Executive Summary

Global development and climate change

Dialogue panel

The Age of Renewable Hydrogen

Center for Strategic Studies and Management
Science, Technology and Innovation

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Brasília – DF
March 2022

Social organization supervised by the Ministry of Science, Technology and Innovations (MCTI)

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Edition: *Danúzia Queiroz/Contexto Gráfico*
Layout: *Diogo Moraes*
Cover and Infographics: *Contexto Gráfico*
Graphic Design: *Núcleo de design gráfico do CGEE*

Cataloging at source

C389d
Desenvolvimento global e mudança do clima. Mesa de diálogos - A Era do Hidrogênio Renovável; Resumo Executivo. Brasília: Centro de Gestão e Estudos Estratégicos, 2022.

54 p. il.

ISBN 978-65-5775-042-1 (Digital)

1. Hydrogen 2 Renewable. 3 Young people. I. CGEE. II. Title.

CDU - 662.769.2

Centro de Gestão e Estudos Estratégicos (CGEE), SCS, Qd. 9, Lote C, Torre C, 4º andar, Salas 401 a 405, Ed. Parque Cidade Corporate, CEP 70.308-200, Brasília-DF, Tel.: (61) 3424 9600, http://www.cgee.org.br, @cgee_oficial.

Bibliographic reference:

CENTER FOR MANAGEMENT AND STRATEGIC STUDIES- CGEE. **Global development and climate change**. Mesa de diálogos - A Era do Hidrogênio Renovável; Executive Summary. Brasília, DF: CGEE, 2022. 54p.

This publication is part of the activities developed under the 2nd CGEE Management Contract. - 18th Additional Term: Internationalization of Brazilian CT&I /Activity: Insertion of CGEE in International Agendas - Positive Agenda Project: Climate Change and Sustainable Development 52.01.50.01/MCTI/2018.

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Sumário

Presentation

The Center for Strategic Studies and Management (CGEE) is a social organization supervised by the Ministry of Science, Technology, Innovation and Communications (MCTI) of Brazil and aims to support decision-making processes on issues related to science, technology, and innovation. In this sense, one of the strategic areas for its operation is the Positive Agenda on Climate Change and Sustainable Development.

In the specific case of climate change - a topic that has been widely debated over the last 30 years - there has been a significant increase in the number of warnings about the irreversible damage caused by human activity on the planet. In this context, the Paris Agreement called for a limitation on carbon emissions so that the average temperature of the Earth's surface does not rise more than 1.5 °C above the temperature that existed during the industrial revolution. As a result, countries have been seeking cleaner alternatives, particularly for the high greenhouse gas (GHG) emitting energy sector, with clean/green/renewable hydrogen seen as an opportunity for this transition to a low-carbon economy. However, there are still several issues to be more deeply researched, such as production processes, dissemination of hydrogen in the market, technological development, establishment of standards and norms, social and environmental implications, strategies, and national plans in the world, among others.

In order to fill these knowledge gaps, CGEE organized, on November 23, 2021, the International Dialogue Panel 2021 - The Age of Renewable Hydrogen. The goal was to find out what actions are being taken in the world to deal with the opportunities and challenges of renewable hydrogen, according to young international researchers. The event had 85 participants, including speakers, organizers, collaborators, and the audience.

The following pages provide general information on the event and the results of the collective debate. This Executive Summary does not necessarily bring the literal transcription of the speakers' and participants' speeches, but their systematization in a free synthesis.

1. Methodological roadmap

Webinar Objectives

General:

- Promoting the dialogue between young experts from different countries, allowing them to share information and exchange experiences on the future of renewable hydrogen

Specific:

- Knowing the actions that are being carried out around the world on the theme.
- Understanding young people's perspectives on the issue.
- Subsidizing a future CGEE report, which will show the results of analysis of scientific production, patents, and commercial projects for the production of renewable hydrogen.

Schedule

Schedule	Activity
10h	**Opening and welcome** ***Eduardo Soriano*** – Director of the Applied Technologies Department of the Ministry of Science, Technology and Innovations - MCTI ***Regina Silverio*** – Director of the Center for Strategic Studies and Management - CGEE ***Marcelo Poppe*** – Leader of the Positive Agenda on Climate Change and Sustainable Development activity at CGEE
10h25	**Webinar Dynamics Presentation** **Interactive Question 1** ***Amanda Ohara*** – Event Moderator - energy portfolio consultant for the Instituto Clima e Sociedade - ICS
10h30	**Presentations** ***Daniela Abaunza*** – Department of Mining Energy Law, Universidad Externado, Colombia ***Vadim Kuznetsov*** – Manager of Sustainable Development Goals Platform, Brics Youth Energy Agency, Russia ***Paul Kanja*** – Renewable Energy Officer of Deutsche Gesellschaft für Internationale Zusammenarbeit – GIZ, Kenya ***Javier Jorquera*** – Analyst at the International Energy Agency – IEA, Chile ***Marina Domingues*** – Executive Secretary, Brazilian Hydrogen Association – ABH2, Brazil
11h40	**Interactive Question 2**
11h45	**Break**
11h55	**Dialogue between speakers and audience**
12h45	**Final considerations from the speakers**
12h50	**Closing**

Webinar Dynamics

Guided by a reflective approach from dialogues, the methodology of the Webinar The Era of Renewable Hydrogen was based on dialogic presentations and debate. The whole Webinar was conducted online via Zoom and is available on the CGEE channel on YouTube.

The first stage began with the welcome presentations, followed by five presentations from experts in the renewable hydrogen field and then a debate (with questions submitted via the questions and answers - Q&A feature of the app).

Prior to the Webinar, the speakers were directed to address the following questions:

- How do you see your country's role in the coming Hydrogen Age?
- What capabilities do you believe your country currently has regarding the green hydrogen development chain?
- Do you believe your country could play an important role in the technological development of renewable hydrogen?
- Would it be worth undertaking the development costs of this aspect, or would it be better to implement international technologies and standards?
- How do you and/or your country see the risk of competition for water resources with increased green hydrogen production?

During the Webinar, there were two moments of interaction with the participants using the following questions: 1) Do you believe renewable hydrogen will solve the issue of climate change? 2) After watching the presentations, what is your opinion about renewable hydrogen? (Appendix A).

The event was registered with the support of a specialized reporter, and its main results are presented in this Executive Summary. The event had about 85 participants online, including speakers, organizing and support staff, and audience.

2. Products

2.1. Opening

Eduardo Soriano
Director of the Applied Technologies Department of MCTI

The Webinar Hydrogen Age is an important step to resume discussions about hydrogen in Brazil. Although it has been discussed since 1995 in the context of the creation of a Reference Center on the subject at the University of Campinas, only now, in 2021, have we received the orientation of the National Energy Policy Council (CNPE) to developed guidelines for the National Hydrogen Program, finally created in June 2021 (BRASIL, 2021). In the meantime, among other initiatives, we had the creation of the Brazilian Fuel Cell Program (ProCac) (CGEE, 2002); the Science, Technology, and Innovation Program for the Hydrogen Economy (ProH2, 2005) the Roadmap for Structuring the Hydrogen Economy in Brazil (2005), published by CGEE in 2010; the Hydrogen Energy in Brazil report: Subsidies for competitiveness policies: 2010-2015 (CGEE, 2005); and the 22nd World Conference on Hydrogen Energy in 2018. However, the interest and investments in the subject have not been constant. While for some years this subject was on the agenda, for other years it was hardly discussed.

This year, with the guidelines of the National Program of Hydrogen, the subject returned to the public policy debate. It is possible to make an energy transition, valuing the potential of all energy resources and thinking about the use of hydrogen for other applications besides energy. This process must be aligned with the decarbonization of the economy as a whole and the promotion of national technological development. We must aim at the competitive market, the synergy with other countries, and promote the Brazilian industry. The program will have six axes: 1) Strengthening the technological basis; 2) Training and human resources; 3) Energy planning; 4) Legal-regulatory framework; 5) Market growth and competitiveness; and 6) International cooperation.

Finally, we highlight that it is crucial to disseminate knowledge about hydrogen to society, demystifying certain ideas and showing that it is possible to work with it safely. For this, it is important to bring new voices and points of view to the debate. This Webinar is especially important for this investigation of new trends. The opinions of young researchers complement the studies about future paths for the economy and technology in Brazil.

Regina Silverio
Director of CGEE

CGEE is a social organization linked to the Brazilian Ministry of Science, Technology, and Innovations (MCTI). One of its roles is to devise structuring subsidies for programs and public policies in all sectors. As the Center is always included in relevant issues for the Brazilian State, it has also been involved with hydrogen for some time, not only contributing to a cleaner energy matrix but its multiple other uses. We seek to develop an innovative agenda that brings competitiveness in a global scenario.At COP-26, we had great advances in the energy area, within the scope of the climate discussion. Hydrogen is a key component for energy transition. Over the years, individual and state awareness regarding the climate has grown. However, we still have to look more broadly at all the problems that concern the population while developing greater collaboration. In this sense, CGEE aims to work in collaboration, involving younger generations, different countries, and sectors such as academia, governments, public agencies, companies, etc.

The partnership between the MCTI and the Ministry of Mines and Energy (MME), in issues related to the energy matrix and climate change, helps in the search for these new technological paths, in which science and technology can demystify issues of great concern to the population. We aim to foster the understanding that science, technology, and innovation can bring improvements in the quality of life in the short, medium, and long term. Our goal is that the comparative and competitive advantages and the popularization of science assist in this process.

Here one must highlight the importance of discussing how future scenarios should be regarded in the current discussion. For example: How does the legal framework keep up with innovations and new elements included in studies? Are human resources sufficient, and do they have adequate training to contribute to the area in the future? What would be potential sources of funding? Will the market absorb new technologies and new forms of renewable resources? The eyes of a new generation of researchers will also be essential in this energy transition process.

Marcelo Poppe
Leader of the activity Positive Agenda on Climate Change and Sustainable Development of CGEE

CGEE supports and advises the decision-making process in the National Science, Technology, and Innovation System, addressing issues of high relevance to the country and aiming to meet market demands. The entire current context of this discussion of hydrogen is guided by events that have already occurred, through the Stockholm Conference (1972); the Rio Conference (Eco-92); the 2030 Agenda; the Sustainable Development Goals (SDGs) and their targets (2015); and the Paris Agreement, with the Intended Nationally Determined Contributions (INDC) (2015). These last milestones innovated in that countries contributed to them in a bottom-up manner, following their respective collective constructions.

More specific to the theme addressed in the Webinar, it is known that the relevance of issues in the energy area has ups and downs, with momentary prominence of some technologies/sources and discussion and development often guided by events in the environmental area. The Rio Conference was of great influence to the technological sector, as it brought awareness on the climate issue and the need for a reduction in greenhouse gas emissions (GHG), mainly from fossil energy sources and raw materials for industries. Due to the resurgence of interest in hydrogen, CGEE is producing a survey with the topics covered in scientific publications, looking for, through patents, the trends of innovation in the sector; and, in the market, the industrial projects that are being developed around the world. The publication should be completed in 2021. Webinar speakers will contribute with information on this new reality, especially given the expectation that the world will soon migrate from the production of hydrogen from fossil sources to renewable sources. It is expected that this production will become sufficiently expressive, replacing the energy sources and industrial raw materials used by our society, based on fossil resources.

Amanda Ohara

Event moderator - consultant for the ICS Energy portfolio

Renewable/green hydrogen is a hot topic in contemporary energy discussions. It is a key enabler of the global energy transition. This element is not new to the global industry, but it is currently seen as having great potential, mainly because it allows the expansion of renewable energy use (such as solar and wind) in places that are difficult to electrify. Hydrogen is the missing link in the process of de-risking the global economy and has attracted much investment from leading countries such as Germany and China.

Renewable hydrogen is produced through the electrolysis of water using renewable energy sources, breaking its molecular structure and releasing energy. Its most discussed use today is for electricity storage, using hydrogen as a battery to store energy that cannot be dispatched; for the generation of other synthetic compounds, producing ammonia; as fuel for aviation and maritime transport - which have difficulty in direct electrification; for industrial processes, such as in steelmaking, etc. However, for this to become a reality, there are several challenges, such as high production costs, technical and safety issues in transportation and storage, the establishment of premium markets willing to pay for the high production costs of this source, etc. The Webinar will contribute to this understanding, through the participation of young experts on the subject and the sharing of their knowledge.

3. Presentations

3.1. Advances in the hydrogen industry in Colombia

Daniela Abaunza
Research Professor in the Department of Mining Law Energetics at the Universidad Externado de Colombia

The Colombian government has used two main approaches to attract investment and encourage national industry with regard to leveraging the hydrogen industry, a process that began two years ago. First, the government decided to promote this element for five main reasons: 1) lowering emissions; 2) promoting renewable non-conventional energy; 3) economic growth; 4) increasing exports; and 5) pursuing energy security.

The use of hydrogen in decarbonizing energy is very important, as it is also a way to promote the use of other non-conventional renewables such as solar and wind. Towards this goal, the government established a roadmap for the sector through 2030, developed in the middle of the pandemic, when the economy was down and hydrogen was being seen as a potential to reheat the economy and create more job opportunities. Colombia's roadmap, unlike other countries, speaks not just of hydrogen, but of blue hydrogen.

The country depends on fossil fuel exports, so there is an attempt to encourage the fossil fuel industry to be part of this energy transition to hydrogen. It's a controversial point, but it's slowly being addressed. By 2030, it is targeted that the country has an installed capacity of 1 gigawatt (GW) of green hydrogen, with a normalized cost of hydrogen production (LCOH) of 1.7 USD/kg. With regard to demand, a fleet of 1,500-2,000 light vehicles, 1,000-1,500 heavy vehicles, 50-100 hydrogen filling stations, and the supply of 40% of the energy consumption of industries are expected. This would reduce 2.5-3 Mton CO_2 Eq (megatons of carbon dioxide equivalent).

Green hydrogen production would be prioritized in the North of the country, which has enough solar and wind energy. Meanwhile, in a 2050 scenario, the whole territory would be involved. In this scenario, the country would become a hydrogen exporter (green and blue), mainly for the Asian markets, notably China, South Korea, and Japan. Some countries in Europe could potentially become importers if they do not advance in their own production initiatives.

Colombia has used different mechanisms to attract public and private investments for the development of the hydrogen economy. As for legal mechanisms, there has been an attempt to extend norms applied for other types of energy: fiscal incentives, customs incentives, access to public funds, research incentive laws, and the possibility of using "regulatory sandboxes". There are already some funds in the country that give access to resources for hydrogen projects, including green hydrogen.

Regarding research, the country has six months to launch a policy to encourage research of new technologies and regulations. Colombia is still to establish a policy that uses existing technologies and creates new ones when necessary. We have an opportunity to create a new industry, to be part of something new, still developing, adapting, and learning from experiences. We must discuss how the country will deal with this, what the role of the State will be, and even if it should be the pioneer in the hydrogen industry. Colombia and all of Latin America must also have this role of developing technologies, not only exporting and using them.

3.2. Energy development through hydrogen in Russia - preparing a clean future

Vadim Kuznetsov
Manager of the Sustainable Development Goals Platform
of the BRICS Youth Energy Agency in Russia

Russia has also been going through a very rapid and recent process (as of 2020) regarding hydrogen. The country has released two main policy guidelines in recent years: a roadmap for hydrogen development by 2024 (2020); and a strategy for social and economic development with low greenhouse gas emissions by 2050 (2021). According to these documents, Russia aims to reach carbon neutrality by 2060 using local hydrogen production as an ally, but there are several challenges related to storage and transportation. Further discussed here are the need for research and development of prototypes for renewable hydrogen production and the development of a hydrogen-based railway.

In this strategy for hydrogen-based energy development in Russia, the main assessment criterion of new technologies is climate impact, i.e., analyzing the carbon footprint through the life cycle of the main hydrogen energy carriers. Thus, brown, coal-based, hydrogen production is not considered an option. Here, the goal is to employ green (decarbonized) hydrogen, produced through electrolysis process with renewable or nuclear energy, and blue (decarbonized) hydrogen, produced from natural gas with catalytic steam reforming of methane and carbon capture and storage - which could also be obtained using coal and gasification process. The country is expected, through multiple strategies, to reach the production goal of up to 0.2 million tons by 2024, 12 million tons by 2035, and 50 million tons by 2050. Green hydrogen is flagged as a priority, especially in areas of the country with excess electricity production.

As strategic regions for the production of hydrogen in the country, the Northwest, South, East, and Arctic regions were mentioned. These are the most attractive areas to implement new facilities or adapt existing ones, aiming at green hydrogen. However, the development of these facilities in Russia is little known, as the country is seen as a gas and oil superpower. Even without market and government incentives, there is still some financial support, as the country recognizes the importance of investing on this front. In the Northwest, production would be directed to exports to the European Union (EU). There is currently a complete gas pipeline to Germany, pending approval and regulation by the German government. This facility is in response to new regulations at the EU border regarding the taxation of carbon-intensive items. Originally, this pipeline is not a structure for the transportation of hydrogen, but it could have that capability.

The Eastern region aims to export to the Asian region, notably China and Japan. Sakhalin Island, Russia's largest island, located in the Japanese archipelago, has the ambition to reach zero emissions by 2025. In addition, it aims to build a railway with hydrogen-powered trains. The project in the Southern region aims to meet the energy demand of the domestic industry, but still with export potential through the Black Sea ports. Finally, the Arctic region facility aims to ensure local energy autonomy, but with the potential to export hydrogen or hydrogen-based energy substances. If the scientific station is built in the region, it could become the first hydrogen-based one in the North, and the facility would also benefit the local native populations. Moscow also has the plan to replace its electric bus fleet with a hydrogen-based fleet. The importance of cooperation between the countries of Brazil, Russia, India, China, and South Africa (BRICS) in this quest to reshape the world energy context was also mentioned, including young researchers on the subject. The holding of a Rio+30 conference could also mobilize and facilitate this cooperation between young people and countries.

3.3. Green hydrogen development in Kenya

Paul Kanja

GIZ Renewable Energy Officer in Kenya

Kenya is located in one of the best areas in Africa for green hydrogen generation, as it has several renewable energy sources that could be used for hydrogen generation. Overall, looking at the current power and water situation in the country, there is an installed capacity of 2,819 megawatts (MW), of which about 29.4% is geothermal; 29.3% is hydroelectric; 25.5% is fossil fuel; 11.88% is wind; 1.77% is solar; 0.99% is coproduced; and 1.14% is from other sources. Demand is equivalent to 68.96% of installed capacity, almost 75% from renewable sources. The country has access to energy for 75% of the population, with 90% from renewable sources. It is expected that in the next two years, the country will reach 100% coverage.

Kenya also has high hydro potential, which will be essential for the electricity generation process. Specific to renewable energy potential, there are an estimated 15,000 MW from solar, 1,073,500 MW from wind, and 10,000 MW from geothermal, which is relatively the lowest cost. A baseline study on green hydrogen in the country, still in progress, analyses the opportunities of PtX (Power to X - electrolytic hydrogen production using renewable energy), assessing its costs (including the cost of electricity and use of solar, wind, etc.), benefits and risks, prioritizing possible technological and industrial routes, with the pros and cons of each one.

However, not all of these routes are feasible, and a short, medium, and long-term perspective is also taken into consideration. In this regard, an action plan has been drafted to support the effective implementation of PtX in Kenya. This will include studies that address the topics mentioned (and existing gaps) and generate policy recommendations, as well as foster RD&I, capacity development through training, and development of necessary infrastructure, among other topics. By mid-2022, some results will be available for use in the recommendations of the country's directions.

Among the potential avenues for hydrogen use in Kenya, agriculture stands out for its high use of nitrogen, phosphorus, and potassium-based fertilizers; the energy-intensive iron, steel, and cement heavy industry sector; and the marine transport sector, which is responsible for high GHG emissions and has the potential to foster decarbonization of the sector. The latter sector is part of a green fleet program in which the country participates (Green Freight Programs by the Northern Corridor Transit and Transport Coordination Authority - NCTTCA). Finally, the country's participation in the African Hydrogen Partnership Trade Association (AFRICA, 2021) was mentioned.

3.4. Outlook for renewable hydrogen in Latin America: Chile

Javier Jorquera
Analyst at IEA

Chile also has hydrogen as a recent but very important topic in terms of energy matrix planning. The country and Latin America as a whole already consume a lot of hydrogen, but mostly produced through the use of fossil fuels (about 85% of natural gas). The demand is mainly for oil refining in Brazil, Argentina, Mexico, and Colombia and for methane production in Chile (oil refining in the South) and Trinidad and Tobago. In this sense, the country has already developed some strategies to implement and consolidate the use of renewable hydrogen.

In November 2020, the document National Green Hydrogen Strategy was launched (CHILE, 2020), with some of the initiatives already in execution. It aims to produce 25 GW of hydrogen by electrolysis by 2030, being the first country outside the EU to launch a target (40 GW in the EU). In Chile, the government, the private sector, and academia are already moving towards local implementation of hydrogen. By 2021, at least 10 projects involving hydrogen have been launched, as well as the design of an operational plant. The target sectors of the strategy are mining, heavy transport, industry, export, and refining, among others. It is worth noting that in the short term, the country is focusing on domestic consumption, while in the long term it is focused on export capacity.

For Latin America, demand is expected to increase in different sectors by 2030, with the prevalence of existing applications (production of methane, ammonia, refining, and steel/iron), considering significant advances in technical and economic infrastructure, as well as devising energy and climate policies in favor of the sector. It is expected that this increase will occur through the use in the cement and transportation sectors and through the increased use of hydrogen in steel production. In this expected scenario, it is also expected that there will be a reduction in the normalized cost of hydrogen, making it cost-competitive, similar to natural gas costs with carbon capture and storage.

Latin America has great potential regarding photovoltaic electrolysis (PV electrolysis - i.e., direct electrolysis of water using solar energy) and wind energy. This potential creates an opportunity for international trade in low-carbon items, even more so in a future where wind and solar energy costs will become more affordable. In Chile, the Atacama Desert stands out as having great potential for wind energy and the production of decarbonizing items.

In the World Energy Outlook 2021 Announced Pledges Scenario (APS) (IEA, 2021), hydrogen trade and hydrogen-based fuels represent 20% of global demand in 2050, with Chile being a key player (exporting to Japan, Korea, and Europe) along with Australia, the Middle East, and North Africa. However, for this scenario to become a reality, technological development and innovation are necessary. Latin America already has several successful experiences - such as biofuels - but some countries will have to observe the specificities of local activities, such as high-altitude mining. Regarding the manufacturing sector, although there are great opportunities for hydrogen in Chile, no public commitment has been made as yet. The creation of a supply chain related to the sector, such as alkaline electrolytes, could be convenient when it comes to the country's ambitions related to hydrogen. In this entire process, regional collaboration will be essential: it can create economies of scale, promote necessary infrastructure, as well as share resources for R&D.

3.5. Hydrogen technologies in Brazil

Marina Domingues
Ph.D., UFMG, ABH2

The emergence of the Hydrogen Age debate in the last two years is strongly associated with discussions on intensive CO_2 emissions in the energy sector and global warming. Coinciding with the prominence of this subject, there is an increasing consensus that hydrogen is the way to zero net carbon emissions and keep the temperature within a minimum warming level. This energy transition, which will depend primarily on existing technologies, will enable different countries to contribute to the global problem of climate change. However, energy transition events are not unique to contemporary life, and human history has seen a number of similar moments when one energy source became more prominent than the others.

Throughout these processes, previous energy sources were not fully replaced but became a complement to other sources (a new technological niche). Consumption also increased. In the current energy transition process, there is a differential in that there is an attempt to replace other sources. The demand now is no longer to increase energy sources but to reduce pollution from the various sources that emit GHGs.

In general, this transition does not have a specific technological niche and aims at substituting the present energy sources due to the demand for less pollution and more quality energy that can be generated by different energy sources and has low energy density. Furthermore, hydrogen will be important not only in the energy sector, but also in the transport, chemical, refinery, and fertilizer sectors, among others, besides being exported to places with high demand and low production capacity.

As part of any country's strategy, one should first reflect on what would be the economic and social benefits of exporting hydrogen to other nations. Each country has its own characteristics and market strategies. In Brazil, there are also certain specificities, such as the fact that 45% of the Country's matrix is already based on renewable energy. This makes it difficult to argue for the need for changes based on the decarbonization of the productive sector. As the country is rich in energy sources, a possible strategy would be the use of different sources for hydrogen production, in a rainbow perspective - prioritizing blue and green hydrogen -, adapted to the characteristics of the domestic market. The country also has large quantities of biomass for hydrogen production, which reinforces its role in the environmental debate and adds value to waste.

The hydrogen opportunities would be immense: in the biomass sector, due to the large agriculture and livestock residues; in transport, due to the experience with ethanol and biodiesel, and with the regulation in the transport sector; in energy security, despite already having 80% of the electric matrix based on renewable energy, it can increase efficiency and guarantee supply in rural and remote regions and in sectors that are difficult to mitigate, such as the ones based on thermal energy and natural gas.

In spite of this enormous potential, Brazil has not yet advanced as much as Colombia and Chile in an action plan for hydrogen. For this process to be developed in the country, it is advisable to mitigate some possible negative implications, such as a strict focus on the export process without benefits to society (such as job creation, especially the high technology ones); without technology knowledge transfer (not to depend on imported equipment, for example); and without developing internal demand (as for use in fertilizers).

As a path for Brazil, attention to market regulation is crucial, noting that it should think beyond a strategy for hydrogen, considering: hydrogen certification, defining if the country is committed to participating in the development of a global certification of green hydrogen; defining norms in agreement with the Brazilian Association of Technical Norms (*Associação Brasileira de Normas Técnicas* - ABNT), defining norms for electrifiers; and the societal commitment, so that hydrogen is seen not only from the point of view of the workforce but of society, benefitting all.

3.6. Comments on the questionnaires and speakers' final considerations

- The Chilean government is planning the transport and export of hydrogen according to the available technologies. For exportation to Europe and Asia, hydrogen will certainly be transported by ship in a liquefied form, while in the country itself, it will use the existing gas pipeline system or a new system built. However, it is still not known whether it is possible to inject hydrogen into the system, and some regulatory changes will be necessary to make it possible. In addition, the Chilean government has yet to develop research to advance the technology involved in hydrogen production, storage, and transportation. Like other developing countries, Chile also does not have much in the way of resources and will likely rely on imported technology. Hydrogen can be produced in a variety of ways, it can be globalized, but that will depend on the democratization of the technology.

- In the APS scenario, hydrogen and hydrogen-based fuels are traded in the form of ammonia (NH_3) and in liquid form, mainly when exports between South America, Europe, and Asia are expected.
- Ammonia is not only a fertilizer. It is an industry that has yet to be developed, especially given the fact that Brazil imports most of its fertilizer - as does Kenya. As a hydrogen carrier, ammonia is easier to transport than hydrogen, since hydrogen has a large mass and low energy density (and would be better exported through pipelines). Exporting ammonia has the advantage of not exporting carbon, different from exporting methane (CH_4). To export hydrogen from Brazil to Europe and Asia, as mentioned, the best way would be via maritime transport and in liquid form. For that purpose, hydrogen needs to be pressurized - until it becomes liquid - or transported via ammonia, which has a good hydrogen-nitrogen ratio.
- It is difficult to forecast what would be the turning point for hydrogen to become an export product, in addition to fulfilling domestic demand. The cost-benefit indicators of hydrogen in Latin America point to an export strategy for several countries, including Brazil, Chile, Colombia, Peru, Bolivia, and Argentina. These, in general, are countries with abundant, competitive, and low-cost resources where hydrogen can be easily produced. In Chile, due to the ambitions of decarbonization by 2050, made possible by the use of hydrogen, it is expected that there will be full domestic use and, only then, any consideration of exports.
- In Russia, the use of existing pipelines to transport hydrogen has yet to be tested. If new pipelines need to be built for this fuel, this may not be seen as an economically viable strategy, as it will not be competitive compared to maintaining fossil fuel-based production.
- In specific to the production of Nord Stream (a natural gas pipeline system offshore in the Baltic Sea from Russia to Germany), which will be exported to Germany, so that the country achieves the gradual process of decarbonization of the economy, there are several negotiations. On the German side, there is a demand for hydrogen to be transported through Russia's existing pipelines. However, Russian experts believe that the metal structure of this pipeline will not be able to hold the same amount of fuel as it has the capacity for today. Another idea is to build green and blue hydrogen facilities on the German Baltic Sea coast where Nord Stream emerges. In this case, the interest would be in using natural gas to produce the hydrogen on the German side, which would prevent the need to refurbish the existing pipeline and the associated costs - which would not be beneficial to either country. This decision will be political, as Germany and the EU must decide whether, with decarbonization targets, the production of low-carbon items through the use of hydrogen produced by natural gas will be competitive.
- Russia will probably not invest in refurbishing the entire pipeline system for hydrogen, as brown hydrogen would become unviable. Specific to Russia's export to Japan and China, hydrogen should be transported to the Japanese islands by sea transport, just as Australia has been testing.
- Regarding the use of hydrogen by the Moscow bus fleet, as an example, it will be assessed whether the economic and environmental benefits associated with its use

are greater than the costs associated with replacing the entire fleet. Furthermore, as no city has installed hydrogen storage capacity, this will also have to be considered.

- To shift away from natural gas, which is quite abundant in Russia, to hydrogen, the country will have to invest in policies with high subsidies and financial support, as consumers and industries do not want to have higher costs due to decarbonization targets. At the moment, the main sectors driving the hydrogen industry are the aluminum and chemical industries, which want to step away from coal. However, for this to happen, the government needs to invest heavily in research, technology development, and subsidies to make hydrogen competitive.
- Kenya sees a transition to green hydrogen primarily based on the agricultural sector. It is expected that the creation of a supply chain involving this and green ammonia (for domestic use and export) will create the conditions for employment generation and the green energy transition - with other social and economic benefits. Currently, 75% of Kenyans have access to electricity, with 100% expected to be achieved in the next two years. Green hydrogen will be critical to stabilizing the country's grid, but much knowledge is still needed about the process of transporting and storing the products.
- As a general rule, hydrogen will always be a second option, as it will never be more efficient than the direct use of the other energy source. For the case of ethanol in a combustion car, for example, it is still better to use ethanol, then to use it to acquire hydrogen and then use it in cars, because the process of transformation of the fuel leads to energy losses.
- Hydrogen is not a primary source of energy: it takes a lot of energy to produce. The main role of this source will be to store excess energy produced without demand. For example, in Denmark, when industries are closed, but wind energy is still being produced, the surplus energy can be stored and used later. In Brazil, the best potential is with the use of biomass waste from ethanol, sugarcane production, and agriculture and livestock for the production of hydrogen. Biogas can also be produced through the natural fermentation process of the residues, with subsequent processing and storage. As a consequence, carbon would be extracted from the atmosphere, since the biogenic carbon released would be re-extracted from the atmosphere.
- Biogas is basically composed of methane and has a lot of moisture. In order to use it, the process of removing the humidity and transforming it into pure biogas or pure methane, different energy vectors with different market values, should be carried out. Hydrogen production with this source would have a higher market value, but the current state of technology is not yet advanced enough for hydrogen prices to be truly competitive.
- Brazil has a long way to go in the hydrogen era, even though it has seen strong technological development in the area since the 1970s, which even gives it space in the Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). Now it is important that the country use its existing scientific and technological capabilities, with the knowledge about gas in the petroleum industry, biogas, regulation, and energy transitions, to set up a strategy to observe where hydrogen would be of great importance, aiming first at fulfilling internal demand.

- One point not mentioned in the discussions was the use of water in the production by electrolysis of hydrogen. An integrated analysis is needed, as some production methods use less of this essential resource.
- Even though the potential of countries and regions has been discussed extensively, there needs to be a general commitment to deliver and implement the necessary technologies for hydrogen. Only then could this element play its part in the decarbonization process of the world economy. Here, one should think mainly about demand-side technology, how to transport, store and deliver, coordinating efforts, and technological advances on the supply and demand side.
- Latin America should increase collaboration on this objective so that economies of scale are exploited, technologies are shared, and production and certification standards are harmonized, seeking to achieve regional, as well as national, goals.
- Kenia has been focusing primarily on producing green hydrogen for domestic consumption. The country also has collaborated with African and other international partners to implement hydrogen as a global option on the path to carbon neutrality.
- A large decrease in the production costs of solar and wind energy has been observed. However, the cost of electrolytes - essential for the production of green hydrogen - has not decreased as much. More technological development is needed in this area so that countries can make an equitable transition.
- The energy transition and the energy system decentralization process have the potential to transform developing economies into potential actors of the Green Hydrogen Age. To achieve that, they must address the hydric issue, which needs to be more seriously approached in the discussions on the subject.
- It is necessary to reflect on how the Hydrogen Age can contribute to reducing energy inequality in the world, reducing the centralization of consumption. Otherwise, new dependencies will be created, rebranded under a green hydrogen seal. This is reflected in the SDGs, especially in goal 7, of clean energy accessible to all.
- It is also necessary to have a broader discussion regarding the regional dimension of a new hydrogen-based economy, since part of the decisions on this topic occur at the local, municipal, and state level (e.g., urban transportation).
- Regarding the legal aspect, the role of the law and the regulators is to enable the attraction of investment, reducing regulatory barriers and allowing hydrogen to become the energy of the future. At the same time, regulators should try to approach scientists and engineers in this field to analyze current initiatives and learn more about the subject.

4. Next steps and conclusion

At the end, the leader of the Positive Agenda on Climate Change and Sustainable Development of CGEE thanked the participation of speakers and the audience in the Webinar, which brought many contributions for reflection and as subsidies for those involved in the decision-making process regarding hydrogen in Brazil and the world.

The path to the Hydrogen Age is full of challenges because many routes are possible, and there are concerns about social insertion and respect for the SDGs. This reinforces the importance of reflecting on the issues of decentralization, promotion of local resources as input for production, development of markets for products derived from hydrogen, and its agricultural and industrial use, among others.

However, the challenges also point to the opportunity to build a better world, with the transition away from the use of fossil resources, which have caused unsustainable climate change for humanity, to a scenario not only of widespread use of hydrogen, but valuing the use of biomass, bioeconomy, renewable energies, such as solar and wind, and even those from the oceans, still little explored.

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Annex A - Moment questions

1. Webinar: The Renewable Hydrogen Age

Do you believe renewable hydrogen will solve the climate change issue? (Single Choice)

- I agree – 11%
- I agree with reservations – 80%
- Disagree – 9%

2. Webinar: The Renewable Hydrogen Age

After viewing the presentations, which of the following statements best represents your opinion about renewable hydrogen (choose one): (Single Choice)

- Renewable Hydrogen is the solution to climate change – 4%
- Renewable Hydrogen is a good option, but with many challenges – 71%
- Not all countries will be able to reach the Hydrogen Age – 25%
- There are better options than Renewable Hydrogen – 0%
- The Age of Renewable Hydrogen will only come with the large-scale development of fossil hydrogen – 0%

Annex B - List of participants

Name	Institution
Adriana Capotosto	EMTU/SP
Adrielle Gerez	SP
Alvaro Monteiro	National Institute of Technology
Alysson Bernabel	EMTU/SP
Amanda Ohara	iCS
Ana Aquino	Embassy of Brazil in Berlin
Anna Lis Costa	Federal District
Ayri Trancoso	Petrobras
Belen Ruiz	PUC
Bianca Torreão	CGEE
Chad Riggle	Recôncavo Institute of Technology
Christian Lyrion de Barros Fontão	Unipampa
Clarissa Lima	Rolim lawyers
Claudio Augusto Oller do Nascimento	São Paulo
Cristine Carneiro	BA
Daniela Abaunza	EU
Daniella Fartes	CGEE
Diego-Intérprete	Interpreter
Eduardo Soriano	MCTI
Edvaldo Morais	LNBR/CNPEM
Elaine Nehme	CGEE
Elba Oliveira	National Institute of Technology
Emilly Silva	CGEE
Fernanda Guedes	BEP/ASI
Flávia de Teixeira	Engie
Guilherme Rodrigues Lima	CBC
Homel Marques	CITinova MCTI Project
Iago Izidório Lacerda	Federal University of Ouro Preto
Itiane Thayna	UnB
Jairo Coura	MCTI
Javier Jorquera Copier	IEA
Jean Campos	CGEE

Name	Institution
Jeremiah Oigara	MMU
Jesús Rojas	Andi
João Arbache	CGEE
João Vitor Nunes Correia	Smartly
Jose Lourival Magri	Engie Brasil Energia
Jose Manoel Antelo Gomez	
José Mauro Morais	Ipea
Joyce Mendez	Latin American Observatory on Energy Geopolitics
Jucimara Santos de Souza Medeiros	Sergipetec
Julia Woo	Federal District
Luane Valim	Omega Energy
Luiz Felipe Faria	Petrobras
Luiz G S de Oliveira	IEA
Luiza Bazan	Adam Smith International
Manoel Regis Leal	LNBR/CNPEM
Marcelo Poppe	CGEE
Maria Vilhena	PA
Mariana Faber	INT
Marina Domingues	ABH2
Marina Tomasini	INT
Mario Leite Pereira Filho	IPT - São Paulo
Mateus Chagas	CNPEM
Muhammed Türkan	Aviation
Natasha Stéphany Gusmão Carvalho da Silva	Senai Cetiqt
Patrícia Mesquita	Rapporteur
Paul Kanja	GIZ
Paulo Augusto Franke	GN-z11 Engineering Solutions
Pedro Pontes	CNI
Peter Muchiri	Energy Intelligence Africa Ltd.
Priscilla Machado Dziuba	Northern University of Paraná
Regina Silverio	CGEE
Ricardo de Oliveira	RJ
Roberto Ferreira	Embraer
Rodrigo Jacob	UFRJ
Rosana Cavalcante	Ipea
Rosane Lourenço	Ipea

Name	Institution
Samara Santos	WWF-Brazil
Santiago Mullin	Independent professional
Sergio Velho	Brazil
Shahid Ali	Blue Power Partners
Simon Pastor	Petrobras
Sonia Regina Mudrovitsch de Bittencourt	Federal District
Susan Luz	CGEE
Susanne Wehrs Pereira Panagoulias	UK Government
Tales Simões Mattos	Petrobras
Diego Damasio	Interpreter
Tatiani Leal	Federal District
Thayse Fernandes	LNBR/CNPEM
Thiago Brito	USP
Vadim Kuznetsov	Brics
Viridiana Ferreira-Leitão	INT
Vítor Ximenes	CGEE

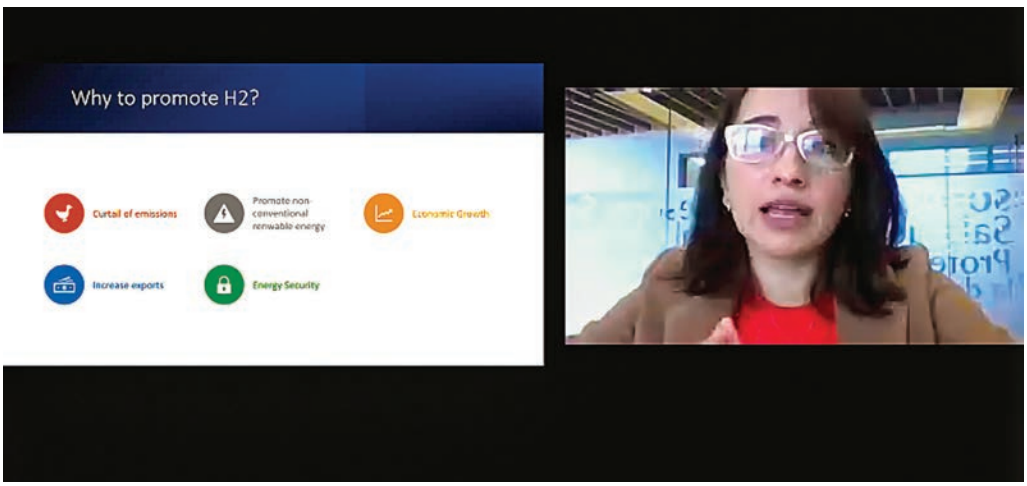
Annex C - Photographic Record

Elaine Nehme - CGEE

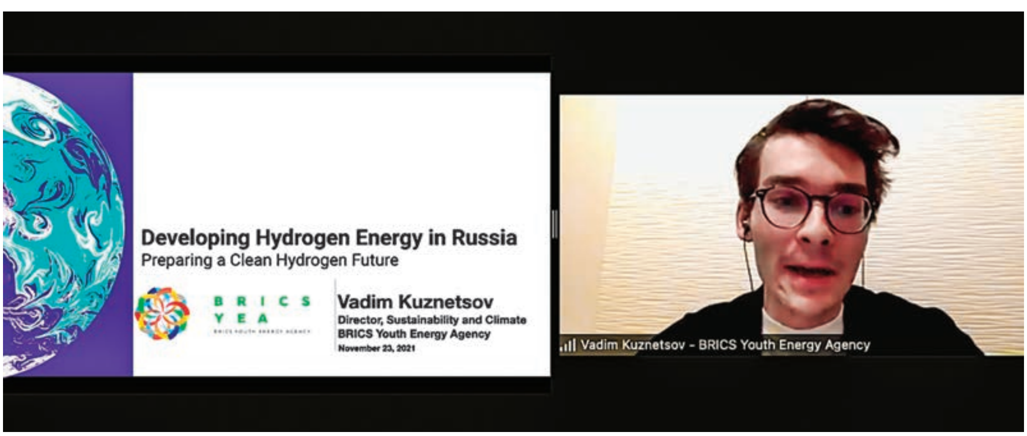
Eduardo Soriano – MCTI

Marcelo Poppe - CGEE

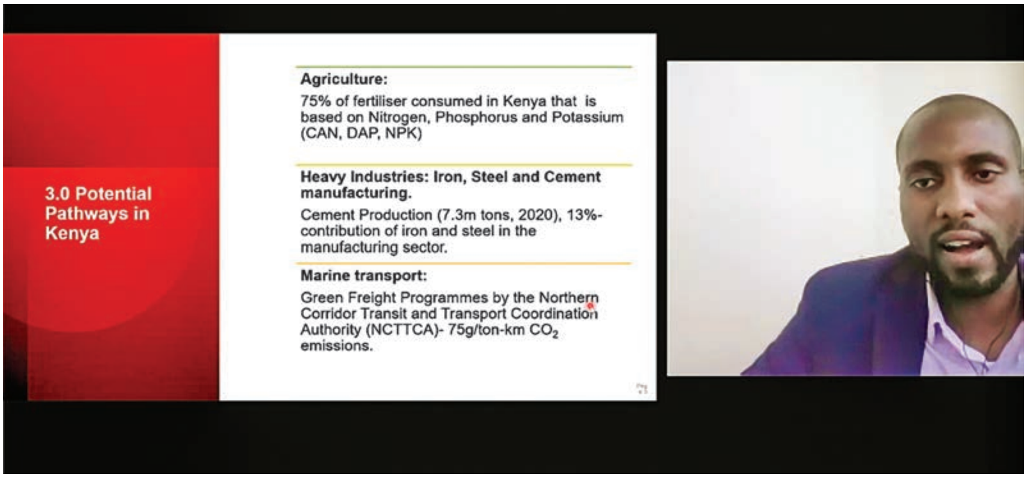
Daniela Abaunza - UE



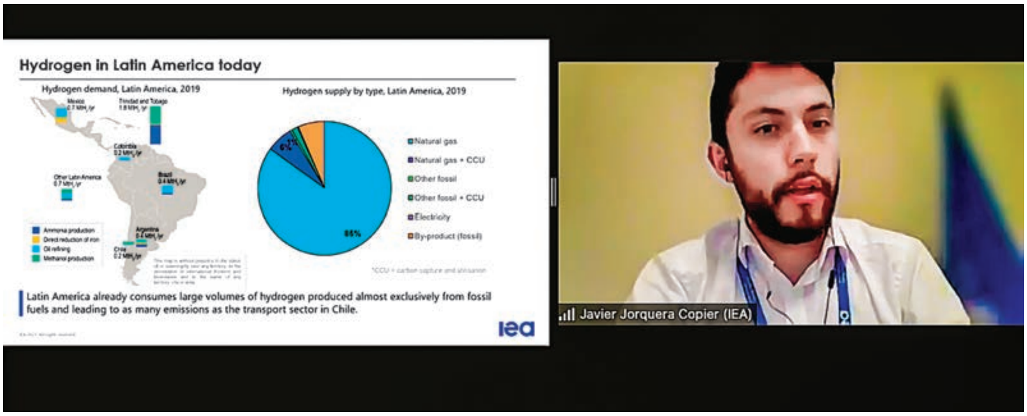
Vadim Kuznetsov - Brics



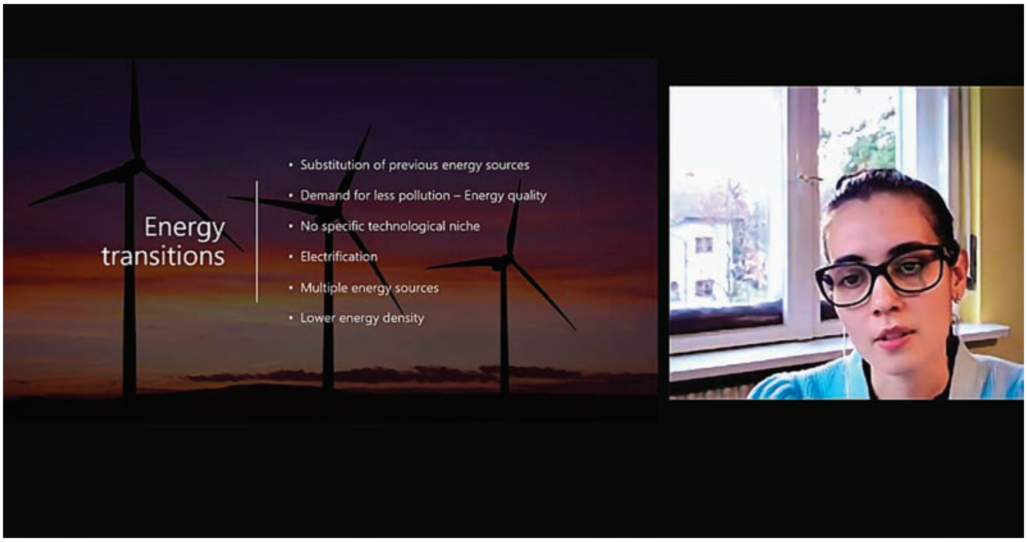
Paul Kanja - GIZ

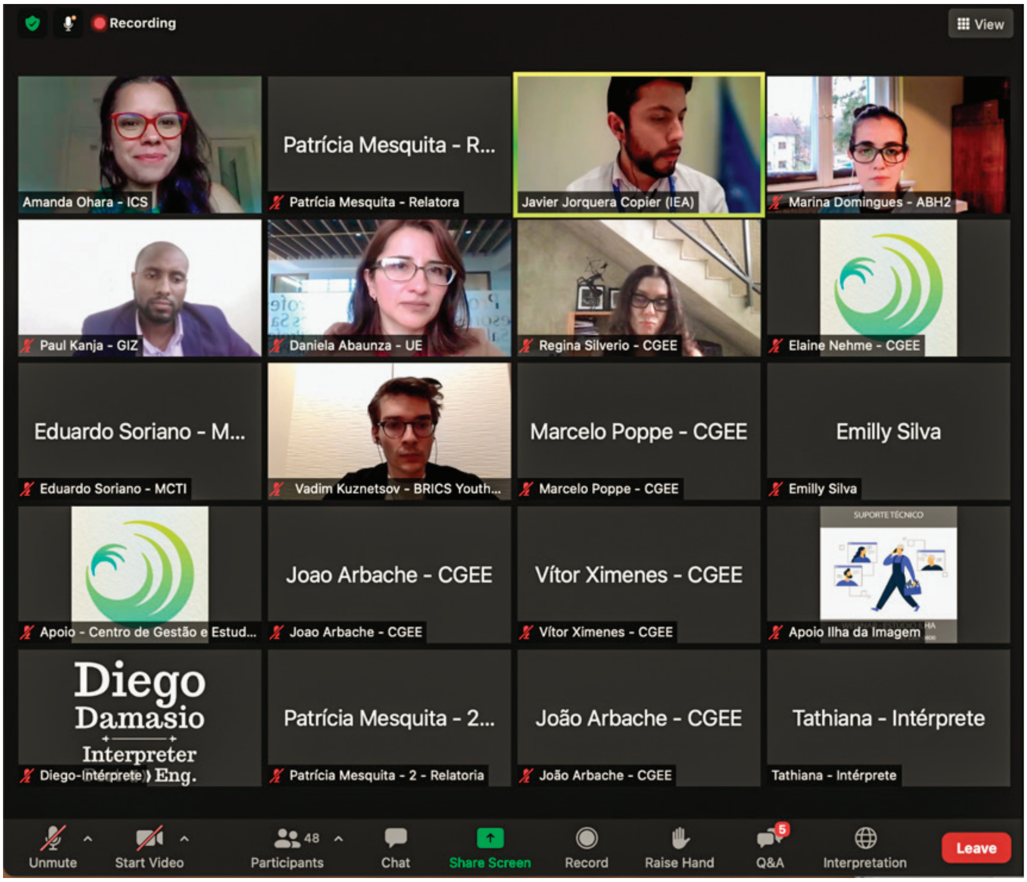


Javier Jorquera Copier - IEA



Marina Domingues - ABH2

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Daniela Abaunza - UE
Regina Silverio - CGEE
Elaine Nehme - CGEE
Eduardo Soriano - M...
Eduardo Soriano - MCTI
Vadim Kuznetsov - BRICS Youth...
Marcelo Poppe - CGEE
Marcelo Poppe - CGEE
Emilly Silva
Emilly Silva
Apoio - Centro de Gestão e Estud...
Joao Arbache - CGEE
Joao Arbache - CGEE
Vítor Ximenes - CGEE
Vítor Ximenes - CGEE
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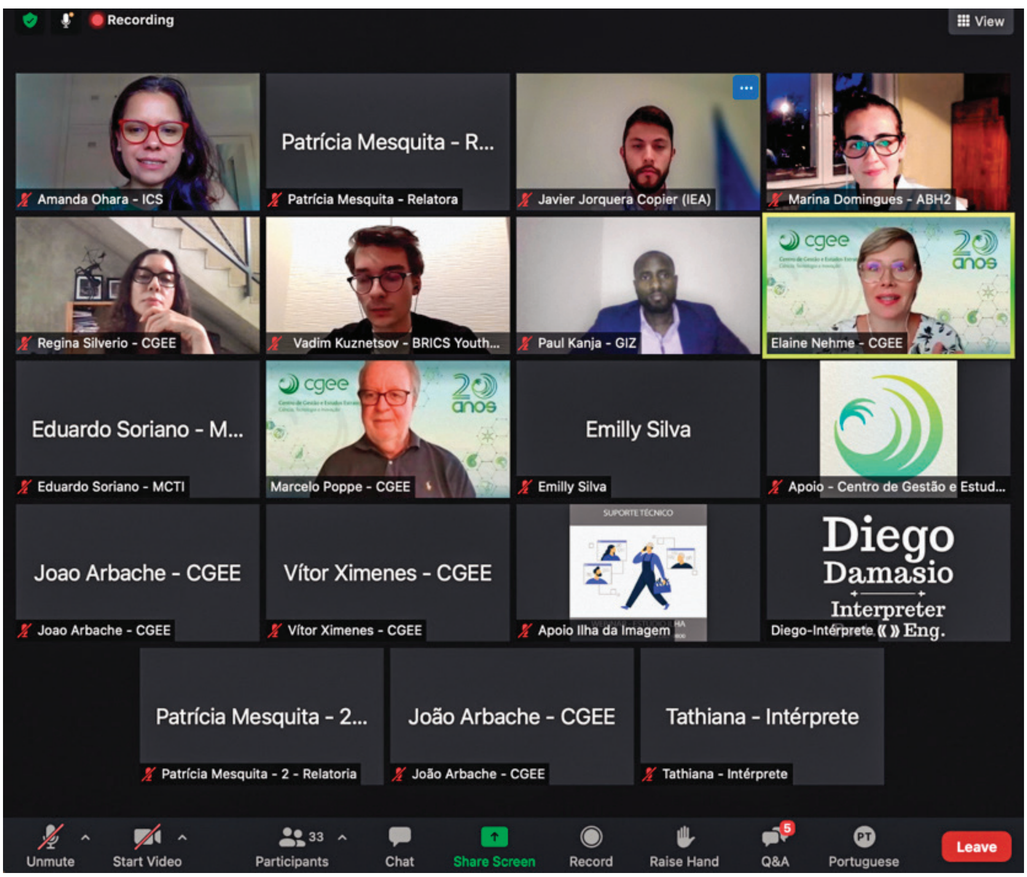
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Vadim Kuznetsov - BRICS Youth...
Paul Kanja - GIZ
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Elaine Nehme - CGEE
Eduardo Soriano - M...
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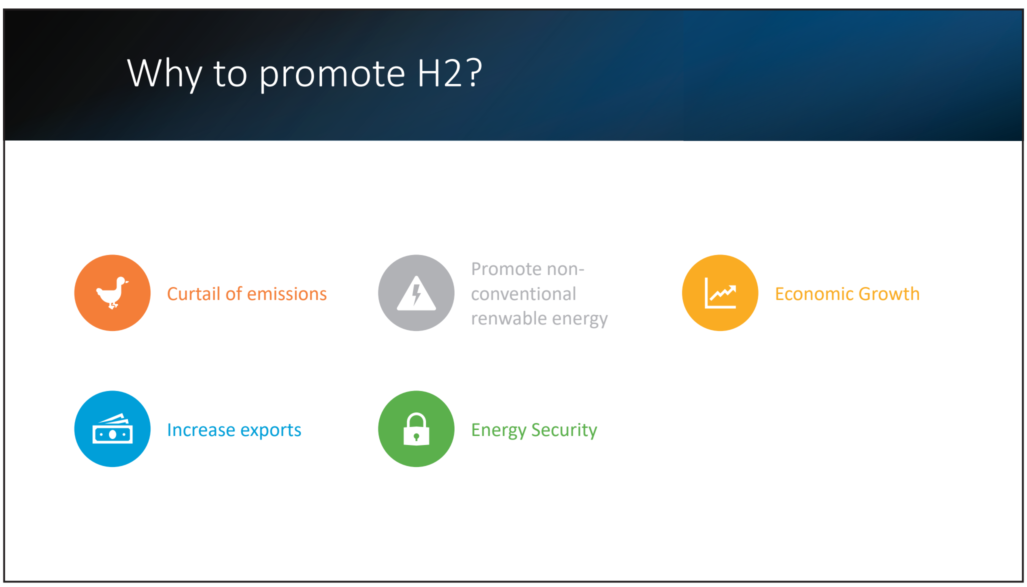
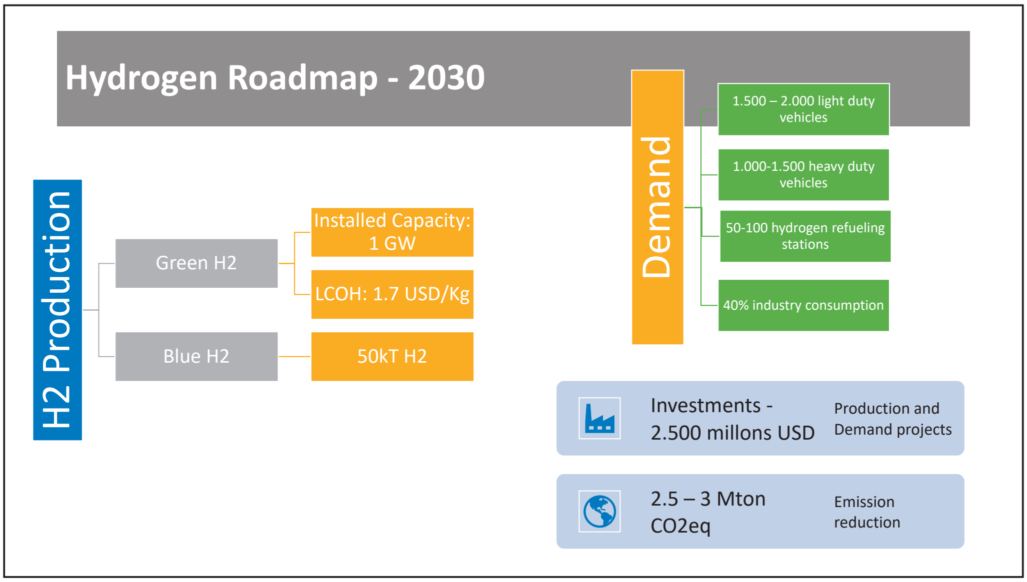
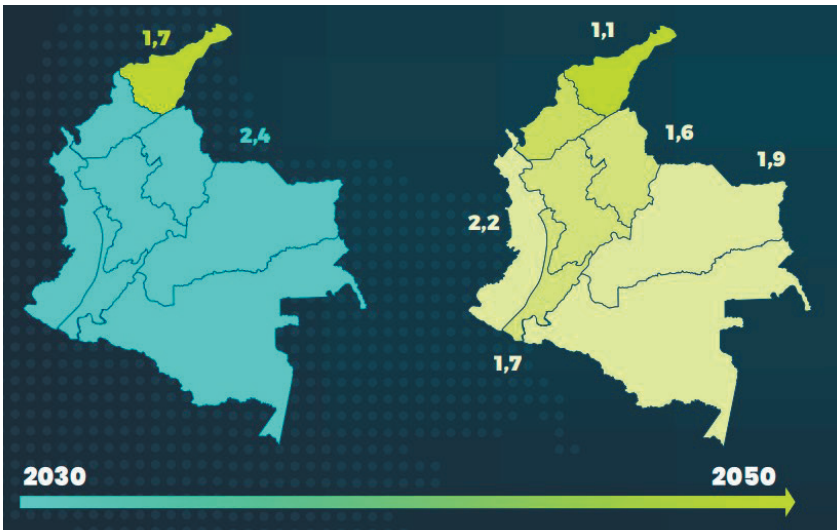
Annex D - Presentations

All the following information was provided by the respective speakers, as well as the authorization for the use and publication of the material.

Daniela Abaunza - Department of Mining Energy Law, Universidad Externado, Colombia
Advances in the hydrogen industry in Colombia

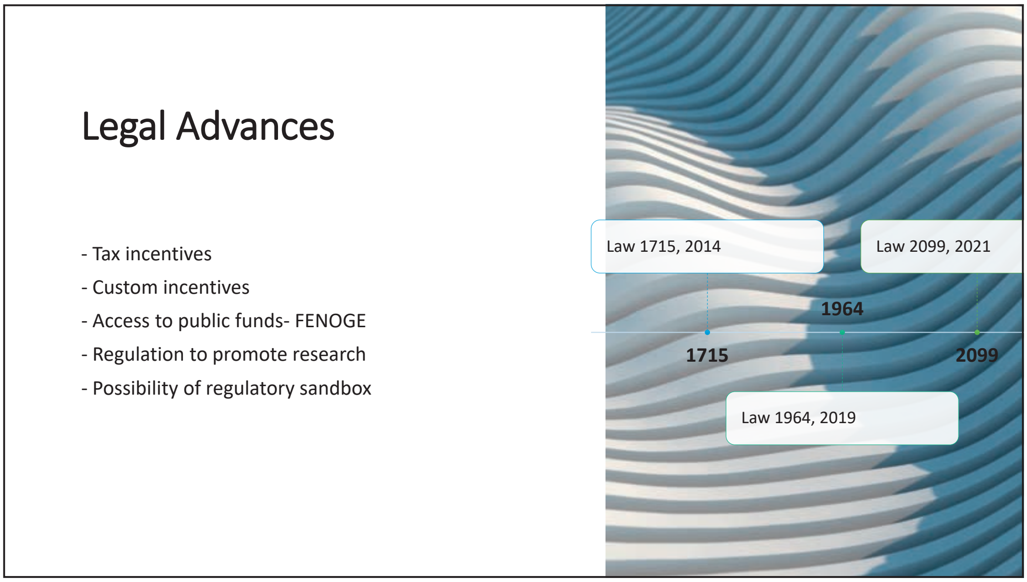






Source: MME, Hydrogen Roadmap

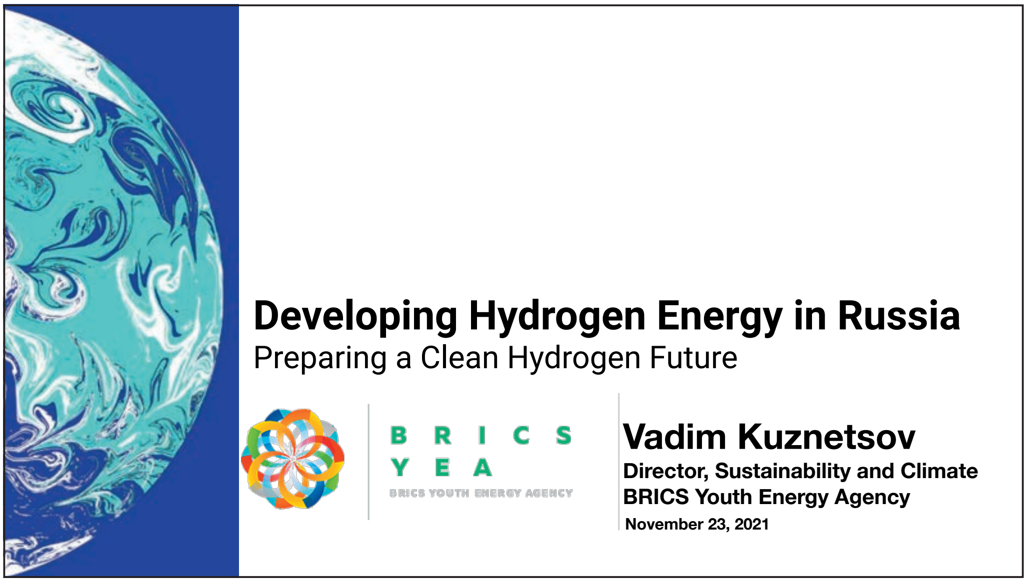
Profile's Country

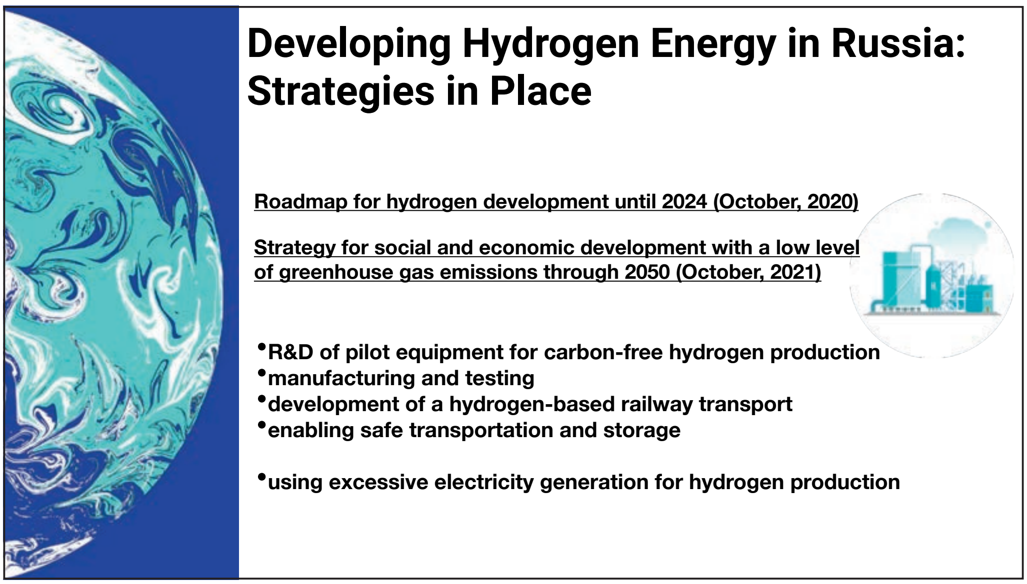

Legal Advances
- Tax incentives
- Custom incentives
- Access to public funds- FENOGE
- Regulation to promote research
- Possibility of regulatory sandbox
Law 1715, 2014
Law 2099, 2021
1964
1715
2099
Law 1964, 2019


New opportunities come with challenges

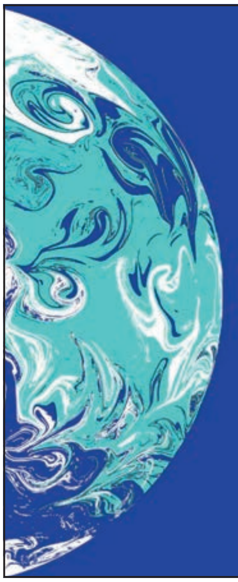
Vadim Kuznetsov - Manager of Sustainable Development Goals Platform, BRICS Youth Energy Agency, Russia

Energy development by hydrogen in Russia - preparing a clean future





Developing Hydrogen Energy in Russia: Strategies in Place



Roadmap for hydrogen development until 2024 (October, 2020)

The main criterion for **assessing hydrogen energy technologies in terms of impact on climate**

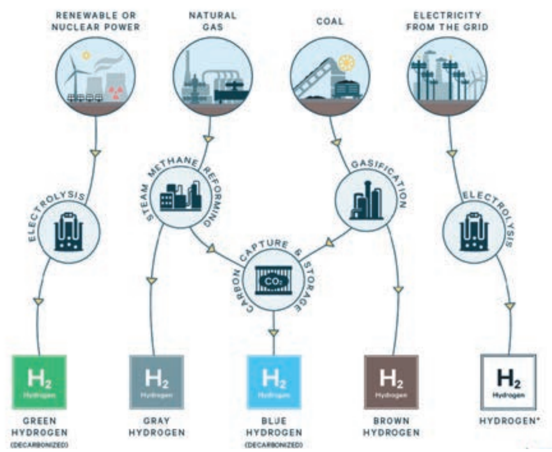
Carbon footprint throughout the life cycle of hydrogen energy carriers

Developing Hydrogen Energy in Russia: Low-carbon and Carbon-free at its Core

Up to 0.2 mill tonnes in 2024

Up to 12 mill tonnes in 2035

Up to 50 mill tonnes in 2050



Developing Hydrogen Energy in Russia: Low-carbon at its Core

Developing Hydrogen Energy in Russia: Low-carbon at its Core

North-Western

- H2 exports to the EU
- EU CBAM —> decarbonizing exports to EU

Kolskaya Wind Park, Murmansk region

Developing Hydrogen Energy in Russia: Low-carbon at its Core

Eastern

- H2 exports to the Asian region
- H2 transport (Sakhalin railway)
- Sakhalin region to go net-zero by 2025

A new wind park to be completed in 2023 on Sakhalin island

Developing Hydrogen Energy in Russia: Low-carbon at its Core

Southern

- Domestic industrial energy supply
- Potential H2 exports through major Black sea ports

Maloderbetovskaya Solar Facility, Kalmyk Republic

Developing Hydrogen Energy in Russia: Low-carbon at its Core

Arctic

- Autonomous energy supply in the Russian Arctic regions
- Potential H2 exports or H2-based energy substances exports

Science Station «Snowflake» to be completed in 2022, Yamal Autonomous Region

Let's cooperate!

soon —> Rio+30 Summit

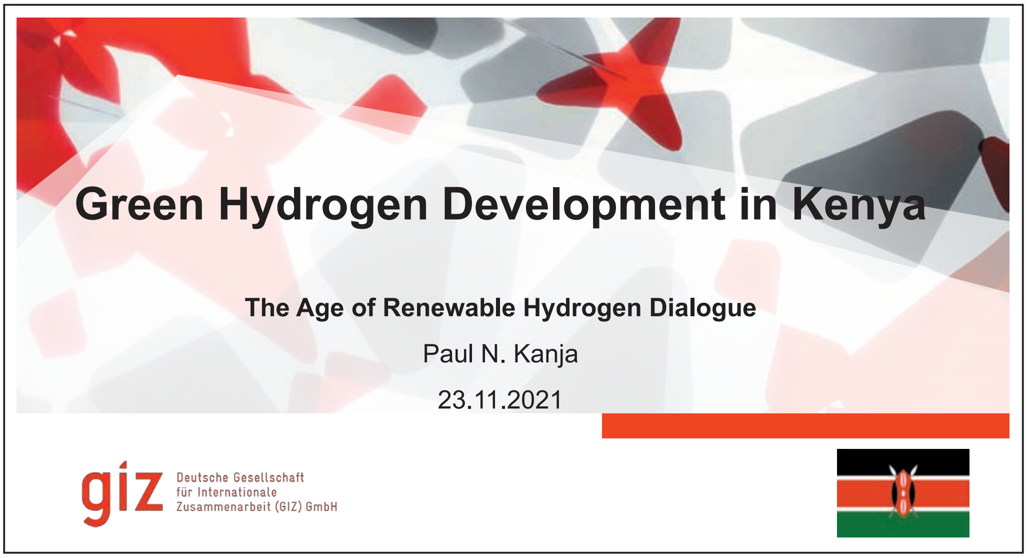
email: kuznetsov@yeabrics.org

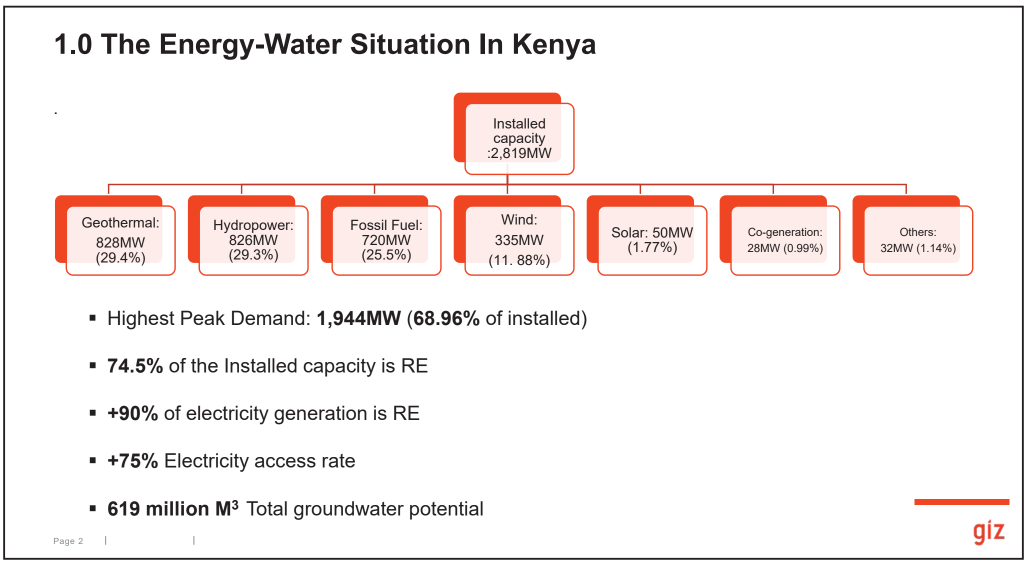
Vadim Kuznetsov

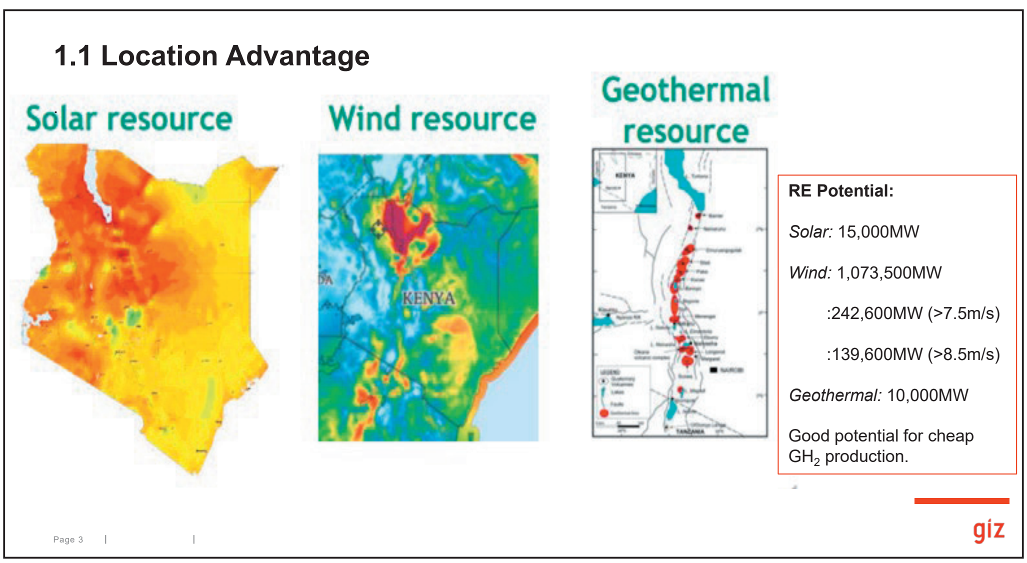
BRICS Youth Energy Agency

Paul Kanja - Renewable Energy Officer, GIZ, Kenya

Green hydrogen development in Kenya







2.0 The Green Hydrogen Baseline Study (in progress)

Detailed assessment of PtX opportunities for Kenya including;

- The associated costs,
- benefits and risks involved,
- prioritisation of possible technological and industrial pathways and
- honest discussion of the pros and cons from Kenyan point of view of pursuing any or all of the analyzed alternative avenues.

Outline of an action plan to support the effective deployment of PtX in Kenya in the short, medium and long term; The action plan shall cover:

- Recommended studies to address the gaps outlined above;
- Research, Development &Innovation,
- Capacity Development through training,
- Local contribution,
- Investment/ financing requirements,
- Regulation and policies improvement and or formulation,
- Required infrastructural development

Page 4 giz

3.0 Potential Pathways in Kenya

Agriculture:
75% of fertiliser consumed in Kenya that is based on Nitrogen, Phosphorus and Potassium (CAN, DAP, NPK)

Heavy Industries: Iron, Steel and Cement manufacturing.
Cement Production (7.3m tons, 2020), 13%-contribution of iron and steel in the manufacturing sector.

Marine transport:
Green Freight Programmes by the Northern Corridor Transit and Transport Coordination Authority (NCTTCA)- 75g/ton-km CO_2 emissions.

Page 5 giz

Q & A

Paul N. Kanja, P.Eng.Tech, MIET

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Page 6 giz

Javier Jorquera - Analyst at the International Energy Agency - IEA, Chile

Perspectives for Renewable Hydrogen in Latin America: Chile

International Energy Agency

Perspectives of renewable hydrogen in Latin America: Chile

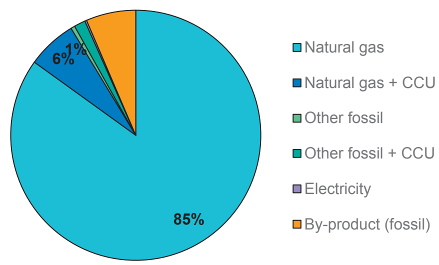
Javier Jorquera, Junior Analyst, International Energy Agency

The Age of Renewable Hydrogen, CGEE, 23 November 2021

Hydrogen in Latin America today

Hydrogen demand, Latin America, 2019

Hydrogen supply by type, Latin America, 2019



*CCU = carbon capture and utilisation.

Latin America already consumes large volumes of hydrogen produced almost exclusively from fossil fuels and leading to as many emissions as the transport sector in Chile.

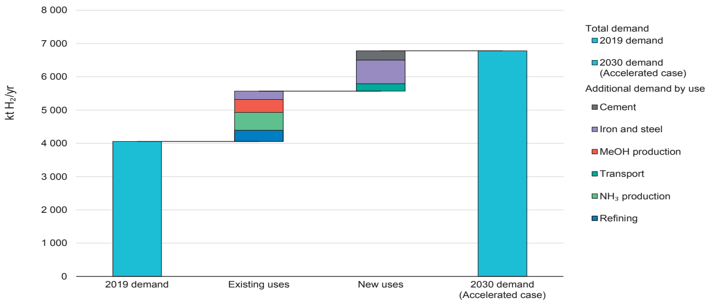
Chile is already acting to deploy renewable hydrogen

- Some existing uses of hydrogen in Chile: refining, methanol production.
- Hydrogen Strategy (November 2020) with initiatives already being executed
- Electrolysis target by 2030 (25 GW) comparable with the EU ambition (40 GW)
- Low-carbon hydrogen projects: as of August 2021, one operational pilot and at least 10 projects announced (5 of them GW-scale)
- Target sectors: mining, heavy transport, industry, exports, refining, among others
- Focus on domestic consumption in the short term to scale up export capacity in the long run

Chile's government, private sector and academia are already advancing towards hydrogen deployment

Hydrogen demand to 2030

Change in hydrogen demand by sector, Accelerated case, Latin America, 2019-2030

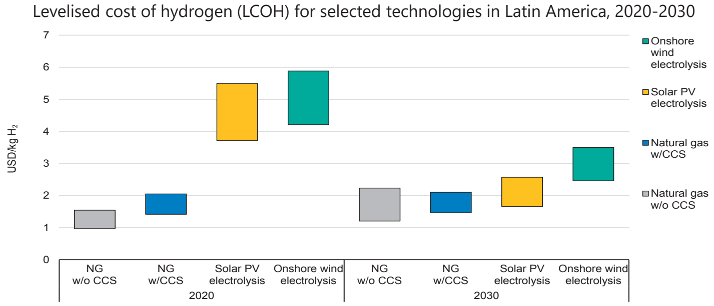


Note: The Accelerated case reflects an optimistic vision for the deployment of hydrogen end-use technologies to 2030, assuming that more ambitious energy- and climate-related policies are put in place and that the required techno-economic and infrastructure progress for the analysed applications will be achieved by that year.

Hydrogen could reach new demand sectors by the end of the decade, but existing uses will continue to dominate total demand.

Deploying low-carbon hydrogen production

Levelised cost of hydrogen (LCOH) for selected technologies in Latin America, 2020-2030

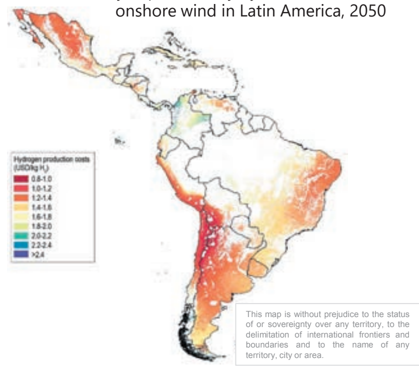


Notes: NG w/o CCS = natural gas-based hydrogen production without CCS; NG w/CCS = natural gas-based hydrogen production with CCS.
Assumptions: discount rate = 6%; system lifetime = 25-30 years; natural gas price = USD 3-7/MBtu (2020 and 2030); solar PV electricity cost = USD 27-43/MWh (2020) and USD 19-30/MWh (2030); onshore wind electricity cost = USD 40-57/MWh (2020) and USD 36-52/MWh (2030); CO2 price = USD 0-10/t CO2 (2020) and USD 15-90/t CO2 (2030).
NG w/o CCS: CAPEX = USD 910/kW H2; OPEX = 4.7% of CAPEX; LHV efficiency = 76%; load factor = 95%.
NG w/CCS: CAPEX = USD 1 474/kW H2 (2020) and USD 1 459/kW H2 (2030); OPEX = 4% of CAPEX; LHV efficiency = 69%; load factor = 95%; capture rate = 90%.
Electrolysis: CAPEX = USD 1 071-1 477/ kWe (2020) and USD 298-436/kWe (2030); OPEX = 0-3% of CAPEX; LHV efficiency = 65% (2020) and 69% (2030); solar PV load factor = 20% (2020) and 32% (2030); onshore wind load factor = 35% (2020) and 50% (2030).

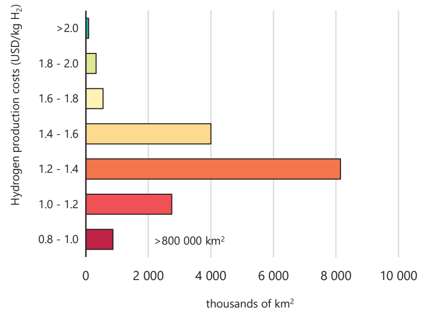
Latin America can retrofit existing production facilities with CCS and produce hydrogen from water and low-carbon electricity, which could already be the most competitive option in the best locations by 2030.

Scaling up low-carbon hydrogen production

LCOH via electrolysis powered by hybrid solar PV and onshore wind in Latin America, 2050



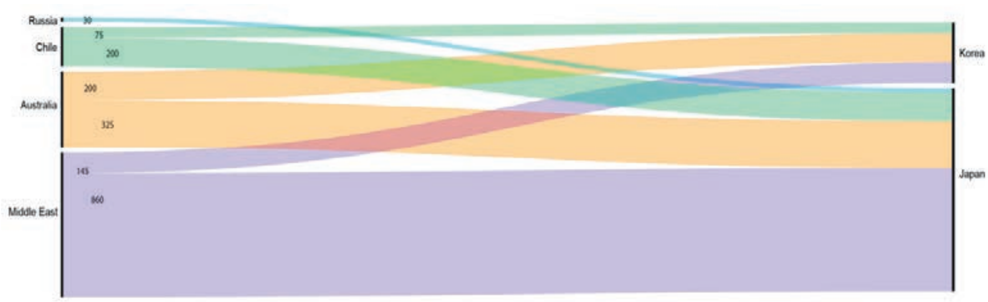
Distribution of hydrogen production potential in Latin America, 2050



In the long-term, Chile and other Latin American countries can produce large amounts of competitive low-carbon hydrogen, creating opportunities for international trade of low-carbon products.

Chile has an important long-term hydrogen export potential

Hydrogen trade flows to Japan and Korea in the Announced Pledges Scenario (APS) in 2050



Trade of hydrogen and hydrogen-based fuels represents 20% of global demand by 2050 in the APS, with Chile being a key player along with Australia, the Middle East and North Africa.

Innovation and technological development will be crucial

- LatAm has successful examples of technological development (biofuels - BR, NG - AR)
- Some hydrogen applications (e.g. high-altitude mining) will need tailor-made solutions
- Hydrogen technology manufacturing presents large opportunities for Chile in the long run (GIZ & Hinicio, 2020), but no public commitment to manufacture technologies has been announced
- Establishing a production chain (e.g. alkaline electrolyzers) could be feasible (compared with e.g. solar panels) and convenient, given the important hydrogen-related ambitions
- Regional collaboration: Pooled R&D resources, economies of scale, enabling infrastructure

No technological role has been clearly defined and there are many opportunities for regional collaboration

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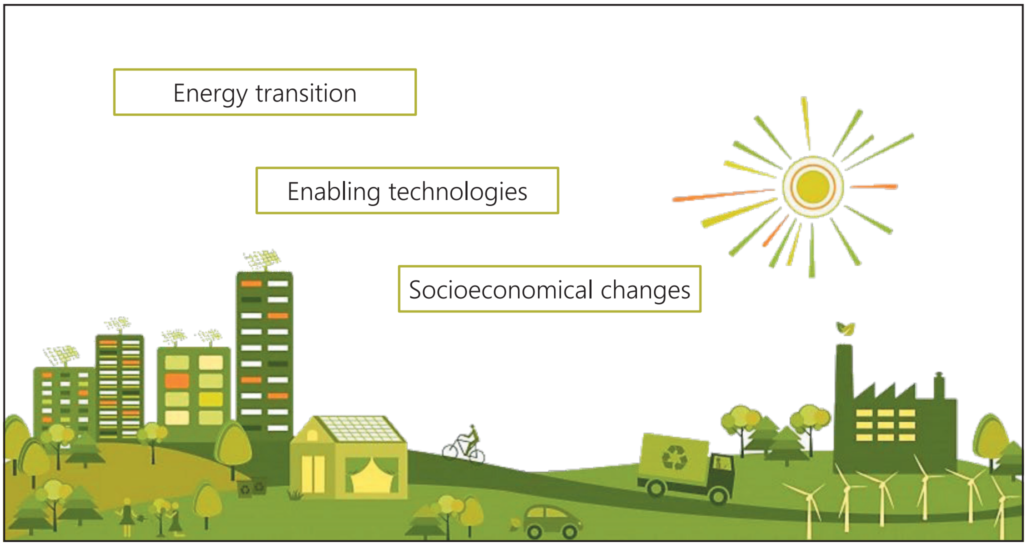
Water consumption needs to be studied from a holistic perspective

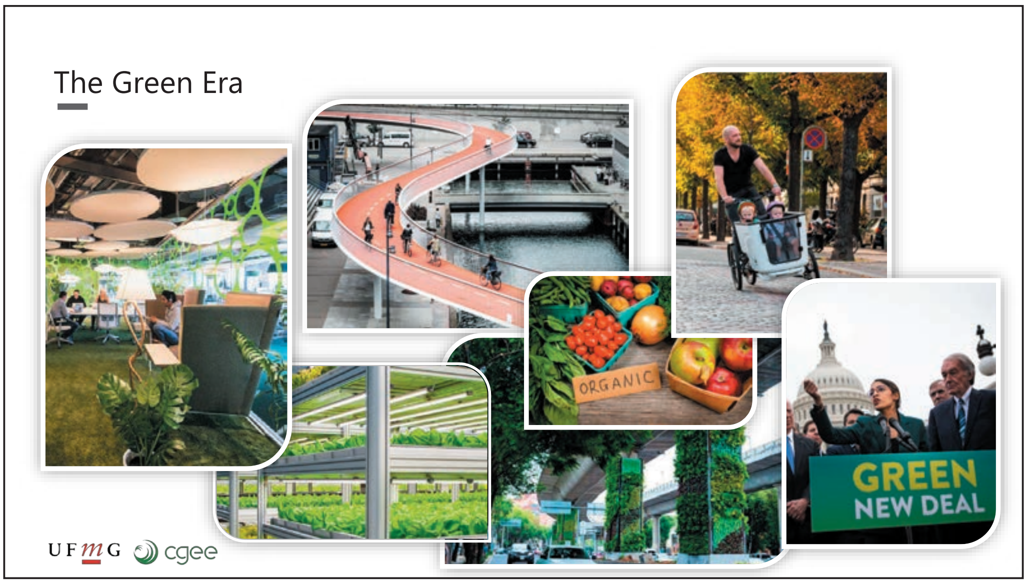
- In some cases electrolysis can be the hydrogen production process with the smallest total water requirements (Hydrogen Council, 2021)
- Replacing fossil fuels with hydrogen in end uses could also reduce total water requirements
- Specific studies required to assess various water supply pathways (desalinated/reclaimed water) and evaluate their risks depending on the location
- Gap to address in terms of knowledge of the impacts of desalinating water in Chile and its regulation
- In general, policies may be needed to ensure proper prioritization of water resources

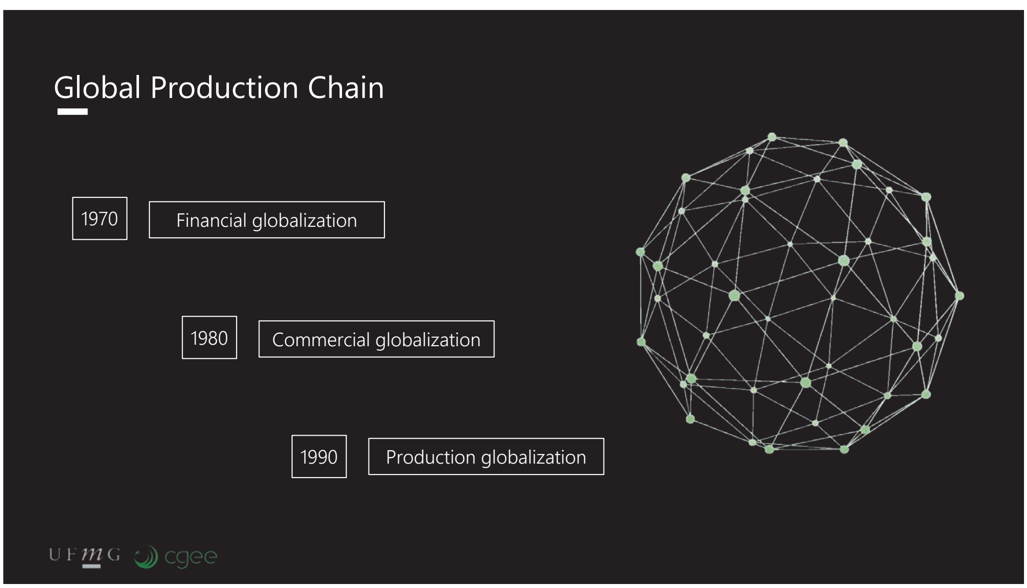
> Water requirements need to be assessed not only on the production side, and further systemic studies may be required to plan for the most water-efficient energy use

Marina Domingues - Executive Secretary, Brazilian Hydrogen Association - ABH2, Brazil

Hydrogen technologies in Brazil


Energy transition
Enabling technologies
Socioeconomical changes


The Green Era
ORGANIC
GREEN
NEW DEAL
UFMG
cgee


Global Production Chain
1970
Financial globalization
1980
Commercial globalization
1990
Production globalization
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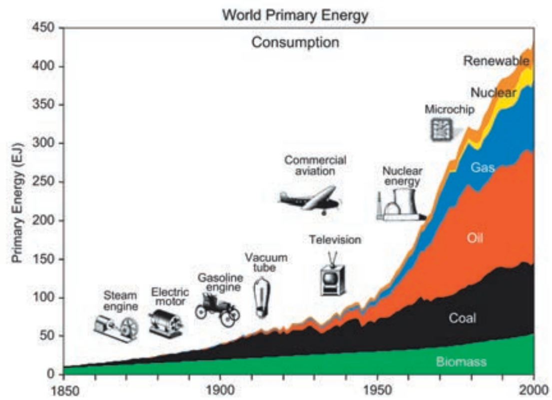
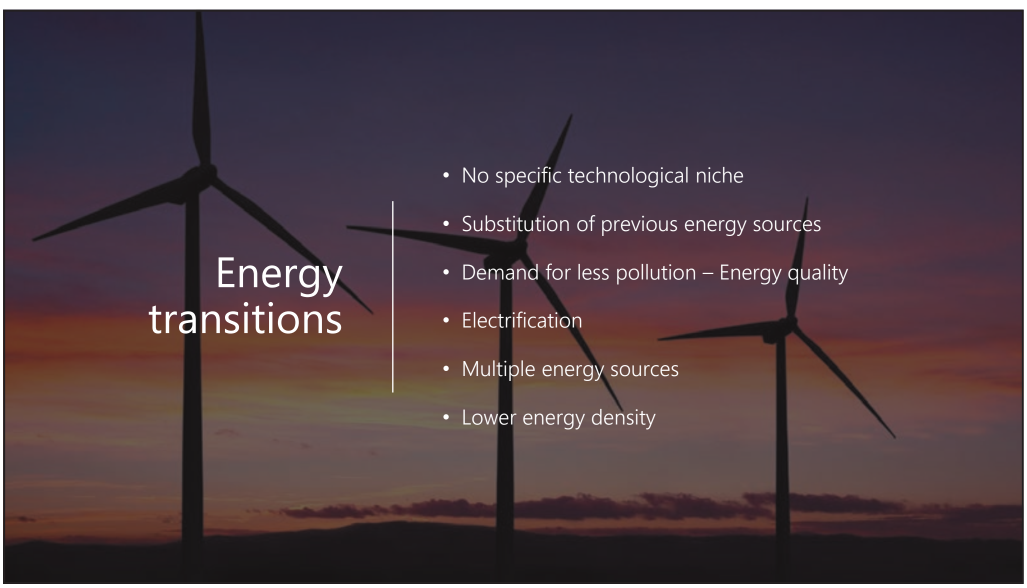
Energy transitions

Higher relative increase in consumption of a primary source compared to others

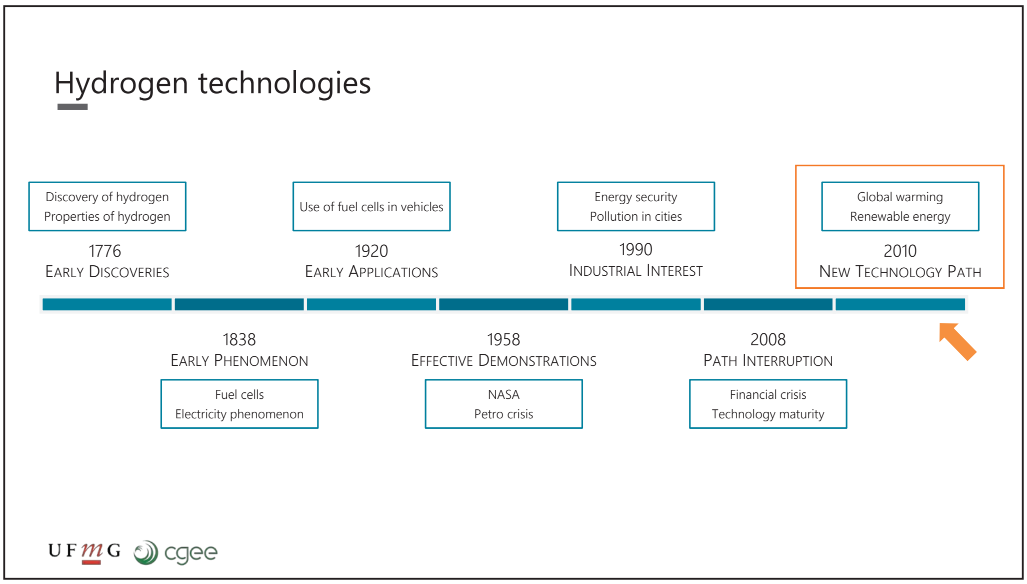
- ✓ Increase in the energy consumption
- ✓ Technological niche for new energy source



UFMG cgee




DECARBONIZATION
TOHO GAS
ENE·FARM
HYDROGEN


Hydrogen technologies
Discovery of hydrogen
Properties of hydrogen
1776
EARLY DISCOVERIES
Use of fuel cells in vehicles
1920
EARLY APPLICATIONS
Energy security
Pollution in cities
1990
INDUSTRIAL INTEREST
Global warming
Renewable energy
2010
NEW TECHNOLOGY PATH
1838
EARLY PHENOMENON
Fuel cells
Electricity phenomenon
1958
EFFECTIVE DEMONSTRATIONS
NASA
Petro crisis
2008
PATH INTERRUPTION
Financial crisis
Technology maturity
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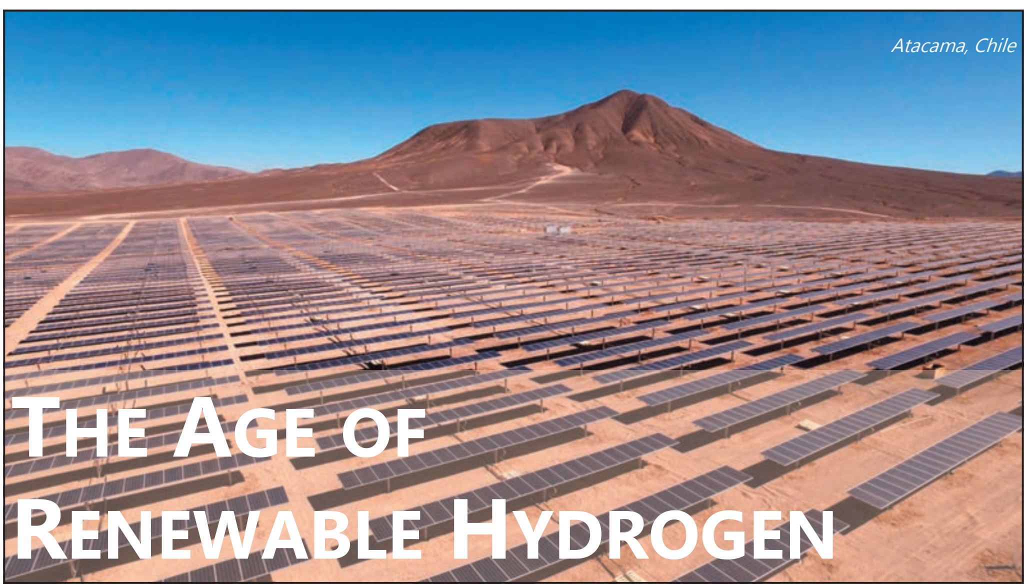
Atacama, Chile
THE AGE OF
RENEWABLE HYDROGEN


WHAT ARE, INDEED, SOCIAL AND ECONOMIC BENEFITS FOR EXPORTING NATIONS?
?
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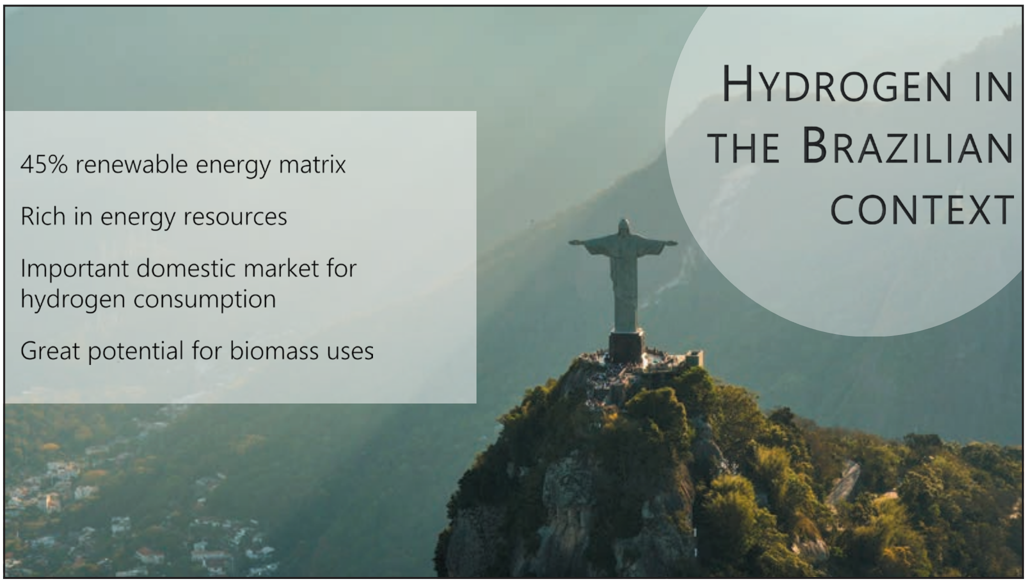
HYDROGEN IN THE BRAZILIAN CONTEXT
45% renewable energy matrix
Rich in energy resources
Important domestic market for hydrogen consumption
Great potential for biomass uses


Biomass
Transport
Hard to abate
Energy security
MAJOR HYDROGEN OPPORTUNITIES IN BRAZIL

Negative implications of H_2 to be avoided

- Exportation focus
- Global use of energy and natural resources
- No benefits for the society
- No technologic knowledge transfer
- No development of internal demand

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Thank you

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List of acronyms and abbreviations found in this publication

Portuguese	English
ABNT | Associação Brasileira de Normas Técnicas	**ABNT** | Brazilian Association of Technical Standards
APS | Announced Pledges Scenario	**APS** | Announced Pledges Scenario
ABH2 | Associação Brasileira do Hidrogênio	**ABH2** | Brazilian Hydrogen Association
Brics | Brasil, Rússia, Índia, China e África do Sul	**Brics** | Brazil, Russia, India, China and South Africa
CGEE | Centro de Gestão e Estudos Estratégicos	**CGEE** | Center for Strategic Studies and Management
CH4 | metano	**CH4** | methane
CNPE | Conselho Nacional de Política Energética	**CNPE** | National Energy Policy Council
GEE | gases de efeito estufa	**GHG** | greenhouse gases
GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit	**GIZ** | Deutsche Gesellschaft für Internationale Zusammenarbeit
GW | gigawatt	**GW** | gigawatt
ICS | Instituto Clima e Sociedade	**ICS** | Climate and Society Institute
IEA | Agência Internacional de Energia	**IEA** | International Energy Agency
INDC | Contribuições Nacionalmente Determinadas,	**INDC** | Intended Nationally Determined Contributions
IPHE | Partnership for Hydrogen and Fuel Cells in the Economy	**IPHE** | Partnership for Hydrogen and Fuel Cells in the Economy
LCOH | custo nivelado de produção de hidrogênio	**LCOH** | levelized cost of hydrogen production
MCTI | Ministério da Ciência, Tecnologia, Inovações e Comunicações	**MCTI** | Ministry of Science, Technology, Innovations and Communications
MME | Ministério de Minas e Energia	**MME** | Ministry of Mines and Energy
Mton CO2 Eq | megatonelada de dióxido de carbono equivalente	**Mton CO2 Eq** | megatonnes of carbon dioxide equivalent
MW | megawatts	**MW** | megawatts
NCTTCA | Northern Corridor Transit and Transport Coordination Authority	**NCTTCA** | Northern Corridor Transit and Transport Coordination Authority
NH3 | amônia	**NH3** | ammonia
ODS | Objetivos do Desenvolvimento Sustentável	**SDGs** | Sustainable Development Goals
ProCac | Programa Brasileiro de Células a Combustível	**ProCac** | Brazilian Fuel Cell Program
PtX | Power to X	**PtX** | Power to X
UE | União Europeia	**EU** | European Union
UFMG | Universidade Federal de Minas Gerais	**UFMG** | Federal University of Minas Gerais

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CIÊNCIA, TECNOLOGIA
E INOVAÇÕES

PÁTRIA AMADA
BRASIL
GOVERNO FEDERAL