G.D. GOENKA MODEL UNITED NATIONS'22

WORLD TRADE ORGANISATION

BACKGROUND GUIDE

WELCOME TO GDMUN 2022

GDMUN was created for the purpose of facilitating an environment where youth can contribute to their community, build confidence and leadership, practice their skills and rights, and familiarize themselves with global affairs. Above all, we thrive to provide participants with an original experience in Jammu by capitalizing on an existing diverse population members and participants while creating an inclusive and innovative environment for individuals to communicate and connect with one another. Having participated in high-level MUN conferences in Jammu and around the world as organizers, GDMUN team understand more than anyone what makes a successful MUN conference. Allow us to demonstrate it to you this fall.

MESSAGE FRON THE DIAS

My name is Arjun Mahajan, a senior student at Delhi University, Desh Bandhu college, majoring in History. It is my utmost pleasure and honour to serve as a Chair in the Dispute Settlement Body - World Trade Organization Committee at the 2nd Session of GDMUN.

Trade has been one of the oldest forms of communication between countries on a regional or global scale. On the one hand, trade can foster economic growth and reduce the economic and technological gap between trading partners. However, on the other hand, trade can create conflicts due to differences in economic, social, and political settings. Since its establishment in 1995, the World Trade Organization has served as an official forum to settle trade disputes and negotiate trade agreements. In this conference, every delegation bears the responsibility and the capability of resolving the fosil fuel depletion problem and bringing the solution of hydrogen economy.

I believe MUN is a platform for everyone from all socioeconomic backgrounds to interact, to exchange ideas, to voice their opinions, to learn valuable professional skills, and to network. As your Chair, I hope that after GDMUN 2022 conference, all delegations will learn something new, grow academically and personally, make unforgettable memories, and importantly, have fun!

Signing off

Arjun Mahajan

Distinguished Delegates, Greetings!

I am delighted to welcome this group of sharp young minds to the second session of the GDMUN'22.

Concerning myself, I am currently in grade 10, and I have been involved in Model United Nations for the past four years. With over 20 years of experience as an enthusiastic participant, MUNs have always been a source of excitement and information for me. MUNs, in my opinion, provide a motivation for adolescents to comprehend global concerns and take appropriate action. I enjoy being surrounded by innovative ideas, thoughtful deliberations and talks, and, most importantly, agreed conclusions and solutions.

Lastly, I would request all the delegates to put sincere efforts in preparation and research for the simulation and work hard to make it a fruitful learning experience for all.

Feel free to contact me via email if you have any queries or doubts.

Regards,

Suvan

Gupta

Vice Chairperson

AGENDA OVERVIEW

WTO: Effects of depleting Fossil Fuel resources on International Trade and Deliberation upon shift to Hydrogen Economy.

TOPIC 1: Fossil Fuel

Depletion of Fossil Fuels

TOPIC 3: Hydrogen Economy

Power Conversion from Fossil Fuel to Hydrogen

Cross Reference

TOIC 2: Hydrogen Power

Usage of Green Hydrogen

FINAL REPORT

RESOLUTION

Discussions on Topic 1 and Topic 2 serve as a reference for discussions revolving around Topic 3. As the result, Topic 3 will bethe last item to be debated on the agenda. The final report will adopt UN Resolution format. Delegates can submit multiple draftresolutions but only one will be adopted as the final report of the committee.

THE WORLD TRADE ORGANIZATION

THE KEY INSTITUTION OF INTERNATIONAL TRADE

The World Trade Organization (WTO) emerged in 1995 following the establishment of the General Agreement on Tariffs and Trade (GATT) in 1947. The GATT was born out of the Bretton Woods Agreementin 1944, which served to ensure economic stability for major economies and promote international trade after World War II.

The GATT, signed by 23 countries in 1947, was the most comprehensive multilateral trade agreement at the time whose aims were to assure action for the reduction of tariff and to give Member States a right to tariff concession on particular products that might be impossible under bilateral agreement. As a result of the Uruguay Round negotiations, in 1995, the WTO was established to replace the outdated GATT, which was no longer relevant in the complex world trade of globalization era and the problematic dispute settlement system. However, the GATT (updated in 1994) remains a critical principal document for WTO. As of 2018, the WTO has 164 members and 23 observer governments, accounting for 98% of international trade.

MANDATE

The WTO is responsible for the regulation of international trade through a system of international rules. The main goal of this intergovernmental organization is to “ensure that trade flows as smoothly, predictably and freely as possible.”

The WTO acts as a forum for governments to negotiate trade agreements and settle trade disputes. Essentially, when governments believe that their trade rights under WTO agreements are being infringed, they bring their dispute to the WTO and follow a naturallegal-based procedure based on an agreed legal foundation to settle their differences. Since 1995, over 500 disputes have been filed to the WTO and more than 300 rulings have been issued.. The WTO trade agreements cover trade in goods, services, and intellectual property.

In addition, the WTO's operations include reviewing national trade policies to ensure transparency in governments' trade policies. The WTO also cooperates with other international organizations and assists developing countries in trade policy issues, through technical assistance and training programmes.

DISPUTE SETTELMENT PROCESS

As WTO Members file a complaint to the WTO, dispute parties enter the first stage, also known as consultations, in which dispute parties attempt to settle their disputes and differences by themselves through a mutually agreed solution.

If consultations fail, parties in disputes enter the second stage of settling disputes through adjudication, leading to the establishment of the Panel by the Dispute Settlement Body (DSB), which includes all WTO members. After discussing the issue, the Panel will send a final report to the parties in dispute. The Panel recommends measures to be made to conform with WTO rules if it decides that the disputed trade measure goes against the WTO agreements or obligations. The report then becomes the DSB's ruling or recommendation.

KEY TERMS AND CONCEPT
THE FOUNDATION OF THE DEBATE

TARRIF

Tariff is a tax on a product made abroad. In theory, the price of taxing items coming into the country means people are less likely to buy them as they become more expensive. The intention is that they buy cheaper local products instead, which boosts your country's economy and thereby protect certain national industries and jobs. Tariffs can also be used as an extension of foreign policy: imposing tariffs on a trading partner's main exports is a way to exert economic leverage. Besides tariff, countries can restrict trade using non-tariff barriers, such as but not limited to quotas, embargoes, sanctions, levies. Tariffs can have unintended side-effects, such as making domestic industries less efficient by reducing competition, hurting domestic consumers with high prices, and creating tensions by favoring certain industries over others. Finally, the act of pressuring a rival country by raising imported taxes can descend into an unproductive cycle of tariff retaliation, known as a trade war.

Trade War

A trade war is a side effect of protectionism that occurs when one country (Country A) raises tariffs on another country's (Country B) imports in retaliation for Country B by raising tariffs on Country A's imports. Trade wars can commence if one country perceives another country's trading practices to be unfair or when domestic trade unions pressure politicians to make imported goods less attractive to consumers.

Free Trade and Protectionism

Free trade is a policy to eliminate discrimination against imports and exports through voluntarily trade without a government applying tariffs, quotas, and subsidies or prohibitions on goods and services. Free trade is the opposite of trade protectionism, which is shielding a country's domestic industries by raising tariffs on imports from foreign countries. As mentioned above, such an act can sour relations among countries and lead to a trade conflict.

FOSSIL FUEL DEPLETION

Fossil fuels, in particular oil, gas and coal are thus bound to remain goods to be dealt with in

accordance with established principles and rules of GATT 1994. However, energy dependent upon

networks and grids is, in our view, much closer to a service, albeit physical properties remain to

some extent. This is true in particular for gas which can be stored to some extent, and thus detached

from a pipeline system. It is, however, different for electricity. importance of fossil fuels in

supplying the energy requirements of the 21st century, their future supply, and the impact of their use on global climate is presented. Current and potential alternative energy sources are

considered. It is concluded that even with substantial increases in energy derived from other

sources, fossil fuels will remain a major energy source for much of the 21st century and the

sequestration of CO_2 will be an increasingly important requirement.

Fossil fuel depletion and other non-renewable material depletion are commonly included among

environmental sustainability indicators for Life Cycle Assessment (Klinglmair et al., 2012; EC, 2013a;

Huijbregts et al., 2017).However, reducing the use of non-renewable materials is also a policy

objective for the European Union (EC, 2013b). From the perspective of internationally accepted

agreements on the rights of present and future generations, safeguard of natural resources,

minimizing depletion of non-renewable resources and their sustainable management are goals

stated in UN declarations, resolutions, and documents.

Fossil fuel depletion and socio-economic scenarios: an integrated approach

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ABSTRACT

The progressive reduction of high-quality-easy-to-extract energy is a widely recognized and already ongoing process. Although depletion studies for individual fuels are relatively abundant, few of them offer

a global perspective of all energy sources and their potential future developments, and even fewer include the demand of the socio-economic system. This paper presents an Economy-Energy-Environment model based on System Dynamics which integrates all those aspects: the physical restrictions (with peak estimations for oil, gas, coal and uranium), the technosustainable potential of renewable energy estimated by a novel top-down methodology, the socio-economic energy demands, the development of alternative technologies and the net CO2 emissions. We confront our model with the basic assumptions of previous Global Environmental Assessment (GEA) studies. The results show that demand-driven evolution, as performed in the past, might be unfeasible: strong energy-supply scarcity is found in the next two decades, especially in the transportation sector before 2020. Electricity generation is unable to fulfill its demand in 2025-2040, and a large expansion of electric renewable energies move us close to their limits. In order to find achievable scenarios, we are obliged to set hypotheses which are hardly used in GEA scenarios, such as zero or negative economic growth.

HYDROGEN

Hydrogen is the most prevalent chemical element in the universe, accounting for approximately 75% of all normal matter. The Sun and other stars are mostly made up of hydrogen in the plasma state. The majority of hydrogen on Earth resides in molecule forms like water and organic substances.

Water, plants, animals, and, of course, people contain massive amounts of hydrogen atoms. While it is found in practically all molecules in living things, it is extremely rare as a gas, with less than one part per million by volume.

Hydrogen can be produced from diverse domestic resources with the potential for near-zero greenhouse gas emissions. Once produced, hydrogen generates electrical power in a fuel cell, emitting only water vapor and warm air. It holds promise for growth in both the stationary and transportation energy sectors.

Why is hydrogen important as a future clean energy source?

A fuel is a substance that can be 'burned' to produce usable energy. When a fuel is burned, the chemical links between the elements in the fuel are destroyed and the components mix chemically with oxygen (often from the air).
For many years, we have utilized natural gas to heat our homes and workplaces, as well as to power plants. Gas presently powers 85% of UK houses and 40% of the country's electricity; in the US, 47% of households use natural gas and 36% use electricity1.
Methane is the primary component of 'natural gas' extracted from oil and gas sources. We've been using natural gas because it's a widely available resource, it's cheap, and it's a cleaner option than coal, the

dirtiest fossil fuel on which we've historically relied for heating and electrical generation.
Natural gas generates heat energy when it is burned. However, carbon dioxide is a waste product that, when released into the atmosphere, contributes to climate change. The only waste product of hydrogen combustion is water vapour.

Is hydrogen already being used as a fuel?

Yes. There are already cars that run on hydrogen fuel cells. In Japan there are 96 public hydrogen refuelling stations, allowing you to fill up just as you would with petrol or diesel and in the same time frame as a traditional fuel car. Germany has 80 of these hydrogen stations and the United States is third with 42 stations.
Hydrogen is also an exciting lightweight fuel option for road, air and shipping transportation. The international delivery company DHL already has a fleet of 100 ‘H2 panel vans’, capable of travelling 500kms without refuelling.

HYDROGEN ECONOMY

Hydrogen economy is at a crucial point. The market demands clean and sustainable energy and fuel cell technologies look viable and quite appealing for a broad range of applications. Moreover, fuel cells are not only clean but also efficient and flexible and, among them, solid oxide fuel cells are very promising. The main problem is to understand which development stage various fuel cell technologies have reached and their yearly performance improvement rates. This information can provide insight into the barriers and the key drivers of innovation of the different types of fuel cells. Furthermore the differences in performance improvement rates could suggest the research direction that the fuel cell industry is taking. In a few words, the combination of patent analysis, bibliometrics, and rationalization of fuel cell technologies can help us to have a complete picture of their technological development

Hydrogen as an Alternative Fuel

Hydrogen is considered an alternative fuel under the Energy Policy Act of 1992. The interest in hydrogen as an alternative transportation fuel stems from its ability to power fuel cells in zero-emission vehicles, its potential for domestic production, and the fuel cell's fast filling time and high efficiency. In fact, a fuel cell coupled with an electric motor is two to three times more efficient than an internal combustion engine running on gasoline. Hydrogen can also serve as fuel for internal combustion engines. However, unlike FCEVs, these produce tailpipe emissions and are less efficient. Learn more about fuel cells.

The energy in 2.2 pounds (1 kilogram) of hydrogen gas is about the same as the energy in 1 gallon (6.2 pounds, 2.8 kilograms) of gasoline. Because hydrogen has a low volumetric energy density, it is stored onboard a vehicle as a compressed gas to achieve the driving range of conventional vehicles. Most current applications use high-pressure tanks capable of storing hydrogen at either 5,000 or 10,000 pounds per square inch (psi). For example, the FCEVs in production by automotive manufacturers and available at dealerships have 10,000 psi tanks. Retail dispensers, which are mostly co-located at gasoline stations, can fill these tanks in about 5 minutes. Fuel cell electric buses currently use 5,000 psi tanks that take 10–15 minutes to fill. Other ways of storing hydrogen are under development, including bonding hydrogen chemically with a material such as metal hydride or low-temperature sorbent materials.

Rapid growth of the global hydrogen economy can bring significant geoeconomic and geopolitical shifts giving rise to a wave of new interdependencies, according to new analysis by the International Renewable Energy Agency (IRENA). *Geopolitics of the Energy Transformation: The Hydrogen Factor* sees hydrogen changing the geography of energy trade and regionalising energy relations, hinting at the emergence of new centres of geopolitical influence built on the production and use of hydrogen, as traditional oil and gas trade declines.

Driven by the climate urgency and countries' commitments to net zero, IRENA estimates hydrogen to cover up to 12 per cent of global energy use by 2050. Growing trade and targeted investments in a market dominated by fossil fuels and currently valued at USD 174 billion is likely to boost economic competitiveness and influence the foreign policy landscape with bilateral deals diverging significantly from the hydrocarbon relationships of the 20th century.

"Hydrogen could prove to be a missing link to a climate-safe energy future", Francesco La Camera, Director-General of IRENA said. "Hydrogen is clearly riding on the renewable energy revolution with green hydrogen emerging as a game changer for achieving climate neutrality without compromising industrial growth and social development. But hydrogen is not a new oil. And the transition is not a fuel replacement but a shift to a new system with political, technical, environmental, and economic disruptions."

"It is green hydrogen that will bring new and diverse participants to the market, diversify routes and supplies and shift power from the few to the many. With international co-operation, the hydrogen market could be more democratic and inclusive, offering opportunities for developed and developing countries alike."

IRENA estimates that over 30 per cent of hydrogen could be traded across borders by 2050, a higher share than natural gas today. Countries that have not traditionally traded energy are establishing bilateral energy relations around hydrogen. As more players and new classes of net importers and exporters emerge on the world stage, hydrogen trade is unlikely to become weaponised and cartelised, in contrast to the geopolitical influence of oil and gas.

Cross-border hydrogen trade is set to grow considerably with over 30 countries and regions planning for active commerce already today. Some countries that expect to be importers are already deploying dedicated hydrogen diplomacy such as Japan and Germany. Fossil fuel exporters increasingly consider clean hydrogen an attractive way to diversify their economies for example Australia, Oman, Saudi Arabia and the United Arab Emirates. However, broader economic transition strategies are required as hydrogen will not compensate for losses in oil and gas revenues.

INDIA

India has started to flesh out its national blueprint to create a hydrogen economy with a series of policy incentives that industry pundits believe can help lower production costs in the coming decade.
Last month, India's Ministry of Power unveiled a national target of producing 5 million metric tons (mt)/year of hydrogen from biomass or renewable electricity by 2030 as part of the country's decarbonization efforts.
Producers will be able to enjoy lower electricity costs as well as better access to land and logistics infrastructure, according to the ministry's Green Hydrogen Policy. The incentives will also apply to plants that convert green hydrogen into ammonia.
Deepak Yadav, a program associate at Delhi-based thinktank Council on Energy, Environment and Water (CEEW), estimated some measures related to transmission charges alone can reduce the production cost of green hydrogen in Uttar Pradesh—India's most populous state—from $4.10/kg to $3.20/kg, compared with $1.50/kg for grey hydrogen.
"The incentives offered by the Power Ministry are the first steps in the right direction," Yadav told *Net-Zero Business Daily by S&P Global Commodity Insights*.
State-owned Indian Oil Corp. believes that green hydrogen's production cost could fall from $5/kg now to below $2/kg over the next five to six years, presenting an even more optimistic view due to the government's policy.

Modi's push

India, the world's third-largest GHG emitter, has been seeking to hike green hydrogen output in its fight against climate change.
In the Union Budget for the fiscal year 2021-2022, India's central government allocated Rs 25 crore ($3.29 million) for the research and development of hydrogen energy to kickstart a shift to low-emissions fuel.

Indian Prime Minister announced the National Hydrogen Mission on Independence Day last August, stating the country's ambition to become a green hydrogen hub.
During the COP26 summit in Glasgow last November, Modi said India will aim to achieve net-zero emissions by 2070 and raised the target share for renewables in the country's power mix from 40% to 50% by 2030. The government wants to have 500 GW of installed non-fossil generation capacity by 2030, some of which can be used for green hydrogen production and some for meeting the energy needs of a growing population.
The recently announced Green Hydrogen Policy centred around the power market: Producers will receive a 25-year waiver for interstate transmission charges, be granted priority when seeking connection to the grid, and get open access within 15 days of an application to the most competitive renewable power on offer.
Analysts said these measures could allow more hydrogen producers to tap into expanding renewable energy supply.
"Waiver of interstate transmission charges would allow states with lower renewable potential or progress to build green hydrogen production facilities and power them with low-cost renewable power through long-term power purchase agreements," said Kashish Shah, an energy analyst at the Institute for Energy Economics and Financial Analysis (IEEFA).
"The power cost is roughly one-fourth of the overall cost of green hydrogen production. Low-cost renewable power will be key to bringing down the production cost of green hydrogen," he added.
Moreover, power distributors and green hydrogen producers can count the usage of renewable energy towards their renewable purchase obligations. And producers would be allowed to bank unconsumed electricity for up to 30 days.
Producers will also have access to land in industrial parks for renewables and can set up logistics facilities at ports for potential export opportunities. India's Ministry of New and Renewable Energy will establish a single clearance window for the production, storage, transportation, and distribution of green hydrogen and ammonia.

Domestic capacity

Meanwhile, Indian energy firms are investing in electrolyzers powered by renewables to produce green hydrogen.
ACME Solar, the first mover, has commissioned a 3.5-MW pilot

electrolysis project in Rajasthan. Indian Oil and NTPC, another state-owned player, both plan to build electrolyzers in the coming years.
In the private sector, Adani and JSW both said they will enter the fledgling sector. Separately, Reliance Industries has provided arguably the most detailed proposal: India's largest publicly traded company by market capitalization wants to build 100 GW of solar capacity by 2030 and plans to invest Rs 595,500 crore ($80 billion) in renewable projects including hydrogen and manufacturing capacity for electrolyzers in Gujarat.
Some experts believe the government should promote local manufacturing of renewable equipment and electrolyzers as part of its Atmanirbhar Bharat (Self-reliant India) strategy, which has so far been applied to the solar sector.
According to CEEW's analysis, India will need at least 40 GW of electrolyzers and 100 GW in renewable generation capacity by 2030 to meet the production target of 5 million mt/year. Yadav estimates this would require $103 billion in investments at today's prices.
"If these electrolyzers are made indigenously…[and] all components of the solar panels and wind turbines are made in India, then the entire economic value can materialize in India," he said.
"The green hydrogen economy is still at a very early stage of development, and India could partake in the global race for green hydrogen by developing a local manufacturing and production value chain to strengthen its energy security," Shah added.

Demand triggers

With the current hydrogen development framework focusing on the producers, analysts widely expect the government to design more policy instruments to promote green hydrogen demand later on.
This could come as a carrot-and-stick approach as green hydrogen is expected to be more expensive than grey hydrogen initially: Some industries could be required to use green hydrogen while receiving subsidies for their consumption, analysts said.

"The policies and incentives need to evolve rapidly to support demand creation for green hydrogen via stricter mandates and cost reduction by providing capital incentives," said S&P Global Commodity Insight's Ashish Singla, ENR's associate director for climate and sustainability.

According to ENR estimates, the demand for hydrogen in India is about 6 mt/year and comes mainly from industrial sectors such as fertilizers and refineries. Singla said these two sectors are likely to see the highest growth in consumption as the green hydrogen policy gets implemented.

Yadav suggested the government could initially impose mandates on blending green hydrogen in refineries, fertilizer plants, and natural gas pipelines. This could offer demand visibility for producers, which are in turn expected to expand output and reduce prices.

"As the cost of hydrogen decreases, steel mills and the transport sector could also see some demand pickup," he said. "In addition to these, green hydrogen can be further processed to produce derivatives like ammonia for marine applications and sustainable aviation fuel."

Yadav sees hydrogen development as part of Modi's ambition in transforming India into an energy-independent nation by 2047.

"In the short-to-medium terms, there would be a marginal increase in the price of commodities… However, in the long-run this would gradually decrease our import dependency and go a long way in making us energy-independent," he said.

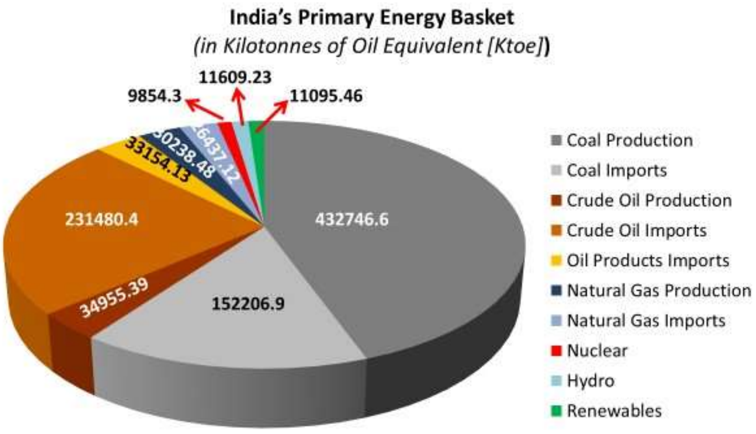


Figure 1: India's Primary-Energy Basket (As on March 31, 2020)
Source: Department of Commerce, Ministry of Commerce & Industry, Government of India

UNITED STATES OF AMERICA

A coalition of major oil & gas, power, automotive, fuel cell, and hydrogen companies have come together to develop a *Road Map to a US Hydrogen Economy*. This comprehensive Road Map details how the U.S. can expand its global energy leadership, by scaling up activity in the rapidly emerging and evolving hydrogen economy, as policymakers and industry work together and take the right steps.

The Road Map stresses the versatility of hydrogen as an enabler of the renewable energy system, an energy vector that can be transported and stored, fuel for the transportation sector, heating of buildings and providing heat and feedstock to industry. It can reduce both carbon and local emissions, increase energy security and strengthen the economy, as well as support the deployment of renewable power generation such as wind, solar, nuclear and hydro.

“This Road Map shows how critically important hydrogen is to achieve a lower-carbon energy mix, and with the right actions now, can reinforce U.S. energy leadership and strengthen our economy by generating $140 billion per year in revenue and 700,000 jobs by 2030, and $750 billion per year in revenue and 3.4 million jobs by 2050,” said Fuel Cell and Hydrogen Energy Association (FCHEA) President Morry Markowitz. “In addition, if the right actions are taken now a competitive hydrogen industry can meet 14 per cent of U.S. energy demand by 2050.”

A coalition of leading companies from the energy, transportation, fuel cell manufacturing and electric power industries worked jointly to develop this comprehensive road map, sharing and developing economic models as well as data on future energy needs and environmental expectations. Analytical support was provided by McKinsey and scientific observations and technical input were provided by the Electric Power Research Institute.

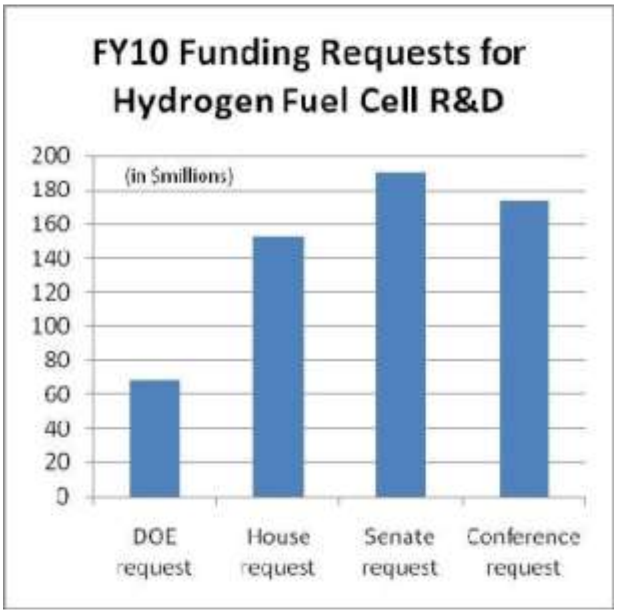
The U.S. is already heavily engaged in the hydrogen economy with hundreds of millions of dollars of public and private investment per year and boasting more than half the world’s fuel cell vehicles, 25,000 fuel cell material handling vehicles, more than 8,000 small-scale fuel

systems in 40 states, and more than 550 MW of large-scale fuel cell power installed or planned.
“The U.S. is a major player,” Mr Markowitz added, “but to remain dominant, and meet future energy challenges, the U.S. has to raise its game with further investments and public policies that reduce regulatory barriers, promote research, development, and deployment, and reward innovation.” He cited the report’s analysis that “other countries are laying plans for hydrogen economies and the U.S. will need to move quickly to continue to lead in this growing industry.”
Each step along the path noted above brings the U.S. closer to the hydrogen future that will help power the nation, clean the air and support crucial new jobs. According to FCHEA’s Markowitz, the U.S. is already making progress on that road. However, “The report makes clear that how far we will go and how fast we get there is very much up to us, and the choices we make over the next few years,” he said.

This summer, the U.S. Department of Energy (DOE) is expected to publish a road map for an $8 billion investment to help develop at least four regional clean hydrogen hubs. The funding was included in the energy provisions of the Bipartisan Infrastructure Law (BIL).

The exact timing for proposal submissions and awards has not been announced, but the program is expected to move forward across fiscal years 2022-2025. Current plans call for five to 10 planning grants followed by a smaller number of deployment grants — deployment funds from DOE will need to be matched by grant recipients.

This isn’t the first time the federal government has put forward a vision of a “hydrogen economy,” a term first used in 1970 to describe a society running on energy from solar- and nuclear-generated hydrogen. In his 2003 State of the Union address, George W. Bush announced a $1.2 billion investment in research to make the U.S. the world leader in hydrogen-powered vehicles.



Funding for that program was cut by the Obama administration. Nobel laureate Steven Chu, the Secretary of Energy at the time, said the decision was based on an assessment that even within 20 years, a transition to a hydrogen car economy was not likely.

Federal support for hydrogen R&D dropped over the last decade, but pressure to reduce greenhouse gas emissions has increased continuously and hydrogen technology has continued to advance.

Today, there is worldwide recognition that “to get to the next level of decarbonization, you need hydrogen as a fuel resource and as a storage medium,” says Frank Wolak, president and CEO of the Fuel Cell and Hydrogen Energy Association (FCHEA).

According to Goldman Sachs, the present “unprecedented momentum” could lead to a 400-fold increase in global clean hydrogen capacity in this decade, and a $250 billion market by 2030.

“It’s more than just a hydrogen ‘moment,’ it’s the starting point of a trend,” Wolak says. “Investment is tracking that, not just waiting for government money.”

At present, hydrogen energy use by industry accounts for about 1 percent of energy consumption in the U.S., and less than 5 percent comes from clean sources. Wolak views the DOE funds for the hubs as a “deposit” that will enable technology innovation, demonstrate an expanded range of uses for clean hydrogen, and fuel more private investment.

Tackling Tough Decarbonization Challenges

The hubs could act as a catalyst for running everything from home heating and fueling automobiles to power generation and industrial processes. The BIL mandates at least one hub demonstrate the use of hydrogen in the power sector, one in the transportation sector, one in the industrial sector and one in the residential and commercial heating sector.

Some applications have greater support than others from energy analysts and climate scientists. “The business case lines up better when you are offsetting the greatest number of hard-to-decarbonize sectors, applications with large, scalable ability to introduce hydrogen in industries that are fossil fuel intensive and can’t decarbonize otherwise,” says Wolak.

Hydrogen can power industrial processes with high energy needs and, if produced using renewable energy, decarbonize a sector that accounts for 24 percent of U.S. greenhouse gas emissions. Taken together, airplanes and container ships account for almost six percent of global CO2 emissions. Developing hydrogen fuel for them and the infrastructure to deliver it would end these emissions. When solar and wind sources create more electricity than the grid needs, it can be used to make hydrogen that is stored for long periods and burned in gas turbines to make more electricity when it is needed.

Dan Esposito, senior policy analyst at Energy Innovation, says his biggest worry is that too much money will be spent trying to use hydrogen for home heating, which does not appear to have much potential to reduce emissions before running into some big challenges.

In meeting home energy needs, only green hydrogen — the purest form of hydrogen production — would have a carbon footprint comparable to that of renewable energy. But Energy Innovation's *Assessing the Viability of Hydrogen Proposals* report says it is 14 times more expensive than current energy sources. Existing gas appliances and industrial equipment can only handle a gas mix that contains about 20 percent hydrogen mixed with natural gas, says Esposito.

"If your plan is to really lean on hydrogen, eventually you're going to have to replace every appliance on that distribution system with one that can burn any combination of hydrogen and natural gas, which would be a whole different type of technology than we have available today," he says.

Electrification of passenger vehicles and buildings has gained considerable momentum and funding in recent years, with the potential for interoperable storage and supply resources for electrical grids. A report from the think tank supporting Germany's energy transition expresses certainty hydrogen won't keep electrification from winning the day on building energy, warning that gas distribution grids "need to prepare for a disruptive end to their business model."

"I don't think we want to go down a road where we spend 10 to 20 years doing research and demonstrations that get nowhere while other jurisdictions are achieving their net zero goals through electrification," says Esposito.

Siting Hydrogen Hubs

In early 2022, the nonprofit Great Plains Institute (GPI) published an atlas of maps highlighting existing factors in regions around the country that could make them candidates for hydrogen production hubs.

GPI identified 14 potential hubs in the U.S. based on factors including existing concentration of industrial emitters, availability of fossil fuels, availability of tax credits for carbon capture retrofits, current hydrogen and ammonia production, potential for geologic storage of hydrogen, and existing transportation and fuel distribution infrastructure.

The maps were not meant to capture every opportunity. “Since industrial production and emissions occur throughout the country, carbon capture, hydrogen production and direct air capture facilities will need to be deployed wherever beneficial and feasible,” said GPI in releasing the atlas.

New Jersey, Connecticut, Massachusetts and New York signed an agreement in a step toward hub development. With backing from U.S. Senators Joe Manchin and Shelley Capito, West Virginia is working on a proposal, as is a public-private group from the same region that would build on resources from Ohio, Pennsylvania and West Virginia.

Other contenders for DOE funding could include the HALO hub coalition in Louisiana, Arkansas and Oklahoma; a Gulf Coast hub in Texas; projects in both Northern and Southern California; and independent hubs in Washington, Arizona, Illinois, Nebraska and Kentucky. A hub being co-developed by Utah, New Mexico, Wyoming and Colorado would be built around a project in the Utah desert that aims to be the largest green hydrogen production and storage facility in the world.

Pennsylvania state Rep. Steve Malagari is working to clear a path for his region, introducing H.R. 178, a resolution calling for Congress and the Biden administration to designate the southeastern region of his state as a hydrogen hub. “I was simply urging the Biden administration to utilize the southeast of Pennsylvania because of our existing infrastructure for natural gas," he says, noting that it's also home to nuclear energy resources.

Malagari sees an opportunity to power trains in the northeast corridor with hydrogen and long-haul trucking, a focus that reflects his roots as a Teamster. "Private company conversations are already occurring," he says. "If the designation were to go through, I think people would jump on board."

Mining a Vast Resource

Hydrogen is an abundant gas, accounting for about 90 percent of all atoms in the universe, and 75 percent of detectable matter. Hydrogen can be made available as an energy source by separating it from the methane released when coal or natural gas are burned, or from the oxygen in water. Various colors have been assigned to hydrogen produced from differing energy sources and chemical processes.

Almost all hydrogen production in the U.S. is currently accomplished by "steam reforming," a process that involves burning natural gas and using steam to catalyze a chemical reaction that produces hydrogen and CO2. This is "grey" hydrogen. If the production process incorporates a system to capture CO2 emissions, the product is "blue" hydrogen.

Hydrogen produced using renewable energy to split water with electricity (hydrolysis) is known as "green" hydrogen. If nuclear energy is used to power hydrolysis, the result is "pink" hydrogen. (There are other colors included in the hydrogen "spectrum," but these are most central to discussions regarding clean hydrogen in the U.S.)

While there's broad agreement that hydrogen has a place in a zero-carbon economy, energy analysts warn that not all hydrogen is created equal and not every end use has equal benefits. Rather than achieving net emission reductions, some approaches could tip the scale in the other direction.

Can Blue Be Green?

The BIL calls for at least two of the hubs to be in regions with the greatest natural gas resources. It does not specify that these resources must be used to make “blue” hydrogen, but climate activists are worried.

Daniel Savery, senior legislative representative for Earthjustice, hopes that DOE will “resist the temptation” to invest heavily in hydrogen projects that use fossil fuels. “There are projections that the cost of green hydrogen will be at parity with blue hydrogen in the next five to 10 years,” he says. Facilities built for hydrogen production with natural gas could become stranded assets.

One solution to this problem would be to capture carbon and store it underground. The notion that carbon capture can turn grey hydrogen production “blue” is more concept than reality, however. In 2021, scientists at Cornell and Stanford made the first peer-reviewed attempt to calculate the carbon footprint of blue hydrogen.

At that time, only two facilities in the world were producing blue hydrogen at commercial scale. The results were not promising in terms of carbon capture efficiency. Blue hydrogen also involves methane emissions from gas mining, pipeline leakage and at the production site, as well as CO2 emissions from the energy used to make hydrogen and power carbon capture.

Too Tiny to Contain

Hydrogen may be a no-emission fuel, but evidence is accumulating that hydrogen leaks during production and transmission can contribute to warming. A paper from scientists at the Environmental Defense Fund (EDF), to be published in *Atmospheric Chemistry and Physics*, urges greater attention to their warming potential.

“We’ve found that hydrogen has significant climate impacts that at this point are widely overlooked and underestimated,” says Morgan Rote, senior manager of U.S. climate at EDF. “The hydrogen molecule is really small and slippery — it’s hard to contain and has large potential to leak out of pipelines, storage tanks, and other parts of the supply chain.”

Increased hydrogen levels in the atmosphere could contribute to warming in several ways, including increasing the atmospheric lifetime of methane and raising ozone levels and concentrations of water vapor. An April policy paper published by the U.K. government observed that any leakage of hydrogen will have an “indirect warming effect on climate, partially offsetting some of the climate benefits of the reduction in carbon dioxide.”

The potential for leakage needs to be considered in infrastructure plans, says Rote. “We need to build in measurement, reporting and verification systems to be able to detect the leaks, to report leakage rates and then verify that we’re doing things to reduce them.”

Sensor technologies are being developed that can make this possible, she says. Federal funds could speed their implementation as well as research to refine them, eventually bringing their cost down. “I think it’s a really exciting opportunity.”

Beyond Paper Talk

The DOE solicited input from stakeholders to help guide the regional hub program, with governments, research organizations, companies and nonprofits providing responses. When the road map is published this summer, it will be possible to see how these comments might have shaped what it is looking for in funding proposals.

“We’re still building up our renewable energy capacity, and we don’t want green hydrogen to sort of cannibalize that market,” says EDF’s Morgan Rote. “Investing in wind and solar resources is not only the

No. 1 priority for grid electrification, it also enables green hydrogen production.”

Energy Innovation’s Esposito doesn’t deny that hydrogen can play an important role in net zero economy plans but advises state and local officials to ask questions and do research about use cases for hydrogen that are proposed for their communities, including how what is being put forward compares to other decarbonization strategies. “It’s really important to compare these things on their merit, side by side, rather than just going with something because it sounds like it’s decarbonizing.”

Interest in hydrogen as an energy source has waxed and waned over the decades, according to FCHEA’s Wolak. Thirty years ago, there was a lot of talk about hydrogen, but climate wasn’t an issue as it is today. In the past 10 years, as climate problems became more urgent, hydrogen has re-emerged as a potential tool to fight change.

“My hope is that the sum total of all the hubs are able to demonstrate scale and the ability to drive down cost,” says Wolak. “That’s a very encouraging starting point for fall-on investments, versus a lot of applications that just show improvements in technologies.”

FRANCE

The French government will invest seven billion euros by 2030 to increase manufacture of electrolysis systems, tanks, fuel cells and related components essential to produce hydrogen from water. The country also wants to install 6.5 GW of hydrogen production capacity from renewable (wind, solar) or nuclear energy.

Large French companies are in the race. The two French automotive manufacturers, PSA and Renault, as well as the bus manufacturer SAFRA, are working on “green” hydrogen buses, trucks and light utility vehicles with the collaboration of Tier I suppliers such as Plastic Omnium (specialized in fuel storage), Symbio (specialized in fuel cell production), or Faurecia (hydrogen tanks). Air Liquide, world leader in specialty gases, has created a subsidiary, Hype, to provide hydrogen tanks and hydrogen for French taxis. Other major international firms such as Engie, EDF, Total, Air Liquide, Schlumberger and McPhy are all focusing on hydrogen production from renewable sources such as wind or solar, rather than relying mainly on nuclear energy for hydrogen generation.

The development of hydrogen filling station infrastructure for vehicles is also an important focus. In the transportation industry, the goal is to continue to work towards the decarbonization of all trucks, buses, boats, trains and aircraft.
The ability to participate competitively in these new endeavors necessitates that U.S. manufacturers of carbon-free hydrogen technologies and equipment consider working with a local partner or establishing a presence in France or Europe.

Hydrogen is used in steel manufacturing and fertilisers, and it is increasingly being considered for transportation to fuel cars and lorries without greenhouse gas emissions.
Most hydrogen today is extracted from fossil fuels. Green hydrogen is made using electrolysis with renewable electricity running through water to separate the oxygen and hydrogen molecules.
This is done using electrolysers. Lhyfe’s are behind a thick concrete wall, connected by a series of colourful tubes funnelling water in, and oxygen and hydrogen out.
“An electrolyser is a big tube, inside of which you put demineralised water and electricity,” explains Antoine Hamon, Lhyfe’s operations director. “At the end of that you have two pipes, one with hydrogen and the other with oxygen.”
It’s a simple process that, in this case, uses seawater and electricity generated from four wind turbines two kilometres away.

No wind, no hydrogen

“This site is really synchronised with the production of the wind turbines,” says Hamon. “If there’s no wind, there’s no hydrogen.”

This is difference between this facility and other green hydrogen plants, which have turbines or other sources of renewable electricity feeding into the general electricity grid, which they pull from when they want to produce hydrogen.

On a platform above the production floor, several computer screens show the water levels and amount of electricity coming from the turbines.
Lhyfe currently produces 300 kilograms of hydrogen a day out of three cubic metres of seawater. At full capacity, the goal is to triple the output, to get to a tonne.
A hydrogen car driving 100 kilometres uses one kilogramme of hydrogen A long-haul truck would consume 20 to 30 kilograms a day.
The hydrogen gas that comes out of Lhyfe's electrolysers is compressed into long metal gas canisters and transported to users in the area.
"The main advantage of hydrogen is it's a gas, so you can transport and store it," explains Guesné, Lhyfe's CEO. "Gas is convenient, which is why our societies run on diesel and gas. You can store it in a pipe, on a truck, in a boat. It can wait an hour, or a day or a week."
Electricity cannot be stored easily. Batteries are inefficient, and use components that are difficult or dangerous to acquire.
And for larger vehicles travelling long distances, like lorries, or trains, batteries would be too big and heavy to be practical.

Hydrogen experiments in Nantes

The city of Nantes, an hour inland from Bouin, which likes to see itself as a technological innovator, has been putting itself forward as a hub for green hydrogen.
Its public transit authority, the Semitan, has been running experiments using hydrogen vehicles for a few years.
"As far as Nantes is concerned, it's important to promote renewal energy - it's a political ambition. And also as an engineer, I am interested in this technique, to know what is good and what is not," says technical director Stephane Bis.

Semitan has two hydrogen utility vehicles - electric Renault Kangoo vans that use hydrogen to extend their batteries' ranges, from 100 to 300 kilometres.

Hydrogen cars have fuel cells that transform hydrogen, stored in their tanks, into electricity to power an electric motor. The output is water and oxygen – a small tube on the side of the vehicle drips out water, and the oxygen is released into the atmosphere.
Semitan uses its hydrogen cars like their dozens of other utility vehicles, but as a kind of proof of concept that hydrogen can work.
They fuel up the cars at a hydrogen service station they have set up at a bus depot northwest of the city centre. It's a collection of tall gas cannisters which are fed through a machine that pressurises the hydrogen into the car. The sound is like a balloon being filled.
Semitan is looking into hydrogen for public transit. Unlike the city of Le Mans, which has been experimenting with a hydrogen bus since last year, Nantes has decided to focus on water transport.
In 2019 the city introduced a hydrogen-powered ferry to take commuters across the Erdre river in the north of the city.
The ferry needed regular maintenance, and is currently docked for a full overhaul.
Bis says it's been a good experiment.
"I wouldn't say hydrogen is the energy of the future, but it is part of the future," he says, about the prospects of expanding the use of hydrogen.
"I think the future will include hydrogen, that is sure, especially for heavy load vehicles- lorries. For large transit, I think hydrogen is a very interesting subject."

Hydrogen in the future

Of course, Guesné, of Lhyfe, is much more expansive in his predictions for hydrogen, driven by the urgency of decarbonising France and Europe's energy to curb the effects of greenhouse gas emissions on the climate.

- **IEA roadmap for clean power shines light on EU's addiction to gas**

“We need to address the climate change. We need to reduce CO_2 emissions by 55 percent, and when you do the math and look at the solutions we have today, you figure out that you cannot achieve that without hydrogen,” he says.

His vision for green hydrogen in France is a series of production plants serving local communities, using local renewable energy sources.

“We want to avoid the refinery model, where you have only three refineries in a country like France that can supply the whole country with oil,” he says.

“There is always local energy. In some areas there are solar panels. Here there’s a lot of wind so we are relying on wind turbines. But it can be energy from waste, from biomass, from hydropower.”

While Guesné anticipates 25 to 30 per cent of French fuel consumption will be hydrogen by 2030, others estimate it will be more like six to 10 percent.

But whatever the amount, hydrogen is a part of the future.

- **Airbus to launch hydrogen-powered commercial aircraft by 2035**

“There will never be enough resources to have batteries for everybody. There is not enough biomass to produce biogas for all heating needs,” he says. “Today we have smart grids, we have batteries, we have renewables. But there was a problem for lorries and busses. Hydrogen was the missing piece of the puzzle.”

JAPAN

The Japanese government has set ambitious goals for a carbonneutral future to enhance its energy security. It plans to establish a full-scale international hydrogen supply chain to cut the cost of hydrogen by 2030 and to encourage the use of ammonia in thermal power generation as a low-carbon transition fuel. In this briefing, we look at

Japan's hydrogen strategy and the policy and regulatory initiatives underpinning the development of the sector. We also explore the pioneering research and development being carried out in Japan, including transportation technologies, and consider the challenges to be overcome in order to establish hydrogen as a core pillar of the Japanese energy system.

ROADMAP TO 2030

In December 2017, the Ministry of Economy, Trade and Industry of Japan (METI) issued the "Basic Hydrogen Strategy" (the Basic Strategy), the world's first national strategy for hydrogen. In March 2019, METI followed up with the "Strategic Roadmap for Hydrogen and Fuel Cell" (the Strategic Roadmap). Together, the Basic Strategy and the Strategic Roadmap set out the broad policy framework for the development of the Japanese hydrogen economy for the next decade and beyond, including the following key objectives: Developing an integrated hydrogen supply chain • Establishing an integrated international hydrogen supply chain by 2030 encompassing upstream (production), midstream (transportation and storage) and downstream (consumption). • Sourcing "blue hydrogen" (produced from fossil fuels, where the CO2 emitted is sequestered via carbon capture and storage) and "green hydrogen" (low or zero-emission hydrogen produced using electrolysis powered by renewable energy) from low-cost, stable producers globally, and transporting hydrogen to Japan using methylcyclohexane (MCH), ammonia or methane as energy carriers and a dedicated shipping fleet, for consumption by industrial and other end-users in Japan.

Reducing hydrogen production costs

- Overall cost reduction: lowering the delivered cost of hydrogen to a level comparable to that of existing energy sources. It targets: (i) JPY30/Nm3 by around 2030 and (ii) subsequently JPY20/Nm3 .

- Green hydrogen: reducing the cost of water electrolysis systems by 75% to JPY50,000/kW, and pursuing enhanced technical specifications for alkaline water electrolysis and polymer electrolyte membrane (PEM) water electrolysis systems.

- Production: reducing the cost of hydrogen produced using brown coal gasification from several hundred JPY per Nm3 to approximately JPY12/Nm3 by 2022/23, together with a reduction in the cost of carbon capture and storage (CCS) technology. Enhancing storage and transportation of hydrogen

- Storage: increasing the capacity of above ground liquefied hydrogen storage tanks from several thousand cubic metres to approximately 50,000m3 by 2022/23.

- Transportation: improving the efficiency of hydrogen liquification process technology. Expanding industrial and consumer use of hydrogen and ammonia

- Gas to power: supporting research and development activities to commercialise the use of hydrogen and ammonia as fuel for power generation by 2030.
- Fuel cell vehicle (FCVs) and hydrogen refuelling stations (HRS): increasing the number of FCVs to 200,000 by 2025 and 800,000 by 2030, and constructing HRS in 320 locations by 2025, with a view to creating a selfsustaining HRS sector by the late 2020s.

Vision 2050

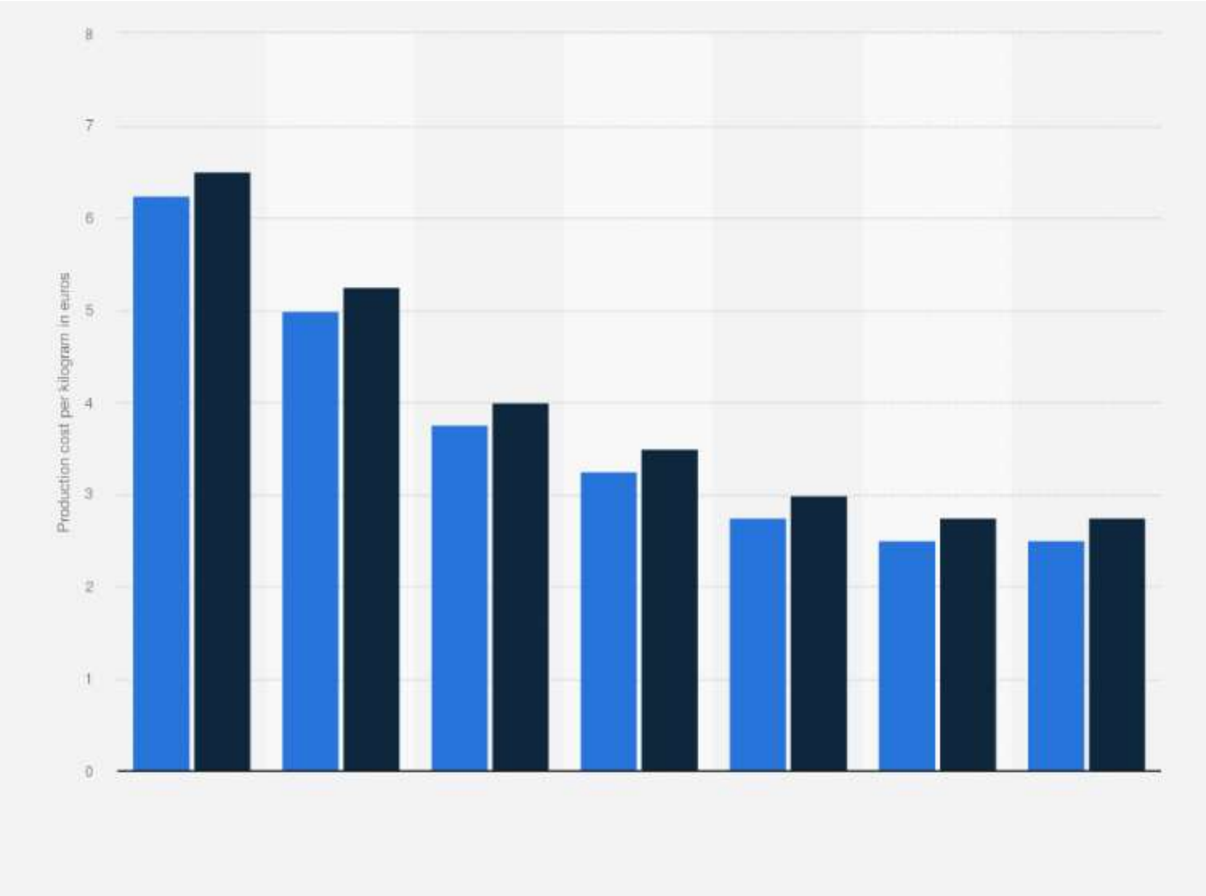
In October 2020, shortly after assuming office, then-Prime Minister Suga announced his vision of a carbon-neutral Japanese society by 2050, with hydrogen and ammonia identified as playing a key role. In line with this policy statement, in December 2020 the Japanese government issued its ambitious "Green Growth Strategy through Achieving Carbon Neutrality in 2050", which was subsequently updated in June 2021 (the Green Growth Strategy), identifying 14 growth sectors for the Japanese economy, including hydrogen and ammonia, and presenting a concrete national vision and goals. Hydrogen and ammonia sit at the core of the Green Growth Strategy and are positioned as "new resources" with significant potential to reduce Japan's reliance on carbon-intensive fossil fuels such as coal and oil.

The Green Growth Strategy established the followingcore targets:

- to increase annual hydrogen consumption to 3 million tonnes per year by 2030 and 20 million tonnes per year by 2050;to reduce the delivered cost of hydrogen to JPY30/Nm3 by 2030 and JPY20/Nm3 by 2050 – in line with the Basic Strategy and the Strategic Roadmap and a level competitive (by 2050) with fossil fuels; and
- in the short term (up to 2030), to introduce co-firing (20% ammonia and 80% coal) in certain coal-fired power plants and, in the long term (up to 2050), to promote the development of technologies enabling a higher cofiring ratio (ammonia of 50% or more).

In addition, the Green Growth Strategy sets out, among others, the following action items:

- commercialising the use of hydrogen in the power sector and other heavy industries, including development of hydrogen-fired power generation turbines and ammonia co-firing for power generation;
- widespread deployment of FCV trucks and encouraging hydrogen reduction steelmaking;
- installation of stationary hydrogen fuel cells for off-grid electricity generation; and
- supporting R&D related to liquefied hydrogen carrier vessels and water electrolyser technologies.



On 26 May 2021, the Japanese parliament passed legislation to amend the Act on Promotion of Global Warming Countermeasures (Act No. 117 of 1998, as amended) enshrining into law the government's objective of achieving net zero greenhouse gas emissions by 2050. Subsequently, in October 2021, and just a few weeks before COP26, METI published the sixth iteration of its "Strategic Energy Plan", setting out the key objectives for energy supply and requisite actions in the relevant industries (the 6th Strategic Energy Plan). The 6 th Strategic Energy Plan puts climate change and decarbonisation at the top of the agenda and adopts the core targets for hydrogen/ammonia under the Green Growth Strategy (as described above) as well as the following additional new targets:

• by 2030, introduction of co-firing (30% hydrogen 70% natural gas) in gasfired power plants and the construction of pure hydrogen-firedpower plants; and

• hydrogen/ammonia to comprise 1% of Japan's overall power generation mix by 2030

CONCLUSION

Japan has one of the world's most ambitious hydrogen strategies and has demonstrated a clear commitment to the sector by allocating a pivotal role to hydrogen and ammonia in realising a carbon-neutral Japanese society by 2050. The twin priorities of (i) establishing a full-scale international hydrogen and ammonia supply chain and (ii) stimulating demand for hydrogen and ammonia among Japanese industries and the general public, are clear, and the Japanese government is certainly directing a significant amount of investment and financial support towards the first of these priorities in particular. However, it is also clear that Japan will need to partner with other countries where hydrogen and ammonia can be produced at a commercially competitive price in large volumes, and foster the development of new technologies. Success will also require clear, consistent and appropriately tailored regulatory regimes at national and international levels in relation to matters such as technical standards, guarantees of origin, health and safety, and environmental protection. All of the foregoing is necessary to give investors the confidence to make the huge capital investments required on the production and supply of hydrogen and ammonia. In parallel, it is crucial that domestic Japanese demand for hydrogen and ammonia ramps up. Regulation has an important role to play here in terms of incentivising hydrogen and ammonia use, and in addressing the hidden carbon costs of existing energy sources in order to accelerate the time frame within which clean hydrogen and ammonia achieve price parity with fossil fuels. The Japanese government is aware of the need for new or modernised regulations in relation to hydrogen and ammonia, and indeed the 6th Strategic Energy Plan expressly states that it is important for Japan to take a lead role in international rule-making. While developments from Japan in terms of regulation and rule-making have been limited to date as compared with the pioneering role played by Japanese companies, with the support of substantial government funding, in driving technological innovation in the sector, the success of the next stage of the hydrogen revolution will depend on a coordinated and consistent regulatory framework. As one of the early adopters of hydrogen technology and prospectively one of the largest future net importers of hydrogen, Japan can and should be at the forefront of these regulatory developments.

SOUTH KOREA

Vision

South Korea is pursuing a hydrogen economy for economic growth and industrial competitiveness more than for climate change objectives. In particular, South Korea sees hydrogen as a potential driver of economic growth worth 43 trillion won ($43 billion) and 420,000 new jobs.

South Korea has robust targets for hydrogen usage that it seeks to achieve by 2040. For consumption, South Korea aims to expand its annual market from 130,000 tons at present to 5.26 million tons per year. For the transportation sector, South Korea's New Deal (announced in 2020) sets the 2040 FCEV target to nearly 3 million, including 2.9 million domestically manufactured FCEVs, 30,000 fuel cell trucks, and 40,000 fuel cell buses. In 2020, South Korea led the world in FCEV installation, with over 10,000 FCEVs on the road, thereby doubling the national stock from 2019.

South Korea's 2040 vision also entails expanding the fleet of hydrogen refueling stations (HRSs). The Hydrogen Energy Network (HyNet) was established in 2019 with an initial investment of $119 million to expand the fleet from about two dozen HRSs in 2019 to 310 by 2022 and 1,200 by 2040. Also, by 2040, South Korea aims to deploy 15 gigawatts of utility-scale fuel cells.

South Korea's New Deal made hydrogen one of its central pillars that would help the country decarbonize while also recovering from the pandemic-induced economic slowdown. The government's vision has the backing of key South Korean industrial stakeholders, including auto manufacturers such as Hyundai Motors Group, whose own FCEV vision for 2030 is accompanied by investment plans of $6.7 billion.

Strategy

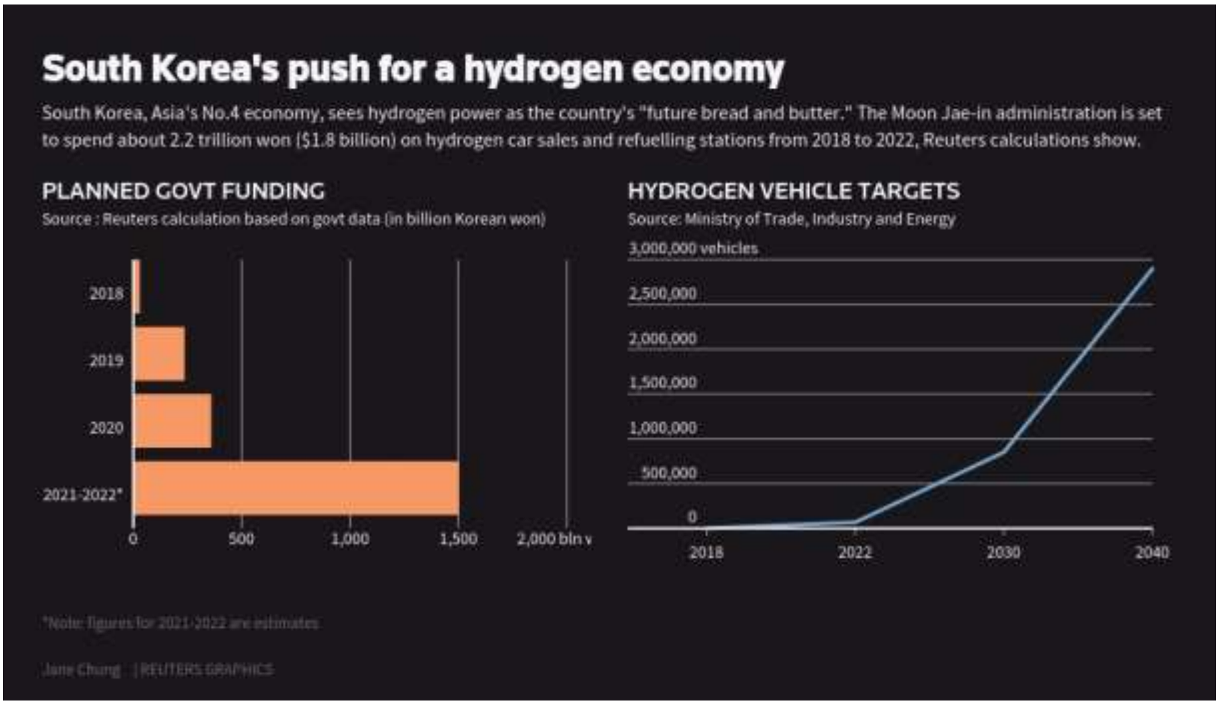
South Korea adopted the Hydrogen Economy Roadmap in 2019. In order to lay the legal foundations for the government's promotion of hydrogen and the implementation of safety standards for facilities, the Korean National Assembly passed the Hydrogen Economy Promotion and Hydrogen Safety Management Law ("Hydrogen Law") in January 2020. The Hydrogen Law, which went into effect in 2021, stipulates several important industrial strategy elements, such as supporting hydrogen-focused companies through research and development (R&D) subsidies, loans, and tax exemptions.

South Korea's efforts also include R&D on liquefied hydrogen storage technology and the reduction of transportation costs. Additionally, the roadmap notes the government's long-term aim of building a specialized hydrogen pipeline network across the country while the development of hydrogen-receiving infrastructure is set to begin in 2022. While about one-third of the country's hydrogen consumption in 2040 is estimated to be based on imported liquefied natural gas (LNG), KOGAS—South Korea's state-run utility—plans to invest $37 billion overseas by 2040 to establish renewable power generation facilities that produce hydrogen.

Large government funding underpins South Korea’s effort to develop a hydrogen economy. The spending for FY2021 is $701.9 million, a 40 percent increase from 2020. Also, the government has committed $2.34 billion to establish a public-private hydrogen vehicle industry by 2022. At present, about half the cost of installing HRSs is subsidized by the government. Moreover, in 2019, the national and local governments provided subsidies for an FCEV purchase ranging from $27,300 to $30,300.

Since 2012, South Korea’s renewable portfolio standard (RPS) has supported the deployment of large-scale stationary fuel cell power generation. Under the RPS, large power producers are mandated to meet a minimum portion of their power generation from new and renewable technologies, including fuel cell power generation. Additionally, the government has reduced the price of natural gas from the grid if it is used to produce fuel cells.

According to South Korea’s economic ministry, five South Korean conglomerates have plans to invest $38 billion in hydrogen technology by 2030.



Geography

In a key step toward powering 10 percent of the country's cities, counties, and towns with hydrogen by 2030, the Korean government identified three cities as "hydrogen pilot cities" (Ulsan, Ansan, and Wanju) in 2019. These pilot cities will begin testing the application of hydrogen in transportation, industry, and space heating in 2022. To look at one example, the pilot city of Ulsan seeks to produce hydrogen from local petrochemical complexes to power buildings and to refuel FCEVs and ships.

South Korea is reportedly exploring various projects with potential hydrogen resource suppliers, such as Australia and Saudi Arabia. For example, Hyundai OilBank Co. plans to take liquefied petroleum gas (LPG) cargoes from Saudi Aramco, convert the LPG into hydrogen, and ship back the carbon dioxide that was emitted in the process back to Saudi Arabia. Additionally, South Korea and Norway announced in 2019 their cooperation on shipbuilding for liquefied hydrogen transportation.

CONCLUSION

Individually, each application (power and transport) has it's own advantages. Using hydrogen storage to balance the grid discourages fossil fuel energy generation and encourages renewable generation. This has many benefits, such as lower emissions and cleaner air. These help to strive towards meeting relevant targets, for example the Paris agreement and Scotland's 2032 targets to be 100% renewable. The presence of hydrogen energy storage allows renewable energy to be harvested at busy generation times, and to be used at low points of generation. Knowing that a reliable storage such as hydrogen is available and ready allows traditional gas and coal power stations to be decommissioned.

Having a system which also serves the hydrogen transport sector brings further benefits. Encouraging hydrogen transport is advantageous in promoting cleaner transport technologies, further reducing emissions in accordance with policies. This also provides cleaner air, and therefore enhances air quality in cities as pollution levels will decrease (petrol cars are replaced by hydrogen cars).

Combining these two applications, power and transport, is unique as it serves two sectors with one infrastructure system. This dramatically reduces the initial investment required and makes the business more financially feasible.

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