Hydrogen economy and transport in Japan

Dikariev Olexander[1] and Stepanov Olexander[2,3]

[1] Department of International Relations, Kiyiv National University of Culture and Art, Kyiv 01601, Konovaltsya, 36
[2] International Relations and Business Department, National Aviation University, 1 Liubomyra Huzara ave., Kyiv 03058, Ukraine

[3] E-mail: apstepanov@ukr.net

Abstract. The article examines theoretical discourse on the ambitious Hydrogen policy in Japan in the context: of (1) problems of existing energy practice's transformation (decarbonisation policies, Ecologically clean hydrogen); (2) theoretical reflection of the synergy of the characters of the Japanese economic (leading positions of the financial and industrial groups, created in the Meiji era (1868-1912) and reached power in the 1950-th. years), technological (catching up (inertial) rather than advancing (complementary) character) and institutional model ("independent electricity producer" status) with the trends of the global energy market (clean energy); (3) Principles of the Japanese Energy Policy (Energy security; Energy supply efficiency; Liberalization of energy industries; Reducing transaction costs when concluding energy contracts); (4) Energy policy perspective development concept and 3Es + S program (the division of production and distribution of energy between different business entities; creation of a transparent scheme for joining the market of new participants; introduction of a flexible system of taxation and financial control.); (5) positioning of the Japan energy program in the form of coordinating and compromising the interests of the energy business and the hydrogen authorities (the Institute of Energy Economics of Japan, the International Energy Agency, the Japanese Ministry of Economy, Trade and Industry, research centres of the Marubeni Corporation, energy companies). As a paradigm in this study was used achievements in development and implementation in Japan "Basic Hydrogen Planning Strategy" as a non-rigid energy plan including: basic energy development strategies, the structure of the energy complex, the expected results 2030 in the achievements of advantages in energy and transport technologies on account and on the basis of hydrogen society.

1. Introduction

In order to deepen the theoretical discourse on the topic put forward, we suggest testing the idea that one of the results of the practice of decarbonisation was the actualization of: the interest to renewable energy sources; such specificity of the resources as stochasticity; the conceptualisation of the need for mutual exchange (Co-sufficiency) based on the principle of collective provision of energy resources, converted into various useful forms on the basis of a universal carrier (electricity, hydrogen); the system where each structural element performs the task of providing, accumulating, using energy; Co-organization as a form of coordinating the actions of many heterogeneous objects for achieving a synergistic effect. Decarbonisation in this context is based on such values of the ontology of sustainable development of the fuel and energy complex as: neoliberalization of the economic model

of the market in the form of reducing the role of state influence on the complex; the positioning of a person as a subject adapting to the superior forces of nature; replacing people by the machines (digitalization). It is necessary to admit at once that the clean energy concept has generated interest in hydrogen and stimulated the so-called technological "transition". The transition included use of hydrogen for reducing greenhouse gas emissions; simultaneous development of renewable energy as the basis for the production of hydrogen; realization of the demand for hydrogen by expanding its use in transport and electric power industry. The elite of Germany, Japan, South Korea – importers of natural gas – were especially interested in such projects of Energy Transition. The transition process in these countries also involves use intelligent management of electric power systems based on machine-to-machine communication (M2M, IoT) in form of "3D": Decarbonisation, Decentralization, and Digitalization). In order to substantiate our theses, let us give examples: 1.The National Hydrogen Strategy of Germany "The National Innovation Program in the Field of Hydrogen and Fuel Cell Technologies" includes both goals and ways to achieve them. The plan assumes manufacturing fuel cells in the special "hydrogen regions" – HyLands [8]; 2.Development programs for fuel cells are approved in Japan, South Korea, USA. In Japan and South Korea were created demonstration regions for: (1) praxeological testing of technologies; (2) positioning technological advances in order to form market infrastructure, determine pricing strategies; 3.We observe trend in the implementation of power plants with fuel cells on the world market: over the period 2007–2019, more than 4.3 GW of fuel cell plants were commissioned in the world, of which more than 70% were for stationary power plants; in 2019, their annual sales reached 70.9 thousand units, and the installed capacity was 1130 MW, which demonstrates a 30-fold increase compared to 37 MW in 2007 [8;10]; 4.The theoretically possible volume of world consumption of hydrogen by 2050 is called the value of 1.37 billion tons per year, or 49% of the world's final energy needs by that time; 5. Japan is not only one of the leading countries in the area of hydrogen-related technologies, but is also the first country to formulate a Basic Hydrogen Strategy which was announced in December 2017 (Basic Hydrogen Strategy) and to host the first Hydrogen Energy Ministerial Meeting in October 2018.

Given the above material, as well as "Japan's enthusiasm for a“ Hydrogen-based Society "and its commitment to making hydrogen a global movement» [12], it can be argued that: hydrogen is Japan's most reliable option to reduce carbon emissions in accordance with the Paris Agreement under the United Nations Framework Convention on Climate Change (Paris Agreement). These plans and the experience of their implementation in Japan require intensive study.

2. Materials and Methods

In our study we turned to the methodology of the systemic analysis accompanied by qualitative literature review for comparison of the theoretical concepts of the Basic Hydrogen Strategy with praxiology of using it real possibilities of national technology to realised hydrogen economy in Japan. First of all, it should be noted that there is a certain theoretical discourse on this topic in which used systemic, comparative, statistical, modelling, scenarios methods, the benchmarks of parameters and scenarios of the formation of a "hydrogen society". The works of such scientists as Reed Blakemore, David W Yellen [6], Dryankin A [3], Korneev K [1], Fillippov Sergey [4], Mastepanov A [3], Pami Aalto [5], Anshuman Chaube, Andrew Chapman [7], Nagashima Monica [11], Matsuo Y; Yanagisawa A; Yamashita [13], Mehta Angeli [14], Niunoya Miho [15], Pajon Céline [16], Pflüger Friedbert [17] proved to be especially useful for our study. Therefore, we consider it necessary to further analyze the specifics of their conceptual approach. Let's start with the ideas of scientists Anshuman Chaube, Andrew Chapman, Yosuke Shigetomi, Kathryn Huff, James Stubbins [7]. They “focuses on the four key sectors of storage, supplementing the gas grid, power generation, and transportation, detailing the potential range of hydrogen technologies which are expected to penetrate Japanese energy markets up to 2050 and beyond and… find that transportation, gas grid supplementation, and storage end-uses may emerge in significant quantities due to policies which encourage ambitious implementation targets, investment in technologies and research and development, and the emergence of a future carbon pricing regime. On the other hand, for Japan which will initially be dependent on imported

hydrogen, the cost of imports appears critical to the emergence of broad hydrogen usage, particularly in the power generation sector" [7, P.1].

Reed Blakemore, David W Yellen [6] state that: 1.Japan's October 2020 pledge to reach net-zero emissions by 2050 presents an opportunity to expand the robust US-Japan energy partnership into additional clean energy areas. But with a stark divide on energy policy in the United States, how can the US-Japan energy partnership appeal to disparate visions of the energy transition and be politically durable?; 2. "The US system of national laboratories run by DOE continues to examine the possibilities for energy storage and smart grid technologies. Most prominent among these bodies is the Central Research Institute of Electric Power Industry (CRIEPI), which collaborates with a number of other research bodies, including the Energy Innovation Centre and eight specialized research laboratories. Its Japanese counterpart, led by METI, has several of its own bodies devoted to innovation in hydrogen, battery storage, and grid development, in addition to those of Japan's National Institute of Advanced Industrial Science and Technology and its National Institute for Materials Science. There are a number of areas of technology development where both parties are already cooperating, from the aforementioned nuclear technologies at the heart of the energy relationship to new technologies, such as quantum computing. Extending these shared technology development platforms to include grid development, hydrogen, and battery technologies would be a natural evolution, especially considering the interest from all participating parties. Both countries should also commit to cooperative funding for technology development and deployment initiatives to avoid funding issues that have plagued past cooperative efforts due to the countries' distinct funding cycles" [6,P.22].

Essay of Céline Pajon [16] offers a general assessment of Japan's performance in the 2019 G20 and G7 Summits, held respectively in Osaka, Japan and Biarritz, France and looked at how Japan elite coordinated with its European partners from The European Union, institutions and the EU Member States) in these international settings. This scholar argues that: (1) Japan should more clearly delineate its priorities, objectives and constraints, while advocating its role as a consensus-builder and go-between in international settings; (2) Europeans should acknowledge the constraints of Japan's strategic autonomy and the characteristics of its diplomatic style in order to ensure an optimal cooperation in the G7 / G20 meetings; (3) A permanent candid dialogue between Europeans and Japanese should strengthen mutual understanding and help advance their partnership. The analysis reveals several differences and expectation gaps between the two partners. In particular, even if Tokyo is aligned with most European objectives in terms of trade and data governance, Japan insists on accommodating the US, on which its security still very much depends. Also, Japan's preference for consensus-building disappoints European states' search for a more ambitious leadership – on the issue of climate change, for example. On Japan's side too, there is frustration. The rigidity of European positions and solutions (on a strict protection of digital data privacy, for example) is a concern. Regarding the G7 Summit held in France, the informality of the meeting was an issue for Japan's formal diplomatic style and Tokyo was disappointed by the very brief mention of Asian affairs in the final communiqué [16].

Pflüger Friedbert [17] suggest that: 1. In 2019, EU Commission President Ursula von der Leyen announced the European Green Deal, which also outlines Europe's ambitions to become carbon neutral by 2050. The EU Commission has set an interim target for 2030: 55 percent reduction in carbon emissions compared to 1990 levels. To this end, the EU plans to invest over €1 trillion by 2030; 2. The US return to the Paris Agreement and the appointment of John Kerry as the new US Special Presidential Envoy for Climate indicate a new paradigm: international energy and climate cooperation is back on the agenda. While there may be challenges to achieving broader goals, hopes are up for a transatlantic New Energy Deal between the United States and the EU in light of new policy substance with ambitious climate targets, and a new tone; 3.Joe Biden intends to restructure the United States into a clean energy superpower and refers to his action plan as a "clean energy revolution." Biden also aims for the United States to be carbon neutral by 2050, with a carbon-neutral power supply by 2030 [17].

Nagashima, Monica [11] believes, that Japan's „Strategy encompasses the entire supply chain from production to downstream market applications. Success will primarily depend on the cost competitiveness and availability of carbon-free hydrogen fuel. Japan's state-backed approach is ambitious, as it involves domestic and overseas industry and government stakeholders on a number of cross-sectoral pilot projects. At this stage, the economic and technical challenges and uncertainties have not been lifted. The government awaits the results of the ongoing pilot projects around 2020 before considering the integration of hydrogen into the wider economic and energy plans. While public funding is steadily increasing, it remains limited and reflective of caution against any long-term commitment. Decarbonization of Japan's energy sector still predominantly rests on nuclear, natural gas, energy efficiency and renewable energy sources (RES). The prospect of hydrogen playing an economy-wide role still meets considerable scepticism both in Japan and abroad. At present, nearly all hydrogen and fuel cell technology is still highly dependent on public financial backing. Beyond transport, industry, and building sectors, the commercial adoption of hydrogen in power generation will be an indicator of the Strategy's success. Given that power plants would consume a lot of hydrogen fuel, an operation of several plants would indicate that the hydrogen fuel supply network is reaching price maturity. In addition to hydrogen, ammonia and methylcyclohexane (MCH) are also being studied for direct and co-fired thermal generation. Japan's Strategy has global implications, including the potential to trigger a new area of international energy trade and industrial cooperation. Japan and its industry stakeholders are already engaging Australia, Brunei, Norway and Saudi Arabia on hydrogen fuel procurement" [11,P.6].

Analists Matsuo Y; Yanagisawa A; Yamashita Y N [12] claim that „The Fukushima Daiichi nuclear power plant accident triggered by the Great East Japan Earthquake in 2011 led to changes in nuclear policies in Japan and other countries, which will greatly affect future fossil fuel demand" [12,P.2.]

Fillippov Sergey [4] in his thesis confirmed by the observed trend in the implementation of power plants with fuel cells on the world market: over the period 2007–2019, more than 4.3 GW of fuel cell plants were commissioned in the world, of which more than 70% were for stationary power plants; in 2019, their annual sales reached 70.9 thousand units, and the installed capacity was 1130 MW, which demonstrates a 30-fold increase compared to 37 MW in 2007 [4].

K Korneev, S Popov [1] defined the specific features of modernization in Japan: (1) preservation of the traditional cultural structure of the Japanese; (2) a combination of new principles of energy policy formation that grew out of a market economy with traditional informal agreements; (3) the dominance of financial and industrial groups created during the Meiji era (1868-1912) in the context of formal conformity Western standards, but in terms of structure and activity, they do not fit into the market models typical of the EU countries and the USA; (4) the presence of indirect, but rather effective interaction between the state and business, as well as public organizations. This scientist also forms a list of the main participants in the process of shaping the energy policy of Japan: 1.Central government, consisting of ministries and departments (accumulates in its hands the solution of the fundamental problems of the successful functioning and development of the energy sector. applies to the regulation of prices for imported petroleum products in the domestic market, ensure uninterrupted supply of electricity to consumers through control over the activities of monopolist companies, the development of effective market schemes for independent electricity producers; 2.Large financial and industrial groups consisting of diversified companies (the share of such groups in electricity trading not affiliated with energy companies-monopolists is up to 16% of the total indicator for countries generating electricity); 3.Authorities of prefectures, including municipalities; 4.Non-profit and public organizations, mainly of environmental profile; 5.Scientific institutes and other organizations dealing with energy problems (when developing the new edition of the Basic Energy Plan, state actively cooperated with the Institute of Energy Economics of Japan, the Institute for Economic Research of Northeast Asia, the Asia-Pacific Centre for Energy Research). These scientists also clarified the stages of the formation of energy policy and its legal framework: 1.The active growth of the Japanese economy in the 1950s, accompanied by the consumption of oil from abroad, mainly from the United

States. At this time, the law "On the promotion of the development of the electric power industry" (1952) was adopted, obliging the official structures to provide centralized and uninterrupted supplies of oil to energy companies for generating electricity; 2.The period of maximum growth rates of the Japanese economy (9-10% per year) in the 1960s. At this time, the Petroleum Law (1962) was passed to encourage domestic refining, the Electricity Law in 1964 to regulate the powers of central authorities, energy companies and prefectures in energy policy; 3.Japan's response to the oil crises of the 1970s-1980s in the context of the depletion of its own coal reserves in the form of refusing to export cheap oil in order to switch to nuclear energy, gas, renewable resources. By the end of the 1980s, the share of nuclear power plants in the total structure of electricity generation was already 20%, and the share of TPPs operating on liquefied natural gas was about 12%. In 1973, the Japan Natural Resources and Energy Agency was created – a specialized unit within the ministry responsible for the operational management of energy and strategic planning of its development. In 1975, the document "Main directions of the general energy policy" was published, defining the directions of its implementation"; 4.Japan becomes in the 1990s-2000s the second economy in the world. In the mid-1990s, a prolonged recession began due to the burden on the country's pension system [1].

A.Mastepanov [2] researched the hydrogen strategy developing role of: the Institute of Energy Economics of Japan (IEEJ), NEDO and strategic partnerships with Japanese technology corporations, the Hydrogen Energy Supply-chain Technology Research Association (HySTRA) of 2016 with main task of developing the project of the Japanese-Australian hydrogen supply chain; Association for the development of the technological chain of hydrogen energy (Advanced Hydrogen Energy Chain Association for Technology Development - AHEAD) of 2017 with main task is the development and implementation of a project for the supply of hydrogen from Brunei in the form of methylcyclohexane; Two programs implemented by NEDO: Advanced research project on hydrogen application technologies. The main objectives of the program are scientific research aimed at improving the efficiency of electrolysis technologies, research and development of large-scale technologies for the use of hydrogen, research of technologies for production [2].

Harding Robin [8] thinks that "It sets a target of 200,000 fuel cell vehicles on the road by 2025 and 800,000 by 2030, fuelled from a network of 900 filling stations, up around nine-fold from today. Analysts remain politely sceptical given the cost challenges and the lack of infrastructure. Toyota, one of the biggest backers of hydrogen, has recently stepped up its investment in battery-powered vehicles'' [8].

Mehta Angeli [14] said that "In Paris, HysetCo, a collaboration between Air Liquide, Société du Taxi Électrique Parisien (STEP), energy infrastructure group Idex, and Toyota, plans to have a fleet of 600 hydrogen-powered taxis in the Ile de France region by the end of next year. Having 600 taxis will guarantee sufficient demand at a limited number of refuelling stations. Fuel costs for new vehicles are getting closer to parity with diesel. "The policy-making conversation is becoming a little more real, with net-zero economy-wide emissions targets [in UK and France]. That really focuses minds and sharpens the pencils." Like battery electric vehicles, fuel cell electric vehicles (FCEVs) use electric motors to drive the wheels. However, they store energy onboard as compressed hydrogen, rather than just in a battery. Hydrogen reacts with oxygen from the air in an onboard fuel cell to produce electricity. Water is the only by-product. No greenhouse gas or air pollutant emissions are produced, meaning FCEVs are zero-emission vehicles. Fuel cells are typically 40-60% efficient (comparing energy input to energy output) [14].

Niunoya Miho [15] said that 1."Japan is now in the third wave of hydrogen. The first wave was in the early 1990s, the second wave was in early 2000s (in 2002, the Japanese government enacted the "Basic Act on Energy Policy" and has been formulating and updating a "Basic Energy Plan" every 3 years since its first publication. Subsequently, in 2008, the "Cool Earth - Energy Innovation Technology Plan" was announced to promote technological innovation and deregulation in the promotion of fuel cell vehicles ("FCV") and hydrogen refuelling stations), and the third wave started around 2015. In pursuit of finding a way to be independent from the fossil fuel produced in the Middle East and recognising both Japan's limited domestic energy resources as well as a desire to decarbonise

its energy mix, Japan made a deliberate choice to develop a hydrogen-based society in the 1990s"; 2.In 2011, Japan was affected by the Great East Japan Earthquake and the nuclear accident at the Fukushima Daiichi Nuclear Power Station. These disasters accelerated the government's efforts to realize a hydrogen-based society; 3.The government announced the "4th Strategic Energy Plan" which was substantially adjusted from the 3rd Strategic Energy Plan. In the same year, the government compiled the "Strategic Roadmap for Hydrogen and Fuel Cells" (the "Roadmap") to implement the "4th Strategic Energy Plan". The plans were further bolstered by the Paris Agreement in December 2015. As a result, 2015 is known as the "First Year of Hydrogen" in Japan; 4.In 2017, the government formulated the "Basic Hydrogen Strategy" (the "Strategy"). Japan has set a long-term goal that, by 2050, aims to reduce 2013-levels of CO2 emissions by 80%; the Strategy sets out an action plan for the period up to 2030. In response to the "5th Strategic Energy Plan" formulated in 2018, the Roadmap was revised for the third time. Japan's current hydrogen programme is based mainly on the Strategy and the latest Roadmap; 5.In March 2020, the world's largest (10 MW) renewable hydrogen production facility "Fukushima Hydrogen Energy Research Field ("FH2R")" was opened in Namie Town, in the Fukushima Prefecture; 6.In October 2018, Japan held the world's first "Hydrogen Energy Ministerial Meeting" ("HEM") under the main theme of "Realization of a Hydrogen-Based Society" and, as a result, the "Tokyo Statement" was released. In 2019, the second HEM was held, with approximately 600 participants from 35 countries, regions and organizations attending. The third HEM will be held online in October 2020 and will share the efforts and progress of each country to realize the hydrogen-based society; 7.Japan has also entered into memorandums of agreement with New Zealand, Argentina and the Netherlands, among others, regarding cooperation for the realisation of a hydrogen-based society. For example, in the memorandum which was entered into between Japan and New Zealand, both countries agreed to cooperate on the exchange of information and personnel, developing technology, and establishing an international supply chain, among other things [15].

3. Results

Building on the results of the literature review we direct our main point of our research on the Japan concept of security, based on the principles adopted in this country. It should be noted right away that the main directions of Japanese energy policy are determined by such objective factors as: 1. Lack of own reserves of fuel and energy resources and more than 90% dependence on energy imports. This problem is solved by a careful study of the legislative regulation of energy relations both within the domestic subjects and with foreign partners. Japanese law empowered the prefectures to build and launch any energy facility (power plants, transmission lines, distribution networks). An example is the Japanese practice of maintaining stable contracts with the countries of the Persian Gulf. Qatar remains Japan's leading exporter of oil and gas. In addition, Japan is striving to meet its climate change commitments to reduce greenhouse gas emissions by 26% by 2030 compared to 2017; 2.The experience of overcoming the world energy crises stimulated the use of gas, nuclear and alternative energy in addition to oil. Thus, Japan was able to reduce the risks of price fluctuations in the world primary energy markets; 3. Japan in the context of the foregoing is forced to maximize the efficient use of energy resources in the energy supply chain. For example, in terms of minimizing losses in the transmission of high voltage electricity over long distances, Japan is the leader in the world (8-9%). One of the world's largest hydrogen production facilities was recently opened during a demonstration of north-eastern Japan's resurgence following the devastating 2011 earthquake. Located in the city of Namie, north of the destroyed Fukushima Daiichi nuclear power plant, the solar hydrogen plant can produce enough gas to fuel 560 fuel cell vehicles a day. The project was implemented by Toshiba, Tohoku Electric Power and Iwatani natural gas distributor; 4.Japan is interested in the development of the infrastructure and the conjuncture of energy markets and due to that has accelerated reforms since the late 1990s in order to strengthen the mechanisms of competition in traditionally monopoly industries. By 2020, it was planned to liberalize the electricity markets with independent generating, grid and retail companies. According to the plans, this will allow the introduction of new technologies, contribute to the development of hydrogen energy, which will ultimately stimulate energy

conservation and reduce electricity tariffs for all consumer groups; 5.The experience of eliminating the accident at the Fukushima NPP in March 2011 and the need to compensate for the loss of NPP capacity required a reduction in transaction costs when concluding energy contracts; 6. Realizing that due to climatic factors and high seismic activity on the Japanese islands, refusal to maintain large reserves will lead to an energy collapse as a result of a man-made disaster, the Japanese government has formed a legal basis for private energy business in the field of renewable energy. In 2009, a law was adopted (a new version was published in 2012), according to which regional monopoly companies were obliged to purchase electricity from independent producers of electricity from renewable sources at discounted prices exceeding the balanced price for the region by 2-3% (FIT-tariff). In 2016, tariffs for solar and wind renewable energy producers averaged 21 yen per kWh, which is broadly comparable to those in the EU. The main energy plan declares the basic directions for the development of the fuel and energy complex until 2030; 7.A number of directions of Japan's energy policy are regulated by the 3Es + S program: stability and security of energy supplies; energy efficiency along the entire production and consumption chain; respect for the environment. In the practical application of hydrogen fuel cells; 8.Japan has from the very beginning played an important leading role in relation to other countries. An example of this is the fact that in 2009 Tokyo Gas Co., Ltd. and Panasonic Corporation were the first to market household fuel cells (Ene-Farm systems) worldwide. Then, in December 2014, Toyota finally implemented plans to bring mass-produced fuel cell vehicles to market. This event also received widespread publicity as it is the first in the world. Corporations and companies Eneos, Iwatani, Kawasaki Heavy Industries, Kobe Steel, Mitsui & Co, Sumitomo Mitsui Financial Group, Kansai Electric Power, Toshiba, and Toyota Motor have established the Japan Hydrogen Association (JH2A), which aims to build H2 supply chains on the ground and international cooperation to create a "hydrogen society". JH2A's activities partially overlap with the global Hydrogen Council, but the new organization wants to strengthen Japan's organization, and a total of 87 companies joined it; 9.In addition to using hydrogen as a source of energy, Japan intends to continue to promote the production of vehicles using this type of fuel, incl. city buses. It is planned to introduce technologies for using fuel cells in the field of sea transportation. So, Kawasaki Heavy Industries wants to start producing cargo ships on hydrogen by 2025. Almost simultaneously with this, Honda Motor Co., Ltd. and Toyota Motor Corporation decided to market fuel cell vehicles, and Iwatani Corporation and JX Nippon Oil & Energy Corporation published retail prices for hydrogen at hydrogen filling stations. Thus, there has been a dramatic increase in efforts to develop the use of hydrogen as a source of energy. Toyota promotes the use of hydrogen as an energy carrier on the railways, in retail chains, at various enterprises and factories, as a power source in emergency situations and, of course, in road transport - from cars with fuel cells to similar trucks and buses.

4. Discussion

We first have accepted main results of investigated sources. Japan is indeed actively positioning its role in the global programs on climate change, intensifying efforts to use renewable resources and hydrogen in particular. Our thesis can be confirmed by the observed trend in the implementation of power plants with fuel cells on the world market: over the period 2007–2019, more than 4.3 GW of fuel cell plants were commissioned in the world, of which more than 70% were for stationary power plants; in 2019, their annual sales reached 70.9 thousand units, and the installed capacity was 1130 MW, which demonstrates a 30-fold increase compared to 37 MW in 2007 [4].

Second, we share Critical Benchmarking of Matsuda Dan concerning the future policy implications for each of the key sectors with respect to the realization of a hydrogen economy in Japan. Our literature review identified three main stimulatory policy types. The first promising class of policies can be broadly described as ambitious reduction targets. These include 80% emission cuts, cognizant of CCS capture limitations, INDC commitments, and low carbon budget scenarios. This finding is consistent with identified policy levers for a successful energy transition in Japan. The second policy instrument which tends to encourage the hydrogen economy is a price on carbon, or carbon taxes. Carbon taxes and subsidies are identified alongside strong INDC commitments in [12], while carbon

taxes in the range of 17,500 JPY/t-CO2 and 58,300 JPY/t-CO2 are considered essential to achieve carbon reductions at the IEA 450 ppm scenario leve, 75% reductions by 2050, and 80% reductions, respectively. These prices are markedly higher than current international norms, in which prices range between less than 110 JPY/t-CO2 and 13,200 JPY/t-CO2 [12]. The third policy instrument identified as stimulatory to the penetration of hydrogen into the energy system is increased investment, both into the deployment of complementary technologies and infrastructure, and also toward research and development. We believe that the Japanese tradition of relying only on its own strength forced both government agencies and energy companies to be extremely cautious about innovation. Modernization of the fuel and energy complex, management tools, marketing strategies in Japan took place only as a result of significant events. Such as: economic, when in the 1970s. the oil crisis broke out, in the 1990s the recession; natural and climatic, especially associated with the destruction of the energy infrastructure, technological (the accident at the Fukushima NPP), as well as organizational factors – until the mid-1970s, there was no planning for the development of energy on a national scale. And the measures developed by the Japanese government to improve energy policy are mainly aimed at overcoming the consequences of the energy challenges and risks of recent years. However, current energy policy and energy financing are geared more towards eliminating supply shortages than solving long-term problems. For Japan, hydrogen energy is not only an energy transition process.

Conclusions

The above allows us to state that: 1.The hydrogen economy is a new global technological way and will go beyond energy and include the distribution, use of hydrogen for technological processes. It is necessary to note in this context that scientists are increasingly prone to catastrophic resource depletion scenarios. That is, by 2025, physically insurmountable limitations on the consumption of the planet's resources can be achieved and extensive progress will end in the lifetime of one generation. As the asymmetry of needs and opportunities will be exacerbated by growing risks, there is a need for security discourse and the search for new possibilities; 2.Japan is now in the third wave of hydrogen. In our opinion, Japan now is among the leaders in building new strategic scenarios. The Japanese road map Strategic Roadmap for Hydrogen and Fuel Cells was launched in the summer of 2014 with aim: simultaneous development of several elements of the "hydrogen" technological chain; start with landmark intercontinental hydrogen export projects from Australia, Norway, the Middle East; to use international assistance for programs of technological and climatic order in a broader context – the deployment of the construction of "a society based on hydrogen“. The roadmap contains specific key indicators for several technologies of the technological chain – in the production, storage, transport and use of hydrogen – with milestones in 2020, 2025, 2030 and 2050. Thus, the goal for the use of hydrogen in Japan – from the current 200 tons in year to 10 million tons in 2050. Will increase the level of 50 thousand times; 3.Significant developments in the formation of energy policy of Japan took place in 2014, when the start of building a "hydrogen society" was proclaimed based on the fourth the Strategic Energy Plan until 2030, which formulated a policy to reduce dependence on nuclear energy and fossil resources and expand the use of renewable energy sources. Energy security is interpreted in this document as improving economic efficiency and environmental acceptability based on safety as a fundamental principle of all development (the “3E + S” goal). The achievement of the "energy dilemma" (energy security, economic efficiency and environmental acceptability) is planned at the expense of hydrogen energy. In this regard, the role of a hydrogen society is interpreted: “A hydrogen society is not a goal, but a means to an end. To achieve the “3E + S” goal, it is necessary to create a society based on hydrogen”. In this regard, the Japanese government allocated funds from the budget to finance a number of "hydrogen" facilities in preparation for the Summer Olympic Games in Tokyo in 2020. In 2014, the Hydrogen and Fuel Cell Strategy Council under the Ministry of Economy, Trade and Industry of Japan (METI), completed the preparation of the Strategic Roadmap for Hydrogen and Fuel Cells. At the same time, Honda and Toyota decided to launch cars on the market, and Iwatani Corporation and JX Nippon Oil & Energy Corporation published retail prices for hydrogen at hydrogen filling stations. Thus, there has been a sharp increase in efforts aimed at developing the use

of hydrogen as a source of energy; 4.Japan's current energy policy has been updated by the Basic Hydrogen Strategy, adopted in 2017 by the Government Council on Renewable Energy Hydrogen and Related Issues in the context of energy poverty, hydrogen could become a breakthrough strategy in ensuring energy security; 5.Japan's energy policy ensures its basic national interests in the historically established institutional model (ramified bureaucratic apparatus), political culture (the gradual nature of changes, the significant role of informal contacts in decision-making); traditions of management (lobbying of 10 regional energy companies-monopolists in the legislative and executive authorities); 6.The main sources of resources for the fuel and energy complex of Japan remain oil and gas (up to 70% of the country's fuel and energy balance), as well as coal, although its consumption is planned to be significantly reduced by 2030 due to the commissioning of renewable energy capacities; 7.As the analysis shows, the economy of modern Japan depends on imported energy resources, since its level of self-sufficiency is less than 10%. At the same time, 87-88% of imported energy resources come from the Gulf countries, which also creates additional geopolitical risks. This fact stimulates the use of hydrogen to diversify the structure of primary energy supply and increase the economic efficiency of energy transactions. These facts determine the national commitment to building a hydrogen society in the country, and the desire to achieve this goal by 2050; 8.Safety problems in nuclear power are growing. The fate of the operation of a nuclear power plant largely depends on the relationship of the state with the authorities of the prefectures and heads of non-profit organizations; 9.In the basic documents defining Japan's hydrogen policy, an important place is given to international relations in the energy sector both in the form of multilateral agreements and on a bilateral basis, including within the framework of various international organizations in order: to build a "hydrogen society"; to make efforts to conduct joint research with other countries (with countries with high technological potential, such as the United States and the EU); harmonize regulations and rules related to hydrogen, and international standardization in this area; 10.To create an alternative to liquefied natural gas in Japan by 2030, the cost of hydrogen must be reduced five times (up to 20 cents per cubic meter) by increasing the volume of hydrogen consumption (10 million tons of hydrogen per year) in the process to scale the hydrogen supply chain into a multilateral supply chain significantly to lower costs.

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