International Experience of Hydrogen Energy Financing

Yarygina Irina*, Arlashchenkova Ekaterina
Economy and Banking Department
Moscow State Institute of International Relations (MGIMO) under the Ministry of Foreign Affairs of the Russian Federation, Russian Federation
76, Prospect Vernadskogo, Moscow, Russian Federation, 119454
Email: jiz4@yandex.ru
* Corresponding author

Abstract

The paper examines international experience in hydrogen energy financing, following the rapid expansion of the global hydrogen market, fuelling interest in hydrogen energy elsewhere. The purpose of the paper is to determine the sources of financing and features of the financial mechanisms of hydrogen programs aimed at boosting economic growth and combating climate change. The study provides the development preconditions of the global hydrogen market, identifies the factors of investment attractiveness of hydrogen projects, and presents the mechanisms for their financing. The analysis reveals the predominance of public financing and multilateral global initiatives underpinning the emerging hydrogen market. The results of the paper determine the methods of risk management for hydrogen energy projects and reveal the experience of China, suggesting the economic viability of hydrogen projects. The paper reveals the necessity for comprehensive risk management of hydrogen projects and concludes on the necessity of expansion of financing through the participation of institutional investors in the programs for the new types of energy production that are safe for the global environment.

Introduction

Research displays the soar of the contemporary hydrogen market, followed by skyrocketing investments in hydrogen projects. In 2023, global accumulated investments in the field reached 29 billion USD, with the forecast indicator being assessed at the level of 320 billion USD till 2030, the International Energy Agency (IEA) reckons (IEA, 2024).

Increased investments in the hydrogen industry require a profound understanding of international practice, sources of financing, analysis of the factors influencing investment decision-making and public development programs, including stimulus and subsidies.

Practice suggests that decarbonization of the global energy balance is the driving force of facilitating renewables as a substitute for fossil fuels, which account for a major part of greenhouse emissions in the energy sector, agriculture and industrial production International Renewable Energy Agency (IRENA, 2022). In view of the following, it is worthwhile to harness the potential of hydrogen in hard-to-abate sectors, such as aviation, marine and rail transport, in remote areas. Besides, wider integration of hydrogen into energy-consuming industries of metallurgy (direct reduced iron) and chemicals (ammonia, methanol and plastics) has the potential to fuel economic growth. Raising investment in the hydrogen industry is crucial for advancing hydrogen technologies and hydrogen commercialization.

Investment attractiveness factors

International research suggest that hydrogen projects are associated with high risks, with less than 10% of their total amount reaching final investment decisions, as indicated in the International Federation for Information data.

Key factors reducing the investment attractiveness of hydrogen projects are as follows:

1. Immaturity of the hydrogen market, lack of clarity, unstable demand and limited utilization, which complicates long-term marketing policy;
2. Absence of business practice and expertise in contiguous industries;
3. Absence of commercial ties and trade routes;
4. Capital intensity and high sensitivity to cost of financing fluctuations amidst macroeconomic turbulence;
5. Absence or insufficient infrastructure; and
6. Innovations and high technological risk triggering delays in delivery or project budget deficits.

Key sources of financing for hydrogen projects (HP) are provided by banks, intergovernmental financial institutes, institutional investors, joint-stock companies, including debt financing, grants and mixed financing (OECD, 2024).

Standard HP's funding mechanisms

According to OECD data, Bank lending and public grants account for more than half of hydrogen projects' financing, indicating the emergence of the hydrogen industry. Current financial structure suggests heavy governmental support and scarce private investment, whose share makes up only 15% of the total investments, well behind the public finance. In the context of the present research, bank lending shall be an umbrella term for financing from state-owned banks, commercial banks, international development banks and international organizations. A large share of bank lending is compiled by multilateral development banks (MBDs), export credit agencies (ECAs), international

Table 1: Global financial initiatives for hydrogen energy

Initiator	Project
World Bank	Scaling Hydrogen Financing for Development, Green Hydrogen Support Program, Hydrogen for Development Partnership, IBRD PROBLUE
African Development Bank	Sustainable Energy Fund for Africa (SEFA), Alliance for Green Infrastructure for Africa
Asian Development Bank	ADB Institute, Green Hydrogen Innovation Center
International Development Bank	Green Hydrogen Bank
European Investment Bank	Regional Integration of the Green Hydrogen Chain
International Energy Agency (IEA)	Clean Energy Ministerial, Global Ports Hydrogen
Green Hydrogen Organization (GHO)	Developing Finance Priority Actions
International Renewable Energy Agency (IRENA)	Energy Transition Accelerator Financing Platform Coalition
Organization for Economic Co-operation and Development (OECD)	Clean Energy Finance and Investment Mobilization
United Nations Industrial Development Organization (UNIDO)	Green Hydrogen Financing, Regional Integration of the Green Hydrogen Supply Value, Global Program for Hydrogen in Industry
World Economic Forum (WEF)	Acceleration Clean Hydrogen Initiative

(Source: Composed by the authors based on (OECD, 2024).)

economic organizations and specialized institutions. Approximately 75% of financial initiatives for hydrogen energy are led by international development banks and international organizations, OECD assesses (Table 1).

The enlisted financial institutions secure strategic financing for the emerging hydrogen industry, mitigating project risks and catalysing private capital. Apart from that, comprehensive tailor-made analysis and sector-specific expertise aligned with peculiarities of national hydrogen strategies are crucial for creating a benign investment climate for hydrogen projects (IRENA, 2024).

Public grants have come to be one of the most widespread financial practices for hydrogen projects, implying financial resources from the government in exchange for a share in a project. Public grants aim at reducing hydrogen cost through partial compensation for capital expenditures, which account for up to 40% of the total costs, and thus, boosting hydrogen economic competitiveness. Yet, public grants may hamper the economic efficiency of a renewables project, the World Bank reckons (World Bank, 2024). Governmental intervention and supervision enhance efficiency of financial input. Yet, heavy governmental regulation of the project poses a threat to management efficiency.

Investors of hydrogen industry

It is worth mentioning the diversity of numerous hydrogen industry investors (Table 2).

International research (OECD, 2024) suggests that China has succeeded in the commercialization of hydrogen in transport and other areas, which leads us to the hypothesis that hydrogen projects can achieve profitability at the stages of production, transport and distribution.

Expenses itemizing of 3 projects in China (Climate Policy Initiative, 2024) was studied to reveal the key characteristics of the financial performance of similar projects. The calculations suggest that the average cost of equipment is 65 thousand USD, operational costs (OPEX) - 2 million USD, construction costs – 50 thousand USD, and financing – 10 million USD. The average financial indicators are provided in Table 3.

The data provided demonstrates that borrowed capital, represented by bank lending, is the key source of financing.

Table 2: Hydrogen industry investors and their role

Investor	Example	Role
Government bodies	State-owned companies	Both lender and shareholder
State-owned and commercial banks	State bank of India, HDFC (India), ICICI (India), Kreditanstalt für Wiederaufbau (Germany), Bank of Baroda (India)	Both lender and shareholder
International financial organizations and development banks	World bank, European Hydrogen Bank	Lender
Investment funds	Clean H2 Infra Fund, Hy23, Environmental Fund of Namibia, Amazon's Climate Pledge Fund	Both lender and shareholder
Insurance companies	Marsh (USA), Munich Re (Germany)	Lender
Industrial conglomerates	Japan Steel Works (JSW), ACWA Power (Saudi Arabia), Industrial and Port Complex of Pecém (CIPP) (Brazil), Scatec (Norway), Lhyfe (France), Posco Holdings (Republic of Korea) etc.	Shareholder

(Source: Composed by the authors based on OECD, 2024; UNIDO, 2024; GHO, n.d.; Climate Policy Initiative, 2024; IEA, 2021)

Table 3: Financial indicators of hydrogen projects in China

Indicator	Meaning
Discount rate	8%
Equity financing/Debt financing	30%/70%
Interest rate	5%
Income tax rate	20%
Operation period	20 years
Payback period	5 years
Internal revenue rate (IRR)	15,38%

(Source: Composed by the authors based on (Taghizadeh-Hesary F. et. al., 2022).)

A large share of bank lending pinpoints high sensitivity of financing to interest rate fluctuations. The global average discount rate for renewable energy projects is 6-10%; meanwhile, in China, it remains at the rate of 8%. Interest rate and income tax rates are 5% and 20%, respectively (Yarygina I. et.al., 2023). Capital intensity of hydrogen projects determines their high sensitivity to income tax fluctuations. Operation and payback periods are calculated as 20 and 5 years, respectively (Taghizadeh-Hesary F. et. al., 2022).

The average IRR for focus groups in China makes up 15,38%, well above the discount rate of 8% in the amount. (IRENA, 2024). Thus, the conducted research proves the economic viability of hydrogen projects.

Institutional investors as a factor in hydrogen energy financing

Actually, institutional investors are defined as special financial institutions that manage savings in the interests of private investors, maintain an acceptable level of risk, with the intent of obtaining the maximum investment return, backed by the terms and conditions of an agreement.

Institutional investors comprise collective investment institutions, pension funds, and insurance companies and participate in the process of direct (on their name) or indirect (as agents) financing and perform the following economic functions:

- they are responsible for the efficient distribution of financial resources among economic entities;
- accumulate savings of the population and reduce transaction costs;
- diversify risks and participate in environmental protection.

The term "institutional investors" is interpreted in the Russian economic literature relatively broadly and includes both non-deposit and deposit intermediaries. Some authors limit themselves to listing most financial intermediaries as institutional investors. At the same time, experts of the Bank for International Settlements (BIS) define insurance companies, pension funds and various collective investment schemes as institutional investors. In a number of studies of Russian economists, the institutional investors are considered as non-bank financial intermediaries who invest funds, which are accumulated during their activity, in financial market instruments in order to gain profit.

We consider that retail banks cannot be classified as classic institutional investors, since their activity is related to attracting deposits and placing them in loans, while institutional investors are mostly focused on long-term investments, required for hydrogen projects.

It is worthwhile mentioning that the term "collective investment" is also widely used in the Russian Federation and relates to non-state pension funds and specialized companies. Sometimes, so-called collective investors are involved in raising funds from a large number of individuals for their subsequent investment as institutional investors. The general approach of financing the hydrogen economy does not prevent from using different forms of financing, but our attention is specifically drawn to institutional investors and their possible contribution to hydrogen energy financing.

Having a wide range of investment options, institutional investors do not limit themselves to financial assets available on domestic markets. The increasing efficiency of information technologies and the easing of regulatory restrictions have contributed to their global activity. The trend towards global investments and integration of national capital markets into the international context has accelerated investments in foreign assets (local currencies) and purchase of securities, depositary receipts, shares of investment funds, etc.

It is worthwhile mentioning that Russian pension funds invest up to 30% of their assets in social projects. It is important to note that green energy and new technologies projects are considered to be of social significance globally. Thus, the origin of hydrogen projects itself accelerates the cross-border supply of services, provided by institutional investors and gives way to life insurers and pension funds to accumulate international resources for sustainable economic development locally and globally.

The contemporary research shows that the main international trend manifests itself in developing resources for green projects and requests improvement of hydrogen production and environmental protection. For example, the International Energy Agency (IEA) estimates that the prevention of major climate changes by reducing carbon emissions requires an additional $500 billion to be invested annually, in addition to the $10.5 trillion of investments in 2010-2030. At the same time British Petroleum experts consider that in the near future, approximately two thousand hydroelectric power plants will operate worldwide (IEA, 2024). It is worthwhile mentioning that electrolysis of water is one of the ways to produce hydrogen. We should consider it for strategic development and planning.

Actually, institutional investors have accumulated a significant amount of capital and a variety of instruments well known to financial professionals that can help to smooth out the consequences of a significant slowdown in global economic growth and ensure energy production. Acceleration of institutional investors' activity will be a positive trend that will contribute to the green energy transition and sustainable development.

Due to financial flexibility and mobility, institutional investors play a significant role in the global financial architecture, which is confirmed by their cooperation with supranational institutions. Management of the global capital flows and contributes to energy production, as well as environmental policy implementation, changes the role of institutional investors in the global economy, turning them into systemic financial institutions. Actually, institutional investors control more than 80 percent of the US stock market capitalization. At the same time, private investors, meeting a policy of strategic investments, control 10 percent of the UK market. It means that institutional investors possess control over business (Fitch, 2023).

The results obtained allowed us to draw the following conclusions. There are several trends for institutional investors in the hydrogen economy: growing competition, passive portfolio management strategies, and demand for new investment instruments to set up securities portfolios.

The trend of growing competition is supported by increasing regulatory requirements for the volume of funds and structure of assets, as well as the constant growth in the number of mutual funds, offering similar services to the population in different sectors of the economy.

There are also some specific challenges for each type of institutional investor that are determined by specific market activity of insurance companies, non-state pension funds, and collective investment institutions. The main challenge for the insurance companies is the reduction of insurance schemes (tax optimization) and the non-state pension funds activity. As one of the elements of scientific foresight, forecasting allows us to display possible scenarios for the development of institutional investors' activity in the Russian green energy sector. The current market environment has proved that the authorities should be interested in developing domestic non-bank financial intermediaries, which help to transform savings into investments.

The activity of institutional investors in hydrogen production is insignificant. Federal loan bonds and deposits in leading Russian banks accumulate the main share of investments. At the same time, based on the analysis of investment strategies and market behavior of key players, we conclude that there is a great potential for institutional investors in the hydrogen production that promotes the development of indirect financing (Yarygina I. et al., 2022)/

The following measures help to realize the potential of institutional investors in the global market and develop their activities in green energy production, namely, in environmentally friendly hydrogen. It is economically reasonable to improve taxation of insurance companies and requirements for the structure of the insurance company's investment portfolio, as well as legislation, by creating a unified code of responsible investments. It is also very important to promote cooperation between insurance, production and management companies, as well as increase information transparency of non-state investment funds. Clarification of the rights and obligations of participants of the non-state investment funds market, primarily in strategic spheres of the economy, will certainly contribute to the activity of institutional investors in different spheres of the economy, namely, in new types of energy production. The above-mentioned measures contribute to financial resources accumulation in the interest of sustainable economic growth and environmental protection.

Risk mitigation strategies for hydrogen projects

In view of the substantial risks inherent in hydrogen projects, it is indispensable to crystallize a comprehensive approach to risk management to enable their economic viability and investment appeal. Key risk factors impacting hydrogen projects' attractiveness and their possible mitigation tools are listed in Table 4.

According to the information presented in Table 4, global practice demonstrates

Table 4: Key risk factors impacting hydrogen projects and their mitigation ways

Risk mitigation tools / Risks	Uncertain market demand	Country risks	Technological risks	Environmental, Social, Governance-risks	Macroeconomic risks
ECAs' cover	+	+			+
Contractors-all-risk insurance (SAR)		+	+	+	
Contracts for difference (CFD)	+				+
Due diligence	+	+	+	+	+
Syndicated loan		+		+	+
Interest rate swaps		+			+
Liquidated damages			+		
Credit-default swaps (CDS)	+	+			+
Foreign currency guarantee		+			+
Loan loss reserve (LLR)	+	+			+
Off-take guarantee	+	+			+
Performance guarantee	+		+		
Foreign investment insurance	+	+			
Partial credit guarantee	+	+			+

(Source: Composed by the authors based on (Bjerde, A. et al., 2024; Climate Policy Initiative, 2024; Cordonnier, J. and D. Saygin, 2023; Pillay K. et al., 2025).)

Table 5: Risk allocation matrix by hydrogen project type (SPP)

Project type/ Risk	Developing and permitting risk	Construction and completing risk	Technological/ Performance risk	Feedstock risk	Market risk	Operational risk	Regulatory risk
Green hydrogen (Electrolyzer + Renewables)	PUB	PRI	PRI	PRI	PRI	PRI	PUB
Green hydrogen (Electrolyzer + Grid Power Purchase Agreement (PPA)	PUB	PRI	PRI	PUB	Shared	PRI	PUB
Blue hydrogen (steam methane conversion (SMC) + carbon capture, storage and utilization (CCUS)	PUB	PRI	PRI	PRI	PRI	PRI	PUB
Public supported hydrogen SPP (offtake or subsidy)	PUB	PRI	PRI	Shared	PUB	PRI	PUB
Merchant hydrogen SPP (no contracted offtake)	PUB	PRI	PRI	PRI	PRI	PRI	PUB
Integrated hydrogen hub (production + storage + pipeline)	PUB	PRI	PRI	PRI	PRI	PRI	PUB

(Source: Composed by the authors based on OECD, 2024; GHO, 2022; Hovy P., 2015; Fitch Ratings, 2023).)

deal structuring and calculations of indicators of source origin.

Global practice suggests that state-private partnership (SPP) secures benign and enabling factors and hydrogen projects (Global Infrastructure Hub, 2020), by providing favourable conditions for their implementation. Deploying SPP in innovative projects provides equal distribution of risks between all the parties involved, thus securing efficient economic contribution of both public (PUB) and private (PRI) parties. The results of our study of SPP hydrogen projects are provided in Table 5.

The provided data are typical. In a variety of cases, peculiarities of hydrogen production and distribution require adjusted indicators. It is worthwhile to pinpoint that up to 85% of hydrogen projects have secure financing within the framework of public and intergovernmental development projects (OECD, 2024). Meanwhile, the involvement of private actors is curbed due to existing economic constraints. On the contrary, national financial architecture is determined by the maturity of the hydrogen market, with inherent risks hampering the inflow of private capital to the developing industry.

Conclusion

Analysis of global hydrogen energy financing demonstrates that the industry is emerging, yet at a strategically significant stage of development. Skyrocketing inflow of investments reflects both joint efforts for decarbonization and the unleashing potential of hydrogen for hard-to-abate industrial sectors. Notwithstanding the strategic role of hydrogen in tackling climate issues, private investments are curbed by market immaturity, technological constraints and high capital intensity of hydrogen projects. Consequently, the current financial architecture of the hydrogen market is dominated by public finance and multilateral global initiatives, well above private investments.

The analysis underpins the necessity to develop a comprehensive approach to risk mitigation and project management to unlock private investments and unleash the potential of the hydrogen industry. The study suggests that, along with the SPP mechanism deal, structuring and financing from intergovernmental development organizations come as a crucial aspect of risk mitigation within the framework of long-term economic programs.

References

✓ Agora Industry, Wuppertal Institute and Lund University. (2021). Global Steel at a Crossroads. Why the global steel sector needs to invest in climate-neutral technologies in the

2020s. Retrieved from https://www.agora-industry.org/.

- ✓ Bjerde, A. et al. (2024). New platform leverages power of guarantees to boost private financing. Retrieved from https://blogs.worldbank.org/en/voices/new-platform-leverages-power-of-guarantees-to-boost-private-financing.
- ✓ Climate Policy Initiative. (2024). Discussion Paper: Financing Industrial Decarbonization: Challenges and Solutions for India's and Steel Sector. Retrieved from https://www.climatepolicyinitiative.org/wp-content/uploads/2024/04/Financing-Industrial-Decarbonization.pdf.
- ✓ Cordonnier, J. and D. Saygin. (2023). "Financing solutions to foster individual decarbonization in emerging and developing economies". OECD Environment Working Papers, No. 226, OECD Publishing, Paris. Retrieved from https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/11/financing-solutions-to-foster-industrial-decarbonisation-in-emerging-and-developing-economies_02297390/24a155ab-en.pdf.
- ✓ Fitch. (2023). Spotlight: Project-Financed Green Hydrogen. Retrieved from https://www.fitchratings.com/research/infrastructure-project-finance/spotlight-project-financed-green-hydrogen-02-05-2023.
- ✓ Global Infrastructure Hub. (2020). InfraCompass 2020. Set your infrastructure policies in the right direction. Retrieved from https://content.gihub.org/live/media/2114/infracompass-2020-report-web-optimised.pdf.
- ✓ GHO. (2022). Green Hydrogen Contracting for People and Planet: Guidance and good practice for decision makers. Retrieved from https://gh2.org/sites/default/files/2022-05/GH2_Contracting%20booklet_2022_A5_FINAL_REF%20ONLY.pdf.
- ✓ Hovy, P. (2015). Risk Allocation in Public-Private Partnerships: Maximizing value for money. Retrieved from https://www.iisd.org/system/files/publications/risk-allocation-ppp-maximizing-value-for-money-discussion-paper.pdf.
- ✓ IEA. (2021). Enhancing Collaboration Between Multilateral Initiatives. Retrieved from https://www.iea.org/reports/enhancing-collaboration-between-multilateral-initiatives.
- ✓ IEA. (2024). Global Hydrogen Review. Retrieved from https://www.iea.org/reports/global-hydrogen-review-2024.
- ✓ IRENA. (2024). Green hydrogen strategy: A guide to design. Retrieved from https://www.irena.org//media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_Green_hydrogen_strategy_design_2024.pdf.
- ✓ IRENA. (2022). Global hydrogen trade to meet the 1,5°C climate goal: Trade outlook for 2050 and way forward. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Global_hydrogen_trade_part_1_2022_.pdf
- ✓ OECD. (2024). Leveraging De-Risking Instruments and International Co-ordination to Catalyse Investment in Clean Hydrogen. Retrieved from https://www.oecd.org/en/publications/leveraging-de-risking-instruments-and-international-co-ordination-to-catalyse-investment-in-clean-hydrogen_9a377303-en.html.
- ✓ OECD/The World Bank. (2024). Scaling Hydrogen Financing for Development. Retrieved from https://www.oecd.org/en/publications/scaling-hydrogen-financing-for-development_0287b22e-en.html.
- ✓ Pillay, K. et al. (2025). "Evaluating institutional climate finance barriers in selected SADC countries", *Climate Risk Management*, Vol. 47. Retrieved from https://doi.org/10.1016/j.crm.2025.100694.
- ✓ Taghizadeh-Hesary, F. et al. (2022). "Green finance and the economic feasibility of hydrogen projects", *International Journal of Hydrogen Energy*, Vol. 47/58, pp. 24511-24522.
- ✓ The World Bank. (2024). Green Finance: A Bottom-up approach to Track Existing Flows. Retrieved from https://documents1.worldbank.org/curated/en/788041573021878350/pdf/Full-Report.pdf. Retrieved from https://doi.org/10.1016/j.ijhydene.2022.01.111.
- ✓ United Nations Industrial Development Organization (UNIDO). (2024). Mapping of financial and technical assistance of clean hydrogen for developing countries. Retrieved from https://hydrogen.unido.org/sites/default/files/2024-05/MAPPING-digital-final.pdf.
- ✓ Yarygina, I. et al. (2023). "Mechanisms of BRICS financial cooperation in contemporary environment", *Journal of Banking Services*, https://doi.org/10.36992/2075-1915_2023_1_2. https://orcid.org/0000-0001-8684-1684
- ✓ Yarygina, I. et al. (2022). "The Impact of Foreign Direct Investment on the CIS: Econometrics Modeling. DOI: 10.1007/978-3-031-09076-9_5. https://orcid.org/0000-0001-8684-1684