PROJECT 27
THE PERSPECTIVES OF BIOMETHANE TO CONTRIBUTE TO INCREASE THE NG SUPPLY

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Research Centre
for Gas Innovation
cleaner energy for a sustainable future

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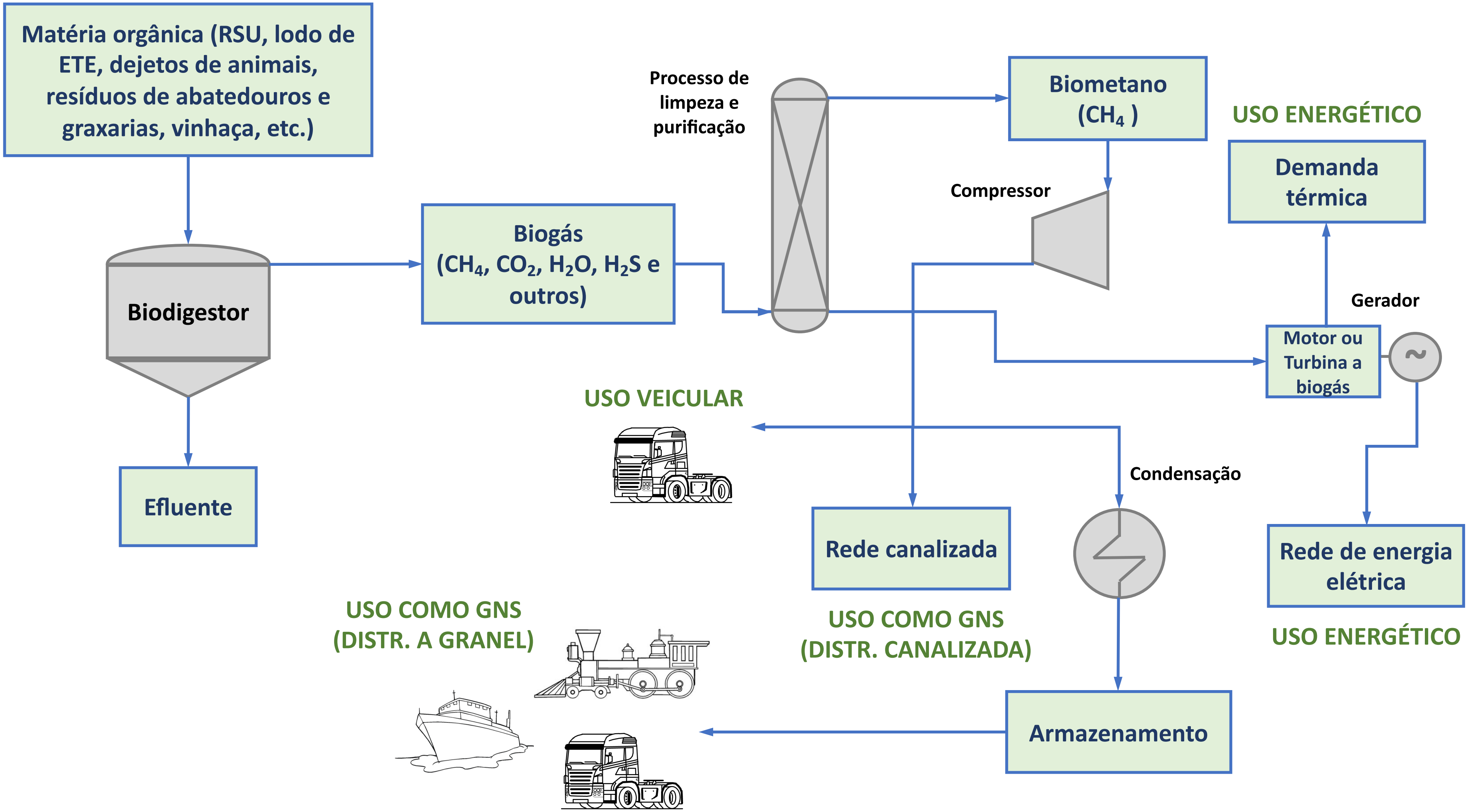
RCGI – PROJECT 27

- Analysis of the **perspectives for biogas and biomethane** (from urban, sugar and alcohol industry and animal residues) in the State of Sao Paulo based on a geo-referenced mapping
- Analysis of **environmental benefits** of increasing the biogas/biomethane share in the energy matrix of São Paulo State
- Analysis of **standards for biomethane injection into NG grid,** as well as for the other biomethane´s final uses, such as in automotive vehicles and biogas for decentralized electricity generation.
- Biogas scenarios for 2030 compared to INDC from Brazil (Paris Agreement)
- **Policy proposals** to improve current legislation in Brazil and São Paulo

Value chain of biogas and biomethane



Matéria orgânica (RSU, lodo de ETE, dejetos de animais, resíduos de abatedouros e graxarias, vinhaça, etc.)

Biodigestor

Efluente

Biogás (CH_4, CO_2, H_2O, H_2S e outros)

Processo de limpeza e purificação

Biometano (CH_4)

Compressor

USO ENERGÉTICO

Demanda térmica

Gerador

Motor ou Turbina a biogás

USO VEICULAR

Condensação

Rede canalizada

Rede de energia elétrica

USO COMO GNS (DISTR. A GRANEL)

USO COMO GNS (DISTR. CANALIZADA)

USO ENERGÉTICO

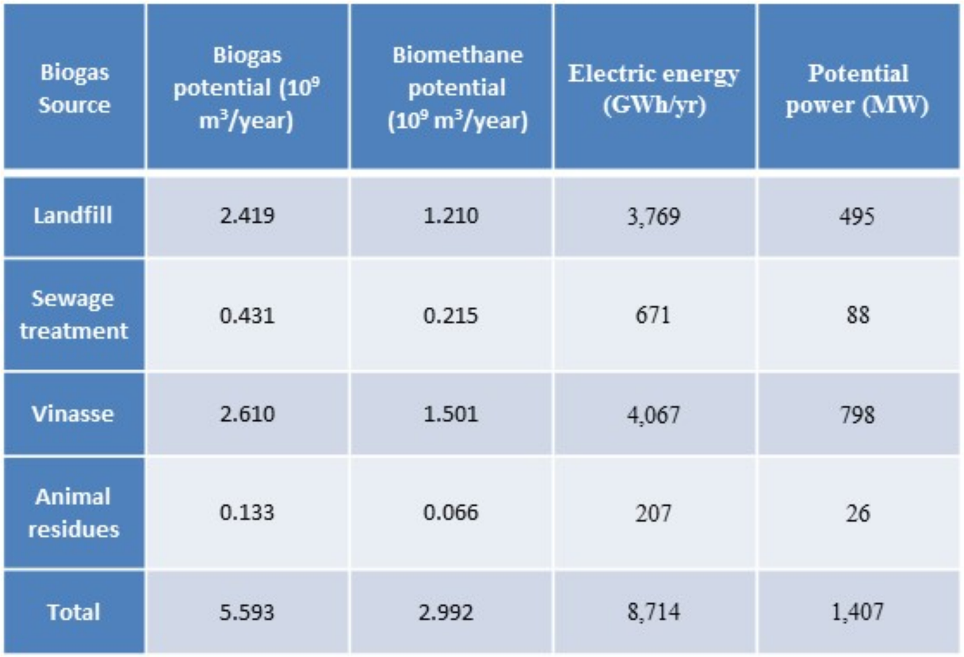
Armazenamento

Biogas and Biomethane Potencial and geo-referenced mapping for São Paulo State

- Potentials
  - The methodologies to determine the potential was already defined
  - The data is being updated for the base year of 2017 and recalculated potentials
- Geo-referenced (iterative mapping)
  - Shape layers was already defined (natural gas network, electric power, lines transmission, electrical substations and environmental protection areas)

Biogas and Biomethane Potential for São Paulo State : Estimations

Project 27 : year base 2015



Biogas Source	Biogas potential (10^9 m^3/year)	Biomethane potential (10^9 m^3/year)	Electric energy (GWh/yr)	Potential power (MW)
Landfill	2.419	1.210	3,769	495
Sewage treatment	0.431	0.215	671	88
Vinasse	2.610	1.501	4,067	798
Animal residues	0.133	0.066	207	26
Total	5.593	2.992	8,714	1,407

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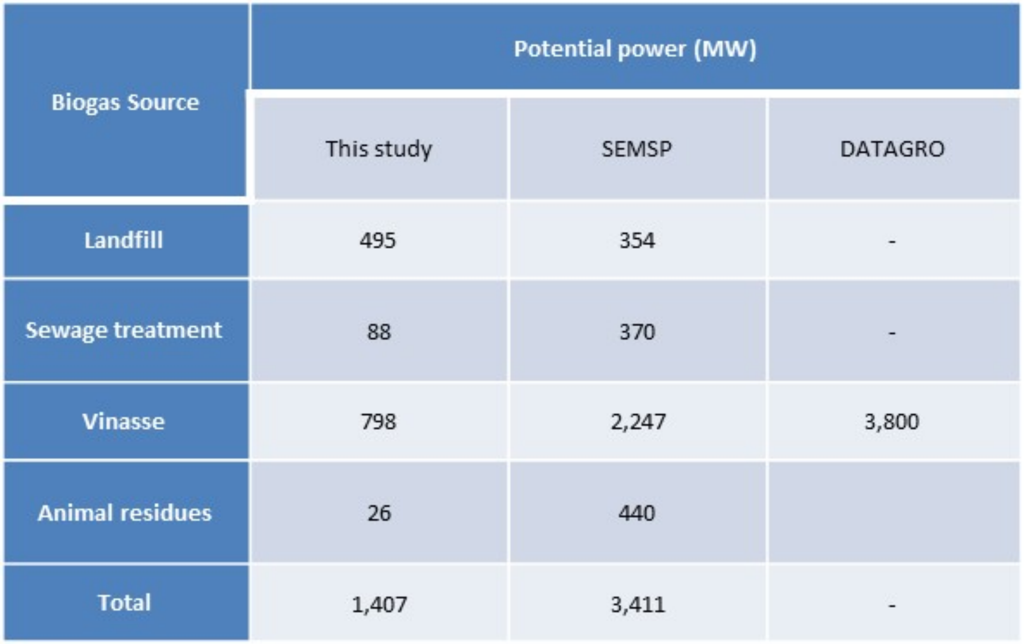

Biogas Source	Potential power (MW)		
	This study	SEMSP	DATAGRO
Landfill	495	354	-
Sewage treatment	88	370	-
Vinasse	798	2,247	3,800
Animal residues	26	440	
Total	1,407	3,411	-

ROADMAP – Biogas and biomethane production and uses technologies

Série RCGI/USP/SYNERGIA – Gases Combustíveis e Sustentabilidade

TECNOLOGIAS DE PRODUÇÃO E USO DE BIOGÁS E BIOMETANO

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- Hot Spots
  - Technological routes for the production of biogas and biomethane
  - National and international scenario of technologies for production and end uses of biogas and biomethane
  - National and International Policy
  - Regulatory Scenario for biogas and biomethane
  - Estimate cost

Comparison among upgrading technologies

Técnica	Lavagem com água	Lavagem com solventes orgânicos	Lavagem com aminas	PSA	Membranas
Princípio	Solubilização seletiva do CO_2 em água	Solubilização seletiva do CO_2 em solventes orgânicos como metanol e poliglicóis	Reação do CO_2 com aminas (MEA, DEA, MDEA)	Adosrção do CO_2 em zeólitas ou silicatos	Passagem seletiva de moléculas de CO_2 pela membrana
Necessário tirar H_2S previamente?	Sim	Sim (pode substituir dessulf. fina)	Sim (pode substituir dessulf. fina)	Sim	Não (mas recomendado)
Meio regenerável?	Sim	Sim	Sim	Sim	-
Custo de investimento	Médio	Médio	Médio	Alto	Baixo
Tratamento do gás residual	Sim	Sim	Não	Sim	Sim
Custo operacional	Baixo	Médio	Alto	Baixo	Médio
Eficiência de remoção de metano (%)	98-99	96-99	99,9	97-98	85 – 99,5
Nível final de metano	96% - 99%	93 - 98%	99%	>96%	90 - 96%
Perdas de metano (%)	0,5 - 2	1-4	0,1	1,5 - 2,5 (relata-se 8%-12%)	0,5-2%
Pressão de trabalho (bar(g))	4 - 10	4 - 8	Atmosférica	2-7	7-20
Demanda de eletricidade [kWh_{el}/ m^3 biogas]	0,2 - 0,3	0,2 – 0,33	0,06 - 0,17	0,15-0,35	0,18-0,33
Demanda de calor (kWh_{th}/ m^3 biogas	Não	0,1 - 0,15	0,4 - 0,8	Não	Não
Temperatura	Não	40 - 80	110 -160	Não	Não
Demanda de água	Sim	Não	Não	Não	Não

Scenarios: Biogas and Biomethane - 2015

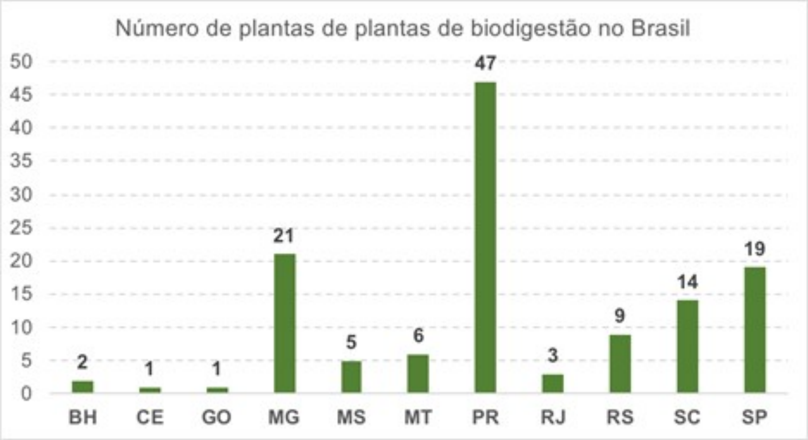
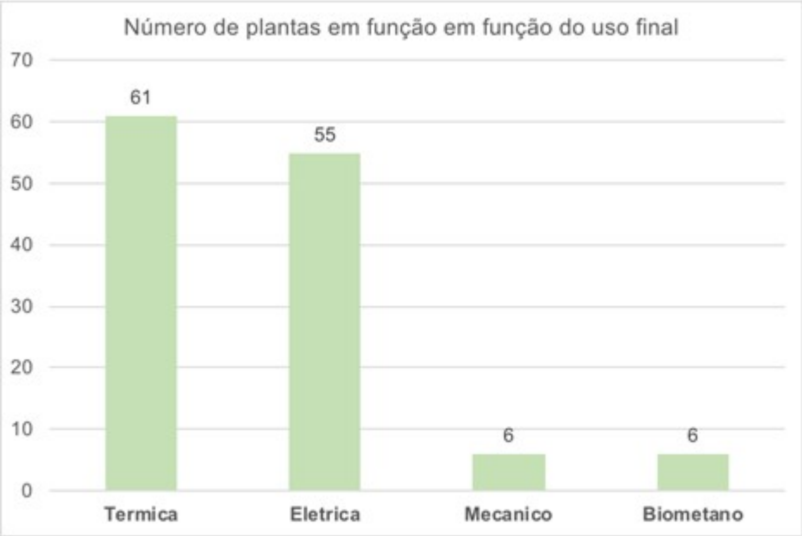
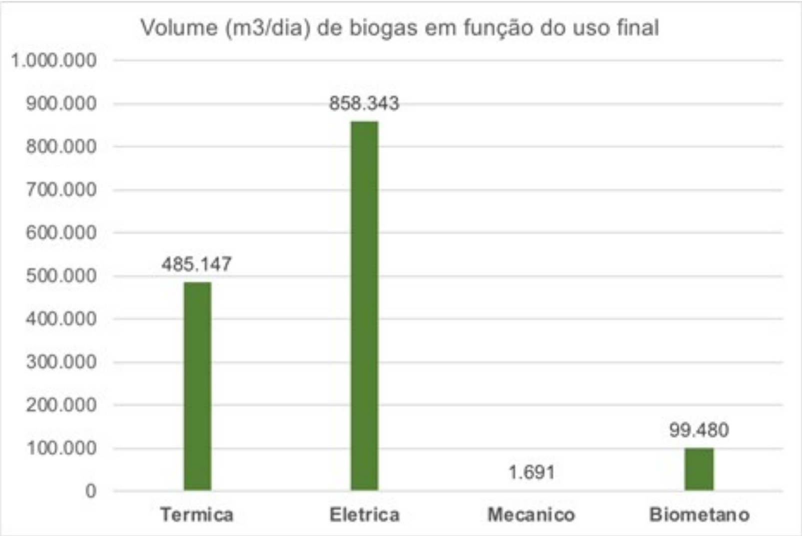

Número de plantas de plantas de biodigestão no Brasil

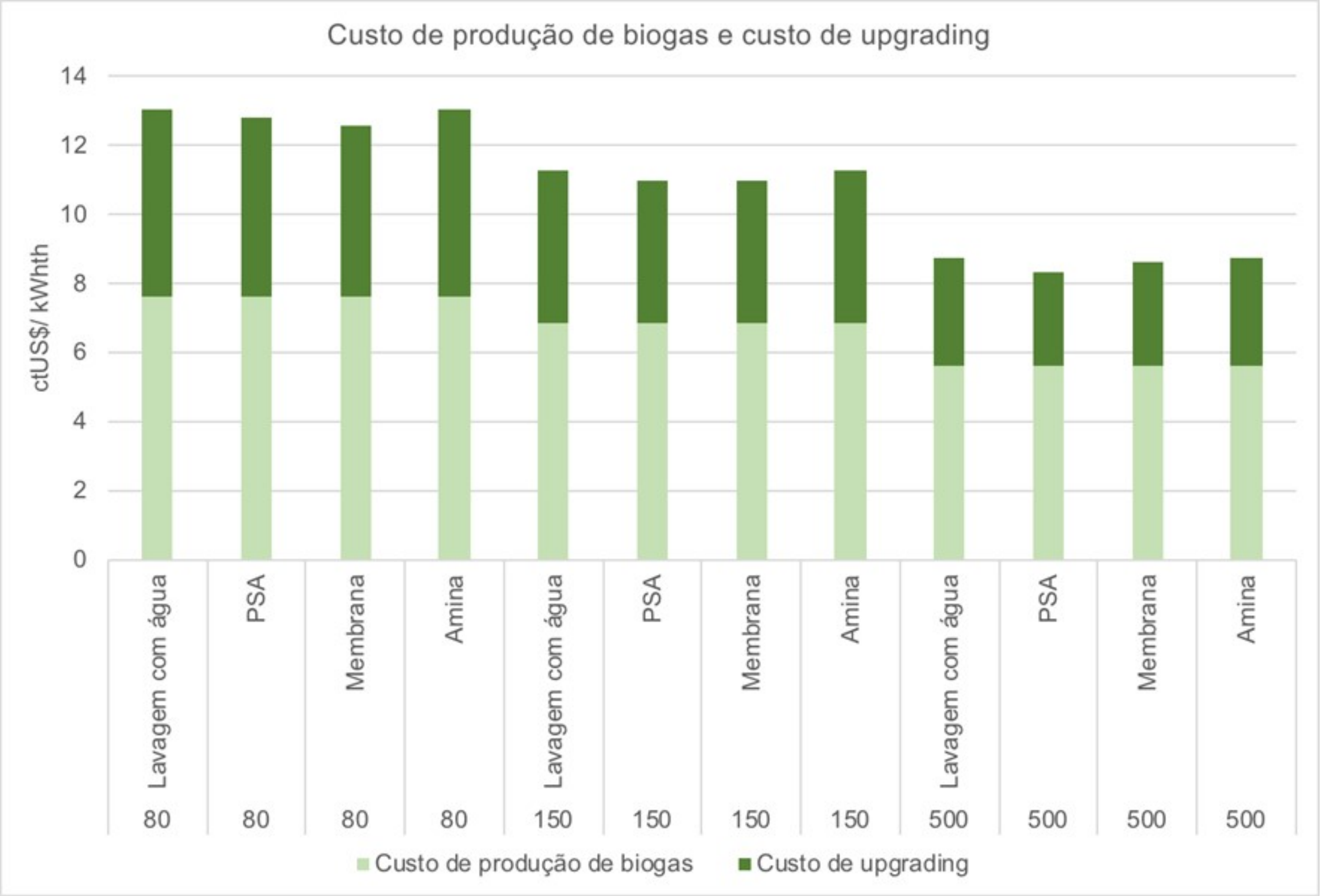

Figura 11.11 – Distribuição das plantas de produção de biogás no território nacional.


Número de plantas em função em função do uso final


Volume (m3/dia) de biogas em função do uso final

Fonte: EPE (2018), adaptado pelos autores.

Comparison cost of biogas production. Upgrading scenarios



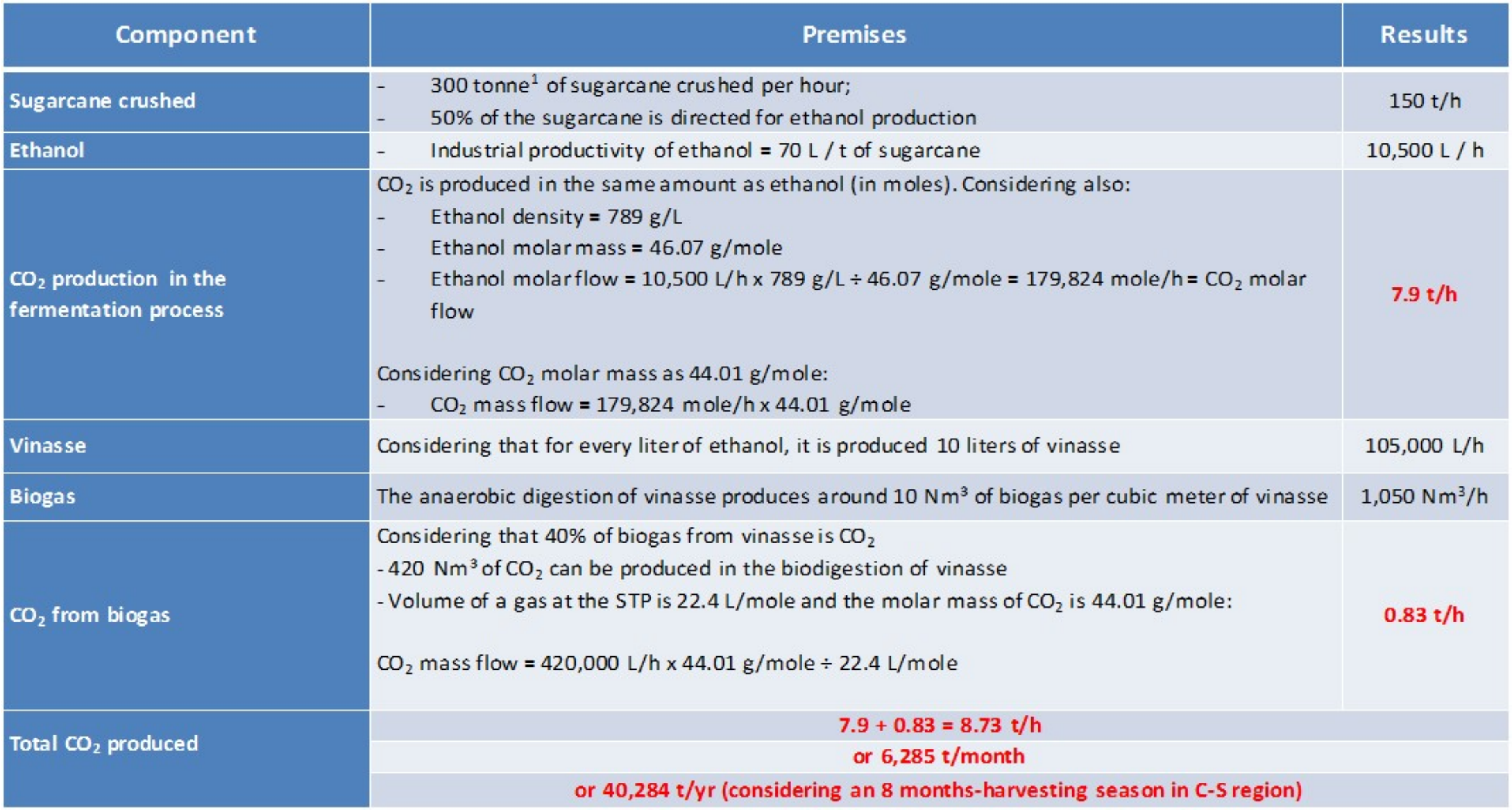
Fonte: Adaptado de Stürmer (2016).

“Carbon capture and use (CCUS) from ethanol production process: CO_2 production costs compared to market prices in São Paulo State”

Deliverables:

1. Roadmap of the BAT for CCUS in an ethanol mill, in particular the best pathway for biogas upgrade and CO_2 capture. **Selection of the best technologies to be implemented in a pilot plant** (vinasse-biodigestion process, biogas upgrade process, CO_2 capture from fermentation and from biogas upgrade).
2. Technical-economic analysis of CCUS and **preliminary costs of CO_2 compared to market prices and CO_2 reuse technologies.**
3. Pilot plant in operation, on the results from the pilot plant.
4. Results from the technical-economic analysis from the **pilot plant for CO_2 production; CO_2 production prices** compared to market prices.
5. Potential prices of **CO_2 from a CCUS process in an ethanol plant** in São Paulo State (300 tc/h). Selection of potential mills to host the CCUS project. Scenarios for Brazil.
6. Report 6: Diesel oil replacement by biogas. Ethanol carbon footprint.
7. Report 7: Perspectives for Bio-products.

“Carbon capture and use (CCUS) from ethanol production process: CO_2 production costs compared to market prices in São Paulo State”



Component	Premises	Results
Sugarcane crushed	- 300 tonne[1] of sugarcane crushed per hour; - 50% of the sugarcane is directed for ethanol production	150 t/h
Ethanol	- Industrial productivity of ethanol = 70 L / t of sugarcane	10,500 L / h
CO_2 production in the fermentation process	CO_2 is produced in the same amount as ethanol (in moles). Considering also: - Ethanol density = 789 g/L - Ethanol molar mass = 46.07 g/mole - Ethanol molar flow = 10,500 L/h x 789 g/L ÷ 46.07 g/mole = 179,824 mole/h = CO_2 molar flow Considering CO_2 molar mass as 44.01 g/mole: - CO_2 mass flow = 179,824 mole/h x 44.01 g/mole	**7.9 t/h**
Vinasse	Considering that for every liter of ethanol, it is produced 10 liters of vinasse	105,000 L/h
Biogas	The anaerobic digestion of vinasse produces around 10 Nm^3 of biogas per cubic meter of vinasse	1,050 Nm^3/h
CO_2 from biogas	Considering that 40% of biogas from vinasse is CO_2 - 420 Nm^3 of CO_2 can be produced in the biodigestion of vinasse - Volume of a gas at the STP is 22.4 L/mole and the molar mass of CO_2 is 44.01 g/mole: CO_2 mass flow = 420,000 L/h x 44.01 g/mole ÷ 22.4 L/mole	**0.83 t/h**
Total CO_2 produced	**7.9 + 0.83 = 8.73 t/h** **or 6,285 t/month** **or 40,284 t/yr (considering an 8 months-harvesting season in C-S region)**	

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