Federal University of Maranhão – UFMA
Institute of Electrical Energy – IEE
Brazil

Ocean Energy in Brazil

INSTITUTO NACIONAL DE CIÊNCIA E TECNOLOGIA
ENERGIAS OCEÂNICAS E FLUVIAIS

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What is INEOF?

NATIONAL INSTITUTE OF SCIENCE AND TECNOLOGY IN OCEAN AND FLUVIAL ENERGIES

FUNDING INSTITUTIONS

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HOW DOES IT WORKS?

- INEOF operates as a collaborative network of federal universities;
- The financing comes from the federal and state government, obtained through public competition;

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FEDERAL UNIVERSITIES

- UFMA – Federal University of Maranhão
- UFRJ – Federal University of Rio de Janeiro
- UFSC – Federal University of Santa Catarina
- UNIFEI – Federal University of Itajubá
- UFPA – Federal University of Pará

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International Collaborators

- INESC P&D
- Indian Institute of Technology Roorkee – India
- Ecole Polytechnique de Lausanne – Switzerland
- Aalborg University - Denmark
- Hydro-environmental Research Centre, da Cardiff School of Engineering, Cardiff University, UK

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What are the goals?

- *Contribute to the research and development of oceanic energies in Brazil;*
- *Human resources in marine energies;*
- *Encourage the formation of an industry related to marine energies;*

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MAIN SUBJECTS

- Wave Energy
- Tidal Currents

Wave Energy in Brazil

Wave potential around the world

Gross estimate for Brazil

- *Considering 7.7 Kw / m (estimated from Ceará coast):*
- *Brazil has 7367 km of coastline.*
- *Gross potential around 57 GW*

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PECÉM - CEARÁ

WAVE PROJECT

WAVE PROJECT –PECÉM - CE

50 kW → **Estimated Cost: R$ 14 million (USS 4.5 mi)** → **LTS - UFRJ**

TRACTEBEL → **ANEEL (P&D)** → **Start of Operation: 2012**

Current Situation: Disabled

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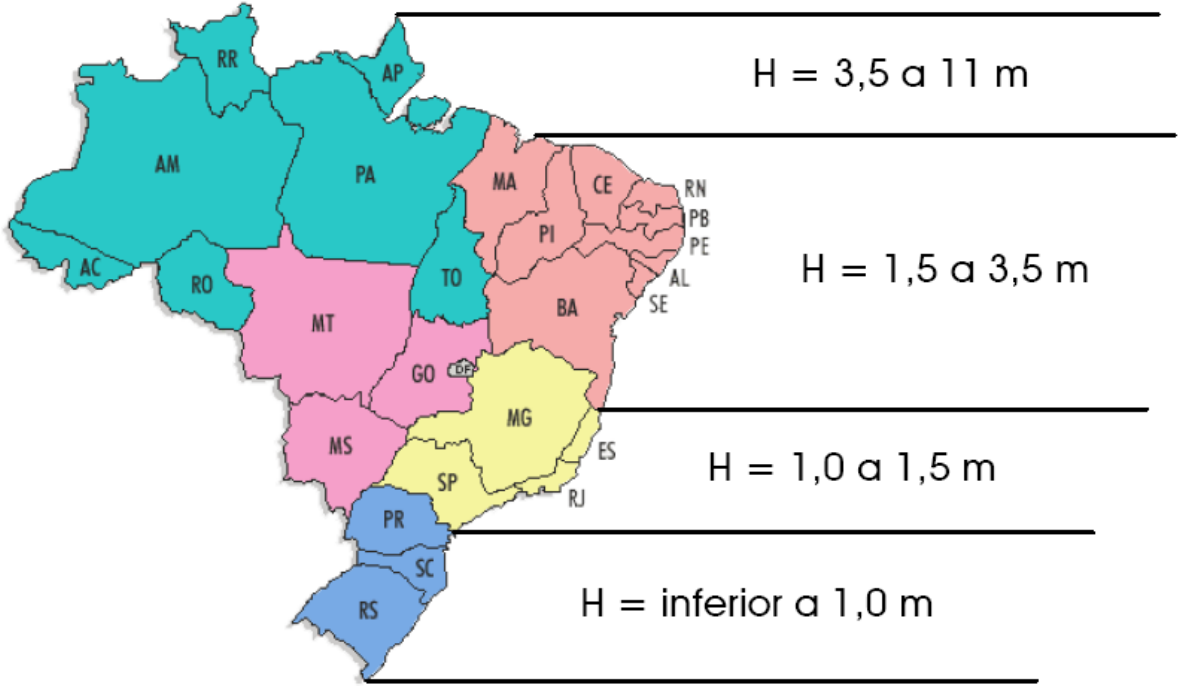
Tidal resorces

Tidal variations



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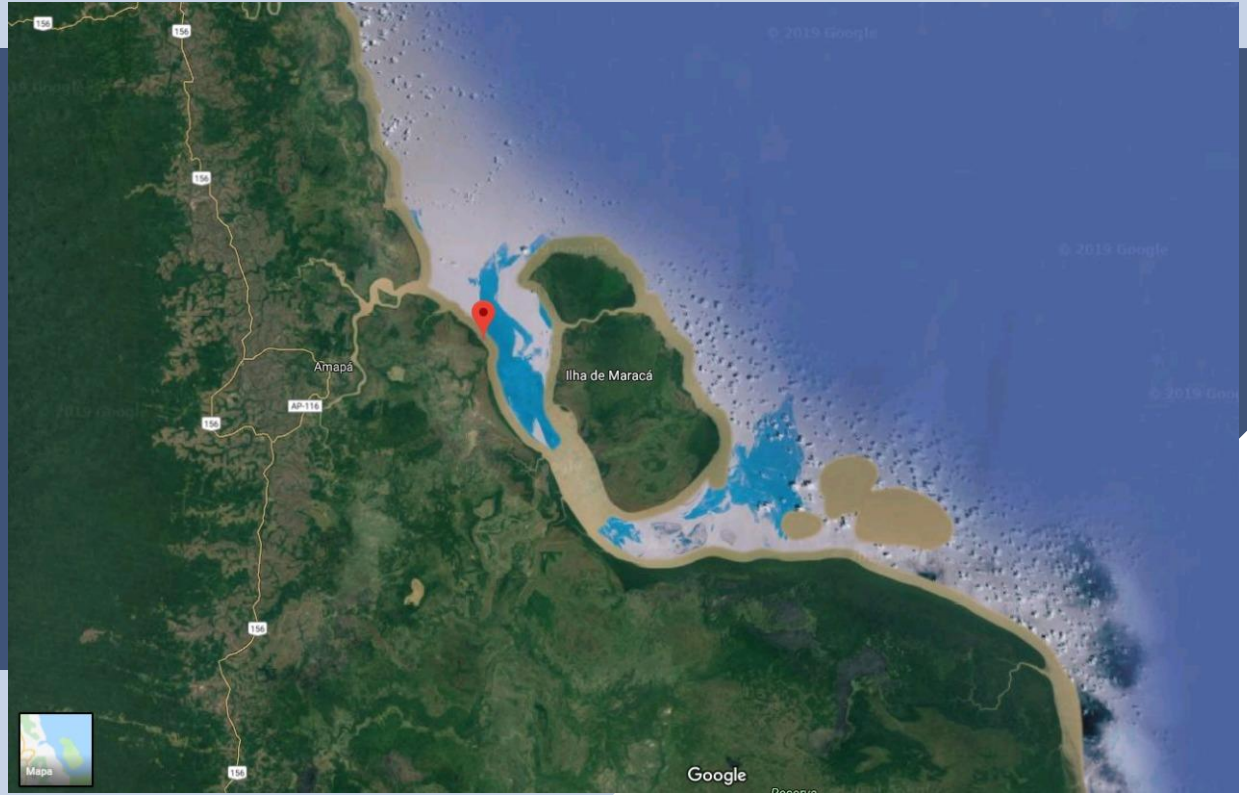
Assessment of tidal potential (barrage)

- Contracted by Eletrobrás
- Executed from1979 to1980
- Assessed region: Maranhão-Pará-Amapá.

Channel of Varador and Island of Maracá



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Estimated values (barrage)

LOCALIZATION	Average tidal Amplitude (m)	Reservoir field (km²)	Installed power (MW)	Annual Energy (GWh)
Island of Maracá - AMAPÁ	8,0	307	4912	13160
Bay of Araguari - AMAPÁ	5,4	157	1144	3066
Bay of Maracanã - PARÁ	3,7	155	530	1421
Bay of Japerica – PARÁ	4,0	115	415	1112
Bay of Turiaçu - MARANHÃO	4,7	616	3402	9114
Bay of Lençóis - MARANHÃO	4,7	316	1745	4675
Bay of São José - MARANHÃO	4,3	451	2084	5585

14232

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Global estimates (barrage)

- *27 GW*
- *72 TWh/year*

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Tidal currents

- *Tidal currents have not been formally evaluated in Brazil*
- *There are preliminary assessments at specific locations*

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Bay of São Marcos
Maranhão, Brazil

São Marcos Bay (MA – BRAZIL)

Zone	Width (m)	Length (m)	Depth (m)	$U_{avg} \pm$ SD (m/s)	U_{50} (m/s)	U_{Max} (m/s)
A	1000	1350	25–40	1.10 ± 0.06	1.20	2.63
B	2600	1900	22	1.10 ± 0.13	1.23	2.42
C	1000	1100	30–35	1.10 ± 0.04	1.12	2.19

Table 1. Hydraulic/ hydrodynamic characteristics of zones with tidal energy potential

Zone	Peak power (kW/m^2)		Avg. annual power density (MWh/m^2-year)
	Spring tide	Neap tide	
A	7.5	2.1	11.2
B	5.1	1.5	10.4
C	4.8	1.5	9.2

Table 2. Power density summary for selected zones

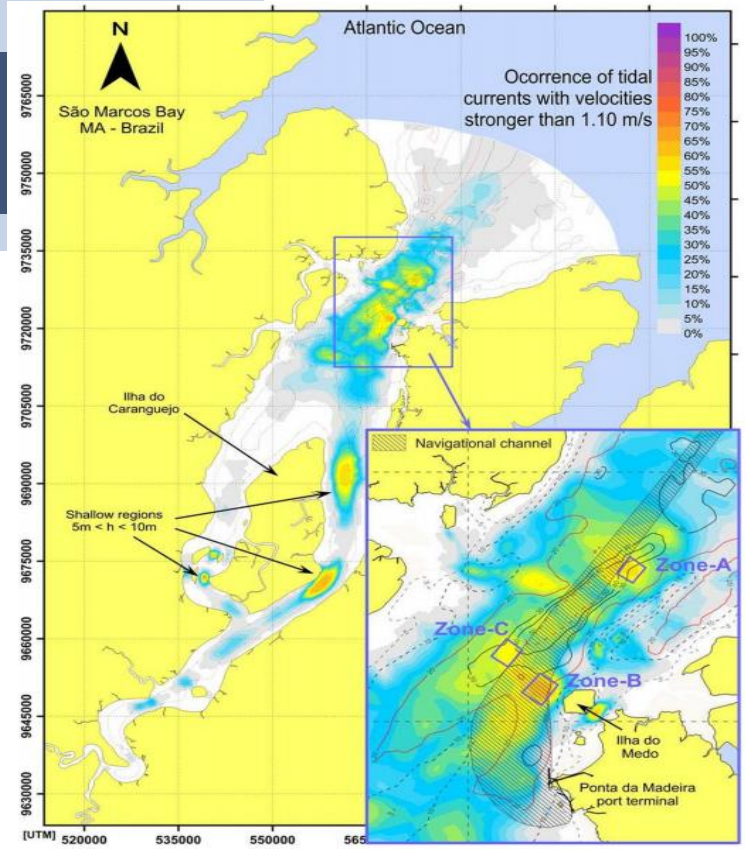


Fig 2. Hot spots for efficient tidal current power extraction in São Marcos Bay. Zoom region shows bathymetry contours

Fonte: GORBEÑA, E.G., ROSMAN, P.C.C., QASSIM, R.Y., 2015.

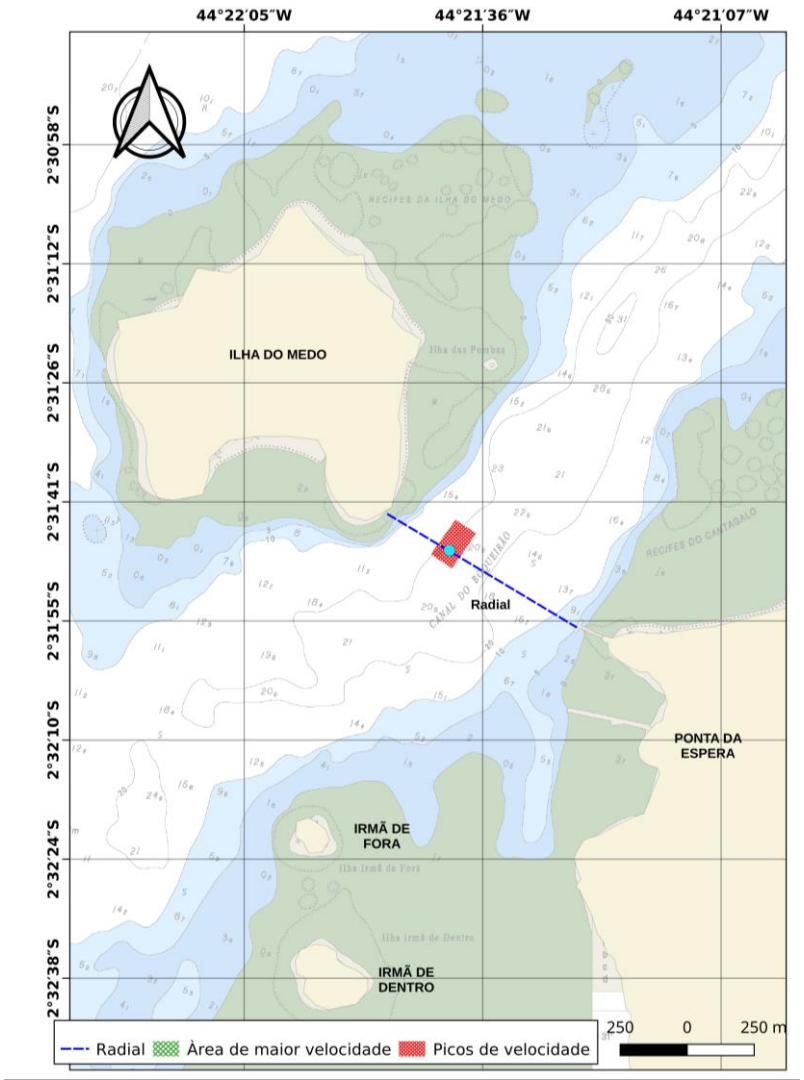
The authors indicate a potential in the range of 300 MW - 800 MW from tidal currents in one of eight promising areas of San Marcos Bay.

BOQUEIRÃO CHANNEL

PRELIMINARY STUDY

Performed by: INEOF

- Years: 2017-Present
- Localization: Maranhão



AVAILABLE ENERGY

Location of tidal current turbines

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FEATURES

SPEED CURRENTS	**3 m/s**
INTERESTING FEATURE	**Quasi-constant direction and value**

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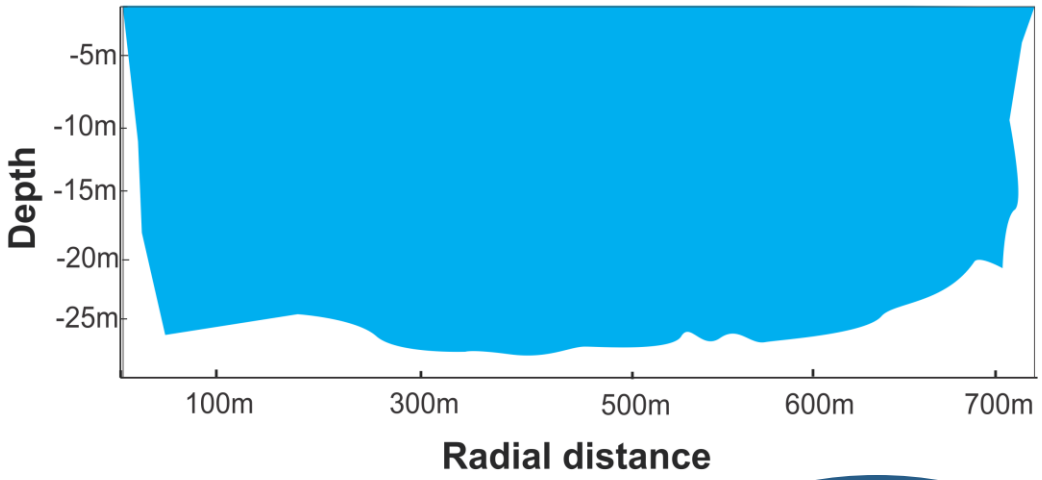
DEPTH ILLUSTRATION OF CHANNEL OF BOQUEIRÃO



$$N_{Turb} = \left[\frac{L}{(3 \times D)} + 1\right] \times \left[\frac{C}{(2 \times D)} + 1\right]$$

L = 800 meters
C = 700 meters

Estimating a tidal farm

- Arrangement of 168 turbines;
- Estimated annual generation: 203.1 GWh;
- Capacity Factor: 27.6%;
- Power Capacity: 84 MW;
- Corresponds to 0.51% of the Energy used in Brazil in 2018;
- Spacing between turbines: approximately 60 meters.

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CHALLENGES

CHALLENGES

- **Assessment of energy potential;**
- **Development of adapted tidal turbine;**
- **Development of source integration technology;**
- **Lack of legislation;**
- **Environmental issues;**
- **Incentive policy.**

FINAL COMMENTS

- **Most of these works are being developed by INEOF researchers;**
- **Financial constraints allow only laboratory scale prototypes.**
- **For real-scale prototype, specific funding is required: new partners!**

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THANK YOU!

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