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Rede Sul de Hidrogênio Verde

Novos materiais e intensificação de processos para produção de hidrogênio verde a partir de fontes de energia e insumos renováveis

EQUIPE E INSTITUIÇÕES

- *Dachamir Hotza (EQA/UFSC)*
- *Regina Moreira (EQA/UFSC)*
- *Débora Oliveira (EQA/UFSC)*
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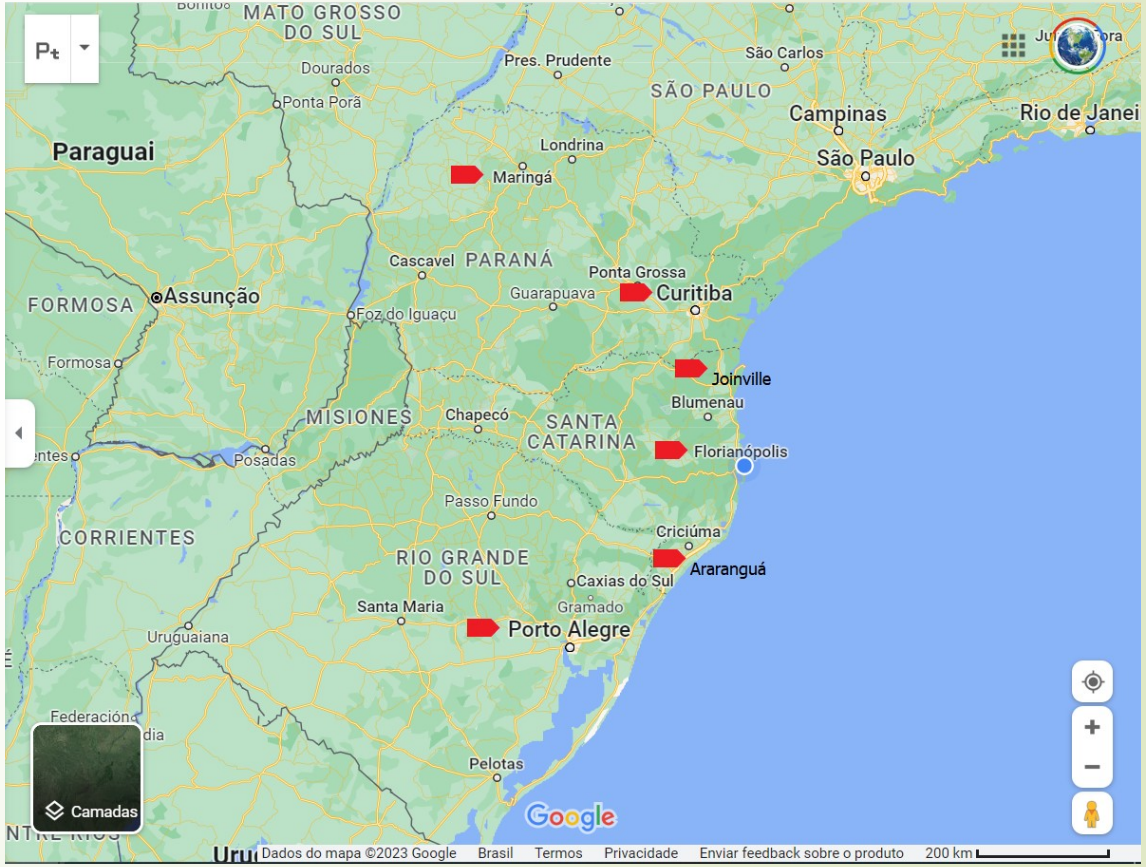

CONTEÚDO

- HISTÓRICO
- PROJETO ATUAL
- PROJETOS FUTUROS
- CONEXÕES

HISTÓRICO

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 33 (2008) 4915–4935

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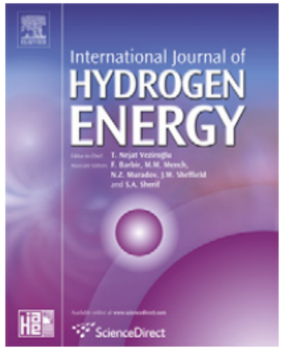


Fuel cells development and hydrogen production from renewable resources in Brazil

D. Hotza[a,*], J.C. Diniz da Costa[b]

[a]Department of Chemical Engineering, Federal University of Santa Catarina, 88040-900 Florianópolis, SC, Brazil
[b]Division of Chemical Engineering, The University of Queensland, 4072 Brisbane, QLD, Australia

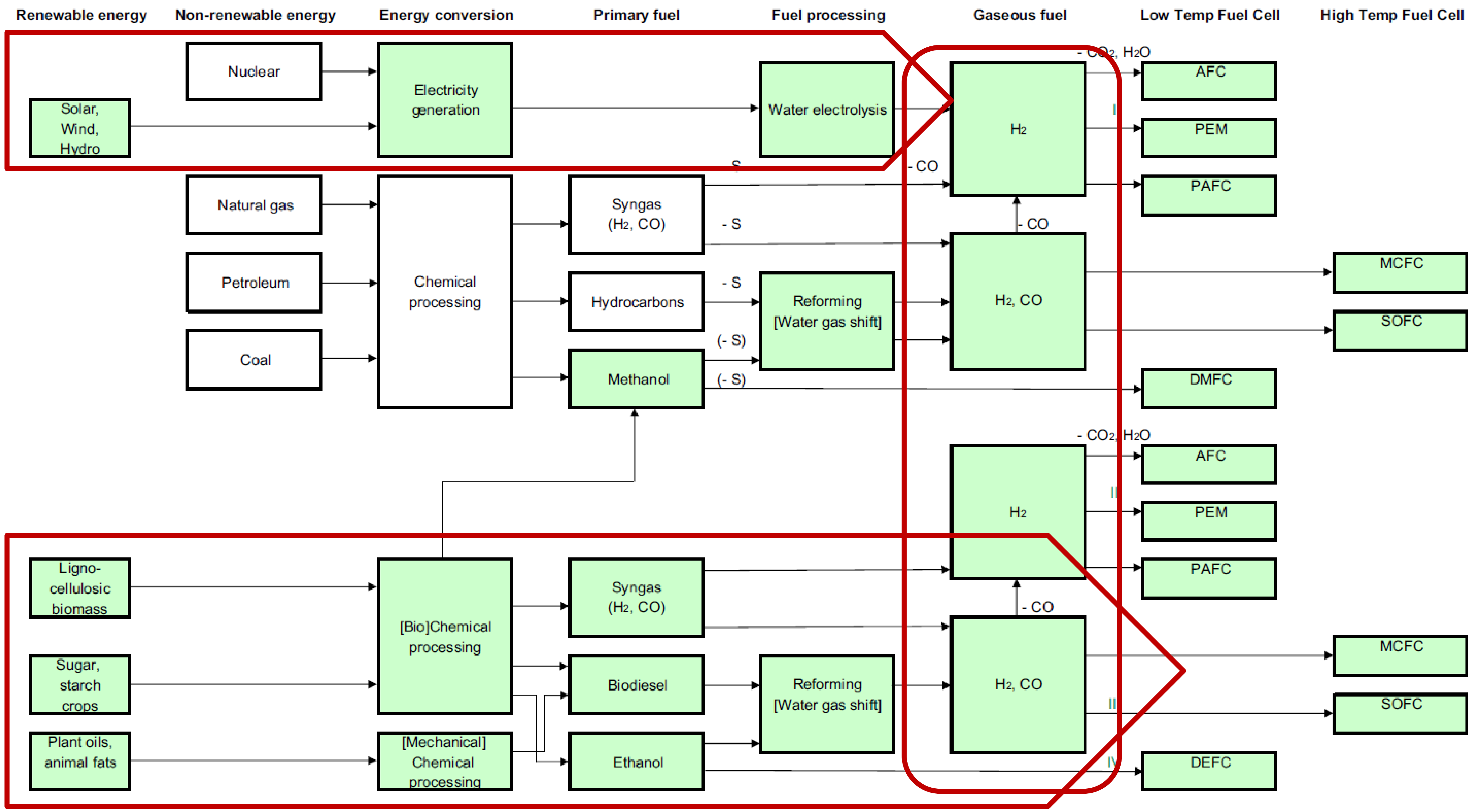


Fig. 1 – Renewable and non-renewable energy sources, fuel processing and fuel cell technologies. The terms and abbreviations are explained throughout the text.

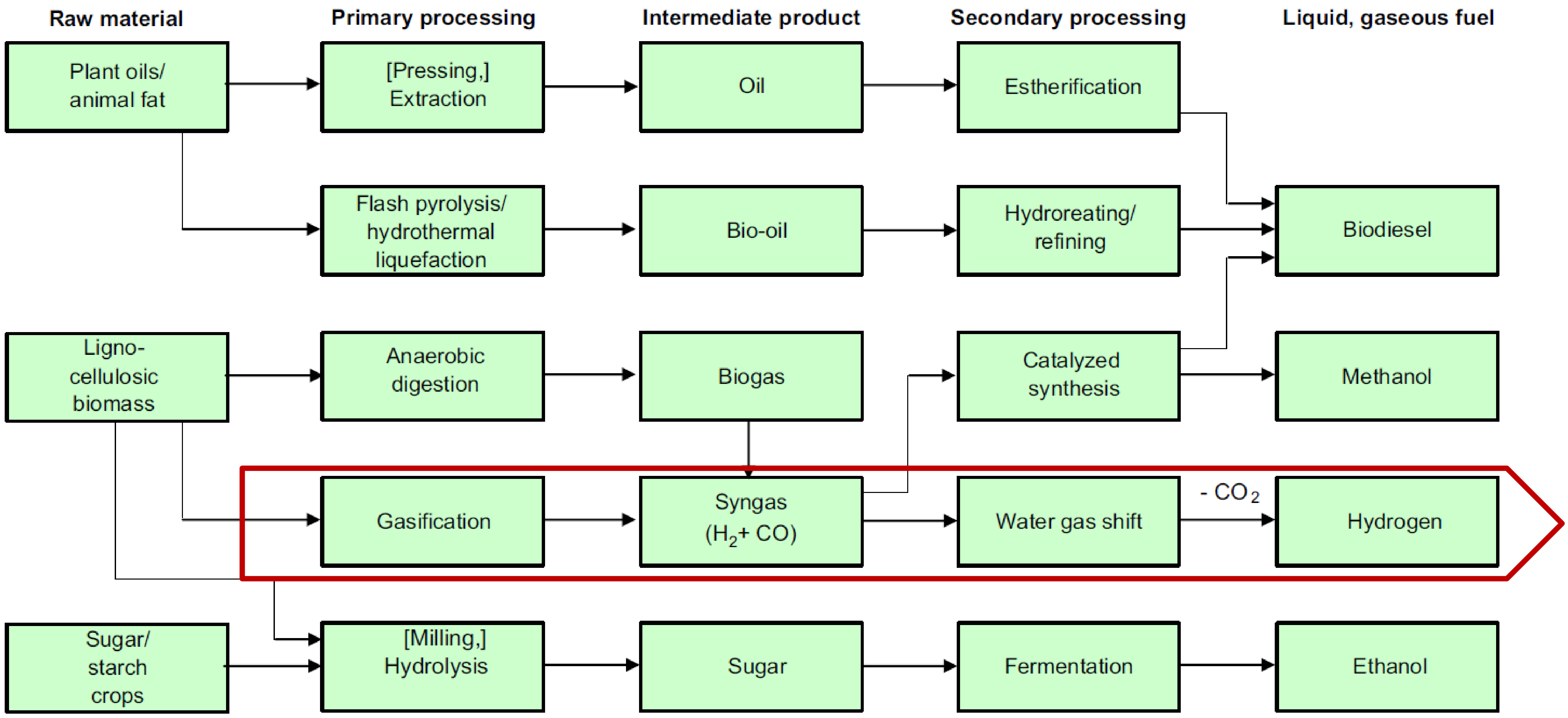
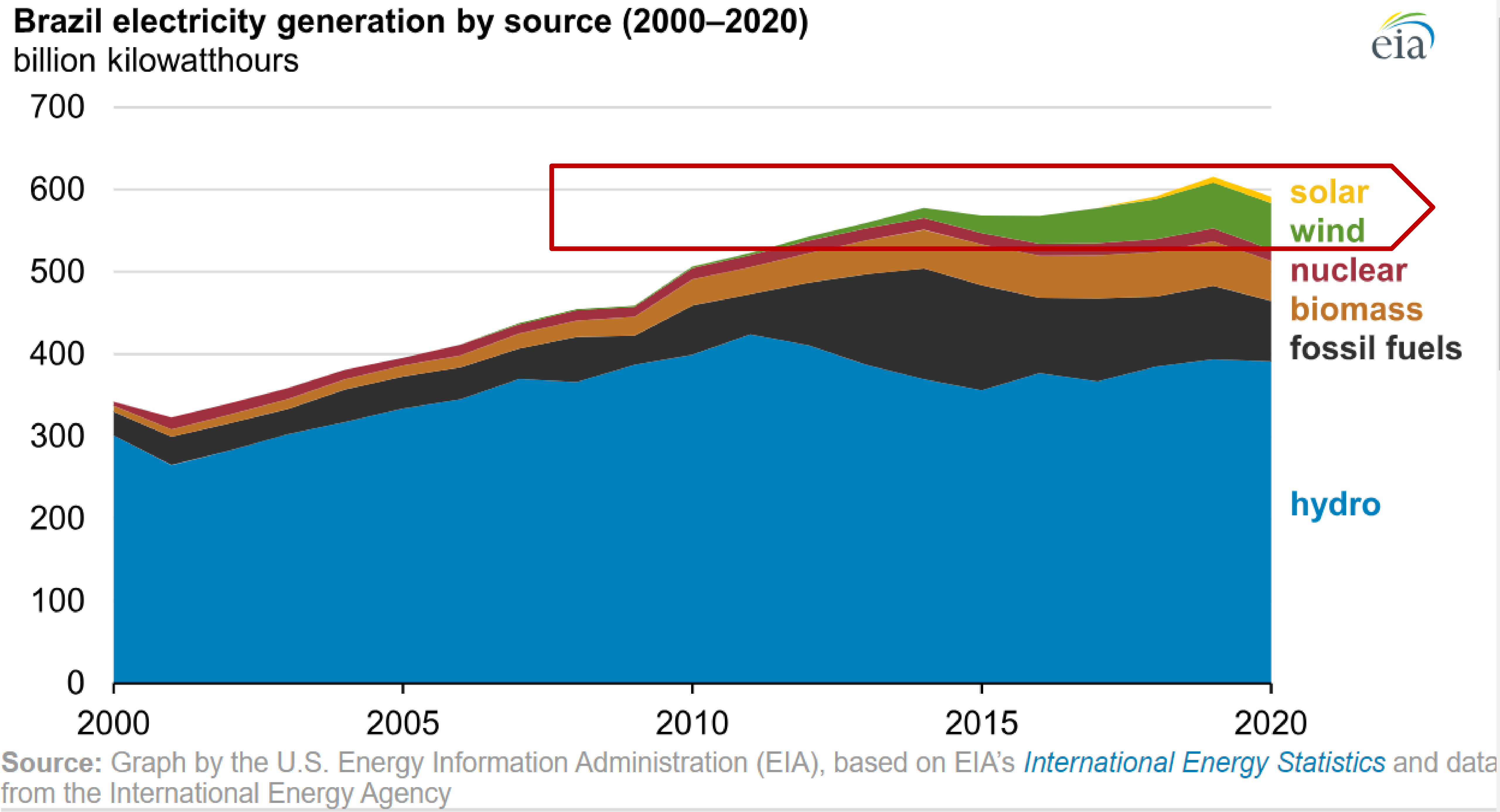
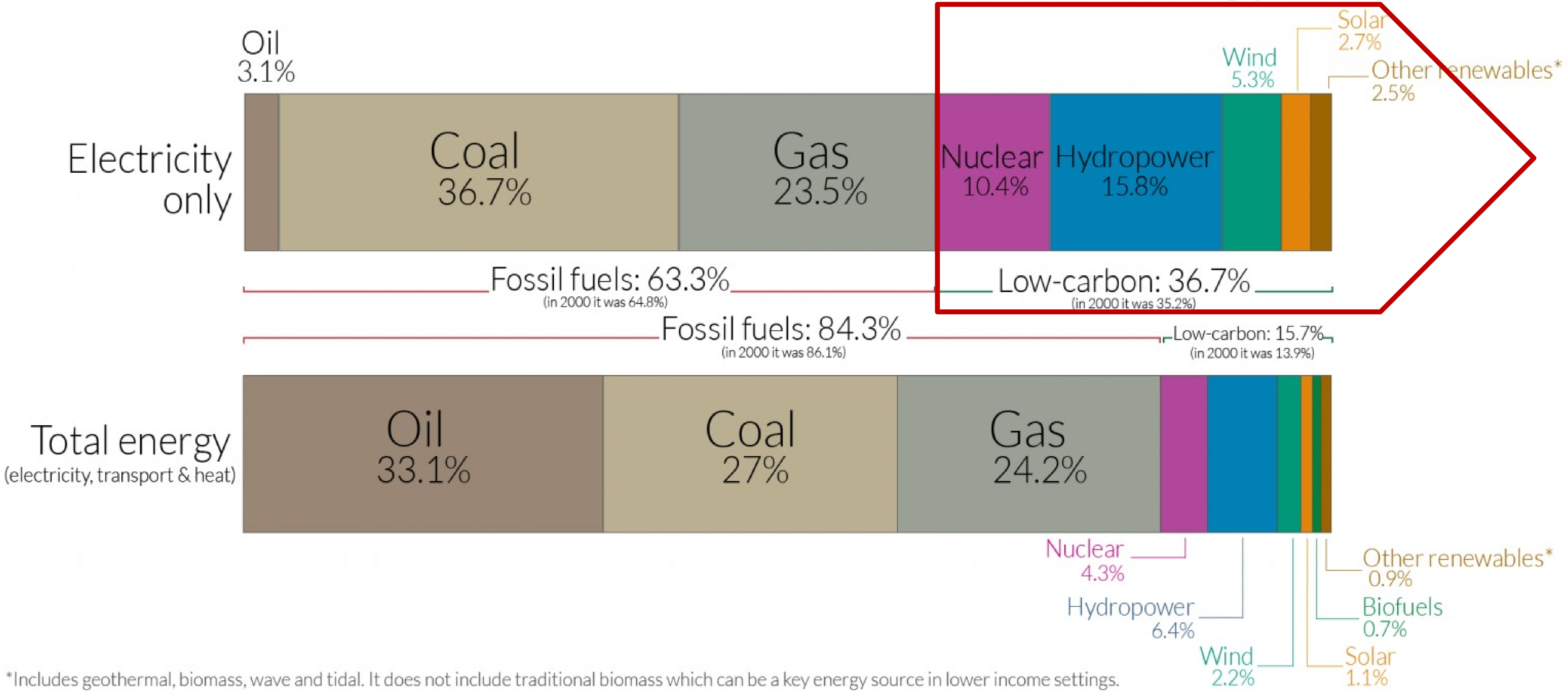


Fig. 3 – Overview of typical processing routes to biofuels.


Brazil electricity generation by source (2000–2020)
billion kilowatthours
eia
700
600
500
400
300
200
100
0
2000
2005
2010
2015
2020
solar
wind
nuclear
biomass
fossil fuels
hydro
Source: Graph by the U.S. Energy Information Administration (EIA), based on EIA's International Energy Statistics and data from the International Energy Agency

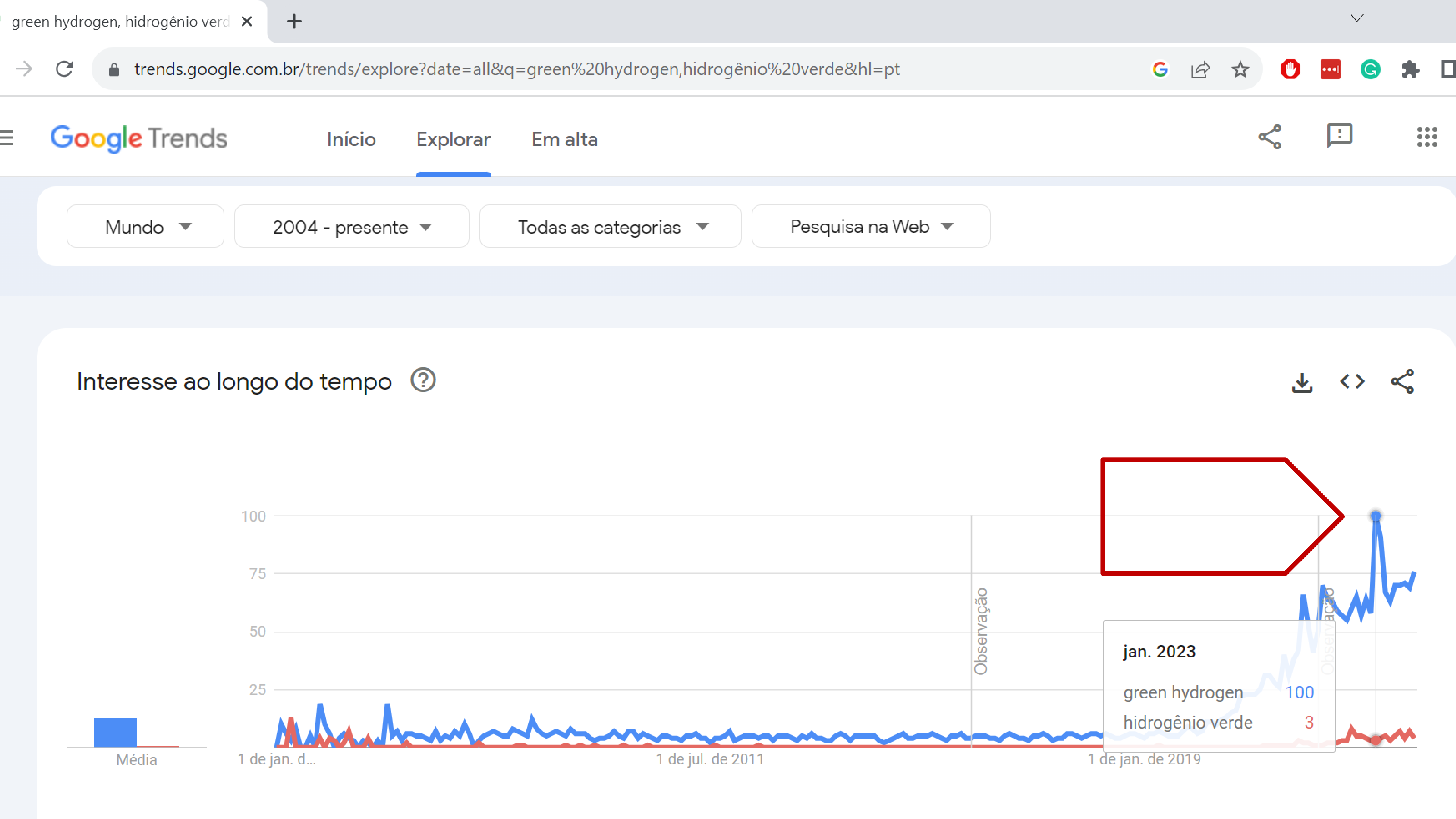
More than one-third of global electricity comes from low-carbon sources; but a lot less of total energy does



*Includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Our World in Data based on BP Statistical Review of World Energy (2020). Based on the primary energy and electricity mix in 2019.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Início
Explorar
Em alta
Mundo
2004 - presente
Todas as categorias
Pesquisa na Web
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J. Am. Ceram. Soc., **96** [10] 3075–3083 (2013)
DOI: 10.1111/jace.12559

journal

Planar Solid Oxide Fuel Cells Using PSZ, Processed by Sequential Aqueous Tape Casting and Constrained Sintering

Jaime Aguilar-Arias,[‡,§,†] Dachamir Hotza,[‡] Pascal Lenormand,[¶] and Florence Ansart[¶]

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[§]Grupo de Procesos Químicos y Biológicos, Universidad Nacional de Colombia – UNAL, CP-111321, Bogotá, Colombia

[¶]Institut Carnot CIRIMAT UMR CNRS 5085, 31062 Toulouse, Cedex 9, France

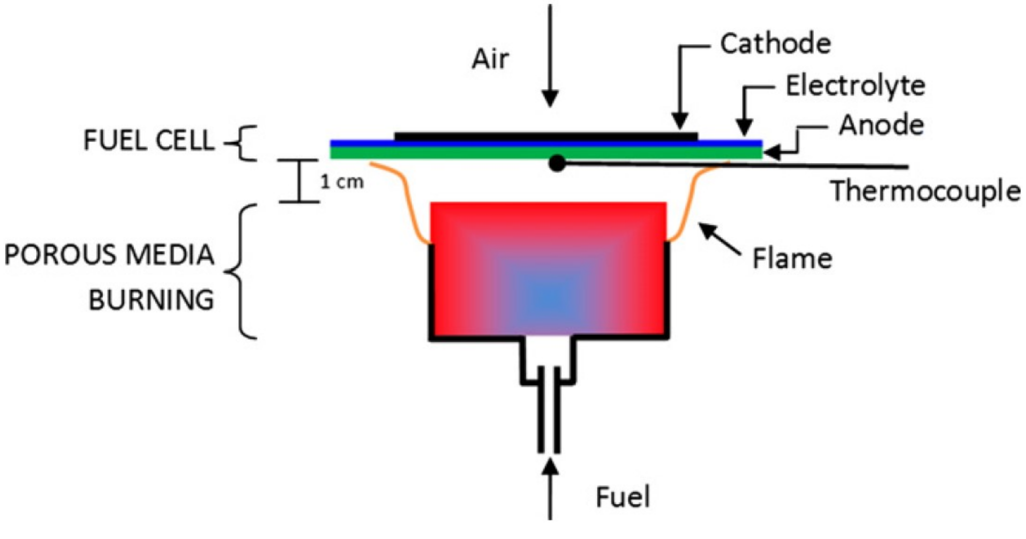
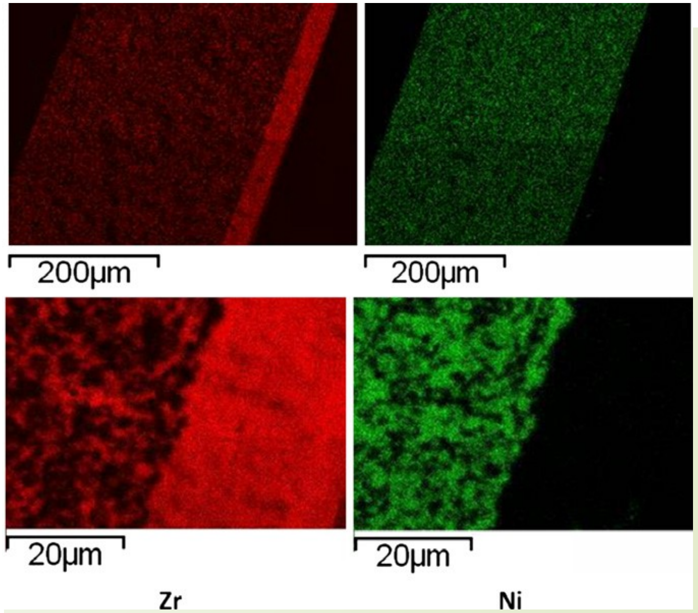


Fig. 3. No-chamber setup for testing solid oxide fuel cells.



Renewable and Sustainable Energy Reviews 61 (2016) 155–174

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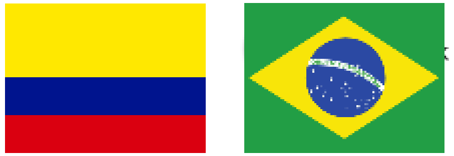
Current developments in reversible solid oxide fuel cells



Sergio Yesid Gómez, Dachamir Hotza*

Laboratory of Ceramic and Composite Materials (CERMAT), Departments of Mechanical (EMC) and Chemical Engineering (EQA), Federal University of Santa Catarina (UFSC), 88040-900 Florianópolis, SC, Brazil

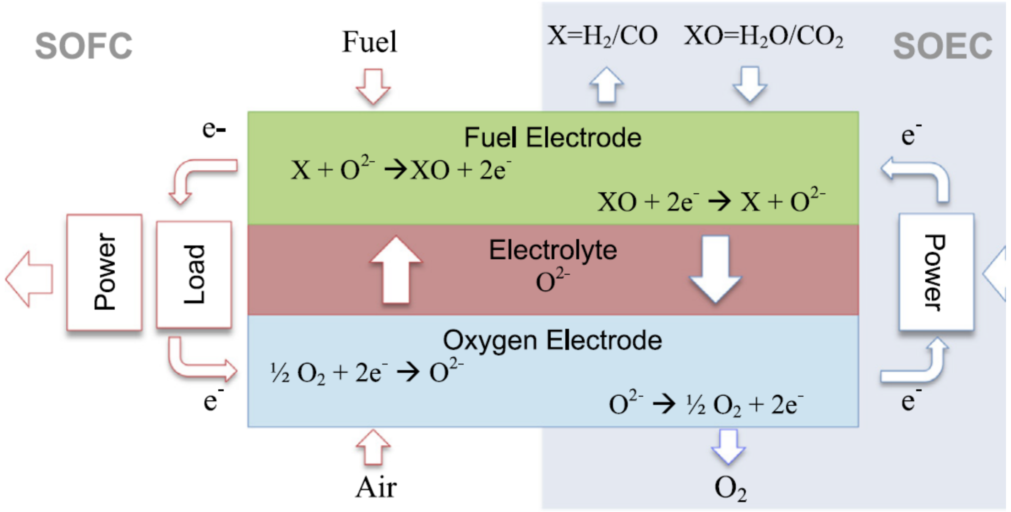


Fig. 1. Operating RSOFC principles: SOFC and SOEC modes.

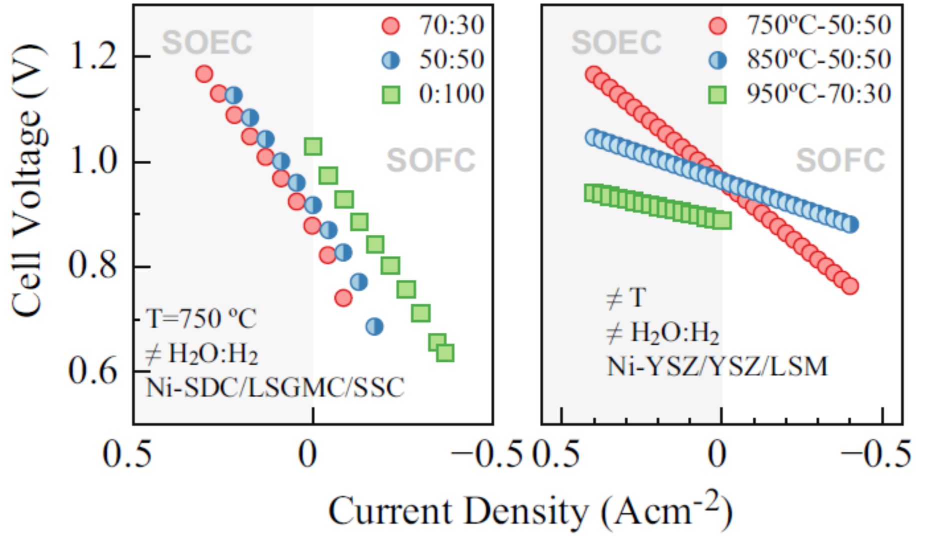
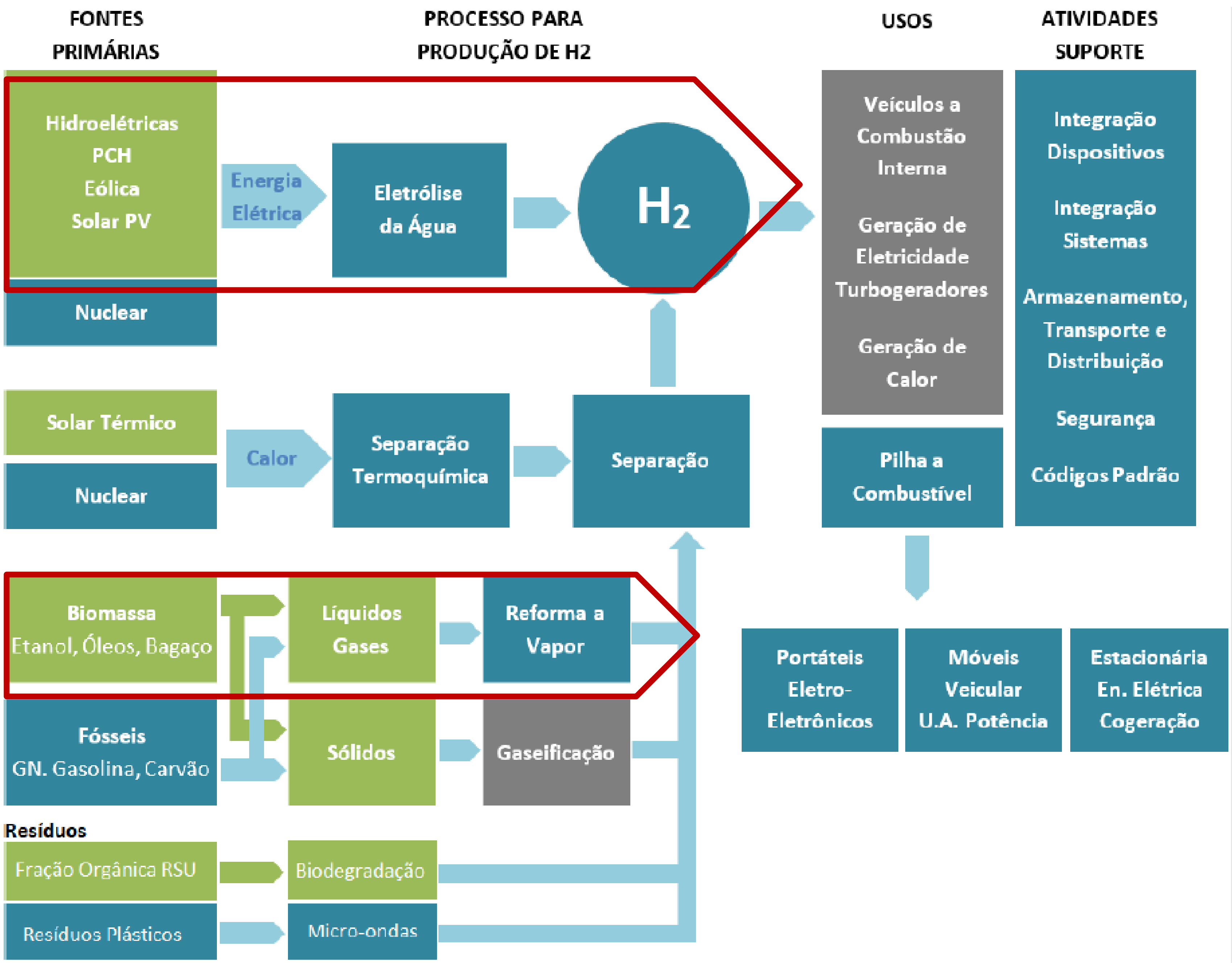


Fig. 3. Current density (J) vs. voltage (V) curves from different works [19,43–45]. Yttria-stabilized zirconia (YSZ), scandia-stabilized zirconia (ScSZ), samaria-doped ceria (SDC), samaria strontium cobalt (SSC), lanthanum strontium gadolinium manganite cobaltite (LSGMC), lanthanum strontium manganite (LSM).

Figura 1 - Representação esquemática de rotas tecnológicas para obtenção de hidrogênio



CORES DO HIDROGÊNIO

Tabela 1 – Classificação do hidrogênio em cores pelo processo de produção

Cor	Resumo do processo de produção do hidrogênio
Preto	Gaseificação do carvão mineral (antracito[1]) sem CCUS[2]
Marrom	Gaseificação do carvão mineral (hulha[3]) sem CCUS
Cinza	Reforma a vapor do gás natural sem CCUS
Azul	Reforma a vapor do gás natural com CCUS
Turquesa	Pirólise do metano[4] sem gerar CO_2
Verde	Eletrólise da água com energia de fontes renováveis (eólica/solar)
Musgo	Reformas catalíticas, gaseificação de plásticos residuais ou biodigestão anaeróbica de biomassa ou biocombustíveis com ou sem CCUS
Rosa	Fonte de energia nuclear
Amarelo	Energia da rede elétrica, composta de diversas fontes
Branco	Extração de hidrogênio natural ou geológico

IRENA
International Renewable Energy Agency

Figure 4: Global hydrogen demand and production sources

INDUSTRY SECTOR	KEY APPLICATIONS	PERCENTAGE OF GLOBAL H_2 DEMAND
CHEMICAL	• Ammonia • Polymers • Resins	65 %
REFINING	• Hydrocracking • Hydrotreating	25 %
IRON & STEEL	• Annealing • Blanketing gas • Forming gas	
GENERAL INDUSTRY	• Semiconductor • Propellant fuel • Glass production • Hydrogenation of fats • Cooling of generators	10 %

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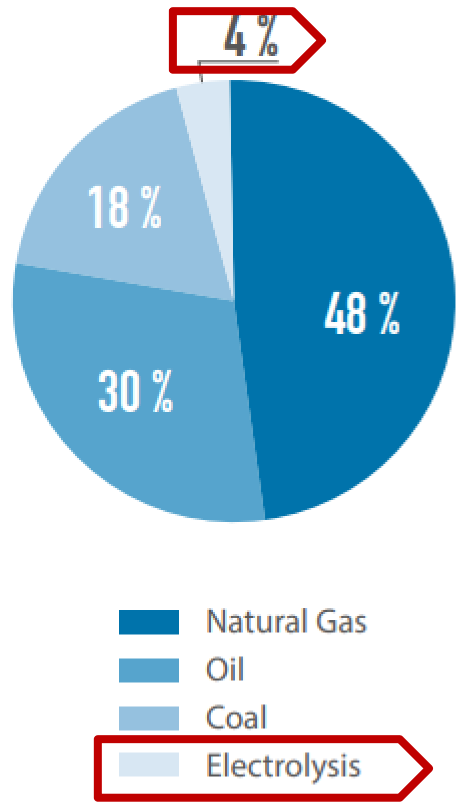
HYDROGEN SOURCES



Source: IRENA based on FCH JU (2016).[3]

CLEAN POWER

Only ~0.03% Of Hydrogen Is Really "Green Hydrogen"

By Zachary Shahan Published December 22, 2021

148 Comments

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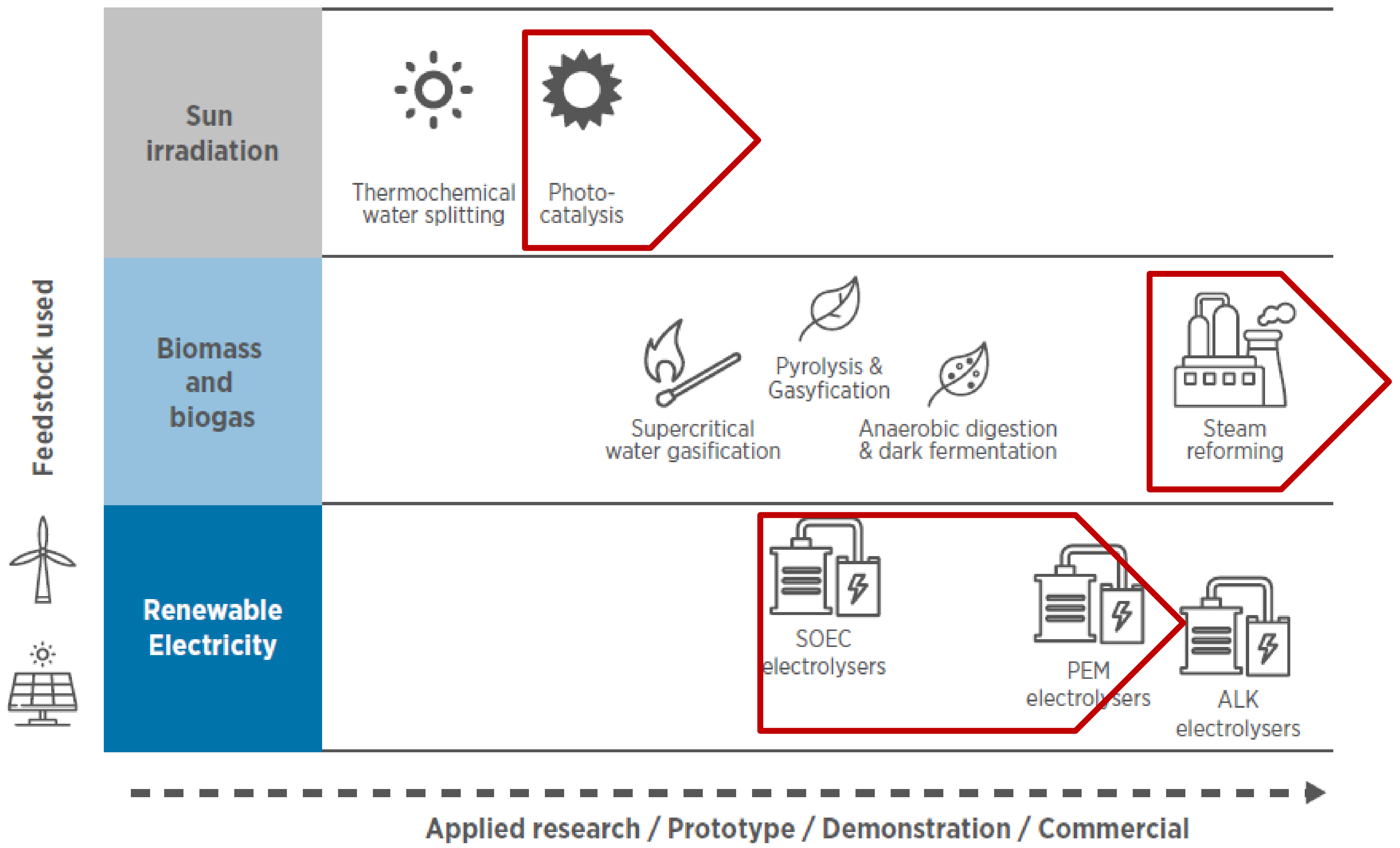
It seems that 95% of headlines and stories about hydrogen focus on green hydrogen, yet green hydrogen is barely present here on planet Earth. So, how much of a disservice is being done to society by all of these headlines and articles implying that hydrogen is clean?

Figure 6: Renewable hydrogen production pathways and current levels of maturity

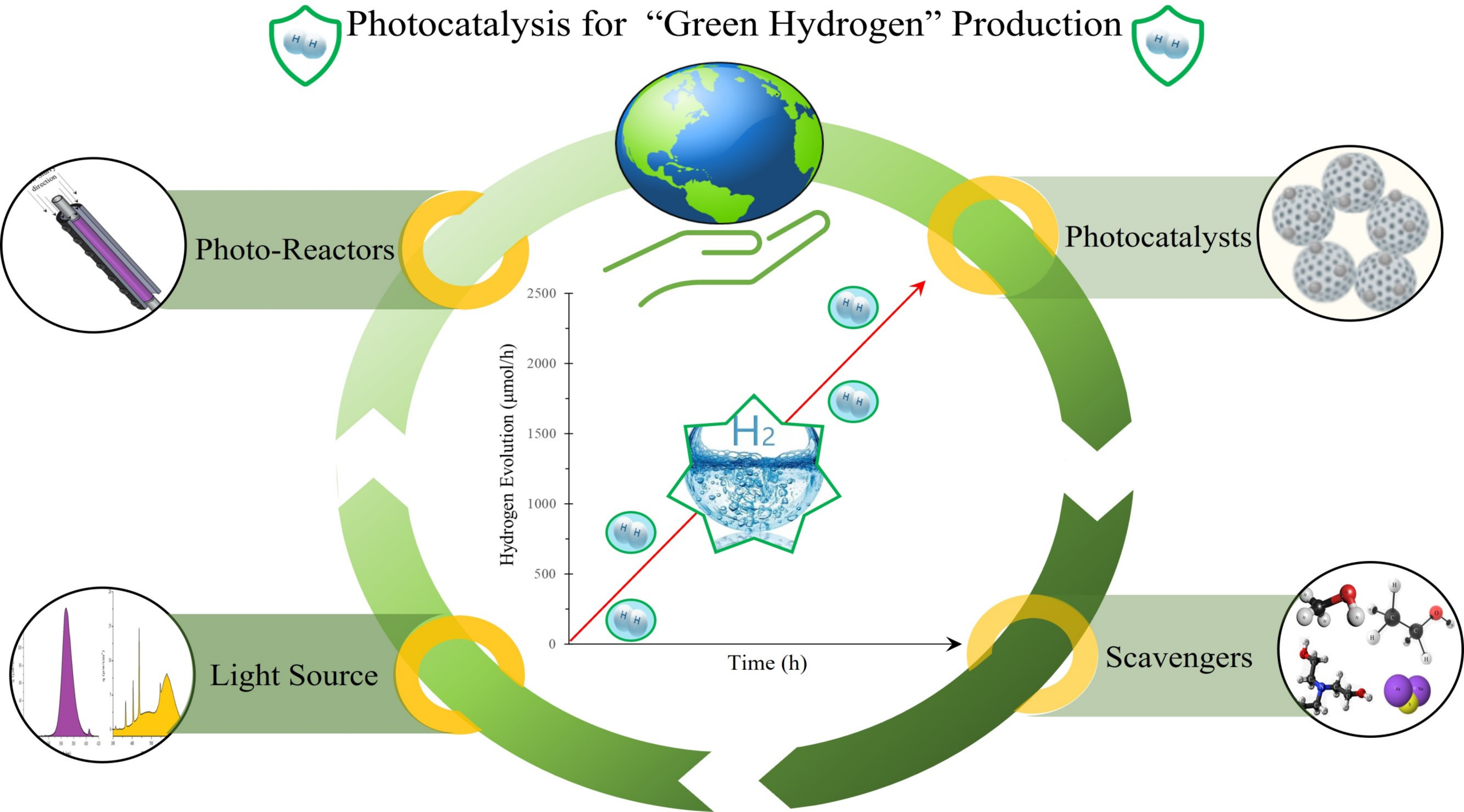


PROJETO ATUAL

- CNPq/MCTI/FNDCT Nº 24/2022 - Apoio ao Sistema Brasileiro de Laboratórios de Hidrogênio - SisH2-MCTI
- Vigência: 14/12/2022 a 31/12/2025 (36 meses)
- Recursos: R$ 2.800.000
- Estados: SC, PR, RS
- Instituições: UFSC, IFSC, UEM, UFPR, UFRGS
- Equipe: 22 pesquisadores doutores

OBJETIVOS

- *Desenvolver* **novos materiais** *e intensificar as rotas tecnológicas de* **reforma e fotorreforma** *para obtenção de* **hidrogênio verde a partir de fontes renováveis** *disponíveis na região Sul do Brasil*
- *Desenvolver* **catalisadores estruturados** *com porosidade hierarquizada resistentes ao coque para uso na reforma a vapor do biogás(birreforma) na presença de contaminantes, como o H2S*
- *Construir uma* **unidade piloto** *de reforma de biogás para produção de hidrogênio*



Photocatalysis for "Green Hydrogen" Production
Photo-Reactors
Photocatalysts
Light Source
Scavengers
Hydrogen Evolution (μmol/h)
2500
2000
1500
1000
500
0
Time (h)
H2

Ceramics International 48 (2022) 32917–32928

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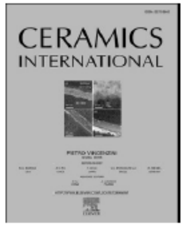
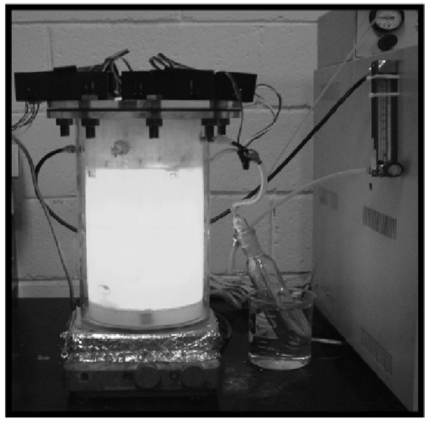


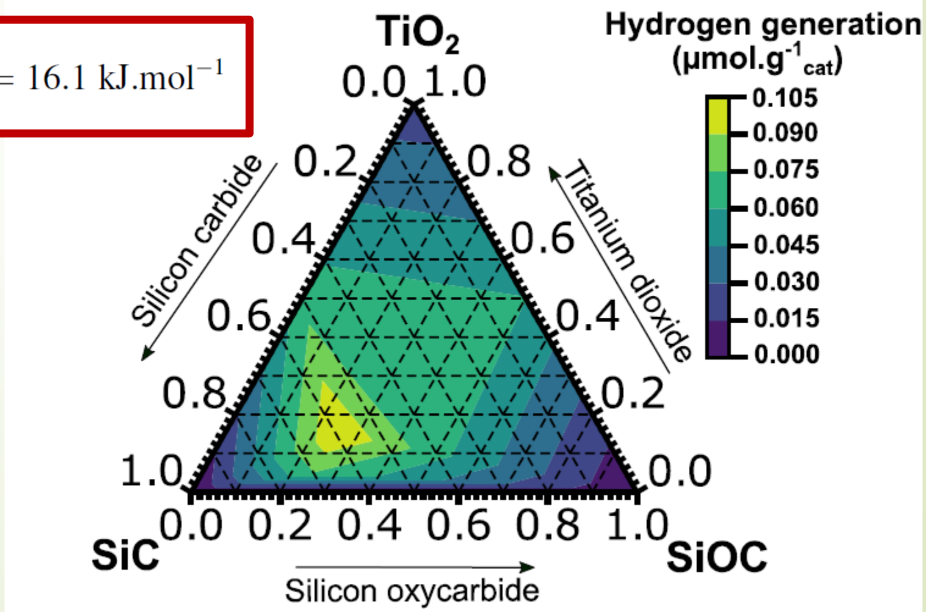
Synergetic one-step synthesis of SiC/SiOC/TiO_2 composites for visible-light-driven hydrogen generation from methanol reforming

Bernardo Araldi da Silva [a,*], Jean Constantino Gomes da Silva [a], Sergio Yesid Gómez González [a,**], Regina de Fatima Peralta Muniz Moreira [a], Rosely Aparecida Peralta [b], Dachamir Hotza [a], Agenor De Noni Junior [a]

[a] Department of Chemical and Food Engineering, Federal University of Santa Catarina, 88040-900, Florianópolis, SC, Brazil
[b] Department of Chemistry, Federal University of Santa Catarina, 88040-900, Florianópolis, SC, Brazil

$$CH_3OH_{(l)} + H_2O_{(l)} \overset{hv,\ \text{catalyst}}{\rightleftarrows} CO_{2(g)} + 3H_{2(g)} \quad \Delta G^\circ = 16.1\ \text{kJ.mol}^{-1}$$





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https://doi.org/10.1007/s10924-023-02759-4

ORIGINALPAPER

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Production of Bacterial Cellulose Hydrogel and its Evaluation as a Proton Exchange Membrane

Margarita Ramírez-Carmona[1] · María Paula Gálvez-Gómez[1] · Lina González-Perez[1] · Valentina Pinedo-Rangel[1] · Tatiana Pineda-Vasquez[2] · Dachamir Hotza[3]

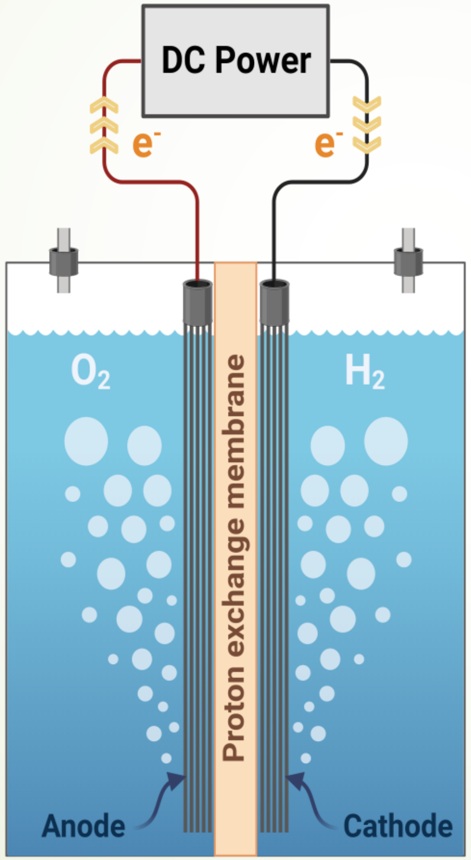
Accepted: 3 January 2023

Abstract

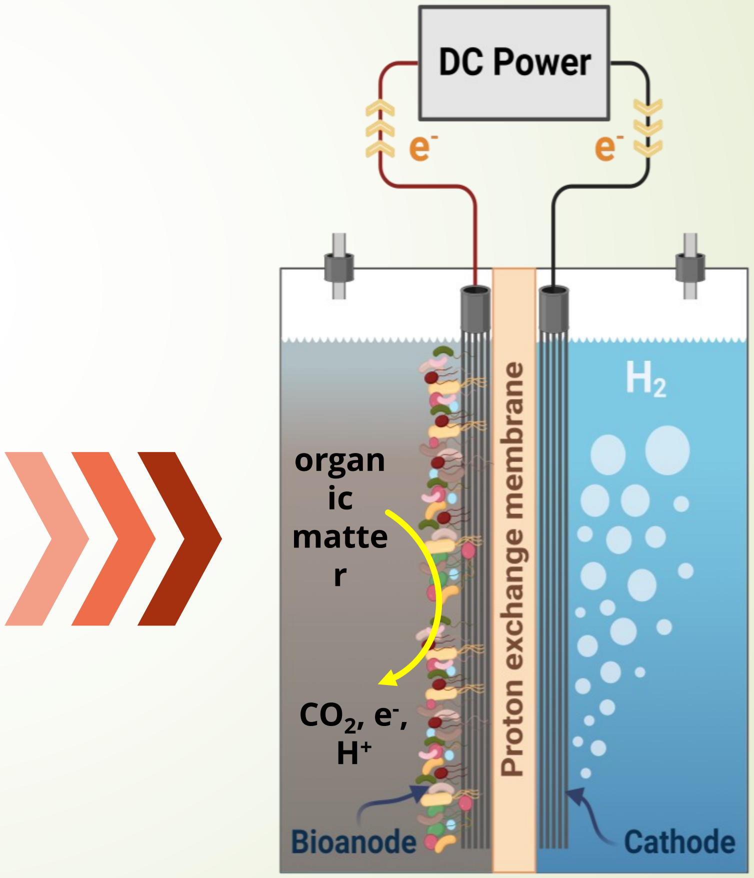
Production of bacterial cellulose hydrogel and its evaluation as a proton exchange membrane (PEM) was evaluated. Initially, the bacterial cellulose hydrogel membranes (BCH) was produced by fermentation in a 600 mL bioreactor with a 300 mL medium volume, 10% v/v inoculum with *Komagataeibacter hansenii* under static conditions, and a temperature of 30 °C. The bacteria were cultivated in Hestrin-Schramm (HS) medium with pH adjustment to 6.6 with HCl and/or NaOH. Five culture media were evaluated to obtain uniformity on the surface and a rapid formation of BCH membrane: HS (M1), M1 + green tea extract (M3), M1 + mixture of extra thyme and green tea (M4), and M1 + glycerin (M5). The kinetics of BCH production was followed by digital images. Subsequently, BCH production cellulose was carried out using M5 under the same operating conditions. After 3, 5, 10 and 13 days of fermentation, the thickness of BCH formed was measured, respectively, as 0.301 ± 0.008 cm, 0.552 ± 0.026 cm, 0.584 ± 0.03 cm and 0.591 ± 0.018 cm. Finally, BCH was characterized by porosity, water absorption capacity, ion exchange capacity, mechanical strength and diffusivity. The results showed that thinner membranes favor the processes of ion exchange (0.143 H^{+}mmol g^{-1}) and water absorption (93%). On the other hand, thicker membranes enhance physical parameters of transport across the membrane and its operability. Nevertheless, BCH membranes can be a good alternative as PEM to microbial fuel cell once they are functionalized.

Keywords Bacterial cellulose · Microbial fuel cells · Proton exchange membrane · Thickness

Microbial electrolysis cell for biohydrogen generation

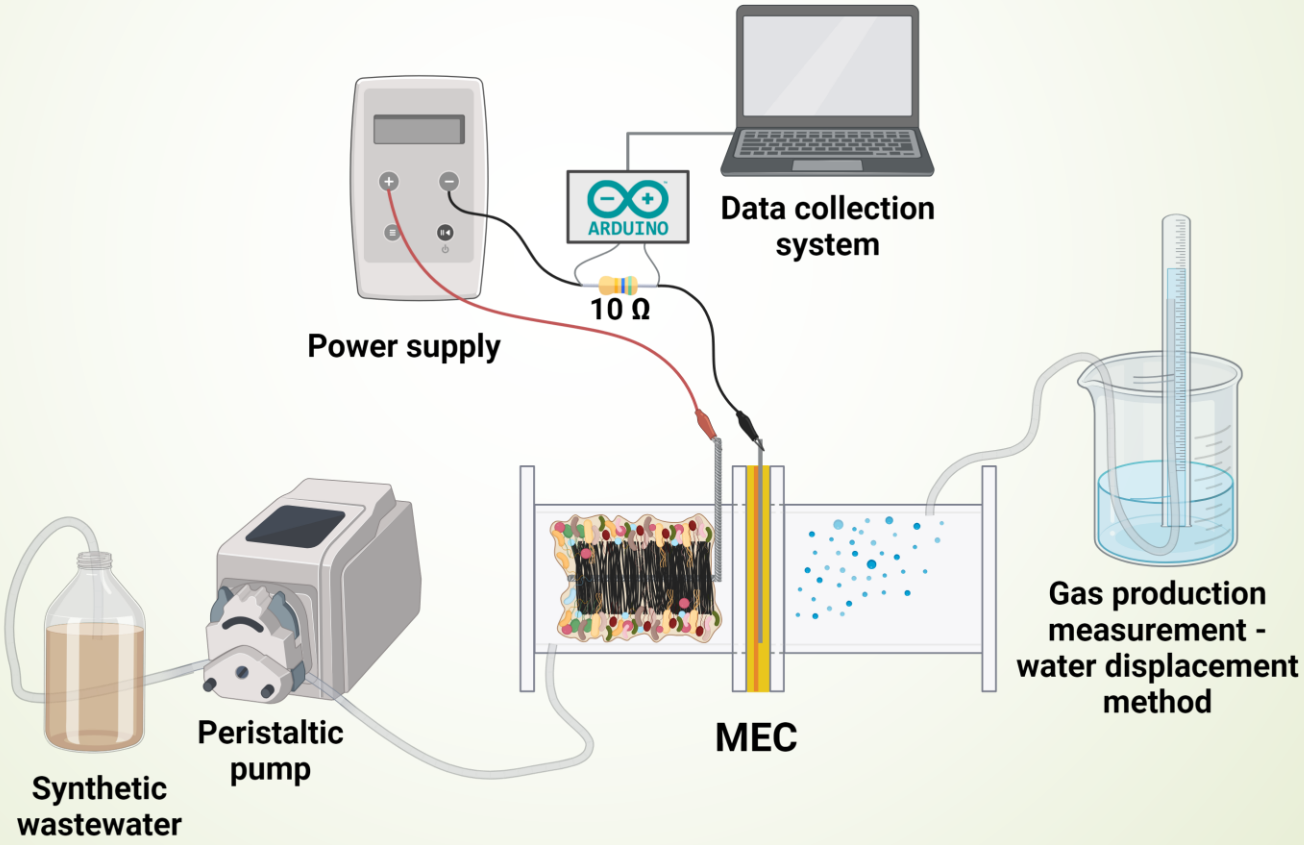


Electrolysis Cell

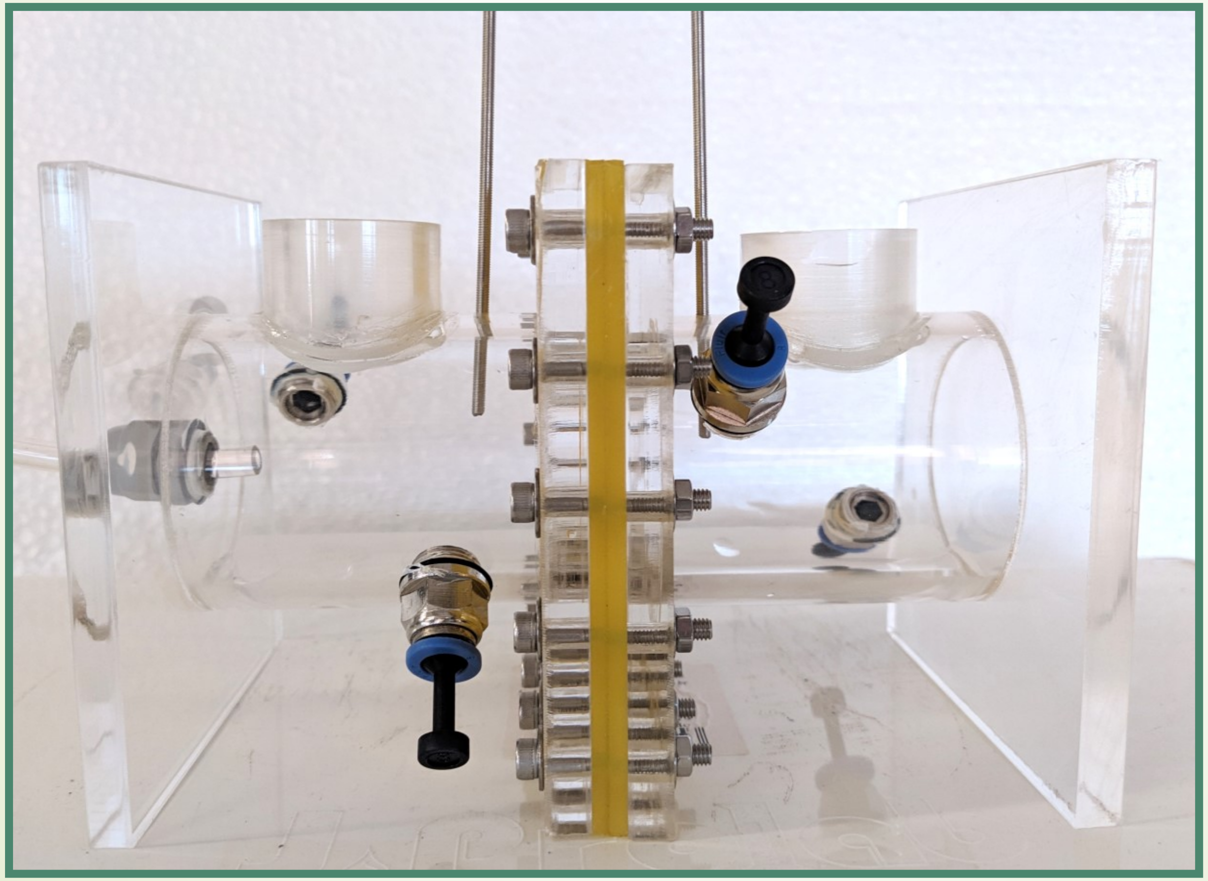


Microbial Electrolysis Cell

Microbial electrolysis cell for biohydrogen generation



Microbial electrolysis cell for biohydrogen generation



Débora Oliveira (EQA/UFSC)
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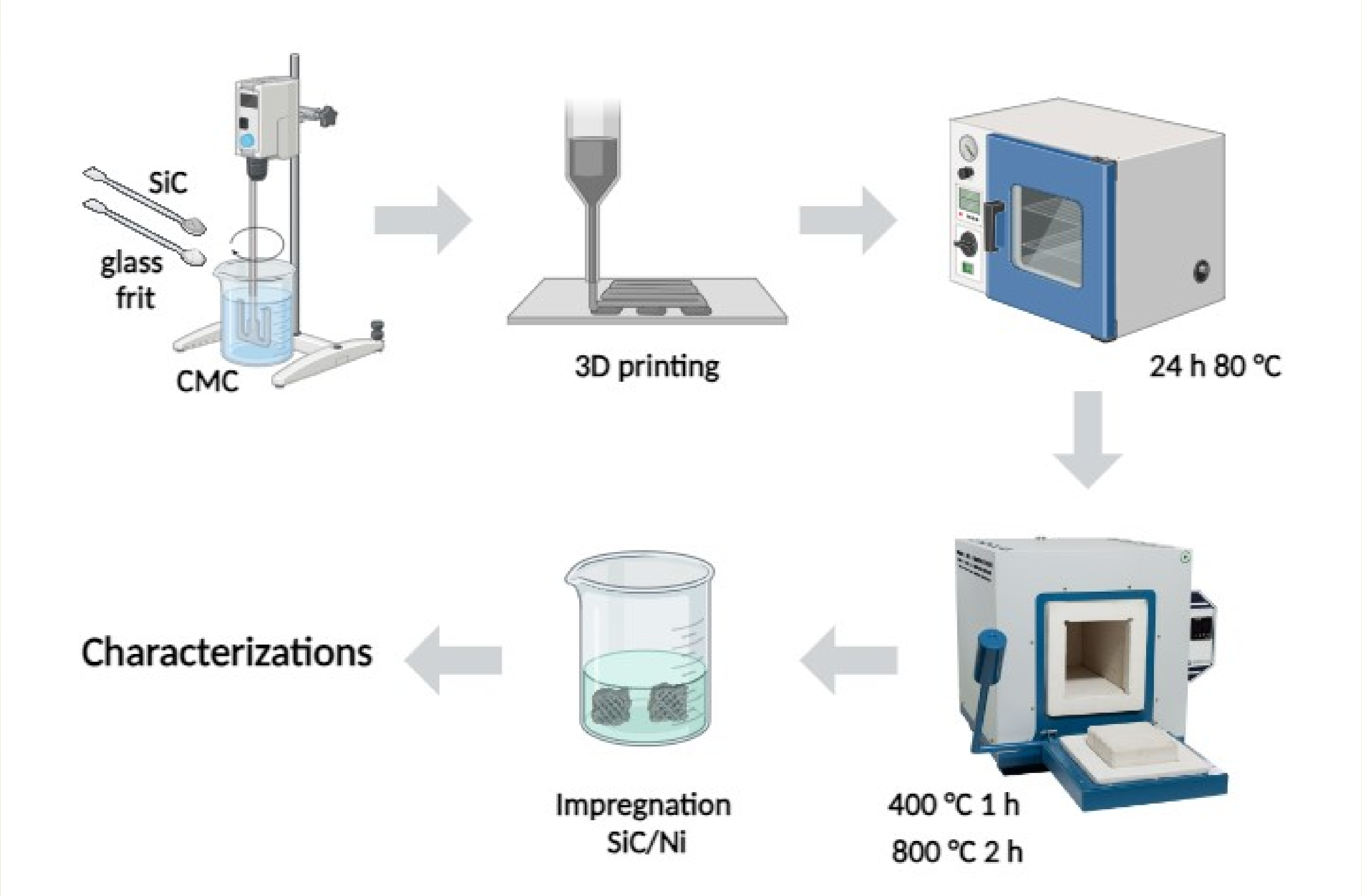
3D-printed SiC+Ni catalysts



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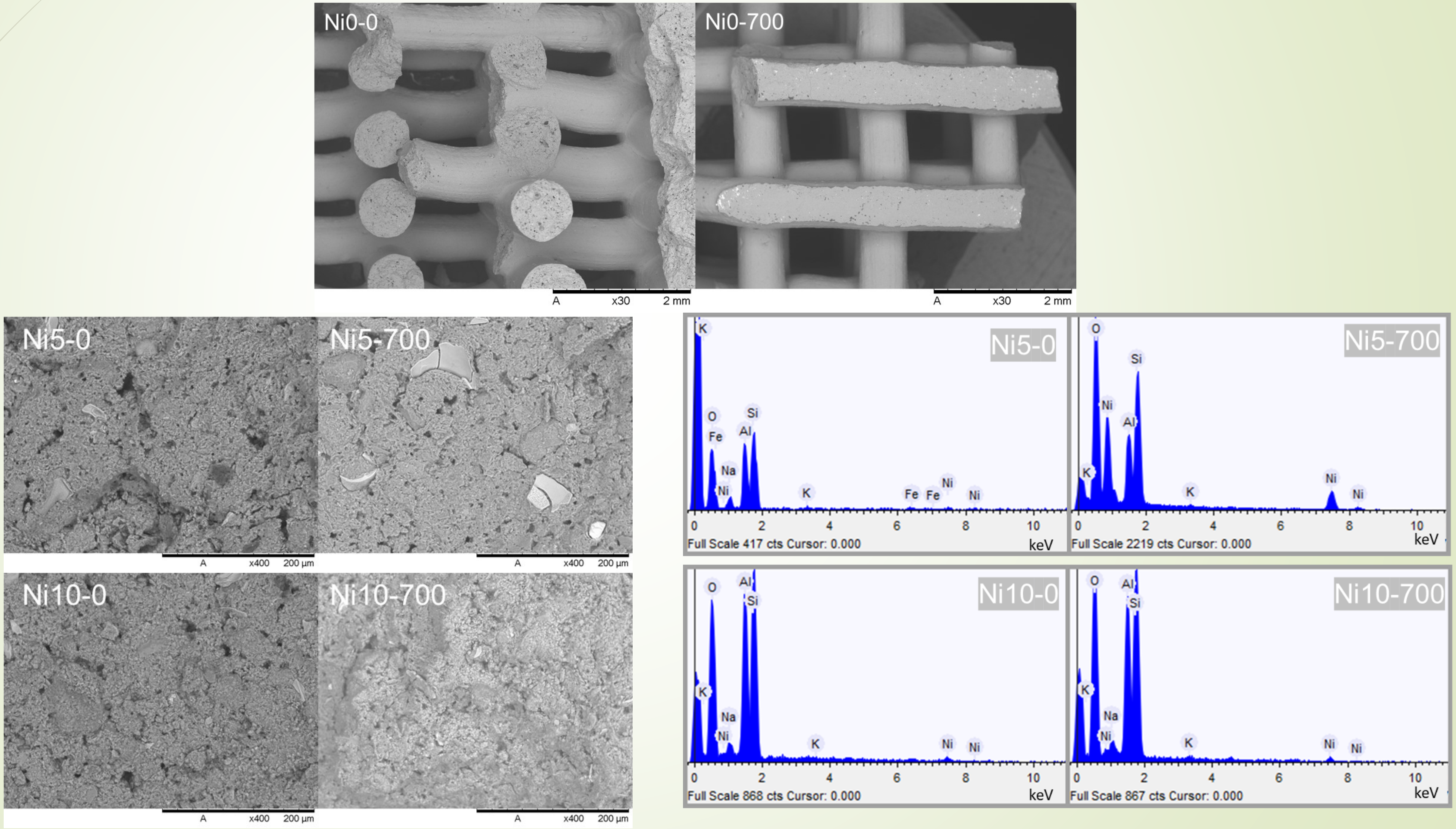
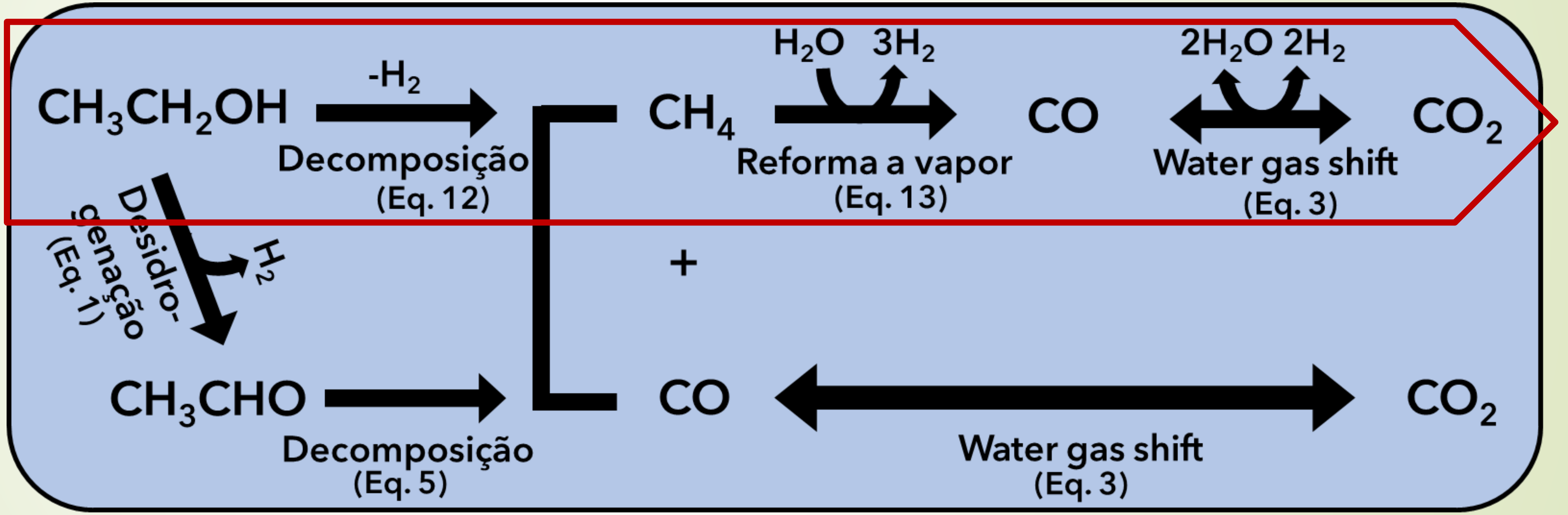


3D-printed SiC+Ni catalysts



Steam Methane Reformation

At high temperatures and pressures methane and steam will react as described in the equation below;

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

The product of hydrogen (H_2) and carbon monoxide (CO) is called syngas and can be used to synthesise other products. More hydrogen can be produced by subjecting the syngas to the water-gas shift reaction, shown below, at lower temperatures.

$$CO + H_2O \rightarrow CO_2 + H_2$$

The overall reaction of the process is then

$$CH_4 + 2H_2O \rightarrow 2CO_2 + 4H_2$$

With the methane and the water each supplying 2 molecules of hydrogen. The hydrogen is extracted from this gas mix by a process known as pressure swing adsorption which adds to the energy needed (and hence CO_2 emission).

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 48 (2023) 28390–28411

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Review Article

Materials and techniques for hydrogen separation from methane-containing gas mixtures

Andrey Lider [a], *Viktor Kudiiarov* [a], *Nikita Kurdyumov* [a], *Jinzhe Lyu* [a], *Maxim Koptsev* [a], *Nahum Travitzky* [b], *Dachamir Hotza* [c,*]

[a] *Division for Experimental Physics, School of Nuclear Science & Engineering, National Research Tomsk Polytechnic University, Lenina Ave. 43, Tomsk, 634034 Russia*

[b] *Advanced Ceramic Processing and Additive Manufacturing, Materials Science III - Glass and Ceramics, University of Erlangen-Nuernberg, Martensstr. 5, Erlangen, D-91058 Germany*

[c] *Department of Chemical Engineering, Federal University of Santa Catarina, 88040-900 Florianopolis, SC, Brazil*

HIGHLIGHTS

- PSA technology is a mature gas separation method for high-purity hydrogen.
- Cryogenic methods are suited for separating hydrogen but not for high purity.
- Membrane separation is most promising with dense palladium-based membranes.
- Polymeric, ceramic, and carbon membranes are also used but with limitations.

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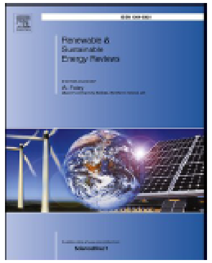
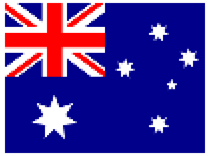




Inorganic membranes for *in-situ* separation of hydrogen and enhancement of hydrogen production from thermochemical reactions

Weijian Wang [a], Gianni Olguin [b], Dachamir Hotza [c], Majid Ali Seelro [a], Weng Fu [d], Yuan Gao [a], Guozhao Ji [a,*]

[a] *Key Laboratory of Industrial Ecology and Environmental Engineering, School of Environmental Science & Technology, Dalian University of Technology, Dalian, 116024, China*

[b] *Pontificia Universidad Católica de Valparaiso, Escuela de Ingeniería Química, Valparaiso, Chile*

[c] *Department of Chemical Engineering, Federal University of Santa Catarina, 88040-900, Florianopolis, SC, Brazil*

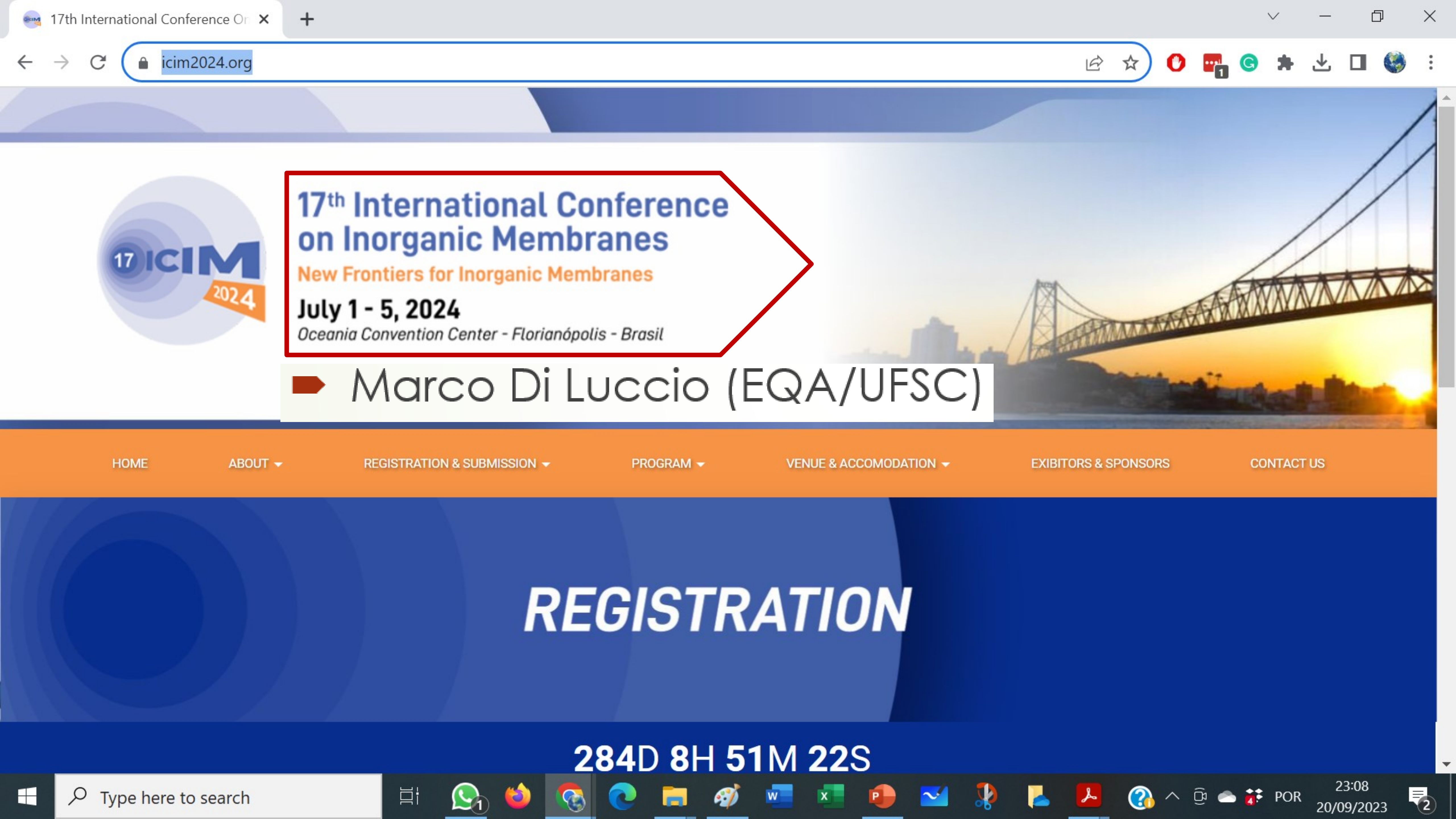
[d] *School of Chemical Engineering, The University of Queensland, St Lucia, 4072, QLD, Australia*

ARTICLE INFO

Keywords:
Hydrogen separation
Inorganic membrane
Steam methane reforming
Water gas shift

ABSTRACT

In the face of a series of global challenges caused by the dependence on fossil fuels, such as the greenhouse effect, energy shortage and air pollution, the development and utilization of hydrogen energy is considered a promising solution. Currently, hydrogen production methods mainly include thermochemical reactions, water electrolysis, biological or plasma processes. Among those alternatives, thermochemical hydrogen production has attracted much attention in recent years, particularly by water-gas shift and steam methane reforming reactions. Improving the hydrogen production efficiency of these reactions is a subject of widespread concern, including the use of inorganic membrane reactors, which have high thermal stability, high mechanical strength and chemical stability. Membranes are used to separate hydrogen generated during thermochemical reactions *in-situ*. They can not only significantly improve hydrogen production efficiency via Le Chatelier's principle but also significantly increase hydrogen purity. This article summarizes the studies that employed inorganic membranes based on palladium, silica, and zeolite molecular sieve, to separate hydrogen *in-situ*, and discusses their respective advantages and disadvantages to enhance hydrogen production from thermochemical reactions.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- *FINEP MONETIZAÇÃO DO GÁS*
- *Intensificação de reatores de reforma de gás natural em operação off-shore*
- *Vigência: 01/01/2024 a 31/12/2026 (36 meses)*
- *Recursos: R$ 4.950.000*
- *Instituições: UFSC (FLN, ARA, JOI)*
- *Equipe: 10 pesquisadores doutores*

CONEXÕES

UFSC

Divulga
Semana
TV UFSC

AGECOM

Conheça a Agecom
Sugestões e Críticas

DIVULGAÇÃO CIENTÍFICA

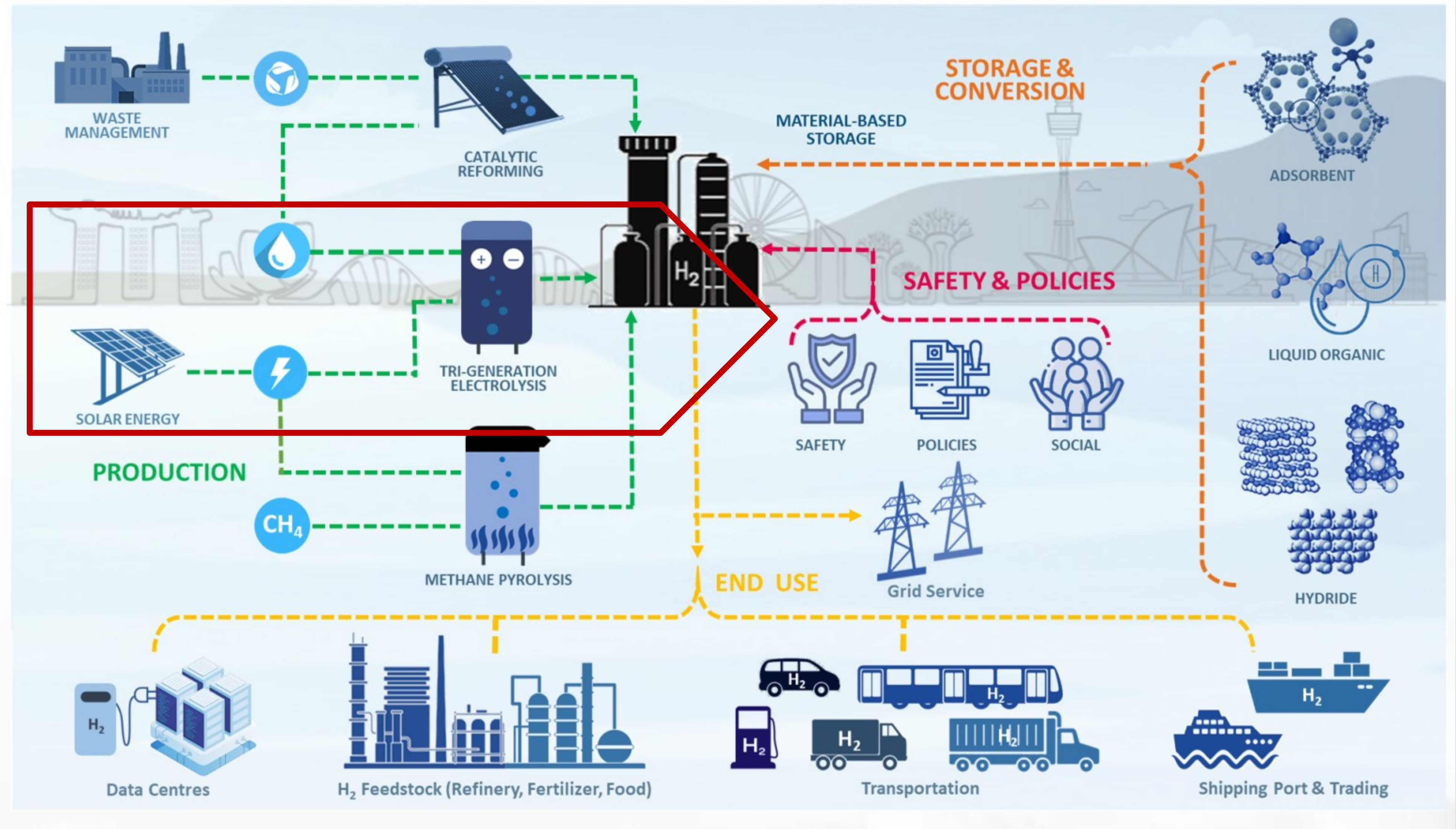
UFSC, MME e Cooperação Brasil-Alemanha inauguram usina de hidrogênio verde em SC

23/08/2023 15:05

Já está em operação a primeira usina de Hidrogênio Verde de Santa Catarina, localizada no Laboratório Fotovoltaica da Universidade Federal de Santa Catarina (UFSC), no Sapiens Parque, em Florianópolis. Considerado o combustível do futuro, por conta da forma sustentável como ocorre sua produção, o hidrogênio está sendo produzido no novo bloco do laboratório, que recebeu investimentos de R$14 milhões. O espaço será inaugurado nesta sexta-feira, **25 de agosto**, às 10h30, com a participação de representante do Ministério de Minas e Energia (MME), da ministra-conselheira e chefe da Cooperação Brasil-Alemanha para o Desenvolvimento Sustentável, Petra Schmidt, e representantes da Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), empresa alemã que implementa os projetos da Cooperação no Brasil.

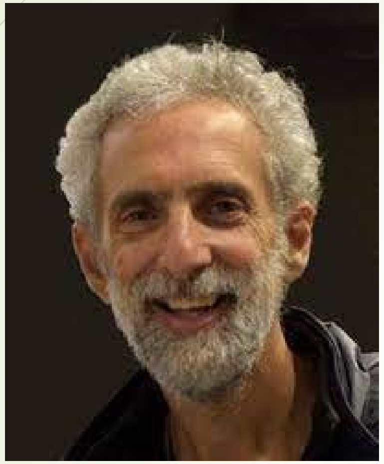
Usina fica localizada no Sapiens Parque, em Florianópolis. Foto: divulgação

CONEXÕES



WASTE MANAGEMENT
CATALYTIC REFORMING
STORAGE & CONVERSION
MATERIAL-BASED STORAGE
ADSORBENT
H_2
SAFETY & POLICIES
LIQUID ORGANIC
TRI-GENERATION ELECTROLYSIS
SOLAR ENERGY
SAFETY
POLICIES
SOCIAL
PRODUCTION
CH_4
METHANE PYROLYSIS
END USE
Grid Service
HYDRIDE
Data Centres
H_2 Feedstock (Refinery, Fertilizer, Food)
Transportation
Shipping Port & Trading

AGRADECIMENTOS



Rede Sul de Hidrogênio Verde

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EQA/UFSC
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