

Dep. Engeharia Mecânica Escola Politécnica Universidade de São Paulo



LABORATÓRIO DE SISTEMAS ENERGÉTICOS ALTERNATIVOS E RENOVÁVEIS RENEWABLE AND ALTERNATIVE ENERGY SYSTEMS LABORATORY

Escola Politécnica da USP Depto. Enga. Mecânica SISEA – Laboratório de Sistemas Energéticos Alternativos e Renováveis

e-mail: jrsimoes@usp.br

Maio/2021



Equipe

Professores associados

- Prof. Dr. José Roberto Simões Moreira (*coordenador*)
- Prof. Dr. Marcos de Mattos Pimenta (*vice-coordenador*)
- Demétrio Zachariadis (especialista em dinâmica e energia eólica)
- José Aquiles B. Grimoni (sistemas elétricos de potência)
- Claudio Roberto de F. Pacheco (energia solar)



Equipe (alunos e membros)

Pós-graduandos

- 2 Pós-doutorandos
- 3 alunos de doutorado
- 3 alunos de mestrado
- 1 aluno de ic

Membros técnico-administrativos dedicados exclusivamente ao laboratório

- 1 secretária
- 1 técnico mecânico



infra-estrutura

- Equipamentos de informática: microcomputadores e outros equipamentos de informática;
- Área ocupada em torno de 250 m²;
- Instalações para estudos experimentais de separação supersônica de gases;
- Instalações para estudos de ciclos de absorção de calor;
- Instalações para análise de ciclos termodinâmicos e energia solar.
- Laboratório de eletrônica e suporte de oficina mecânica.



Colaborações nacionais e internacionais

- Université de Savoie Polytech Annecy Chambéry Campus scientifique Savoie Technolac (França)
- Queen Mary U. of London
- Universidade Federal de Mato Grosso
- USP São Carlos
- Universidade Federal da Paraíba
- IPEN SP



Curso de Especialização em Energias Renováveis, Geração Distribuída e Eficiência Energética

Esse curso de especialização universitária (360 hs) está na sua 22a edição desde 2011.

Conta com um corpo discente de mais de 400 alunos da indústria da Grande São Paulo e de outros estados. Outros dados podem ser encontrados em:

http://www.pecepoli.com.br/PT/ERG/

Este curso tem por objetivo abordar os seguintes tópicos:

1 - Revisão da teoria e tecnologias de máquinas de produção de energia eletromecânica; 2- Apresentação da legislação técnica e ambiental para a implantação de projetos de energia de pequena e média escala; Lei solar paulistana 3 - Cálculo de viabilidade técnica-financeira de projetos de energia; 4 - Análise de projetos de energia baseados em fontes renováveis: solar, eólica e biomassa; 5 - Uso eficiente da energia e cogeração; 6 - eficiência energética - normas Ashrae 90.1 e 189.1.



Linhas de Pesquisa

Diffuser

Dry Gas

75 bar,9C

(1088 psi,48F)

Static Guide Cyclonic Separator Laval (500,000g) Nozzle Vanes \ Saturated Feed Gas 100 bar, 20C (1450 psi, 68F) Tapered Vortex Inner Body Generator Liquids + Slip-gas 75 bar, 7C (1088 psi, 45F)

Separação supersônica de gases







Linhas de Pesquisa





Linhas de Pesquisa

• Ciclo de absorção de calor de amônia-água









Linhas de Pesquisa - Projetos

Eficiência Energética em Postos de Combustíveis





Linhas de Pesquisa – solar alta temperatura

GASEIFICAÇÃO DE BIOMASSA A PARTIR DE ENERGIA SOLAR COM ALTA CONCENTRAÇÃO





GASEIFICAÇÃO DE BIOMASSA A PARTIR DE ENERGIA SOLAR COM ALTA CONCENTRAÇÃO



RESULTADOS ESPERADOS:

- Economia de 30% do combustível em relação à gaseificação tradicional, onde a combustão da biomassa fornece calor
- Eliminação da contaminação dos produtos gasosos devido à ausência de combustão
- Redução das emissões específicas de gás carbônico (kgCO₂/kWh)
- Ganho energético em relação à queima direta do combustível



SIMULADOR DE RADIAÇÃO SOLAR DE ALTA TEMPERATURA

- Simula a distribuição direcional, espacial e espectral da radiação solar obtida no plano focal de um concentrador
- Permite a realização de testes *in-door* e elimina a dependência de fatores naturais como condições do tempo, intermitência e movimento da direção da radiação solar



Laboratório de Desempenho Energético de Edificações

Coordenação: Prof. Dr. Alberto Hernandez Neto



Contato: ahneto@usp.br



Laboratório de Desempenho Energético de Edificações

Objetivos:

- Análise de estratégias para a redução do consumo de energia em edificações climatizadas
- Diferentes topologias (edifícios comerciais, escolas, shopping centers, hospitais, etc.) novas ou em operação
- Tipos de estratégias:
 - Ativas (sistemas de climatização, iluminação, equipamentos)
 - Passivas (sombreamento, ventilação natural)
- Aumento da resiliência de edificações em cenários de aquecimento global e mitigação de contaminação em ambientes climatizados

Laboratório de Desempenho Energético de Edificações

Projetos atuais:

- Avaliação do desempenho de edificações climatizadas: Estudo de estratégias para redução de consumo de energia em edificações climatizadas para diferentes condições climáticas brasileiras em cenários de aquecimento global e de mitigação de contaminação
- Análise exergética de sistemas de climatização: Aplicação de análise exergética para avaliação do desempenho do sistema de climatização em edificações climatizadas
- Avaliação do desempenho de edificações energia e/ou emissão zero para condições climáticas brasileiras em cenários de aquecimento global e de mitigação de contaminação
- Avaliação de sistemas de resfriamento geotérmico puros e/ou híbridos para aplicação em edificações climatizadas
- Análise do impacto em sensores e equipamentos de sistemas de climatização no desempenho de edificações climatizadas;

Bolsas a serem solicitadas em função do interesse dos alunos

2021 Research topics

Fernando Luiz Sacomano Filho





Laboratory of Environmental and Thermal Engineering



2021 | Fernando Luiz Sacomano Filho | fernando.sacomano@usp.br | 1

Research topics – long term



- Spray combustion is quite often hiden in our day life
 - IC- engine
 - Aircraft turbine
 - Power generation
 - ..
- It is a quite promising energy conversion process
 - New biofuel demands → Indian market
 - Intermediary energy storage following solar fuel technologies
 - Production of nanoparticles
- Improvements of the prediction ability of CFD models is a <u>need</u>!





Research topics – long term



- Chemical Looping Combustion is the most promising technology associate to combustion processes regarding carbon capture processes (CCS) → capture is straightforward and combustion is much more efficient.
- Contact of fuel with air is circumvented by the usage of oxygen carrier particles → pure CO2 and H2O as flue gas.





Spray combustion



- Direct numerical simulations of flames interacting with stationary vortices → advanced turbulence-flame interaction models.
 - assessment of different numerical approaches applied to the solution of the reaction zone with stationary vortices.
 - <u>Student</u> will have the opportunity to:
 - learn the fundamentals of CFD, programming, and turbulence-flame interaction.
 - contact national research groups





Spray combustion



- CFD simulations of liquid biofuel combustion using detailed chemistry → interaction of liquid fuel droplets with combustion reactions.
 - Expected results will deliver important contributions to technical and scientific communities of spray combustion.
 - <u>Student</u> will have the opportunity to:
 - learn about programming, reaction kinetics, spray flow.
 - Potential contact international research groups



■ Concept design of an ethanol turbulent spray burner → allow future experimental investigations about the initial mixture composition and air humidity in the produced flame.



Chemical Looping Combustion



- Análise técnico econômica da utilização de biomassa produzida em território nacional em processos de combustão do tipo chemical looping -> da continuidade e insumos a iniciação científica em andamento (bolsa FAPESP)
- Implementation of a one-dimensional model for the characterization of a packed-bed CLC reactor → estudo fortemente conectado a 3 trabalhos de formatura em andamento



RCG21 **RESEARCH CENTRE FOR GREENHOUSE GAS INNOVATION**

CLEANER ENERGY FOR A SUSTAINABLE FUTURE



×

Research Centre for Gas Innovation

INTRODUCING RGCI

CLEANER ENERGY FOR A SUSTAINABLE FUTURE



Research Centre for Gas Innovation



A centre for advanced studies on the **mitigation of green-house gases**, investigating carbon capture, usage and storage (CCUS); the sustainable use of natural gas, biogas and hydrogen; gas in transportation; monitoring; and abatement of CO_2 emissions.





FOUNDING SPONSORS





RCGI HEADQUARTERS Escola Politécnica, University of São Paulo

RESEARCH CENTRE FOR GAS INNOVATION

ENGINEERING



PHYSICAL-CHEMISTRY

ENERGY POLICIES & ECONOMICS

CO2 ABATEMENT

GEOPHYSICS



PARTNER INSTITUTIONS



RESEARCH CENTRE FOR GAS INNOVATION

370+ researchers

46 research projects

5 programmes

Internacional projection



HIGHLIGHTS OF PROJECTS: INNOVATION



Research Centre for Gas Innovation



Main Benefits

- Able to reduce around 60% of fugitive methane emissions in the world.
- Efficiency gain and reduction in emissions.



Optimized labyrinth seal

TION TOPOLOGY

Innovation: Supersonic separator with feedback control



Carmo et al. (2018): Project 39

Main Benefits

- Able to separate CO2 and Methane in associated gas with high content of CO2.
- Work at optimum condition even with CO2 content varying in the inlet.

k control







S Ū CaV .0 U0 Salt ratic sepa Ġ L Q а Л Л H⁴ ()storage 0 σ 5

MAIN BENEFITS

- High storage capacity: 8M ton of CO₂ per cave.
- Separate and store methane (monetization).
- Solution for the production of pre-salt gas (high CO₂ content).
- Integration with other energy sources.
- Integration with other gas separation processes.
- ANP INNOVATION PRIZE 2019





cleaner energy for a sustainable future

RCG₂I – RESHAPE







Towards RCG₂I: Research Centre for Greenhouse Gas Innovation

Background

- A step-up opportunity is triggered for RCGI to:
 - link RCGI's objective with Brazil Energy Transition program: real and tangible abatement impact taking into account unique aspects of Brazil while also being globally relevant.
 - narrow down the research topics and increase abatement impact (towards a dedicated centre for GHG Abatement Technology fundamentals focussed on Energy Transition);
- Excellent foundation already created by the Shell Fapesp USP partnership (Company Government Academic Research): to further build upon and support Brazil's NCF Ambition.

Drivers

- Align this research portfolio with Brazil's Intended Nationally Determined Contribution to Paris Agreement (iNDCs);
- Support Brazil to achieve the iNDC through Research & Innovation performed in the new RCGI center .

Fundamental questions to be addressed by RCG₂I

NBS	BECCS	CCU	GHG	ADVOCACY	Regulation
How to incorporate nature based Carbon sinks in novel CO2 Abatement value chains?	How to achieve negative carbon intensity biofuels with NPV+ type of projects?	How to deploy novel value chains/ archetypes to create or unlock a carbon products market?	How confident are we in terms of real quantification of GHG emission and sequestration?	What are the market mechanisms required for a Low-Carbon economy?	NBS CCU BECCS GHG







RESEARCH CENTRE FOR GAS INNOVATION

RCG₂I Governance Structure (from Q1/2021)



RESEARCH CENTRE FOR GAS INNOVATION

RCG₂I Executive Committee (EC)



Julio Meneghini

Director RCGI, Full Professor at University of Sao Paulo jmeneg@usp.br

Full Professor of Applications and Principles in Mechanical Engineering, Escola Politécnica, University of São Paulo, PhD in Aeronautics, Imperial College – University of London (1993). DIC-Diploma of Imperial College in Aeronautical Engineering (1993). He has a first degree in Physics (BSc) from Instituto de Física, USP (1989) and in Civil Engineering (EEM, 1984). He has been working in research projects in Aeronautical, Mechanical, Naval and Oceanic Engineering, as coordinator or consultant. His main areas of interest are investigations focusing on vortex shedding, vortex- induced vibration, computational fluid dynamics, bluff body flow and aeroacustics. He is the Scientific Director of the Research Centre for Gas Innovation (RCGI), sponsored by FAPESP/SHELL. He is the coordinator of the Fluid & Dynamics Research Group (NDF) at EPUSP. He was appointed in July 2017 a Full Member of the Academy of Sciences of São Paulo State – "Academia de Ciências do Estado de São Paulo" – ACIESP.

RCG₂I Executive Committee (EC)



Alexandre Breda

CO2 Abatement Technology Lead

alexandre.breda@shell.com

Alexandre Breda joined Shell Brazil in December 2013; he holds a B.Sc. degree in Mechanical Engineering from Unicamp (University of Campinas) with a Master in Energy from USP (University of Sao Paulo). He has also a Black Belt (Six Sigma Academy-Arizona) and followed courses in Business Strategy and Management (Unicamp) and Legal Contracts for Infrastructure (FGV-Law). Prior joining Shell, he worked for Comgas, Cummins Power Generation and BG Group; he has a solid experience in new business development, gas supply chain, climate change and greenhouse gases, project management, contract negotiation, renewables integration with natural gas and end-use of gas, mainly cogeneration and air conditioning. At Shell, he is responsible for the CO2 Abatement R&D Projects in Brazil, aiming the growth of CCUS and Methane Emissions technology solutions, working with leading universities and suppliers through open innovation. Alexandre is married and has two young daughters (Laura and Helena); he lives in Rio-Brazil.

RCG₂I Executive Committee (EC)



Bruno Souza Carmo

Professor Mechanical Engineering, Deputy Scientific Director RCGI

bruno.carmo@usp.br

Dr Bruno Souza Carmo obtained a degree in Mechatronics from the University of São Paulo (2002), completed an MSc in Mechanical Engineering at the University of São Paulo (2005) and did his PhD in Aeronautics at Imperial College London (2009). He joined the Department of Mechanical Engineering at the University of São Paulo, São Paulo campus, in July 2010 and has been carrying out research as a member of the Centre For Dynamic and Fluids (NDF) since then. He has also been part of the Research Centre for Gas Innovation (RCGI) since its origination, working as deputy scientific director and coordinating two projects in the Engineering programme and one project in the CO2 abatement program. His areas of expertise are fluid mechanics and energy, and he is currently working on projects and supervising students in the following research lines: hydrodynamic stability, fluid-structure interaction, spectral element methods, hybrid power systems, wind energy, aeroacoustics, biological flows, CFD-based optimization and gas purification.

RCG₂I Executive Committee (EC) – NBS Programme Coordinator



Carlos Eduardo Pellegrino Cerri

Professor Agriculture , Esalq - University of Sao Paulo

cepcerri@usp.br

Graduated in Agronomic Engineering from the University of São Paulo (1997), master's degree in Soil and Plant Nutrition from the University of São Paulo (1999), doctorate in Environmental Science from the University of São Paulo (2003). He is currently Associate Professor at the Soil Science Department at the Luiz de Queiroz School of Agriculture, University of São Paulo, working mainly on topics related to Organic Soil Matter, Global Warming and Climate Change, Agriculture and the Carbon Credit Market, Mathematical Modeling , geostatistics and geoprocessing. CNPq Productivity Scholarship and Affiliate Member of the Brazilian Academy of Sciences.

RCG₂I Executive Committee (EC) – BECCS Programme Coordinator



Marcos Buckeridge

Full Professor at the Institute of Biosciences at the University of São Paulo msbuckeridge@gmail.com

He was President of the Association of Students and Researchers in Great Britain (1993 and 1994) and President of the Botanical Society of São Paulo for two terms (2001 to 2005). Between 2015 and 2019 Buckeridge was president of the São Paulo State Academy of Sciences. In October 2018 he was elected Director of the Biosciences Institute of the University of São Paulo. He is a member of the USP Advanced Studies Institute, where he created and coordinates the USP-Global Cities program. Buckeridge's work has already generated 4 books, 8 patents, more than 50 master's and doctoral theses and more than 180 scientific publications in plant physiology, biochemistry and molecular biology. He was a founding member of the BIOEN-FAPESP Program and from 2009 to 2012 he was the Scientific Director of the National Bioethanol Science and Technology Laboratory (CTBE) in Campinas. Since 2008 Buckeridge has been director of the National Bioethanol Science and Technology Institute (INCT do Bioetanol). His work today focuses mainly on systems biology, mainly with the application of network theory to understand the functioning of the plant as a whole. He carried out pioneering studies on how Brazilian plants respond to the increase in atmospheric CO2 and more recently to combinations between CO2, water stress and temperature, elucidating fundamental mechanisms of plant responses to climate change. In 2017, he became the only scientist based in Brazil to participate as the author of the Special Report 1.5C Warming Word of the IPCC, published in December 2018

RCG₂I Executive Committee (EC) – CCU Programme Coordinator



Liane Rossi

Full Professor at the Department of Fundamental Chemistry at the University of São Paulo

lrossi@iq.usp.br

Full Professor of Chemistry, Institute of Chemistry, University of São Paulo. BS degree in Chemical Engineering from the Federal University of Rio Grande do Sul (1994). PhD in Chemistry from the Federal University of Santa Catarina (2001). After a two-year postdoctoral stay at Federal University of Rio Grande do Sul (Brazil) and a one-year postdoctoral stay at University of New Orleans (USA), she joined the Institute of Chemistry at University of São Paulo (IQUSP), in 2004.

Her research interests in the field of chemistry and catalysis include novel approaches for the synthesis of supported metal nanoparticles with controlled size, morphology and surface properties, catalyst recovery and recycling, new reactivity patterns at metal-ligands interfaces, bimetallic and hybrid catalysts, and the concepts of green chemistry in selective reactions. The main catalytic processes under study are selective hydrogenations and oxidations, biomass conversion into chemicals, including CO2 conversion and valorisation. She is the author or co-author of more than 100 papers published in indexed peer-reviewed scientific journals, two book chapters and two patent applications filled. She is a member of the Brazilian Chemical Society (SBQ), Brazilian Catalysis Society (SBCAT) and American Chemical Society (ACS). She holds a CNPq's fellowship (PQ) Level 1B.

RCG₂I Executive Committee (EC) – GHG Programme Coordinator



Emilio Carlos Nelli Silva

Full Professor at the Department of Mechanics and Mechatronics at the University of São Paulo

ecnsilva@usp.br

He began his work as Professor in the Department of Mechatronics and Mechanical Systems at the Polytechnic School of the University of São Paulo (EPUSP), Brazil, in 1998. He is currently a researcher of CNPq 1A level in Brazil. He obtained Bachelor and master degree in Mechanical Engineering from EPUSP in 1990 and 1993, respectively, and the Ph.D. degree in Mechanical Engineering from The University of Michigan – Ann Arbor, USA, in 1998.

He specializes in Computational Mechanics, particularly in the application of finite element and topology optimization methods in smart structures and materials, such as piezoelectric actuators and sensors, piezocomposite materials (including functional gradient materials – FGM), energy harvesting devices, microelectromechanical systems (MEMS), and flow machines. He was invited as visiting professor at Kyoto University, Japan, in 2003, and University of Illinois at Urbana-Champaign, USA in 2003, 2004, 2006 and 2007. He has published articles in international journals of selective editorial policy, acted as reviewer of international journals, and international conferences, and as ad hoc consultant for international funding agencies such as NSF (USA), NRF (South Africa), and ISF (Israel).

RCG₂I Executive Committee (EC) – Advocacy Programme Coordinator



Edmilson Moutinho dos Santos

associate professor at the Institute of Energy and Environment at the University of São Paulo edsantos@usp.br

Graduated in Economics (1990) and in Electrical Engineering (1988) from the University of São Paulo. Masters in Energy Management and Policy (University of Pennsylvania; 1993) and in Energy Systems Planning (State University of Campinas; 1992). PhD in Energy Economics from the French Petroleum Institute and Université de Bourgogne (1997). He is currently an associate professor at the Institute of Energy and Environment at the University of São Paulo (IEE-USP). Since March / 2019, CNPq Category 2 Scientific Productivity Scholarship. Since November 2017, he has chaired the Graduate Commission of the USP Institute of Energy and Environment. Develops research and teaching activities with an emphasis on Economics and Energy Policies. He acts as an advisor and independent consultant with development and research agencies, companies, governmental and non-governmental agencies. He is coordinator of the Human Resources Training Program in Oil and Natural Gas at IEE-USP (PRH-04, with financial support from the National Agency of Petroleum, Natural Gas and Biofuels - ANP -, and Petrobras). He also coordinates the International Academic Cooperation Agreement between IEE / USP and IFP SCHOOL, France. IEE / USP. President 2014/2016 of the Brazilian Association of Energy Studies AB3E; and President 2011/2012 of the Brazilian Society of Energy Planning (SBPE).

RCG₂I Executive Committee – Members

• Members:

- 1. Julio Meneghini, RCGI's Director
- 2. Alexandre Breda, Shell's Sustainable Gas Program Lead;
- 3. Bruno Souza Carmo Deputy Scientific Director
- 4. Gustavo Assi Director Dissemination of Knowledge and Technology Transfer
- 5. Carlos Eduardo Pellegrino Cerri Director NBS Programme
- 6. Marcos Buckeridge Director BECCS Programme,
- 7. Liane Rossi Director CCU Programme
- 8. Emilio Silva Director GJG Programme
- 9. Edmilson Moutinho Director Advocacy Programme
- 10.Luis Moreira Executive Manager
- 11.Karen Louise Mascarenhas Director HR&L
- 12. Ana Paula Vasconcelos Manager DoK&ITT

Chair: Julio Meneghini



cleaner energy for a sustainable future

THANK YOU







