Opportunities and Priorities for Research and Collaboration in Clean Energy and Sustainability with the Federal University of Santa Catarina

Prof. Amir A. M. Oliveira Jr., Ph.D.
Chair of the Department of Mechanical Engineering
amir.oliveira@gmail.com

Clean Energy and Sustainability Symposium: Australia - Brazil

18-19 March 2024, Curitiba, Brazil

FEDERAL UNIVERSITY OF SANTA CATARINA – UFSC

Curitiba

Florianópolis

307 km from Curitiba

FEDERAL UNIVERSITY OF SANTA CATARINA – UFSC

Created in 1960
Students (2022): 37,738
- Basic education: 1,235
- Undergraduate: 26,160
- Graduate: 10,343

Faculty: 2,638
Staff: 2,927
- 130 undergraduate programs
- 94 master programs
- 59 doctor programs

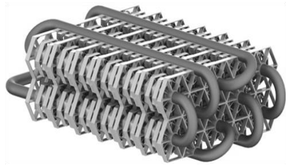
DEPARTMENT OF MECHANICAL ENGINEERING - EMC

Departamento de Engenharia Mecânica

Created in 1962
Graduate and Undergraduate programs in
Mechanical Engineering (CAPES 6)
Materials Science and Engineering (CAPES 7)
Students: 1,500 (about 700 graduate students)
Faculty: 70
27 research groups (2 EMBRAPII units)

two graduate and undergraduate programs in the department

Prototypes, Technologies



Publication

Patent, Innovation

Technology-Based Spin-offs

ESSS

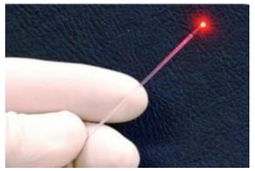
ASPS
Sistemas e Processos de Soldagem

welle
Welle Tecnologia Laser Ltda ME

nano
SOLUÇÕES INOVADORAS PARA A SAÚDE

Engineers, Masters & Doctors

New frontiers



EMBRAPII Units

Originated from the ME Department

Operating in the ME Department

Intelligent Systems

Refrigeration and Thermophysics (2014)

INCT in Refrigeration and Thermophysics

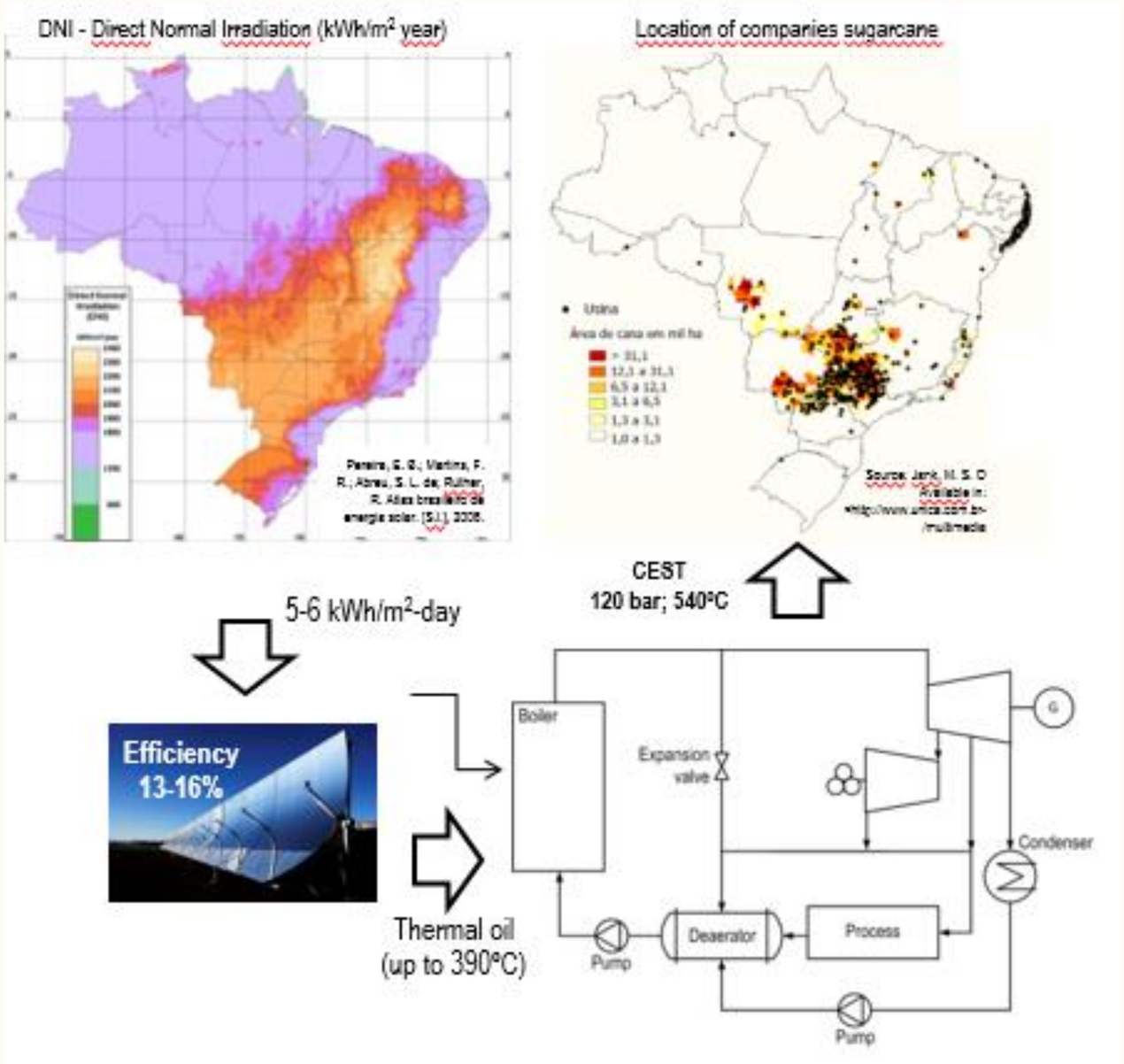
Mobility (2021)

LABORATORIES
(https://emc.ufsc.br/portal/laboratorios/)

SUMMARY

1. Hybrid biomass/solar (CSP) thermoelectric power plants
2. Electrical energy storage – hydrogen, fuel cells and batteries
3. Rare-earth based permanent magnets
4. Macroalgae (Ulva ohnoi) biorefinery
5. Biofuels and advanced combustion systems
6. Marine microplastic litter
7. Open source drifting buoys

HYBRID BIOMASS/SOLAR (CSP) THERMOELECTRIC POWER PLANTS

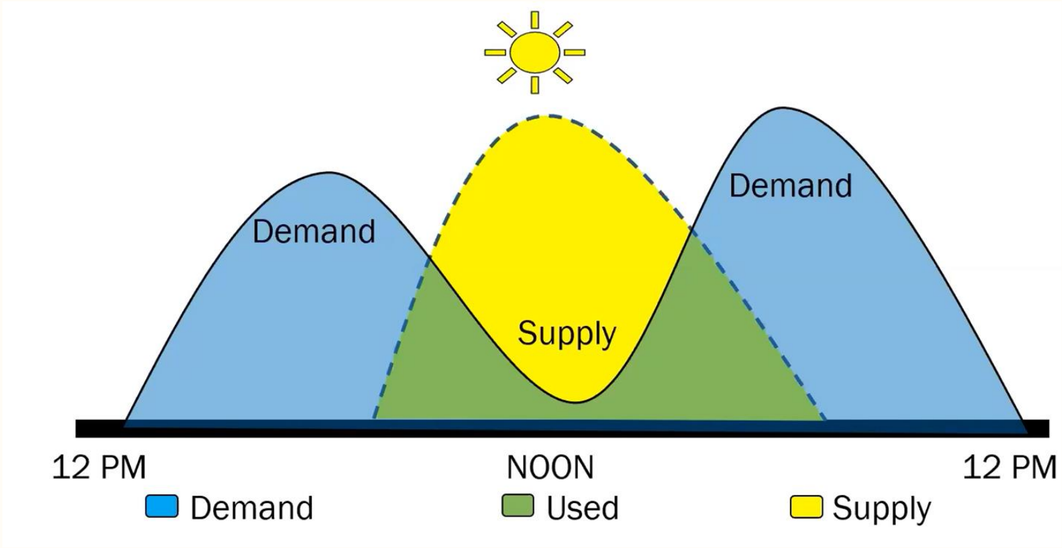


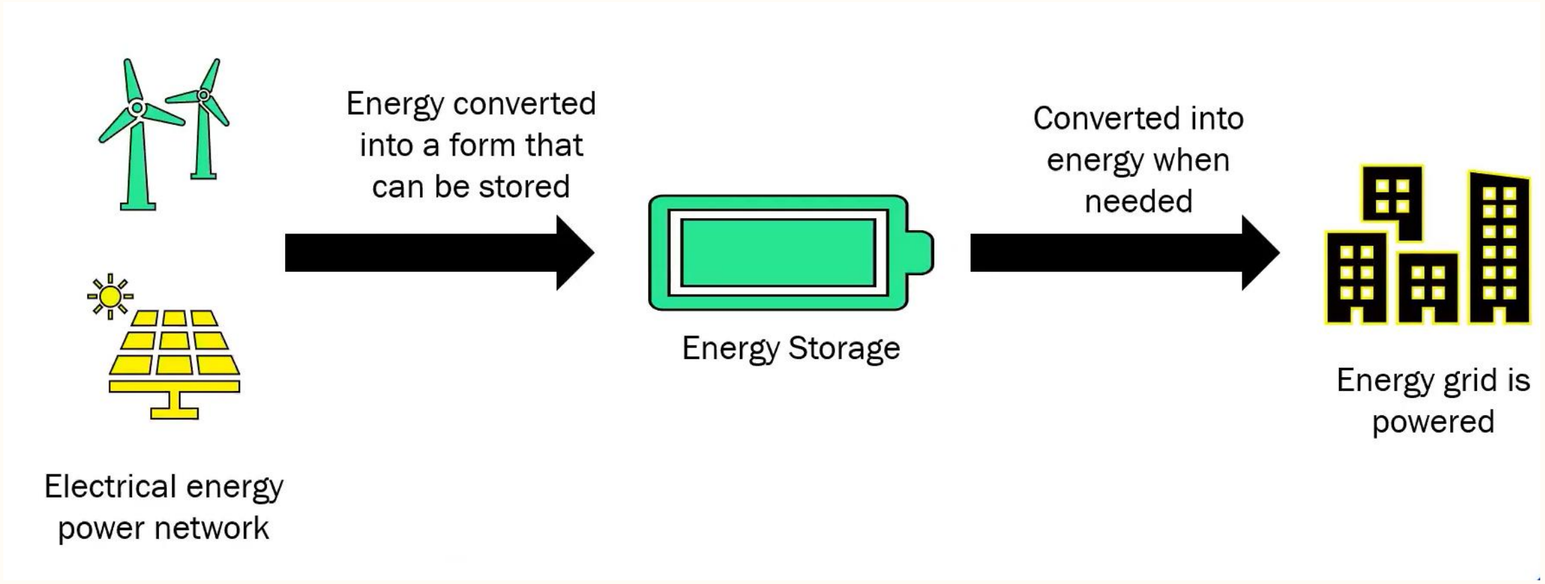
Hybrid biomass/solar cogeneration plant applied to the sugarcane sector

Research aiming at collecting technical and economic information for improving the availability and competitiveness of new plants as well as existing cogeneration plants applied to the sugarcane sector.

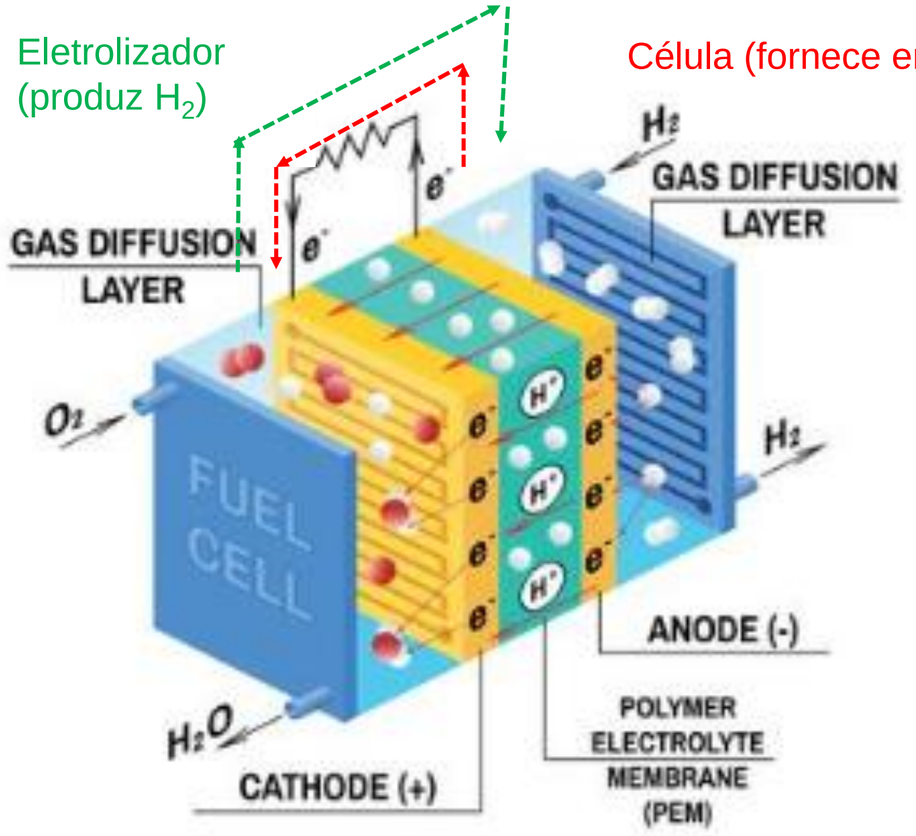
Outcomes: (i) Increase the power generated, (ii) full knowledge of the dynamics of hybrid plants operation and (iii) Brazilian potential related to solar energy applied to existing power and cogeneration plants.

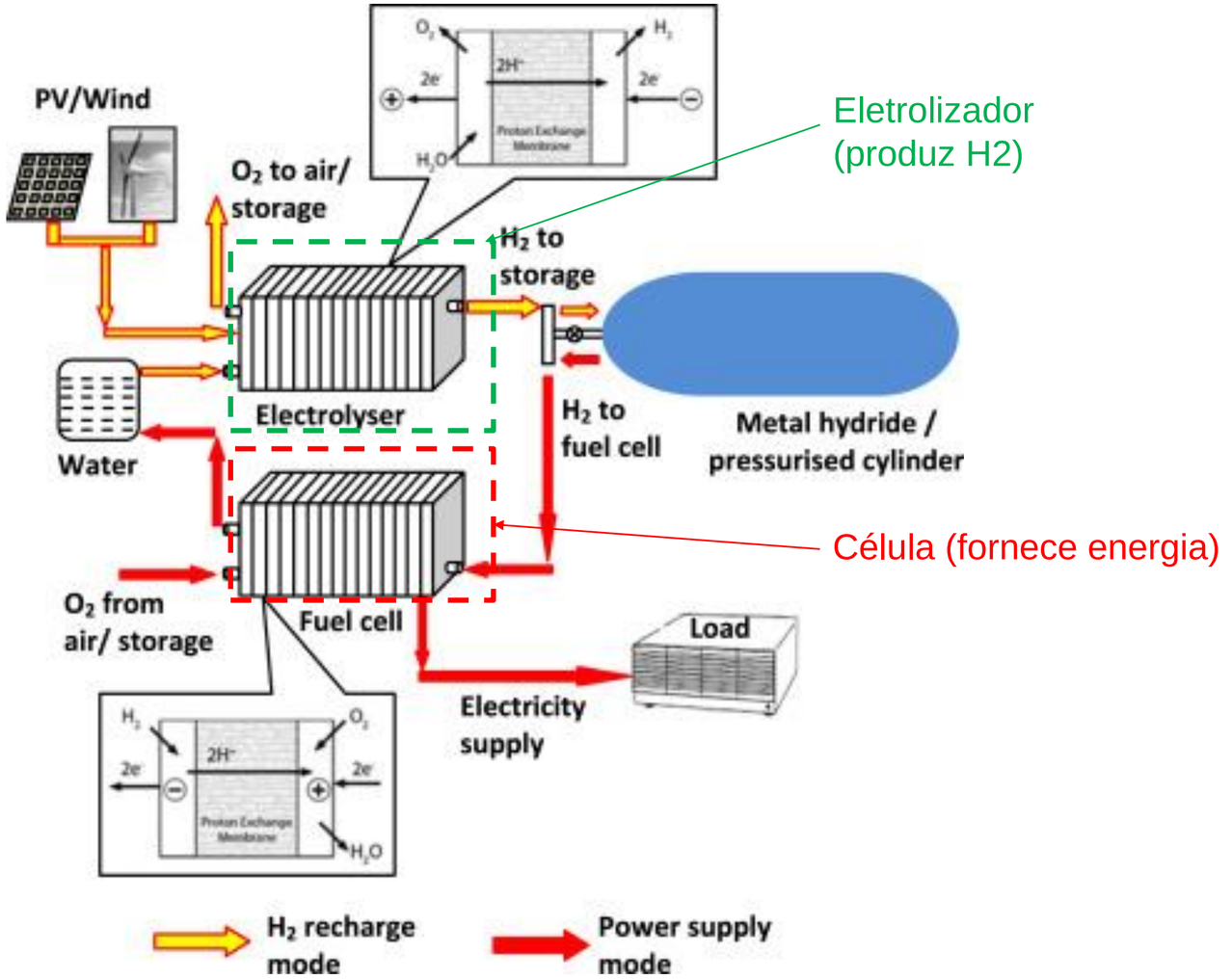
Electrical energy storage





Hydrogen storage and fuel cells





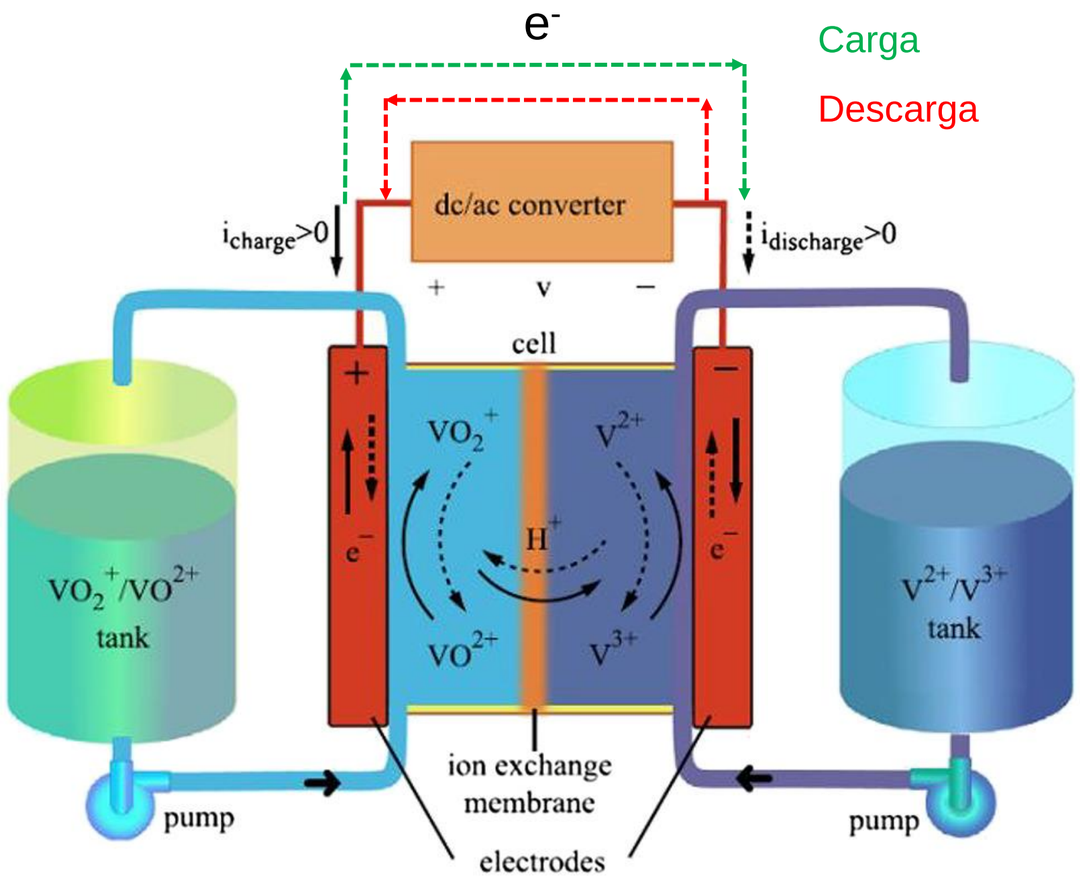
Cátodo:

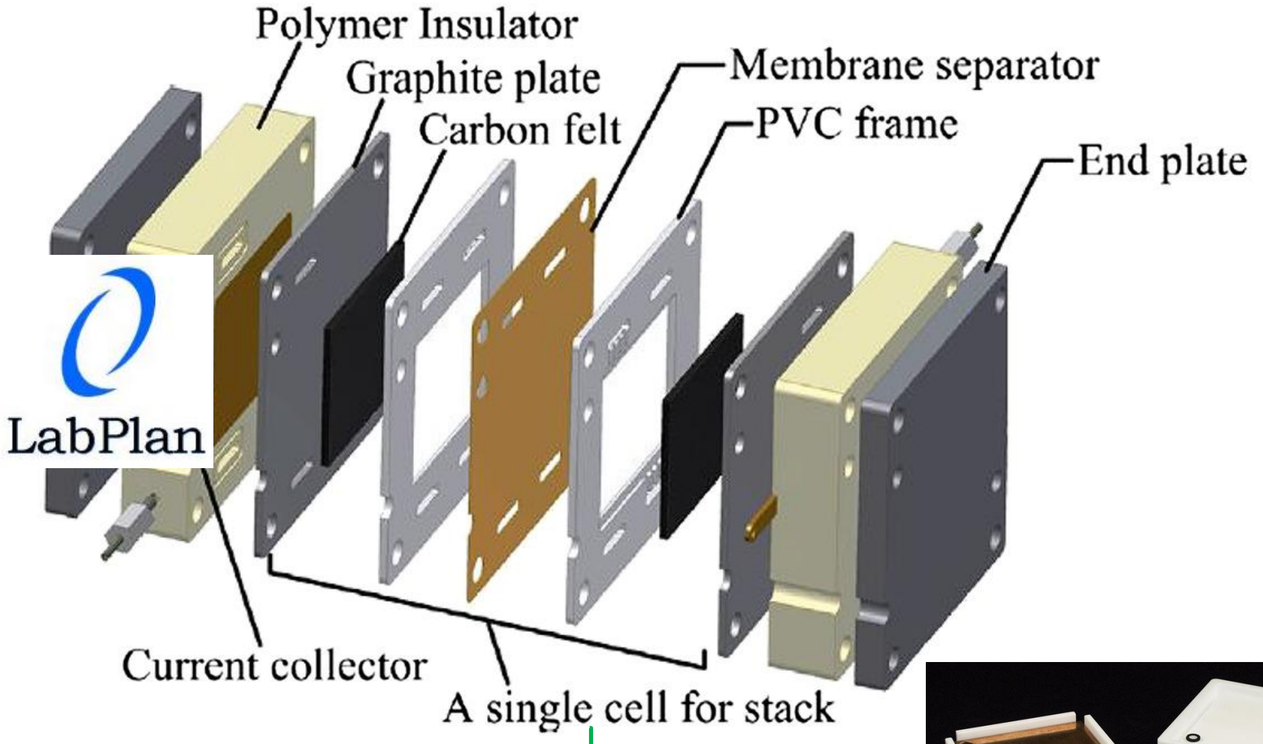
$4\ H^+ + O_2 + 4\ e^- \rightarrow 2\ H_2O$

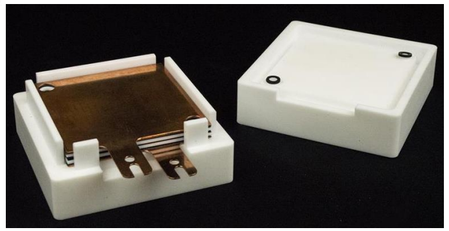
Ânodo:

$2\ H_2 \rightarrow 4\ H^+ + 4\ e^-$

Redox flow batteries







Cátodo:

$VO_2^+ + 1\ e^- + 2\ H^+ \rightarrow VO^{2+} + H_2O$

Ânodo:

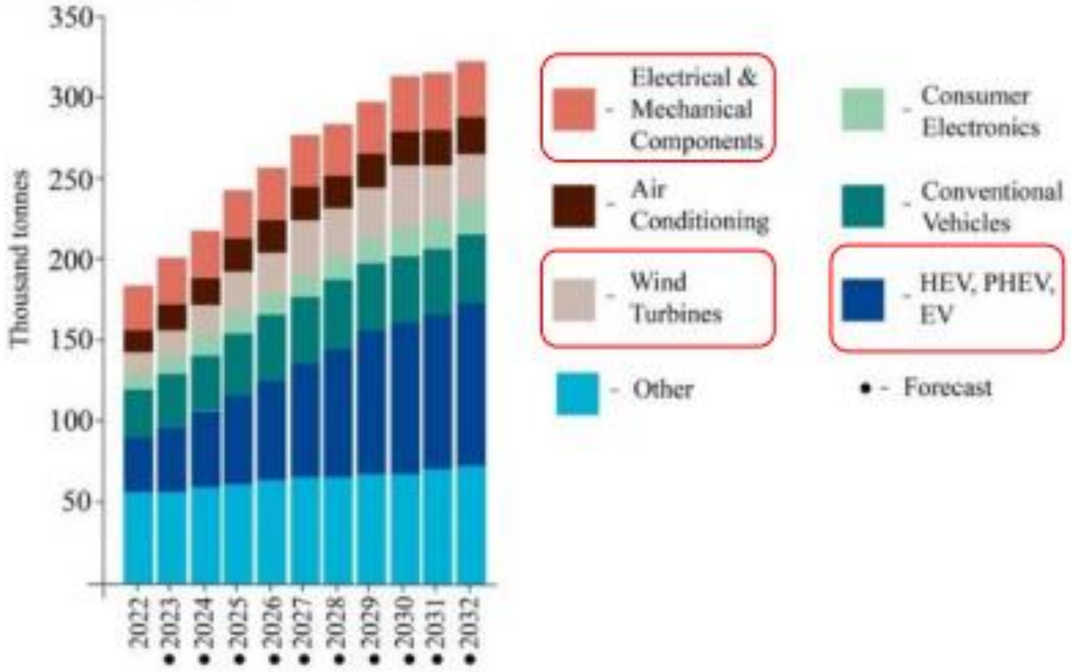
$V^{2+} \rightarrow V^{3+} + 1\ e^-$

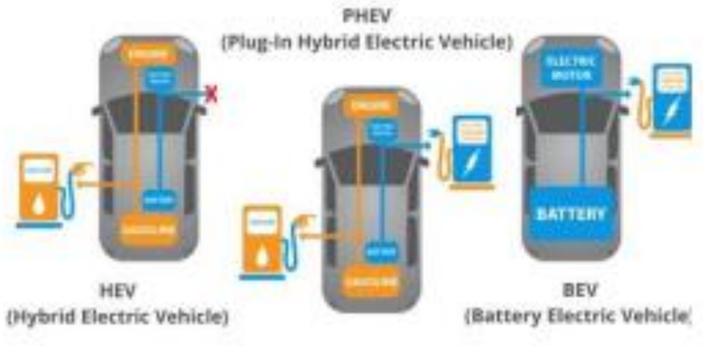
Yuan et al., A review of all-vanadium redox flow battery durability: Degradation mechanisms and mitigation strategies, International J. Energy Research, 2019. https://doi.org/10.1002/er.4607

Rare-earth based permanent magnets

- Among the main applications of rare-earth permanent magnets, **those linked to sustainability stand out**.

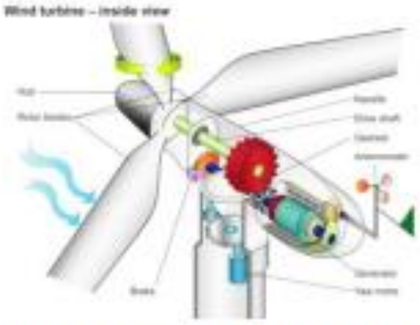
From: The Role of Permanent Magnets, Lighting Phosphors, and Nickel–Metal Hydride (NiMH) Batteries as a Future Source of Rare Earth Elements (REEs): Urban Mining Through Circular Economy





Electric Mobility

Electric Motors



Wind Power Generation

- In this scenario, **recycling** becomes more relevant in the permanent magnet industry, **given the high value of rare-earth elements and the new abundance of magnets coming from obsolete devices.**

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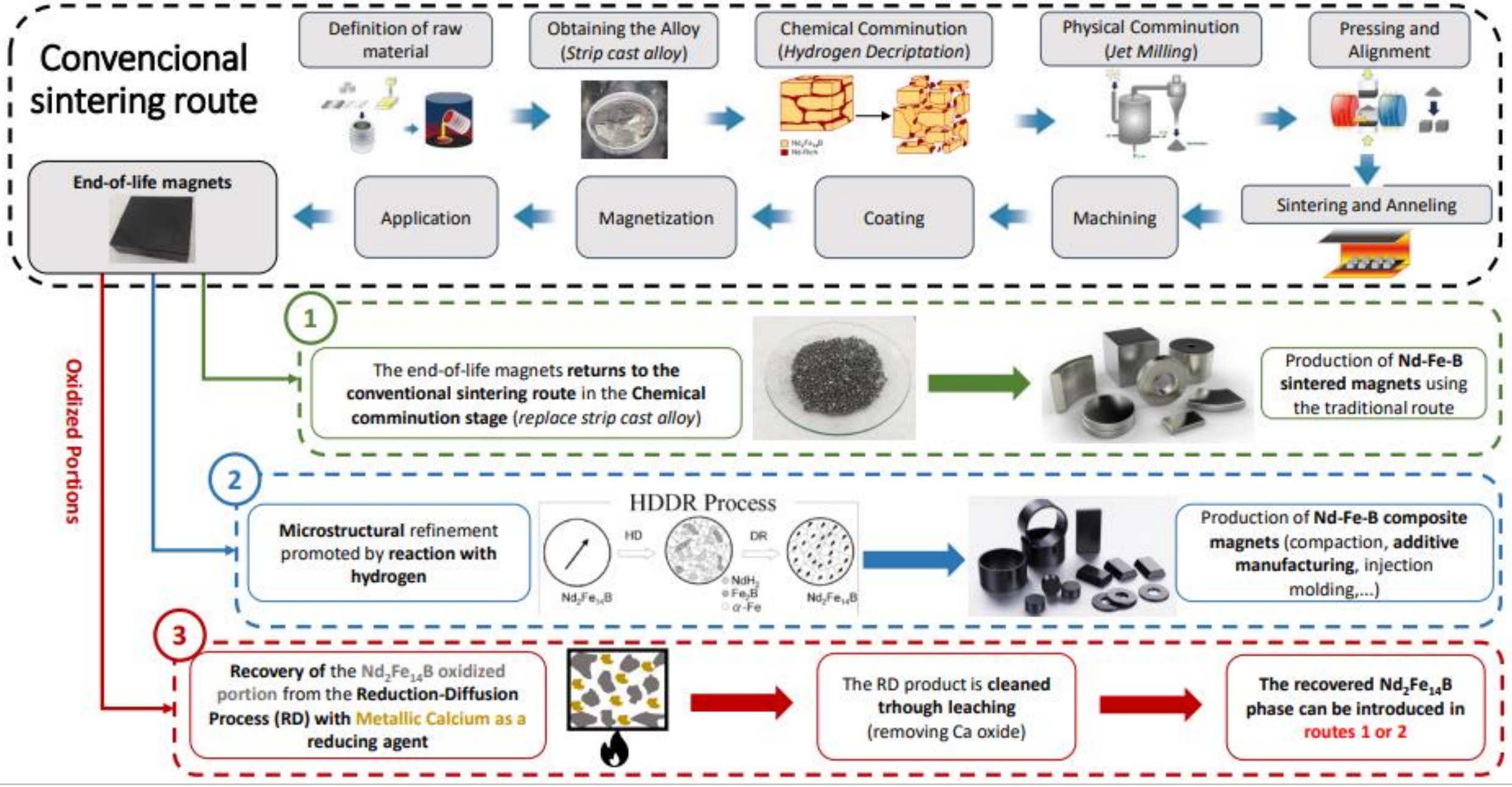
Departamento de Engenharia Mecânica

magma

Production and recycling routes



Projects reveloped at MAGMA related to sustainability

Project FUNTEC

Challenges in obtaining (Nd,Pr)Fe-B Magnets from Didymium Oxide for Applications in the High-Tech Motor and Electric Generator Industry

Project AM-RPM-BR

Development of Particulate Raw Material from Urban Mining and Its 3D Printing as Recycled Rare Earth Magnets

Project Urban Mining

Urban Mining, recycling of rare earth permanent magnets

REGINA I

(Rare Earth Global Industry and New Applications) Sustainability in the Production Chain and Magnet Manufacturing Technologies

REGINA II

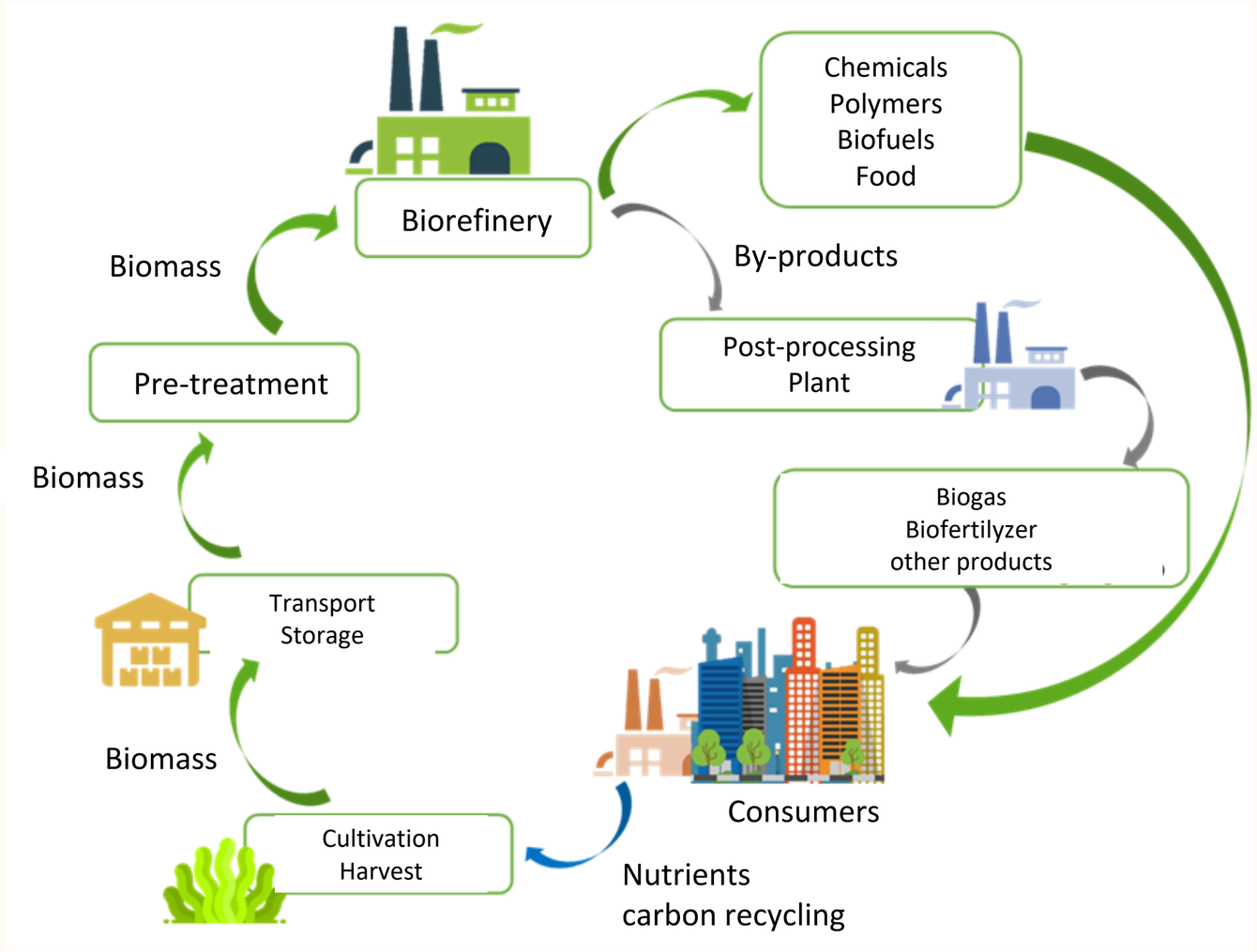
(Rare Earth Global Industry and New Applications) International Cooperation for the Competitive and Sustainable Development of Processes and Products within the Scope of the Rare Earths Production Chain

INCT-PATRIA

Processing and Applications of Rare Earth Magnets for High Technology Industry

MACROALGAE (ULVA OHNOI) BIOREFINERY AS A SUSTAINABLE RESOURCE IN THE EXTRACTION OF ULVAN FOR THE DEVELOPMENT OF BIOPRODUCTS

This project aims to investigate biorefinery processes using algae and to develop a biomass processing model for the extraction of Ulvan to obtain bioproducts. We are seeking to define a biorefinery process that adapts to the phytochemical composition of the algae (Ulva ohnoi). Another aim of the project is to capture CO_2 and generate carbon credits and to use biomass for the development of sustainable products.

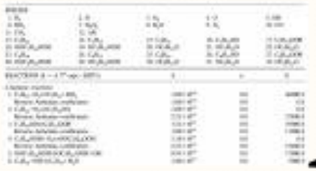


BIOFUELS AND ADVANCED COMBUSTION SYSTEMS

From electrons to devices

Fundamental experiments

Detailed Chemical Kinetic Models



Validation against experimental data

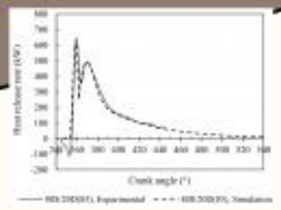
Model Reduction

Validation against experimental data

Combustion interaction with fluid flow

Model ling

Numerical study on devices



Validation against experimental data

Device experiments

Application to energy generation and transportation

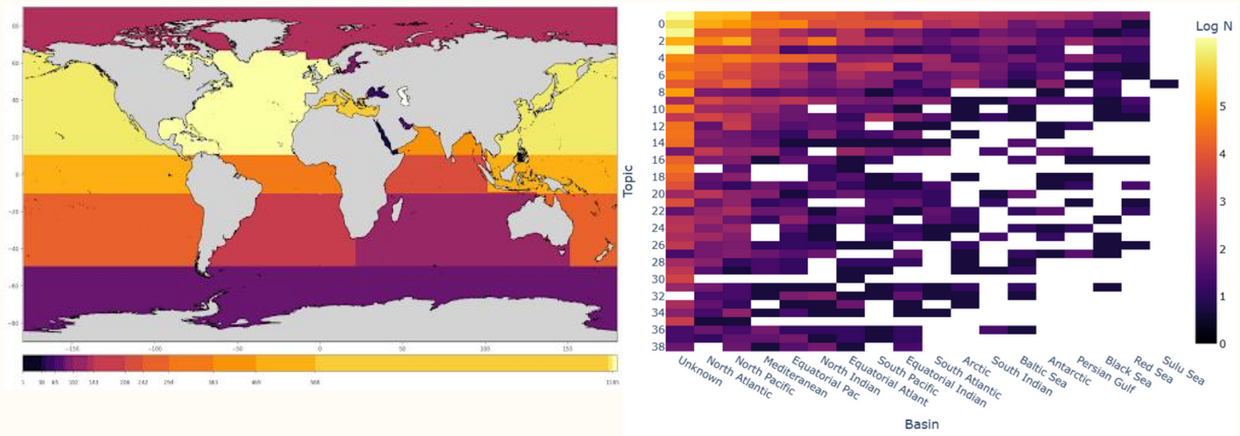
MAPPING THE LANDSCAPE OF MARINE PLASTIC LITTER RESEARCH WITH LARGE LANGUAGE MODELS

	Degradation process			
Weathering Factor	**Photo**	**Chemical**	**Thermal**	**Bio**
UV				
Temperature				
Moisture				
pH				
Oxygene				
Organic Compounds				
Microorganisms/enzymes				
Polymer properties				
Bond energy				
Linearity				
Functional groups				
Cristallinity				
Molecular weight				
Chain mobility				
Glass transition temperature				
Defects				
Chromophores		-	-	-
Carbonyl group				
Free radicals				
Residual Monomers				
Catalysts				
Additives				

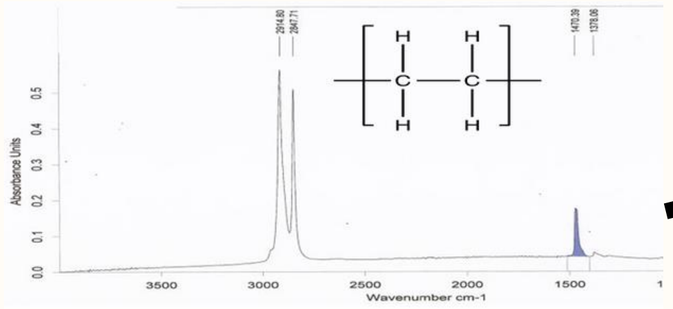
Drivers of the degradation of plastics in the environment rated by importance.

There is great interest in the biodegradation of polymers in the sea. A cluster analysis of scientific articles using LLMs (Large language models: GPT, BERT...) shows a large number of scientific publications, but focused on a few topics and regions, with a lack of data for the southern regions. The research aims to correlate key results with marine conditions and to match these results with the measured concentration of microplastics.

Distribution of topics by ocean basin. Studies are concentrated on few topics and few regions.



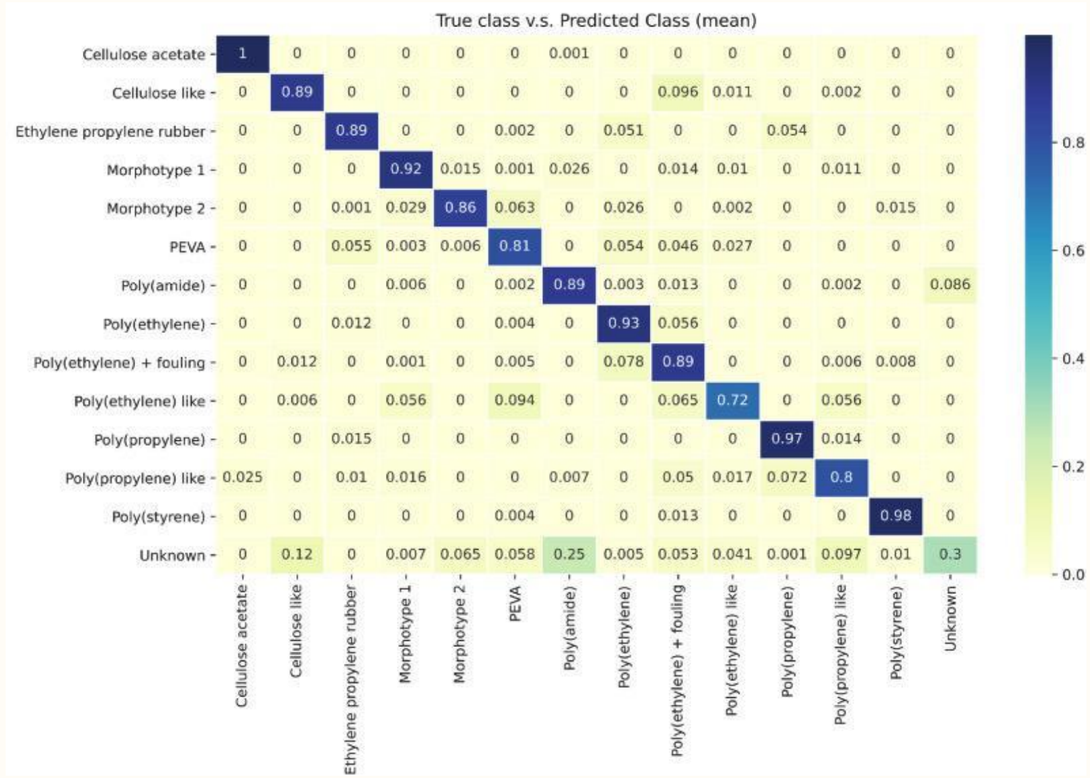
TRAINING AND EVALUATING MACHINE LEARNING ALGORITHMS FOR OCEAN MICROPLASTICS CLASSIFICATION THROUGH VIBRATIONAL SPECTROSCOPY



Data base of ~1k spectra previously identified and attributed to 17 classes of polymers

Machine learning model

Confusion matrix with prediction accuracy by polymer type



The study shows with a robust statistical analysis that machine learning models can be used to characterize environmental plastics. While there are still limitations to its automatic application, it can be used reliably and quickly, significantly reducing the need for individual spectra analysis by a specialist and analysis time.

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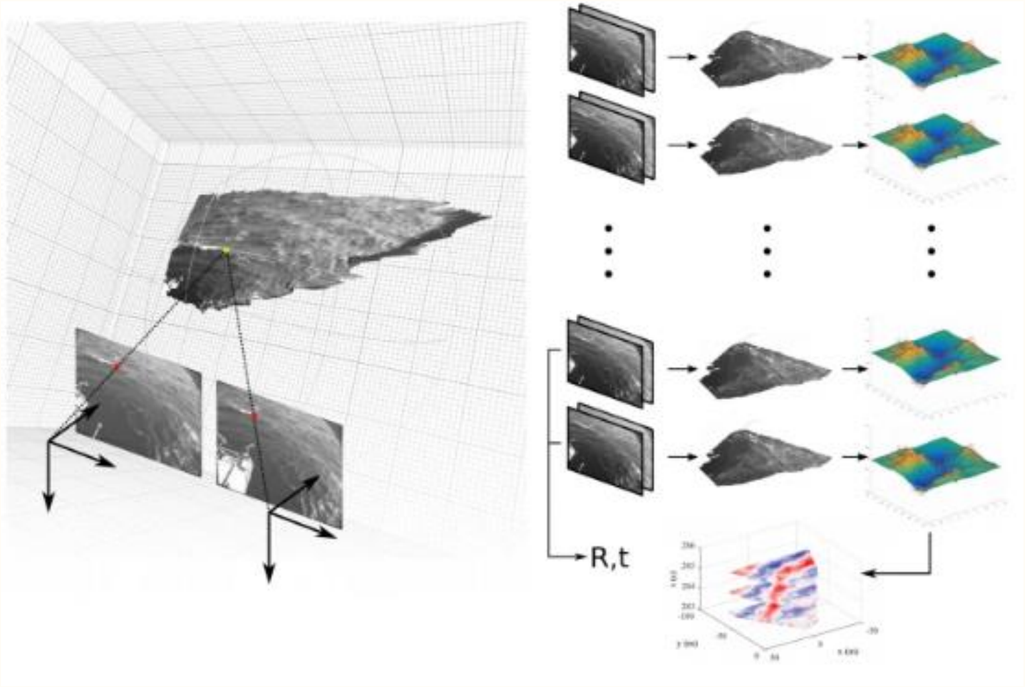
HOW WELL DO WE UNDERSTAND STORM CONDITIONS?

Effect on marine and offshore structures



Stereo imaging of the sea surface elevation allows to retrieve the 4-D ocean topography (3-D space+time) at high frequency (up to 15–20Hz) over a sea surface region of area ~10^4 m^2.

P. V. Guimaraes et al., A data set of sea surface stereo images to resolve space-time wave fields, Scientific Data, volume 7, Article number: 145 (2020)

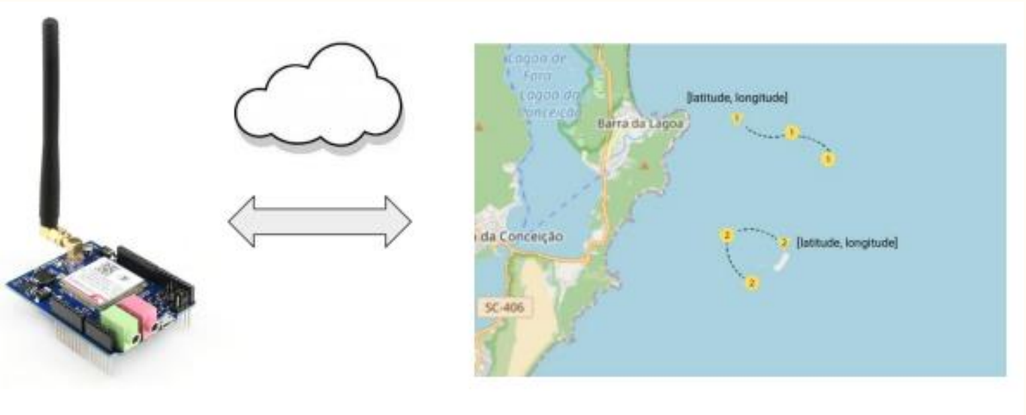
OPEN SOURCE DRIFTING BUOYS

This project aims at developing:

- A small, lightweight and easy-to-build hull to house electronic components;
- An integrated electronic GNSS, accelerometer and data transmission system at low cost;
- Collaboration with other institutions and private companies;
- Reproduction of the directional spectrum of waves between 13 and 1s;
- Validation of the results; transmission of data in real time;
- Study of the equipment's ability to perform moorings;
- Study of different data transmission systems;

Development and test of prototype





Data reception and transmission

OPEN SOURCE DRIFTING BUOYS

Rede Nacional de Observação e Monitoramento Oceânico
ReNOMO

OPEN SOURCE DRIFTING BUOYS

Rede Nacional de Observação e Monitoramento Oceânico
ReNOMO

Collaborative development

Guimarães, P. V.; Guths, S.; Alarcon, O. E; Pimenta, F. M; Downie, I; Lima, J. F; Novick, I.; De Paula, F. N.; Dill Bruxel, L. H.; da Silva, G. L. M. ; Donnangelo, A.; Rosa, R.; Cecconello, C.; Nassif, F.; Freitas, B. C.; Cavalcante, Y.; Nascimento, F.; Lima, S.

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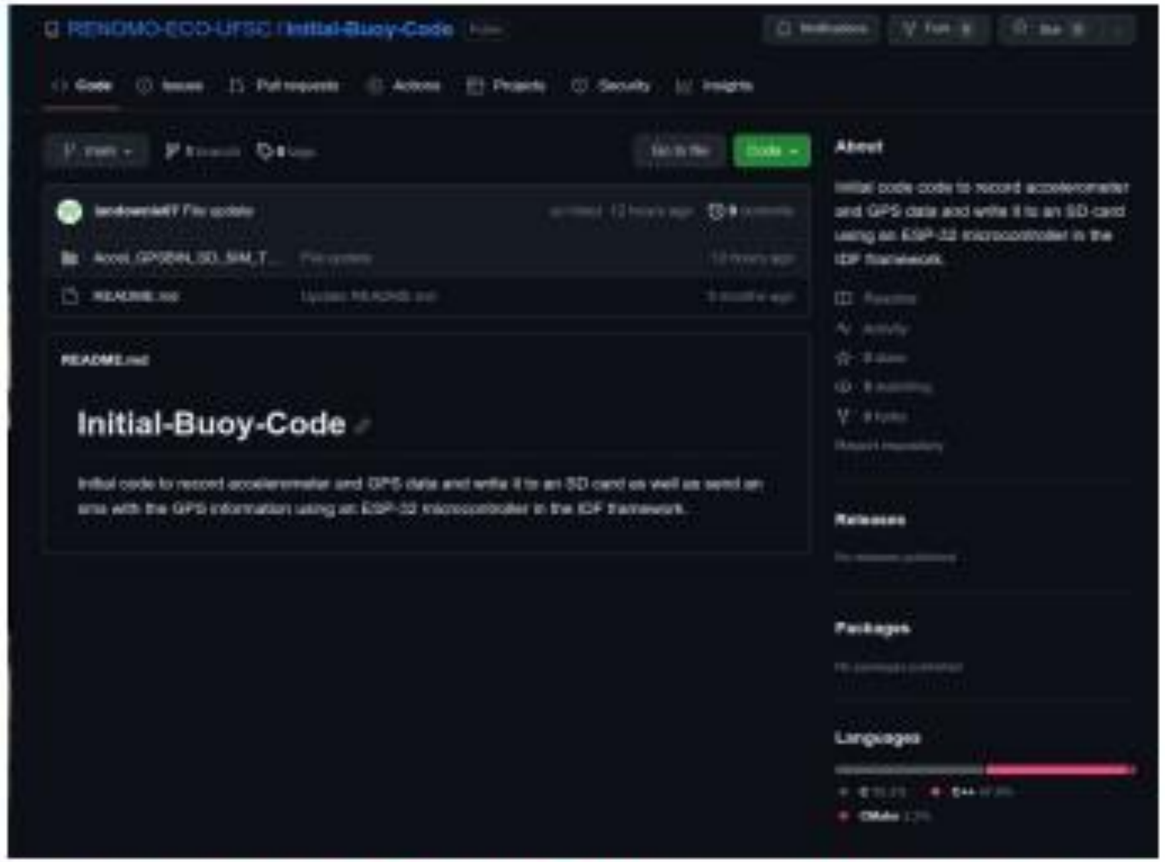

https://github.com/RENOMO-ECO-UFSC/Initial-Buoy-Code

ECO Sail Boat

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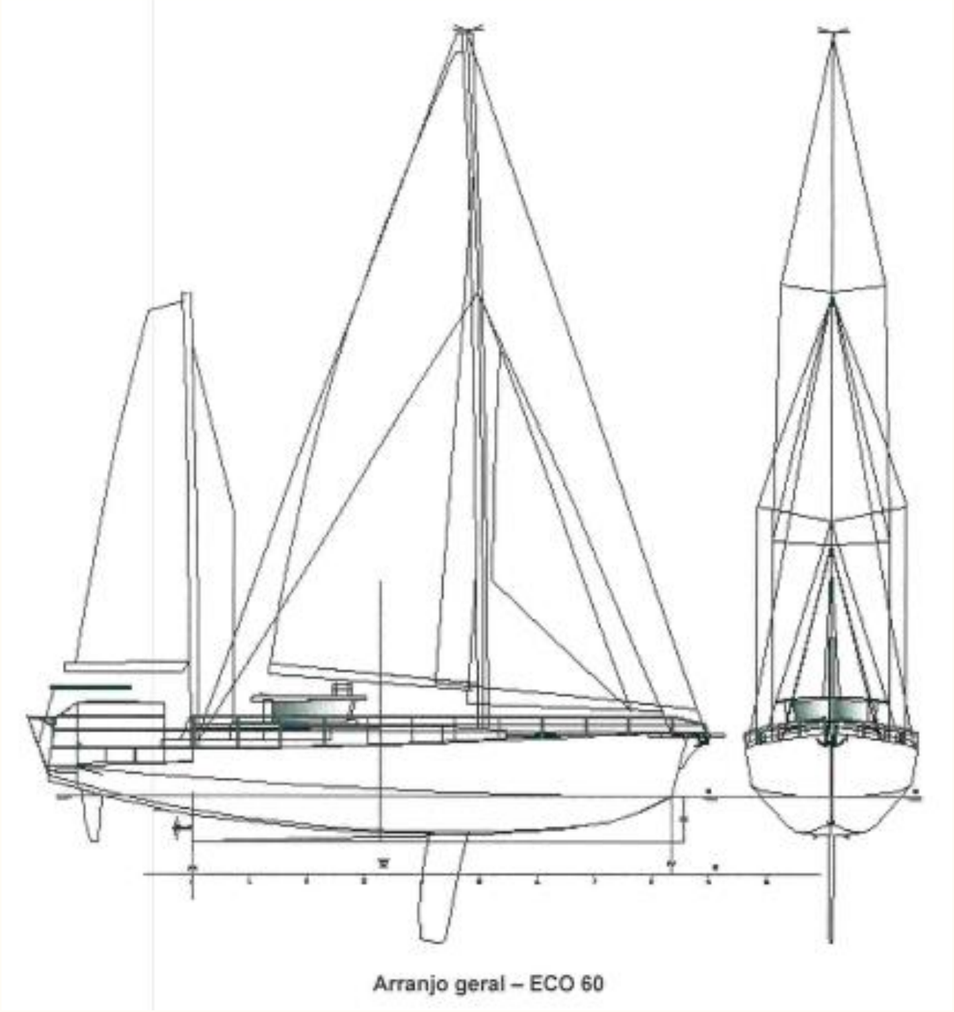

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ECO Sail Boat

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ECO Sail Boat

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Department of Mechanical Engineering
Federal University of Santa Catarina - UFSC

Prof. Amir Antonio Martins Oliveira Jr., Ph.D.
Department Chair
amir.oliveira@ufsc.br
Tel.: +55 48 9 9972 1546

Prof. Milton Pereira, Dr. Eng.
Department Vice-Chair
milton.pereira@ufsc.br
Tel.: +55 48 9 9925 9770

chefia.emc@contato.ufsc.br
https://emc.ufsc.br/portal/laboratorios/