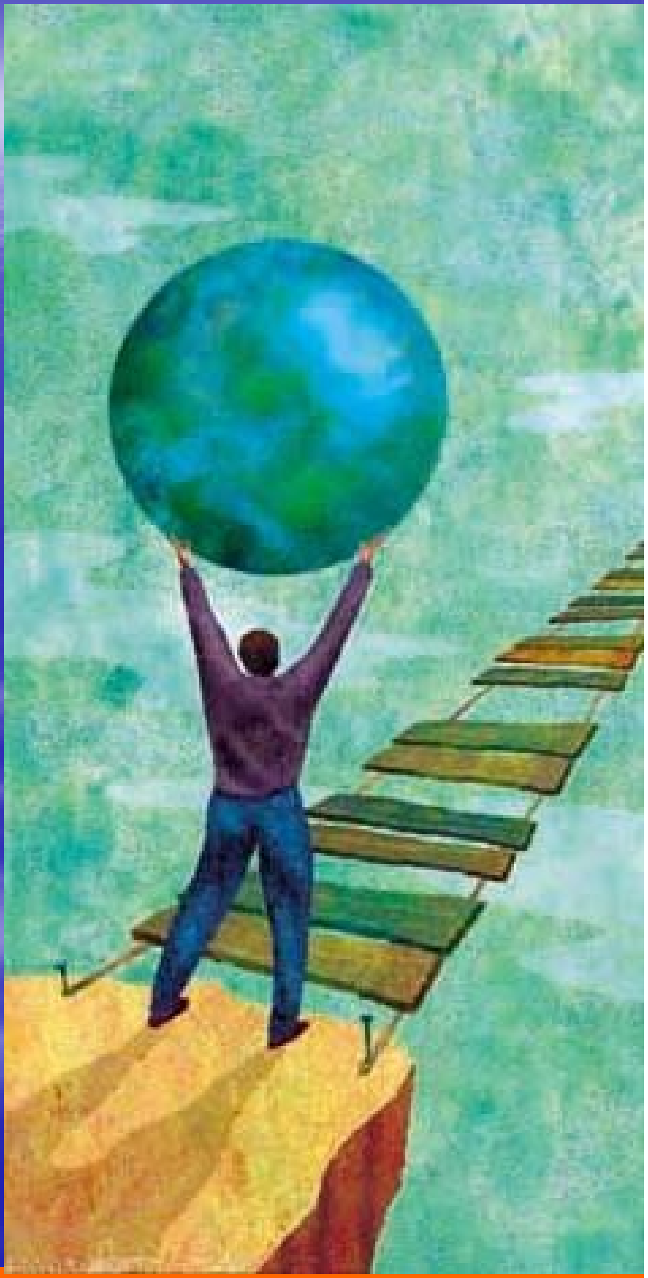
- An evaluation of sanitation, health implications, costs, development, economy.
- Economical x new technologies
- Biofilm control technology ?
- Nanotechnology ?
- New membranes ?
- Sludge and Biogas recovery ?

MAKING SANITATION SUSTAINABLE

CAN WE MAKE IT ?



THANK YOU



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