

Research Centre for Gas Innovation - RCGI FAPESP - BG Group www.usp.br/rcgi

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IPEN³
BG Brasil - BG Group⁴

21st - 22nd of April 2016

- The importance of Natural Gas in the years to come.
- Natural Gas: a Premium Fuel.
- The road from an economical model based on fossil fuels and high CO₂ emissions to a sustainable economy: the important role played by Natural Gas.
- “We not only want to change the World but we also NEED to change it...”
COP21

Outline

- 1 Industry-Academy Interaction: TT and DoK
 - Building a concrete knowledge: the necessity of infra-structure and laboratories
 - Recent Publications: Technology-Transfer and Diffusion of Knowledge
 - Past experience, some few examples: Vortex-induced Vibration (VIV) on Risers, Drag Reduction Devices, and Aeroacoustics
- 2 Fapesp-BG Brasil Research Centre for Gas Innovation
 - Institutions Participating in the Centre
 - Research Programmes
 - Energy Mix in the USA and in Brazil
 - Main Objectives
 - Engineering Research Programme
 - Physical & Chemistry Research Programme
 - Energy Policy & Economics Research Programme
 - Proposals of New Projects
- 3 Conclusions
- 4 Acknowledgments

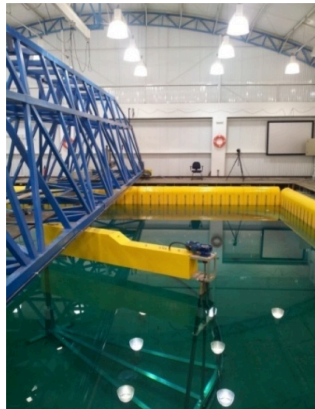
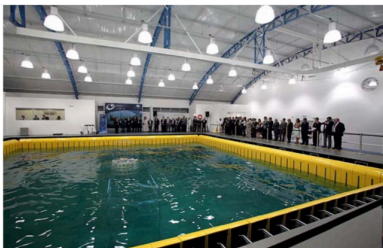
Laboratory of Environmental and Thermal Engineering - LETE



Fluid & Dynamics Research Group - NDF



Numerical Wave Tank - TPN

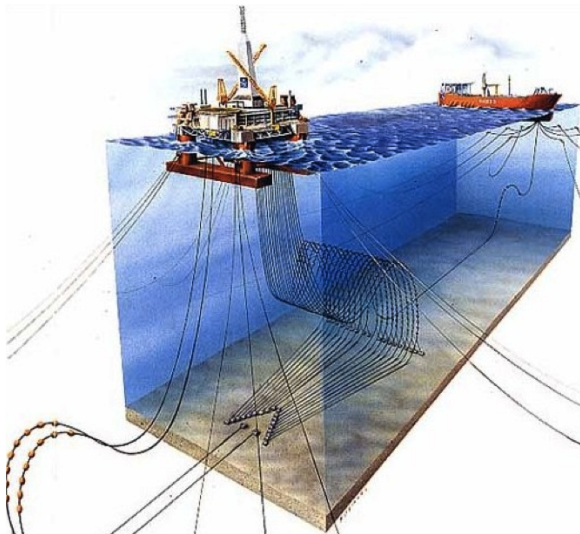


Some recent "publications": Technology Transfer from Academy to the Industry and Diffusion of Knowledge

"Veja" Magazine, 22 Dec 2012, Prototype Machine: Manifolds and Landing Gears, Gustavo Ássi, NDF



Motivation 1: VIV on Risers and Oil and Gas Transport Ships



Moving Boundary Surface Concept for VIV Suppressor and Drag Reduction Device: Ivan Korkischko and Julio R Meneghini, 2010

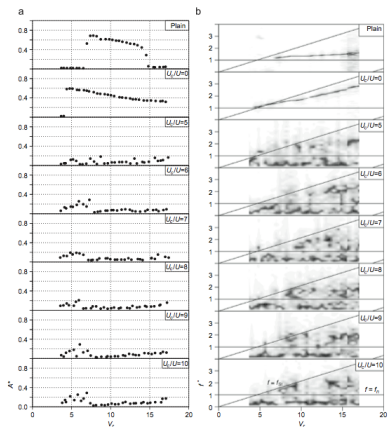


Fig. 2. Amplitude and frequency responses of isolated circular cylinders with and without MSRC ($Re = 1600 - 7500$, $d_r/d = 0.06$ and $g_r/d = 0.07$). (a) Amplitude response and (b) frequency response. PSD contour plot.

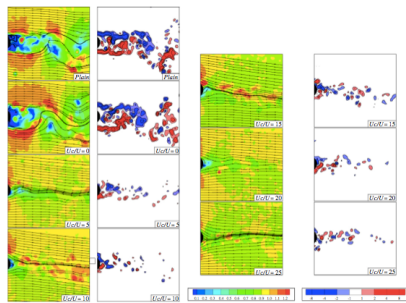


Fig. 4. Nondimensional instantaneous fields of velocity magnitude (left) and vorticity ω_r (right) of circular cylinders with and without MSRC ($Re = 3000$, $d_r/d = 0.06$ and $g_r/d = 0.07$).

Moving Boundary Surface Concept for VIV Suppressor and Drag Reduction Device: Ivan Korkischko & Julio R Meneghini, 2010

I. Korkischko, J.R. Meneghini / *Journal of Fluids and Structures* 34 (2012) 259–270

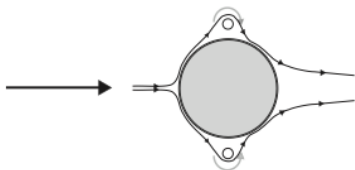
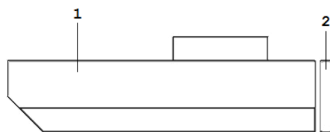
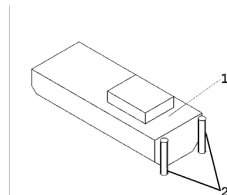
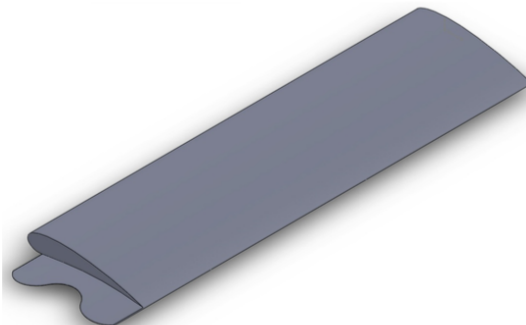


Fig. 8. Schematic of the flow around the circular cylinder with MSBC.



USA Patent Pending



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Host Institution, Associate Institutions and Associate Institutions Abroad

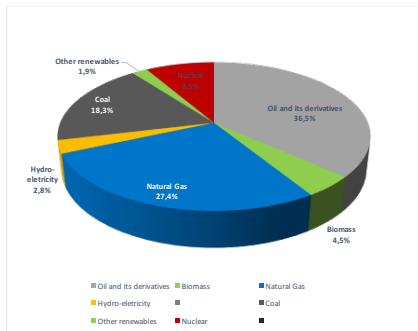
- Host Institution: "Escola Politécnica - USP" - University of São Paulo
- Associate Institutions:
 - Instituto de Energia e Ambiente (IEE)
 - Instituto de Pesquisas Energéticas e Nucleares (IPEN)
- Associate Institutions Abroad:
 - Imperial College London - SGI (Sustainable Gas Institute)
 - University College London
 - University of Illinois at Urbana-Champaign
 - University of Cambridge
 - Texas A&M University
 - Technische Universität Darmstadt - Germany
 - University of Leeds, UK
 - University of Lyon, France

Research Programmes

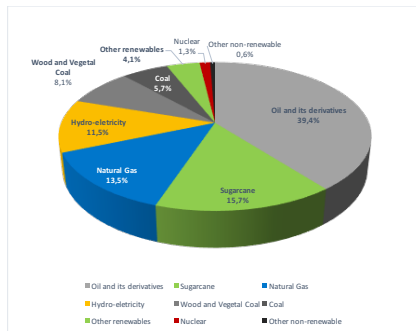
- Engineering Research Programme
- Physical & Chemistry Research Programme
- Energy Policy & Economics Research Programme

Energy Mix in the USA (2012) and in Brazil (2014)

- Energy Mix in the USA (2012), DOE/EIA-0035 (2013)



- Energy Mix in the Brazil (2014), "Balanço Energético Nacional 2015, EPE, MME (2015)"



Main Objectives of the Research Centre for Gas Innovation

- Increase the use of Natural Gas in São Paulo State and in Brasil.
- Increase the efficiency and develop new concepts of hybrid propulsion for BG's fleet of Methane Ships.
- Attach the great challenges to separate and transport natural gas from the pre-salt basin in Santos to shore.
- Explore the potential of Natural Gas as a transitional fuel from a fossil fuel based society to a sustainable and environmental friendly society.
- Mitigate CO₂, CH₄ and other gases emissions which are contributing to the Green House Effect.
- Increase the efficiency of combustion processes employing Natural Gas.
- Produce Bio-gas and integrating its production to Natural Gas Network in São Paulo State.
- Development of hybrid energy production involving Natural Gas: Solar + Natural gas, Solar + Wind power, Fuel Cells.
- Development of innovative, lightweight storage systems.

Scope in the Engineering Research Programme

- Engineering based - scientific and technological research focused on engineering to promote new applications and low-carbon power generation, including:
 - Small scale natural gas generators;
 - Natural gas/hydrogen fuels for shipping: to address:
 - the technical questions around production and handling of blended fuels, and
 - the development of codes and standards.
 - Associated developments to optimise use of natural gas in shipping: to increase and optimise the usage of natural gas based fuels in the marine transport system two main developments are required:
 - development and optimisation of natural gas and hybrid powertrains, and
 - development of innovative, lightweight storage systems;
 - Opportunities to detect measure and minimise methane emissions/losses from gas supply and utilisation systems.

Projects in the Engineering Research Programme

- Project 1: Development of an advanced natural gas burner using the oxy-fuel concept.
- Project 2: Laboratory of Advanced Diagnostic for Combustion.
- Project 3: Advanced combustion systems using diesel and natural gas blends for internal combustion engines applications mitigating methane slip.
- Project 4: Feasibility/Conceptual designs of energy efficient and environmentally friendly ships with natural gas as a fuel.
- Project 5: Design optimization of adsorbed natural gas storage systems.
- Project 6: Adjoint-based optimisation of natural gas adsorption systems for storage purposes.
- Project 7: Conceptual design of natural-gas-based hybrid power trains for vessels.
- Project 8: Numerical simulation and modelling for Engineering and Physical Chemistry (See Physical and Chemistry Programme Theme 1 and 2).
- Project 9: Studies of the application of laser-based remote sensing techniques (LIDAR) in the measurement of atmospheric pollutants.
- Project 10: Design Optimization of Labyrinth Seals.

Scope in the Physical & Chemistry Research Programme

- Physical Chemistry based - scientific and technological research focused on physical chemistry to promote low-carbon power generation, fuel substitution and transport and new applications for gas, including:
 - Advanced and cleaner natural gas combustion: to develop the ability to reduce the environmental impact of natural gas combustion, reduce emissions of unburned methane when combusted and promoting more competition with hydro power in Brazil;
 - Fuel Cell Developments: research to help position Brazil within a global Centre of Excellence in fuel cell developments;
 - Conversion of natural gas to chemicals (e.g. H_2 , CO & NH_3): the two main objectives are:
 - to generate added-value products from methane for the Brazilian (and global) markets, and
 - to provide in-situ manufacture of chemicals which carry a significant transport hazard.

Projects in the Physical & Chemistry Research Programme

- Project 11: Development of an advanced natural gas burner using the Flameless Oxidation concept.
- Project 12: Advancing Fuel Cells for Operation on Natural Gas.
- Project 13: Synthesis Gas Production by Tri-reforming of Methane.
- Project 14: Methanol Production from CO₂ Hydrogenation.
- Project 15: Gas-to-Liquids via Fischer-Tropsch Synthesis.
- Project 16: A Hybrid Solar-Gas System for Natural Gas Steam Reforming.
- Project 17: Bio-conversion of CO₂.
- Project 18: Bio-conversion of CH₄.
- Project 19: Novel Structured Ceramic Membrane for Low Cost CH₄ / CO₂ Separation.
- Project 20: Supported metals nanoparticles prepared by different methodologies as catalyst for the PROX reaction.

Scope in the Energy Policy & Economics Research Programme

- Energy Policy and Economics based - promotion of infrastructure and policies to encourage gas utilisation, including:
 - Policies for the development of gas in energy systems: to develop information sources which will provide credible and authoritative information for the development of gas as a key energy source and to demonstrate how gas can be integrated into emerging energy systems in the Brazilian context;
 - Development of supply chains for natural gas for remote areas: to promote the use of natural gas in remote areas and in areas where it is not currently viable and to reduce CO2 emissions by replacing other fossil fuels with natural gas.

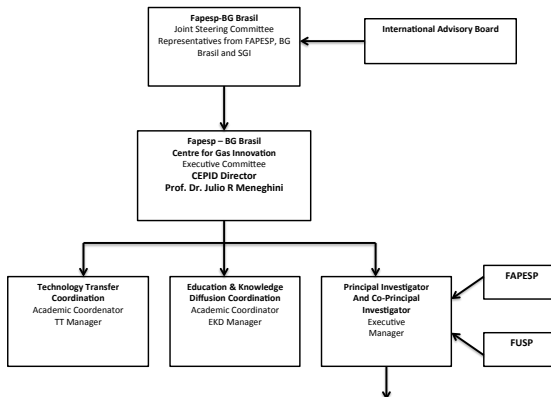
Projects in the Energy Policies and Economics Programme

- Project 21: Setting up of the Brazilian and Paulista Natural Gas Law Service: USP's Interdisciplinary Natural Gas Policy, Legal and Regulatory Intelligence Service.
- Project 22: Producing Benchmark Studies about Natural Gas Efficient Uses in the Industrial Sector.
- Project 23: Brazilian Greenhouse Gas Inventory and Scenarios for Emissions Reductions Related to Natural Gas.
- Project 24: Estimation of price and income elasticities for natural gas: A modeling for various segments of demand in Brazil taking into account the growing perspective for carbon markets.

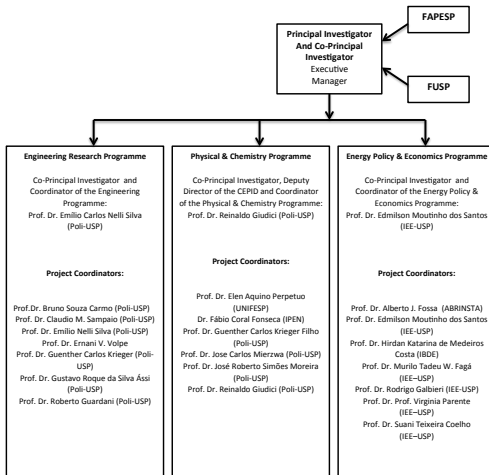
Projects in the Energy Policies and Economics Programme

- Project 25: Integrated Sustainability Analysis of Natural Gas as a Transportation Fuel in Heavy-Duty Vehicles - The Paulista Blue Corridor.
- Project 26: Evaluation of small LNG and CNG supply options for transportation and off-grid locations in southeast Brazil; and planning expansion and operation of multi-modal integrated networks.
- Project 27: The perspectives of biomethane to contribute to increase the NG supply.
- Project 28: GEODIS - Geographic Dispersed and Integrated Energy Planning Systems - An Approach to Integrated and Spatial Urban Energy Systems Planning: The Role of Natural Gas.

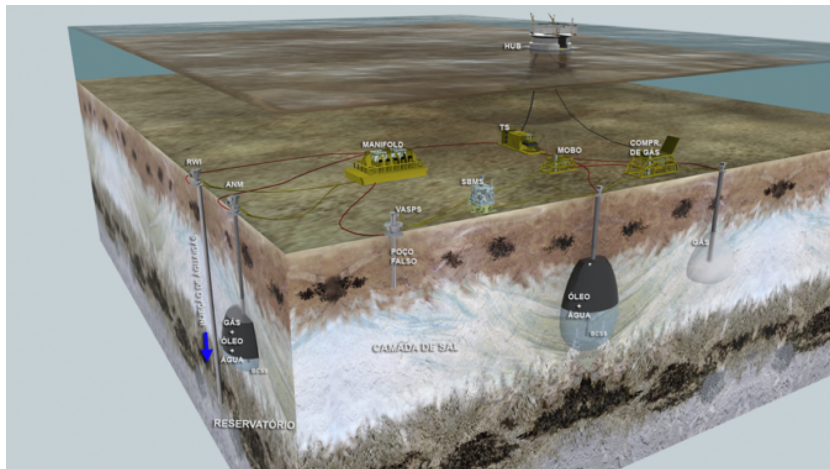
Fapesp-BG Brasil Centre for Gas Innovation: Organisational Structure



Fapesp-BG Brasil Centre for Gas Innovation: Organisational Structure of the Research Programmes



Proposals of New Projects involving GTW with CCS, Kazuo Nishimoto and Alvaro Maia 2015



Proposals of New Projects involving Buses running with H₂ obtained from NG reform: Project PUD-EMTU-Petrobras



Proposals of New Projects involving Ship Engines Suppliers, Fuel Cell Suppliers, State of São Paulo Secretariat, Comgas, among others

- Reform of Natural Gas to produce Hydrogen
 - Possible collaboration with EMTU, Hytron, Caio, Weg, to test a Hydrogen Bus at USP (São Paulo City Campus)
 - Possible collaboration with Toyota to test Mirai Veicule at USP (São Paulo City Campus)
 - Involvement of Comgas with the initiative of the Secretariat of Energy of Sao Paulo State in the Incor-Hospital das Clinicas-Escola Medicina's USP Complex to have Hybrid/Distrital Electricity Generation: gas turbines, gas engines, photo-voltaic and fuel cells
- Employ hydrogen for energy storage: natural gas reform and electrolise
- Produce Bio-gas and integrating its production to Natural Gas Network in São Paulo State
- Development of hybrid energy production involving Natural Gas: Solar + Natural gas, Solar + Wind power, Fuel Cells
- Development of innovative, lightweight storage systems
- Propose energy policies and economics to increase the participation of Natural Gas in the Energy Mix

Proposals of New Projects involving Ship Engines Suppliers, Fuel Cell Suppliers, State of São Paulo Secretariat, COMGAS, among other

- Residential and Comercial Air-Cond.and Fuel Cell - Test cases: 10-30 homes
- Bus and Veicular Fuel Cell: EMTU and Toyota
- Hybrid Generation at University of São Paulo:
 - NDF case (0.5 MW): Fuel Cell with Gas Reformer, Solar Energy, Small Turbine, Engine-Generator (NG)
- Cogeneration at University of São Paulo:
 - University Hospital
- Involvement of Comgas with the initiative of the Secretariat of Energy of Sao Paulo State in the Incor-Hospital das Clinicas-Escola Medicina's USP Complex to have Hybrid/Distrital Electricity Generation: gas turbines, gas engines and fuel cells

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Conclusions

- A very long way....

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- Capes
- Embraer
- Voith Hydro
- Oxiteno
- BP

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- Academic Members of Staff, Researchers and Students from IEE-USP
- Academic Members of Staff, Researchers and Students from IPEN-USP
- Academic Members of Staff of the Associate Institutions and Institutions Abroad involved with the Centre

Acknowledgments

- THANKS TO YOU ALL