International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2022, 12(5), 392-408.

Comparative Analysis of the Financial Stability of Renewable-based Electricity Companies: The Case for Hydroelectric Organizations

Oksana V. Savchina[1]*, Dmitriy A. Pavlinov[1], Alexander L. Bobkov[2], Natalia Konovalova[3]

[1]Department of Finance and Credit, Faculty of Economics, Peoples' Friendship University of Russia (RUDN University), Moscow, Russian Federation, [2 3]Department of Industrial Economics, Higher School of Economics and Business, Department of the Theory of Management and Business Technologies, Higher School of Management, Plekhanov Russian University of Economics, Russia, [3]Department of Economics and Finance, Faculty of Business and Economics, RISEBA University of Applied Sciences, Riga, Latvia. *Email: savchina-ovl@rudn.ru

Received: 01 July 2022 **Accepted:** 10 September 2022 **DOI:** https://doi.org/10.32479/ijeep.13575

ABSTRACT

Hydroelectricity remains the dominate RES (Renewable Energy Source) and the most developed, reaching growth rate peaks in some countries in the 20th century. However, the share of it has fallen over the last few years, as other renewable sources have received rapid development. Despite this, growth for hydroelectricity has remained stable, with China, India, Japan, Russia, Turkey, France, Norway, Canada, USA and Brazil as market leaders. This article analyzes the key trends of development of the hydroelectricity market as a whole, as well as the financial stability of its organizations using bankruptcy likelihood prediction models. The Brazilian and Russian companies were chosen to assess as both countries are classified as developing markets. The bankruptcy prediction models indicate that overall, the financial stability of hydroelectricity giants of Brazil and Russia is at a high level, though profitability ratios are very low. During the COVID-19 pandemic, several financial support measures were implemented by governments, along with the already existing instruments for stimulating renewable energy growth. Authors' forecasts show that current trends on the market indicate that net addition capacity growth in the next few years will not be enough to meet Net Zero goals for the renewables market.

Keywords: Hydroelectricity, "Green" Energy, Renewable Energy Sources, Financial Stability, Bankruptcy Likelihood Prediction Models, Net-zero Economy

JEL Classifications: G30, L94, Q42, Q25

1. INTRODUCTION

Hydropower holds a crucial role in the economy of many countries, and in the last twenty years, it has only expanded, holding important opportunities for poverty alleviation and sustainable development (The World Bank, www). However, this sector of renewable sources still has significant economic constraints, such as a lack of financing, comprehensive planning, adequately assessed project pipelines, as well as unsettled conditions that can lead to private sector participation discouraged.

Despite this, today, hydroelectricity remains the dominant source amongst "green," renewable electricity sources, providing half of it in the world (International Energy Agency, www). Published in the summer of 2021, the Hydro Special Market Report by the International Energy Agency highlights that hydropower has a higher contribution than nuclear energy, and is larger than all other renewables combined, remaining third in global electricity generation after coal and natural gas. Its' main contribution is evident especially in emerging and developing economies, where it meets almost all of electricity demand in 28 emerging and developing countries. What is more, hydropower plants are one of the most flexible, as they can easily adjust to changes in demand and cover fluctuations in supply from other electricity sources.

Although hydroelectricity has a definite benefit that differs it from wind and solar sources in being able to be easily dispatched at any time, electricity companies still have to consider that energy project diversification is more important now than it has ever been, as the cost of wind and solar is dropping, with efficiencies being up and price competitiveness is being attained for these sources. This is why companies have to coincide with the main trend of hydropower – the move from big dams to a combination of instream turbines and diversified energy sources. Existing dams require investment and diversification with solar and wind power, as the future of hydropower lies within playing a partnering role with solar, biomass and wind and working as a provider of inexpensive energy from instream hydro (Moran et al., 2018).

In many parts of the world, the hydropower is indeed seen as the optimal catalyst for a successful energy transition. Although most investments today are commissioned to solar and wind projects, it should be noted that these sources are variable and are difficult to align with demand. This is where hydropower can gain further growth after a somewhat stagnating growth in the last few years: it can support integration of other renewable sources into the supply grid due to its' flexibility in electricity generation, as well as its' ability to serve as storage capacity. With the largest uncovered potential, hydropower has strong prospects of meeting rising energy demand (Schleiss, 2020).

Many studies have shown that the development of hydroelectricity has an impact on economic growth, especially in the long-term perspective. It has been shown that shortages of hydropower resources can inhibit economic growth, while shocks to hydroelectricity can be passed to the output. As a result, it is important for policymakers to enhance the use of hydroelectricity, as it directly impacts real GDP growth of a country (Solarin and Ozturk, 2015). The impact of real GDP per capita on hydroelectricity energy consumption per capita has previously been described as a positive one and one of statistical significance (Apergis et al., 2016). Researchers note that hydroelectricity energy consumption and economic growth have a bidirectional causality, indicating that such resources help sustain economic production and growth. This highlights the importance of hydroelectricity in the overall development of a country.

Along with economic growth the development of hydroelectricity also provides an economy with many other benefits, in particular social ones: the construction of a dam has social impacts and benefits human well-being – this includes the provision of secure water supply, irrigation for food production and flood control, increased recreational opportunities, improved navigation, further development of fisheries and cottage industries, as well as many others (IEA Hydropower, www). Hydropower is also seen as one of the most efficient power generation technologies, as it is used in many countries is proven to be technologically mature (Kaunda et al., 2012). Restraining factors of the development of this sector include high investment costs, which is why small-scale projects, as previously mentioned, can help developing countries with large hydropower potential to impact further growth of this energy source, creating standalone energy systems for rural power supply. This also makes it possible for hydroelectricity to impact national energy access and security, mitigate risks of climate change in reducing harmful air pollutants, which in return effectively stimulates sustainable development.

Despite hydroelectricity strongly impacting economic growth and having multiple social and ecological benefits, many countries have started to diversify their energy mix in favor of other renewables, largely due to the impact climate change has on this energy sources (for example, reduced rainfalls and droughts). Decreased stream flow can cause insufficient supplies for growing water demands, and, in some cases, hydroelectric production can overall cease within the coming decades (de Jong et al., 2021). Such a case emphasizes the importance of policy initiatives to support their climate goals more seriously, as a handful of countries are highly dependent on hydroelectricity sources. Moreover, reoccurring climate cataclysms have a direct impact on the overall state of the hydroelectric market, effecting the overall financial stability of the sector in the long run.

During the COVID-19 pandemic, electricity supply and demand experienced decreases in total electricity consumption for companies, although residential loads experienced an increase. Electricity generations were also reduced, especially coal-based generation. Renewables, on the other hand, saw an increase in electricity generations, which made the pandemic somewhat of a stimulator for renewable electricity growth (Olabiwonnu et al., 2021). These factors and current tendencies on the renewables market highlight an increased interest in analyzing its' current condition as a whole and at a country-based level. Furthermore, there is a relatively small amount of research dedicated to analyzing the financial stability of the companies on the renewable energy source market (though available research indicate that there is room for improvement for profitability levels of hydroelectric companies (Li, 2019), Thus, this article seeks to identify in what financial condition were the organizations of the largest renewable source in developing countries in a year before the COVID-19 pandemic and in a year during the crisis. As mentioned in our previous work, in 2020, many power plants completely stopped working as businesses shut down, which could have largely affected financial results of electricity companies, including renewable electricity companies, as it was the case during previous crises (Savchina et al., 2016; 2017).

2. DYNAMICS OF THE RENEWABLE ELECTRICITY MARKET AND THE ROLE OF HYDROELECTRICITY IN IT

Under the influence of several global, national and regional initiatives set to transition to a low-carbon economy, the share of renewable "green" energy sources have increased, while traditional nonrenewable sources, such as coal, oil and nuclear sources have decreased their shares in the structure of electricity generation (Savchina, et al., 2021). Over the past 14, total electricity generation from renewable energy sources has grown from 3554 TWh in 2007 to double of that amount in 2020 - 7449 TWh. The compound annual growth rate (CAGR) for this period sits at 5.4% per year (Figure 1). This growth rate is two times higher than the growth rate of the electricity generation market as a whole, which highlights the increasing importance of renewable energy sources.

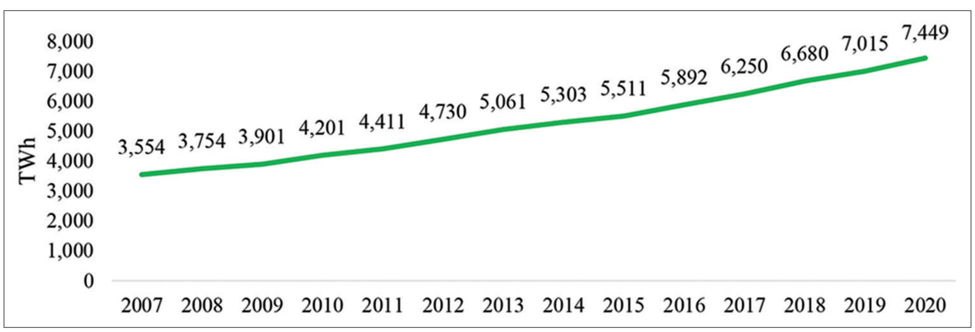
When looking at the CAGRs of each renewable energy source separately, we can see that the key leaders of growth are solar PV, solar thermal and wind - from 2007 to 2020 they amounted to 40.2%, 23.7% and 17.3%, accordingly. Bioenergy, tide, wave and ocean; geothermal and hydroelectricity sources have grown at a CAGR of 7.1%, 6.5%, 3.1% and 2.4%, accordingly (Figure 2). The growth of solar and wind sources has even exceeded earlier forecasts: The International Energy Agency expected that solar energy generation would reach 550 TWh only by 2030, however it managed to reach this number by 2018 (Figure 2). The differences between forecasts and reality mainly have to do with the fact that the growth of these sources was expected to be linear, but turned out to be exponential (World Resources Institute, www).

There are many reasons as to why these renewable sources have seen such growth. For example, falling costs of production: solar photovoltaic, concentrating solar power, offshore wind and onshore wind prices have fallen from USD 0.381/kWh to USD 0.057/kWh (–85.0%), USD 0.340/kWh to USD 0.108/kWh (–68.2%), USD 0.162/kWh to USD 0.084/kwh (–48.1%) and USD 0.089 to USD 0.039/kWh (–56.2%), accordingly (Figure 3), while prices for electricity from biomass, geothermal and hydro sources have either stayed at the same level or gotten higher – by 0.0%, 44.9% and 15.8%, accordingly (International Renewable Energy Agency, www).

Falling prices for wind and solar sources have to do with technological development, which in turn stimulates even further areas of deployment. Furthermore, the growth in popularity of such sources leads to increased political influence (which includes supporting instruments such as renewable energy tax credits and subsidies, feed-in tariffs and competitive auctions, as well as government investments in R&D) and financing, which also makes it easier to attract further policy support and finance. There have also been studies that prove a "contagious" factor of installing PV systems – adding one rooftop system on a block increased the average number of installations with a half mile radius by 0.44, creating a "neighbor effect" (Graziano and Gillingham, 2014).

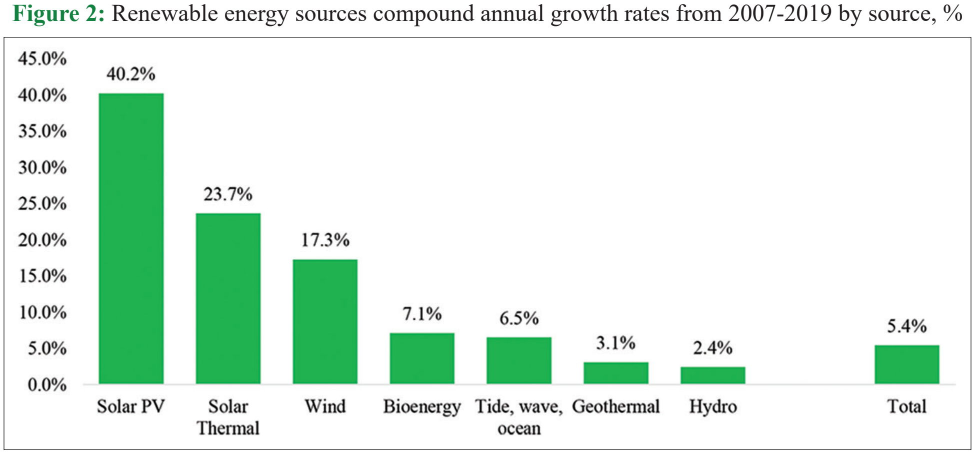
Although solar and wind sources have shown impress growth, especially over the last decade, this article aims to exam the world's largest source of "green" energy – hydropower. Though the share of hydro electricity generation in total renewable electricity has fallen by 28.8 p.p. from 2007 due to the rapid development of wind and solar electricity, it still makes up for the majority of all renewable electricity generation, currently sitting at 57.9% in 2020 (Figure 4) and 45.6% of renewable electricity capacity (down 39.7 p.p. from 2007).

Figure 1: World electricity generation from renewable energy sources in 2007-2020, TWh



Source: Compiled by the authors according to the international energy agency (IEA) www.iea.org

Figure 2: Renewable energy sources compound annual growth rates from 2007-2019 by source, %

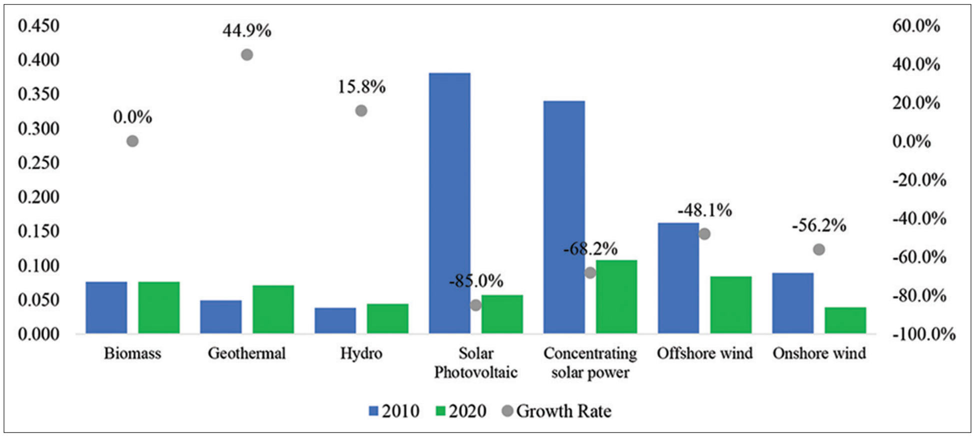


Source: Compiled by the authors according to the international energy agency (IEA) www.iea.org

As mentioned previously, hydroelectricity generation, as a leader of renewable energy, has seen much slower compound annual growth rates than other renewable sources, amounting to 2.4% from 2007 to 2020. Capacity of hydro energy sources has grown by 2.6% annually, which is 5.1 p.p. lower than the compound annual growth rates of capacity from all renewable energy sources. Electricity consumption from hydro energy sources has had the lowest CAGRs amongst key energy indicators, amounting to 1.9% annually from 2007 to 2020 (Figure 5).

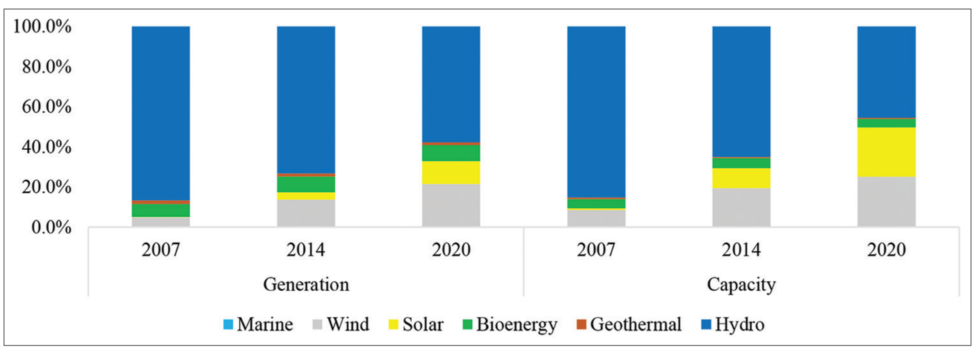
Low CAGRs for hydroelectricity is a trend that each renewable energy source will reach as the growth of these sources goes through an S-shaped curve, where they increase due to the accelerated growth of new technologies, reach a point of maximum growth and then eventually slow down (Cherp et al., 2021). Cherp's study has shown that in countries where solar and wind growth has stabilized at a maximum growth, the current annual growth rates are lower than those needed to meet the 1.5°C goal of the Paris Agreement. This coincides with a recent report from the International Energy

Figure 3: Dynamics of electricity costs by source in 2010 and 2020, USD/kWh, %



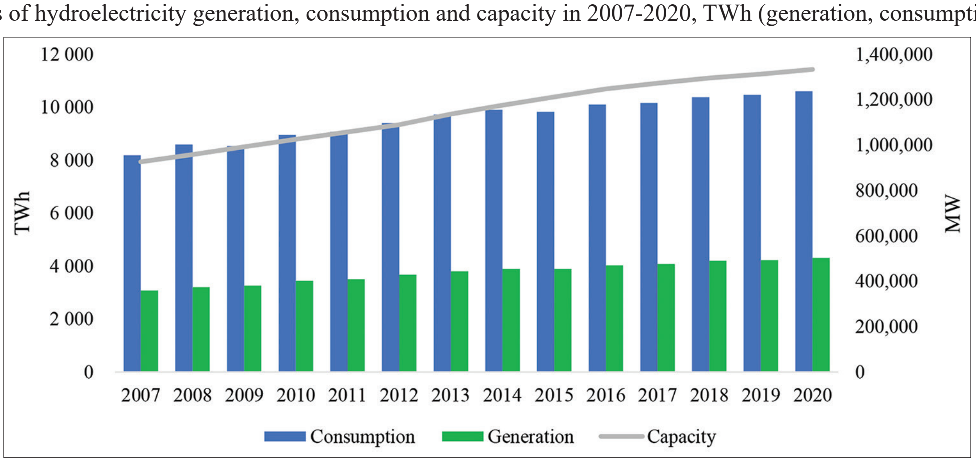
Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

Figure 4: Generation and capacity structure by renewable energy source in 2007, 2014 and 2020, %



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org (capacity), the International Energy Agency (IEA) www.iea.org (generation)

Figure 5: Dynamics of hydroelectricity generation, consumption and capacity in 2007-2020, TWh (generation, consumption), MW (capacity)



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org (capacity), the International Energy Agency (IEA) www.iea.org (generation), BP www.bp.com (consumption)

Agency on the hydro market, where the executive director of IEA, Dr. Faith Birol, has highlighted the importance of hydropower in reaching climate goals: "Hydropower is the forgotten giant of clean electricity, and it needs to be put squarely back on the energy and climate agenda if countries are serious about meeting their net zero goals", states Dr. Birol (International Energy Agency, www).

During the COVID-19 pandemic in 2020, after 5 consecutive years of decline, hydropower capacity additions had rebounded due to the commissioning of several large power plants in China and Turkey (International Energy Agency, www). Significant efforts are needed to accelerate current capacity growth trends for them to be in accordance with the net-zero trajectory. One of the key problems today are ageing hydropower plants, with their average age currently sitting at 32 years, and 40% of global fleet is at least 40 years old. This means that serious modernization plans are required to improve the performance and flexibility of these plants, especially in countries where old plans have a large share in its' renewable electricity – investments are key.

When looking at investments in renewable energy sources of available data from 2013-2018, we can see that over 88% of them have been directed to solar and wind energy sources, amounting to 1586 billion dollars in 2013-2018. Investments in hydroelectricity are currently low, however this source still ranks third amongst all renewable energy sources (4% or 74 billion dollars in 2013-2018). In recent years (2017-2018) investments for hydroelectricity have grown, reaching 26 billion dollars in 2017 and 15 billion dollars in 2018 (Figure 6). A majority of these investments come from project developers (55% in 2018), commercial financial institutions (24% in 2018), households/individuals (9% in 2018), corporate actors (6% in 2018) and institutional investors and funds (6% in 2018).

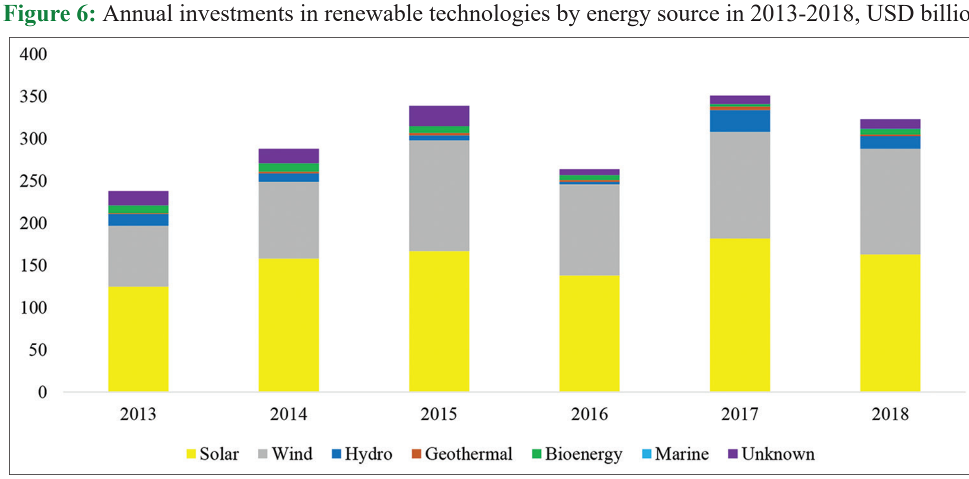
When analyzing renewable energy public investment dynamics separately (for which more data is available), we can note that from 2007 to 2019, hydropower received the most investments – over 37.3%, mainly due to the large role of this energy source in developing countries. However, over time, the share of such investments in the total amount of public investments has fallen – from 84.4% in 2007 to 32.0% in 2014 and 18.0% in 2019 (Figure 7). 89.1% of such finance flows by instrument were in the form of debts, 5.3% – grants, 4.4% – equity and shares in collectives, 1.1% – guarantees and other, and the rest (0.1%) – mezzanine finance.

The impact of hydroelectricity can also be characterized by analyzing the patent landscape and the number of workers that are employed in this sector. From 2007 to 2019 (Figure 8), 33690 patents were registered in the hydroelectricity sector, which makes up 4.2% of total renewable patents registered during this time period (the majority of patents registered were for solar and wind energy sources – 78%). In 2020, hydropower ranked third in terms of total employment (2182 thousand, or 18.2% as a share of total employment in renewable energy).

Finally, to identify the countries whose hydroelectricity companies will be assessed, we will look at the TOP-10 leaders on the market in terms of generation and overall capacity. In 2020, the TOP-10 leaders on the hydropower market when looking at total electricity generated are China, Brazil, Canada, the United States, Russian Federation, India, Norway, Turkey, Japan and Sweden (these countries together made up 73% of total electricity generated through hydro sources in 2020). The TOP-10 leaders on the hydropower market in terms of total capacity are similar, however there are some differences – China, Brazil, the United States, Canada, the Russian Federation, India, Japan, Norway, Turkey and France – these countries make up 68% of total hydroelectricity capacity (Table 1).

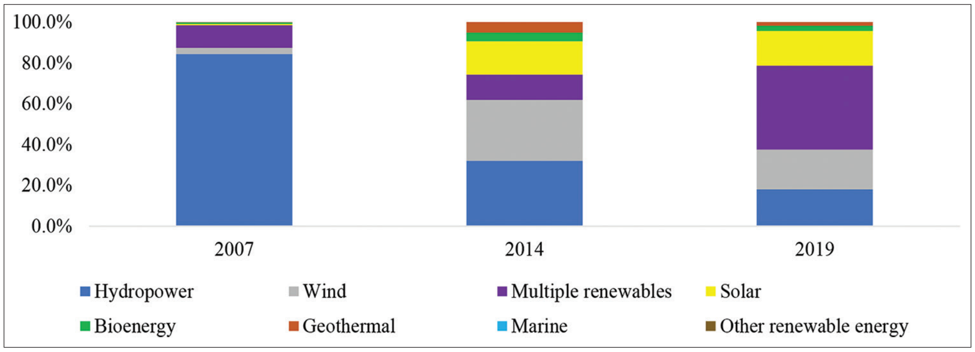
This article aims to analyze the hydroelectricity companies of Brazil and Russia, mainly for two reasons: both countries are a part of BRICS, an associate of five major emerging economies, including China, however unlike China, the generation and capacity values of Brazil and Russia are closer to each other. Though it is important to note that the electricity market models are different – the Russian electricity market model is one that is mostly deregulated, saving regulated parts only in some regions. The Brazilian electricity market model on the other hand has been predominately a regulated one, which occurred after a market reform in the early 2000s (NP Market Advice Association, www). Though in recent years, there have been new legal frameworks in Brazil aimed to modernize and

Figure 6: Annual investments in renewable technologies by energy source in 2013-2018, USD billion



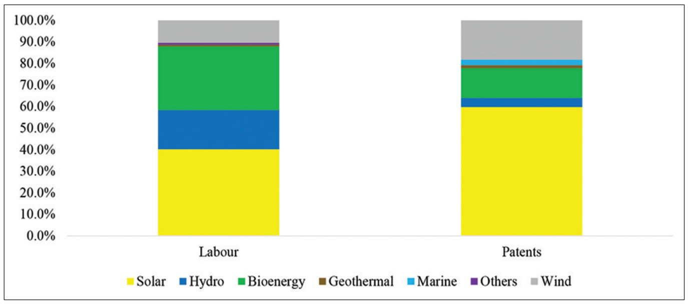
Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

Figure 7: Structure of public investments in renewables by energy source in 2007, 2014 and 2019, %



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

Figure 8: Structure of renewable energy employment (2020) and patents (2007-2019) by sector, %



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

liberalize the energy market, in hopes of increasing private investments (before the COVID-19 pandemic, there were also plans of privatizing hydroelectricity giant Eletrobras). This initiative includes opening the market to new customers, gradually removing subsidies, increasing energy prices and operations cohesion, amongst others (International Hydropower Association, www).

3. THE HYDROELECTRICITY LANDSCAPE OF RUSSIA AND BRAZIL

Hydropower has many important environmental and economic impacts, such as sufficient energy production, employment generation, enhancement of water quality, expansion of working posts offers during power plant constructions, low-cost energy (von Sperling, 2012). It serves as a sustainable substitution for diesel based thermoelectric generation plants.

Hydroelectricity is a vital part of Brazil's economy: in 2020, hydroelectricity made up 29% of primary energy consumed, which is 4 times higher than the share of hydroelectricity in the energy consumption of Russia – 7% (Figure 9). Overall, energy consumption in Brazil is almost equally divided into renewable and non-renewable sources (47% and 53%, accordingly), whereas in Russia, this is not the case: energy consumption from oil, natural gas and coal sources make up 86% of total energy consumption. Energy consumption from other renewable sources (wind, solar, bioenergy) is almost non-existent.

When looking at electricity generation by fuel, the role of hydroelectricity in Brazil becomes even more evident: this source makes up 64% of all electricity generated, a further 19.4% is also made up of other renewables, which highlights the role of such sources on the electricity market of this country (Figure 10). In Russia, the share of hydroelectricity is almost three times lower, however it is still significant and makes up almost a fifth of total electricity generated. As with energy consumed, in Russia most electricity that is generated comes from non-renewable sources, primarily natural gas (44.7%) and coal (14.0%).

The structure of renewable installed electricity capacity also highlights the dominant position of hydroelectricity: in Russia, hydropower makes up 95.5% of total renewable electricity capacity installed, with solar, bioenergy, wind and geothermal amounting to 2.6%, 2.5%, 1.7% and 0.1%, accordingly (Figure 11). In Brazil, the structure of installed renewable electricity capacity is more diverse, however hydropower still tops the list at 72.9%, followed by wind (11.5%), bioenergy (10.4%) and solar (5.3%).

In 2007-2020, energy consumption from hydroelectricity in Brazil experienced negative compound annual growth rates (-0.1%), while in Russia they were positive and totaled to 0.8% per annum. This mainly is because hydroelectricity's peak growth rates came earlier than the period that is being assessed (Figure 12). Brazil has been using hydroelectric power since the late 19th century, with the 1960s and 1970s being the years of increased investment for large plants (von Sperling, 2012). Today (Statista, www), Brazil has two of the largest hydroelectric dams in the world (Itaipu Dam with 14 GW of generating capacity and Tucuruí with 8.37 GW of generating capacity in 2019), while Russia has one – Krasnoyarsk with 6 GW in 2019 (Figure 13). Hydroelectricity generation in Brazil in 2007-2020, on the other hand, had a CAGR of 0.4%, in Russia – 1.3% (Figure 14). Finally, hydroelectric capacity installed in Brazil grew at a 2.5% rate annually, whereas in Russia the growth rates were lower by 1.8 p.p. at 0.7% (Figure 15).

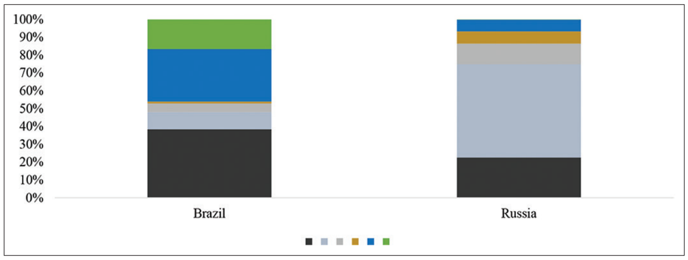
In terms of social impacts, 175.8 thousand people are employed in the hydropower sector in Brazil, which makes up for 14.6% of total workforce in renewable energy. In Russia, the absolute value of workers is lower (57.6 thousand people), however they make up most of total workforce employed in renewable energy sectors – 78.8% (Figure 16). Innovation development in the forms

Table 1: TOP-10 countries in hydroelectricity generation and capacity in 2020, TWh (generation), MW (capacity), % (where noted)

Serial number	Country	Generation - TWh	Generation - %	Country	Capacity - MW	Capacity - %
1	China	1322	30.8	China	370,160	27.8
2	Brazil	397	9.2	Brazil	109,318	8.2
3	Canada	385	9.0	US	102,938	7.7
4	US	289	6.7	Canada	81,404	6.1
5	Russia	212	4.9	Russia	52,427	3.9
6	India	164	3.8	India	50,740	3.8
7	Norway	141	3.3	Japan	50,041	3.8
8	Turkey	78	1.8	Norway	33,003	2.5
9	Japan	78	1.8	Turkey	30,984	2.3
10	Sweden	73	1.7	France	25,897	1.9

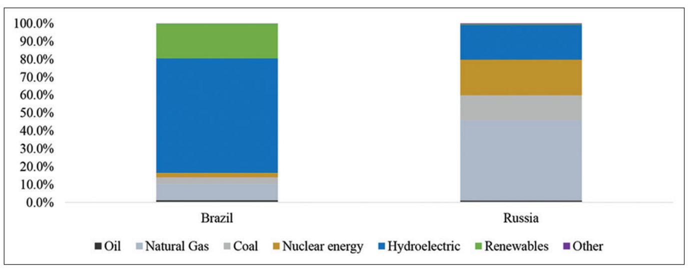
Source: Compiled by the authors according to the IRENA www.irena.org. IRENA: International Renewable Energy Agency

Figure 9: Structure of primary energy consumption in 2020 by fuel, %



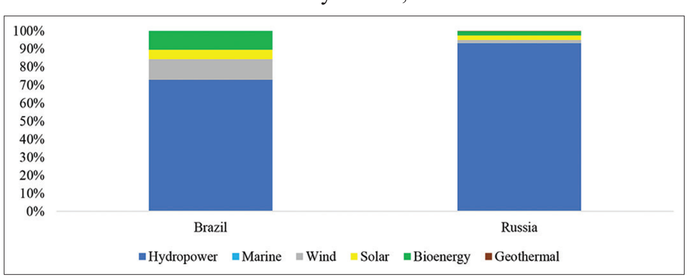
Source: Compiled by the authors according to BP www.bp.com

Figure 10: Structure of electricity generation in 2020 by fuel, %



Source: Compiled by the authors according to BP www.bp.com

Figure 11: Structure of total renewable electricity capacity installed in 2020 by source, %



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

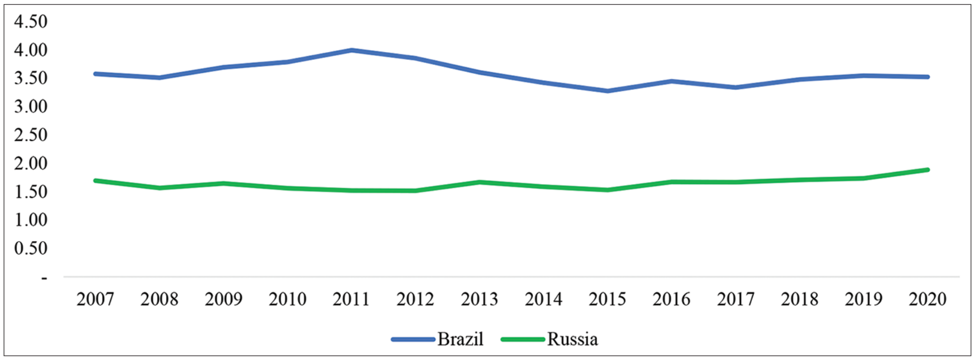
of net additions of patents in hydropower in 2007-2019 was more evident in Russia (Figure 17), where a total of 1202 patents were registered (14.1% of total patents registered in renewable electricity sectors). It should be noted that the traditional approach to the assessment of innovation development involves considering a narrow range of indicators, usually focused on determining economic competitiveness, innovation infrastructure and scientific and production efficiency or R&D costs (Mikhaylova et al., 2019). In Brazil, a total of 301 patents were registered (6.0% of total patents registered). However, for both countries the majority of developments were in bioenergy solar and wind sources (38.0%, 28.0% and 24.8% in Brazil and 21.4%, 25.8% and 32.8% in Russia, accordingly).

Currently, hydropower in Brazil is expected to keep its' position as the largest renewable source for years to come. However, there are still some problems in Brazil's hydropower market landscape, such as hydropower facilities being decades-old, needing modernization for plant operators and grid operators (International Hydropower Association, www). On top of that, in recent years the country has gone through chronic drought, which had led to low levels of precipitation during the wet season. This can lead to major risks as the country is highly dependent on hydropower: reservoirs in 2021 were operating at very low capacity because of this, which can lead to a rise in electricity prices due to a shortage of supply. Despite this, in 2020 Brazil remained the leading country in terms of hydropower capacity added amongst countries in Southern America with an additional 213 MW.

In Russia, the use of hydropower resources in comparison to European countries is very low, indicating huge potential of development, seeing as this resource is considered to be the most efficient and stable renewable energy source in the country (Bogoviz et al., 2020). Reasons as to why they are not as efficiently used include material, monetary and labor resources not being sufficient enough for fast development, an absence of investors for newly built HPSs, demographic problems in the eastern parts of Russia, leading to a deficit in personnel for hydropower engineering. In spite of these problems, Russia was one of the main countries contributing to capacity growth in hydroelectricity in 2020-2021. During the COVID-19 pandemic, Russia managed to commission 4 hydropower plants – Zaramagskaya-1 (346 MW), Verkhnebalkarskaya (10 MW), Ust-Dzhegutinskaya (5.6 MW), Barsuchkovskaya (5.25 MW), and finish an upgraded Irkutsk project, which added an additional 22.9 MW.

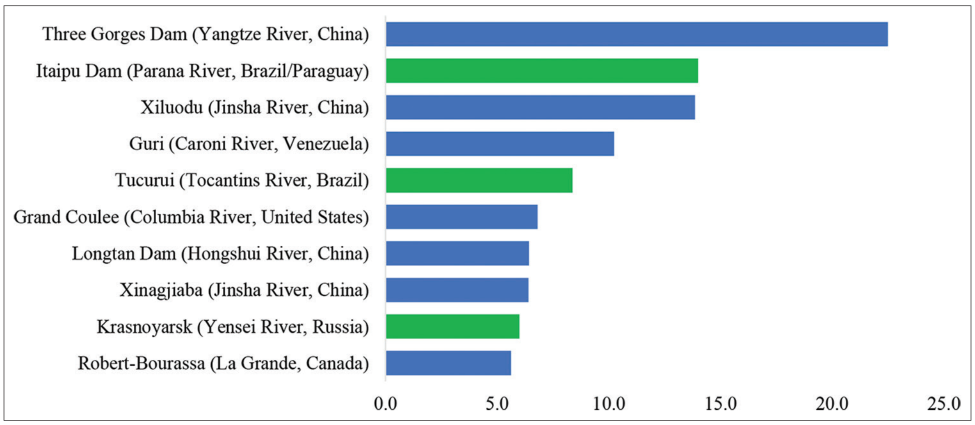
The hydropower sector in both Russia and Brazil is mainly publicly owned and, despite its serious contribution to electricity generation, especially in Brazil, it has struggled financially in recent years (mainly in Brazil). For Brazil, this was a result of a 2012 energy sector reform that was not met well with large state-

Figure 12: Dynamics of energy consumption by hydroelectricity in Brazil and Russia in 2007-2020, exajoules



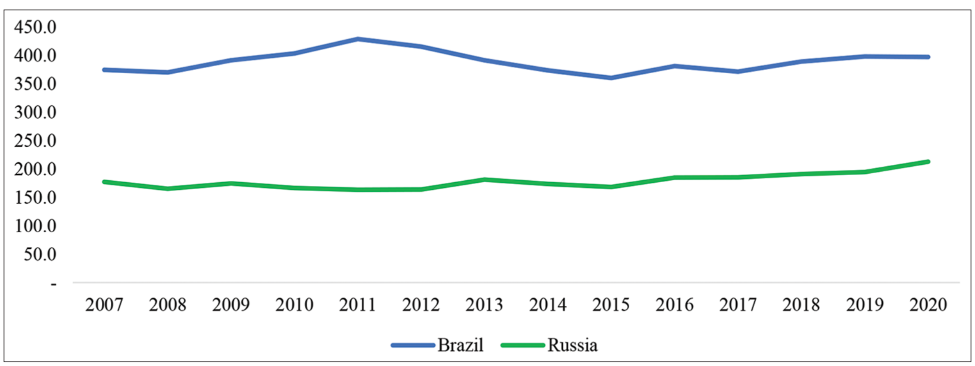
Source: Compiled by the authors according BP www.bp.com

Figure 13: TOP -10 largest hydroelectric dams in 2019, GW



Source: Compiled by the authors according Statista www.statista.com

Figure 14: Dynamics of electricity generation by hydroelectricity in Brazil and Russia in 2007-2020, TWh



Source: Compiled by the authors according BP www.bp.com

owned companies, as they were made to accept unprofitable new terms. This fact highlights the relevance of assessing the degree of the current financial stability of hydroelectricity giants in two leading countries of this sector, as profitability and investment potential are key driving forces in further development of hydroelectricity, which is necessary to meet key climate goals.

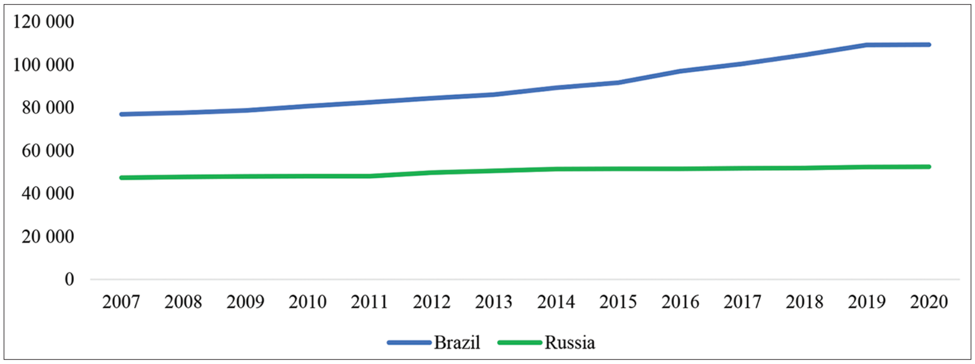
In the next two parts of the article, two hydroelectricity giants from Brazil and Russia will be assessed, in particular Eletrobras and RusHydro, which both rank amongst the TOP-250 global energy companies, according to S&P Global Platts. In 2021, Eletrobras ranked at 63, while RusHydro ranked at 107 (Table 2). For most indicators, Eletrobras has higher values than RusHydro: assets are

Table 2: 2021 S and *P* Global Platts TOP - 250 Energy Company Rankings: set indicators for Eletrobras and RusHydro (in millionUSD and %, where applicable)

Indicator/ Company	Centrais Electricas Brasileiras S.A. – Eletrobras	PJSC Federal Hydro-Generating Co – RusHydro
Assets	35,723	12,886
Revenues	5805	5876
Profits	1265	634
ROIC (%)	5.0	6.0
3 year CGR % revenues	5.9	4.1

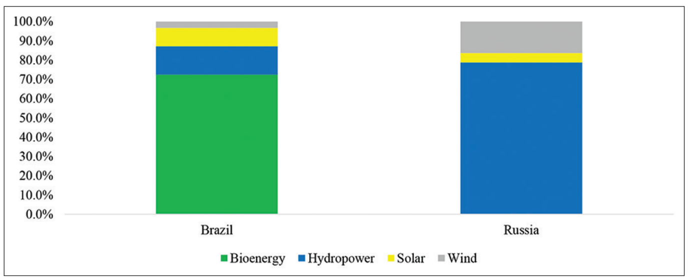
Source: Compiled by the authors according to the The Platts Top 250 Global Energy Company rankings www.spglobal.com. ROIC: Return on invested capital

Figure 15: Dynamics of total electricity capacity installed in hydroelectricity in Brazil and Russia in 2007-2020, MW



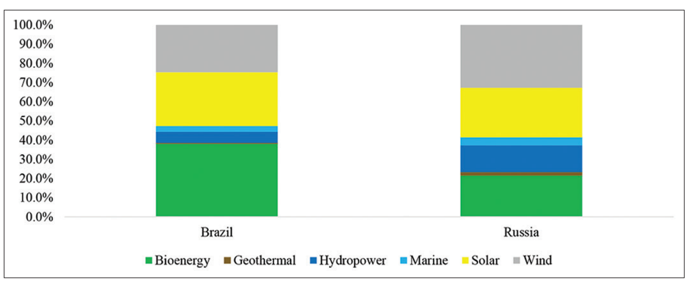
Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

Figure 16: Structure of renewable energy patents registered in Brazil and Russia in 2020 by sector, %



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

Figure 17: Structure of renewable energy employment in Brazil and Russia in 2007-2019 by sector, %



Source: Compiled by the authors according to the International Renewable Energy Agency (IRENA) www.irena.org

2.7 times higher ($35723 million versus $12886 million); profits are 2 times higher ($1265 million versus $634 million), and 3-year compound growth rates of revenues are 1.8 p.p. higher. However, RusHydro has higher revenue values (by 1.1% - $5876 million versus $5805 million) and a higher return on invested capital rates – by 1 p.p.

4. METHODOLOGICAL APPROACH OF ASSESSING THE FINANCIAL STABILITY OF CORPORATIONS USING BANKRUPTCY LIKELIHOOD MODELS

For more than 50 years now, bankruptcy likelihood models have been evolving as significant interest in them amongst researchers increases, especially in periods of economic and financial crises. The breakthrough bankruptcy prediction model was introduced by Altman back in 1968, and since then a lot of research has been dedicated to predicting corporate financial failure (Shi and Li, 2019).

In this article, bankruptcy likelihood models will be used partially not for their initial purpose, as the organizations to be assessed have significant government control, so the actual likelihood of them becoming bankrupt is almost minimal. However, as most of the models that will be used require calculating key financial ratios, they help identify the current level of financial stability of a company, and highlight its' main weak spots.

A total of three bankruptcy prediction models will be used to assess the financial stability of Eletrobras and RusHydro. Two models are largely popular and frequently used amongst researchers all over the world, and are quite similar in usage – these models are the Altman's Z-score model and Ohlson's O-score for predicting bankruptcy.

Altmans Z-score models have had many modifications and different types of this model are used depending on the companies that are being assessed. In our case, since both companies function in countries that are classified as ones with emerging markets, we will be using the EM Z-score that was developed by Altman in 1995. The formula for this model is as follows (Altman, 2005):

$$EM\ Score = 6.56 * X1 + 3.26 * X2 + 6.72 * X3 + 1.05 * X4 + 3.25 \quad (1)$$

where:
X1 – working capital/total assets
X2 – retained earnings/total assets
X3 – operating income/total assets
X4 – book value of equity/total liabilities

An EM score that is larger than 2.60 means that the likelihood of bankruptcy is low, indicating that the company is financially stable. If the EM score lies between more than 1.10, but < 2.60, we cannot make a certain conclusion of the financial state of a company. Finally, if the EM score is lower than 1.10, the situation of a company can be seen as critical, with a high chance of bankruptcy within the next couple of years.

The Ohlson bankruptcy prediction model is a bit more complex in terms of the number of indicators used. Ohlson also questioned the discriminate analysis method that was implied by Altman, nothing that the model imposed restrictive statistical requirements. So, to overcome these limitations, Ohlson employed logistic regression to calculate the likelihood of company failure (Karamzadeh, 2013). The formula for calculating the Ohlson O-score includes nine independent variables (Ohlson, 1980):

$$O-score = -1.32 - 0.407 * SIZE + 6.03 * TLTA - 1.43 * WCTA + 0.0757 * CLCA - 2.37 * OENEG - 1.83 * NITA + 0.285 * FUTL - 1.72 * INTWO - 0.521 * CHIN \quad (2)$$

where:
SIZE – log (total assets/GNP price-level index)
TLTA – total liabilities/total assets
WCTA – working capital/total assets
CLCA – current liabilities/current assets
OENEG – this indicator is equal to 1 if total liabilities exceed total assets and 0 - if otherwise
NITA – net income/total assets
FUTL – funds provided by operations/total liabilities
INTWO – this indicator is equal to 1 if net income has been negative for the last two years, 0 - if otherwise
CHIN – $(NI_t – NI_{t-1})/(|NI_t| + |NI_{t-1}|)$, where NI_t is net income for the most recent period.

It is said that results greater than 0.5 indicate that a firm has a high chance of default.

Finally, the last bankruptcy prediction model that will be calculated for Eletrobras and RusHydro is a model developed by the economist Savitckaya G.V. The purpose of this method is to calculate a set of three key financial indicators and give them a certain number of points. The ratios include return on total capital, equity ratio and current ratio. After giving each indicator a certain number of points (in accordance with Savitckaya's table of classifying companies into classes depending on the level of their solvency, see Table 3), they are totaled and each organization is classified into a group, indicating the level of their financial stability and the likelihood of bankruptcy (Savitckaya, 2002).

Due to the scoring table having only interval values for each indicator, for a more accurate calculation when needed a system of equations was formed and the key parameters were identified. For example, if the return on total capital for a company was calculated as 22.7%, we can see that in Savitckaya's table this value is in the range of the 2 class: companies whose return of total capital value is equal to 29.9% earn 49.9 points, whereas companies whose return on total capital value is equal to 20%, receive 35 points. To calculate the exact number of points for a value that lies in between the maximum and minimum values of a certain class, we will solve (when necessary):

$$\begin{cases} 29.9k + b = 49.9 \\ 20k + b \end{cases} \quad (3)$$

Let b=49.9-29.9k, then:

k=1.5051, b=4.8989, as a result we get an equation: y=1.5051k+4.8989. If we insert the value 22.7% into the equation, we will get 39 points for this organization. After calculating all points for these three financial ratios, we can identify the class of a company.

So, using bankruptcy likelihood prediction models, we will calculate over 10 financial indicators for the most recent years of available full-year financial results for RusHydro and Eletrobras (2019-2020), which will give us an idea on the current level of financial stability of the two major hydroelectricity companies.

5. COMPARATIVE ANALYSIS OF THE FINANCIAL STABILITY OF THE RUSSIAN AND BRAZIIAN HYDROELECTRICITY CORPORATIONS

First, we will calculate the EM-score in 2019 and 2020 for RusHydro and Eletrobras using Altman's Z-model for emerging

Table 3: Classification of companies by the level of their solvency according to G.V. Savitckaya

Indicator	Ranges of values of financial rations for each class				
	1st class	2nd class	3rd class	4th class	5th class
Return of total capital, %	30% and higher – 50 points	From 20% to 29.9% – from 35 to 49.9 points	From 10% to 19.9% – from 20 to 34.9 points	From 1% to 9.9%– from 5 to 19.9 points	Less than 1% – 0 points
Current liquidity ratio	2.0 and higher – 30 points	From 1.70 to 1.99 – from 20 to 29.9 points	From 1.4 to 1.69 – from 10 to 19.9 points	From 1.1 to 1.39 – from 1 to 9.9 points	Less than 1 – 0 points
Equity ratio	0.7 and higher – 20 points	From 0.45 to 0.69 – from 10 to 19 points	From 0.3 to 0.44 – from 5 to 9.9 points	From 0.20 to 0.29 – from 1 to 5 points	Less than 0.2 – 0 points
Total ranges for each class	100 points and higher	From 65 to 99 points	From 35 to 64 points	From 6 to 34 points	0 points
Interpretation	Companies with high financial stability	Companies with slight credit risk, but are still not seen as ones with high risk	Companies with significant problems in their financial stability levels	Companies with a high risk of bankruptcy even after applying countermeasures to improve their financial state. Creditors can loss their money and interests	Companies of severe risk, practically bankrupt

Source: Compiled by the authors according to G.V. Savtiskaya (2002) markets (Table 4). The first indicator, indicated as X1, shows the share of current assets in total assets. In the case of RusHydro and Eletrobras, we can see that for both of them the value of this variable is similar – around 20%, with it increasing in 2020. The next variable, X2, shows the share of retained earnings in total assets, and is also similar for both RusHydro and Eletrobras, amounting to about 10-15%. In 2020 the value of this indicator had increased for both organizations. X3, which is calculated by dividing operating income by total assets, also had an increase in 2020 for both companies due to an increase in operating income, and the values for RusHydro and Eletrobras are quite similar. The last parameter, X4, is where these two companies differ: RusHydro is far less dependent on external financing as its' equity almost doubles its' total liabilities. For Eletrobras, this isn't the case, though the value of X4 is still considered to be high.

The EM-scores for both RusHydro and Eletrobras are almost 3 times higher than the value that indicates that the likelihood of bankruptcy is almost non-existent – in 2019 they were equal to 6.79 and 6.00, accordingly, and in 2020, despite the COVID-19 pandemic, they increased by 0.93 points and 0.49 points and amounted to 7.62 and 6.49, accordingly. These values show that both of these corporations have a very high level of financial stability and currently do not have any major risks that would indicate financial failure.

Next, we will calculate the O-score using Ohlson's model, which includes a larger set of key financial ratios than Altman's model. Calculations of the 9 variables that are included in Ohlson's model indicate the following:

- In terms of asset size, Eletrobras is far larger than RusHydro.
- Eletrobras is more dependent on external resources than RusHydro is, the share of liabilities in total assets is 66% higher.
- The assets structure of these two companies is similar, as current assets for both RusHydro and Eletrobras make up about 20-25% of total assets.
- For both organizations, total liabilities are lower than total assets, which can indicate a high level of risk protection for creditors.
- A similar share of net income is generated from RusHydro's and Eletrobras' assets.
- Both companies have been profitable over the last two years, however during the COVID-19 pandemic, Eletrobras witnessed a decrease in net income levels, whereas RusHydro significantly increased its' profitability.

For both RusHydro and Eletrobras the O-score for 2019 and 2020 had negative values, which also indicate that the likelihood of bankruptcy is low, the corporations have a high level of financial stability (Table 5).

Finally, we will classify RusHydro and Eletrobras into solvency groups by using Savitckaya's scoring model, which includes three key financial ratios – return on total equity, equity ratio and current ratio. For RusHydro, the current ratio in both 2019 and 2020 lied within the normative value range of 1-2, amounting to 1.55 in 2019 and slightly decreasing to 1.40 in 2020. The equity ratio for this company in both 2019 and 2020 was within the normative value of 60% (in particular 62% in 2019 and 65% in 2020). Return on total equity, however, was very low in 2019 (only 0.1%), and higher, but still relatively low in 2020 (7.7%).

For Eletrobras, the current ratio also lied within the normative range (1.57 in 2019 and 1.71 in 2020), however the equity ratio was 19-20% lower than the normative range (40% in 2019 and 41% in 2020). In 2019, profitability rates for total equity were relatively higher, however in 2020 they decreased by 9.9 p.p., totaling to 8.7%. This significantly lowered the overall score for the company from 53 points in 2019 to 47 points in 2020 (Table 6).

The results of the Savitckaya scoring model differ from the results previously obtained using Altman's and Ohlson's models. The solvency groups in which RusHydro and Eletrobras were classified into based on the number of points earned for each ratio calculated indicate that the level of their financial stability is low and there are many risks for creditors and investors. However, we would argue that this is far from the case as the ratios that indicate solvency and liquidity level for both corporations are mostly within the normative range. Such results mainly have to do with the return on total equity ratio giving the greatest number of points (a total of 50, which, for example, led to RusHydro being put into the fourth group in 2019, although the company had high liquidity and solvency rates). So, the results for this model mostly highlight

Table 4: Results of calculating the EM-score of Altman's Z-model for RusHydro and Eletrobras in 2019 and 2020

Altman model parameter	2019		2020	
	RusHydro	Eletrobras	RusHydro	Eletrobras
X1	0.21	0.23	0.22	0.25
X2	0.11	0.13	0.13	0.16
X3	0.02	0.02	0.09	0.05
X4	1.60	0.67	1.83	0.70
EM score	6.79	6.00	7.62	6.49

Source: Calculated and compiled by the authors according to IFRS balance sheets and income statements of PJSC RusHydro and Eletrobras http://www.rushydro.ru/investors/reports/; https://ri.eletrobras.com/en/information/financial-statements/

Table 5: Results of calculating the O-score of Ohlson's model for RusHydro and Electrobras in 2019 and 2020

Ohlson model parameter	2019		2020	
	RusHydro	Eletrobras	RusHydro	Eletrobras
Size	4.31	6.42	4.37	6.52
TLTA	0.38	0.59	0.35	0.59
WCTA	0.21	0.23	0.22	0.25
CLCA	0.64	0.63	0.72	0.58
OENEG	0.00	0.00	0.00	0.00
NITA	0.00	0.06	0.05	0.04
FUTL	0.21	0.04	0.30	0.00
INTWO	0.00	0.00	0.00	0.00
CHIN	−1.00	−0.09	0.97	−0.27
O-score	−0.43	−0.69	−1.74	−0.67

Source: Calculated and compiled by the authors according to IFRS balance sheets and income statements of PJSC RusHydro and Eletrobras http://www.rushydro.ru/investors/reports/; https://ri.eletrobras.com/en/information/financial-statements/; OECD (GNP price-level index) https://data.oecd.org/price/price-level-indices.htm. TLTA: Total liabilities/total assets, WCTA: Working capital/total assets, CLCA: Current liabilities/current assets, NITA: Net income/total assets, FUTL: Funds provided by operations/total liabilities

Table 6: Results of calculating the Savitckaya's scoring model for RusHydro and Electrobras in 2019 and 2020

Indicator/ Company	2019		2020	
	RusHydro	Eletrobras	RusHydro	Eletrobras
Return on total equity, %	0.1	15.6	7.7	8.7
Equity ratio	0.62	0.40	0.65	0.41
Current ratio	1.55	1.57	1.40	1.71
Points for return on total capital	0	28	16	18
Points for equity ratio	16	8	17	9
Points for current ratio	15	16	10	20
Total points	31	53	43	47
Solvency group	Fourth	Third	Third	Third

Source: Calculated and compiled by the authors according to IFRS balance sheets and income statements of PJSC RusHydro and Eletrobras http://www.rushydro.ru/investors/reports/; https://ri.eletrobras.com/en/information/financial-statements/

the problem of low profitability rates of the two hydroelectricity companies, rather than problems of financial instability.

The assessment of the financial stability of RusHydro and Eletrobras using bankruptcy likelihood prediction models has shown that overall, these companies can be characterized as ones with relatively no risk of becoming bankrupt. This is proven by higher liquidity rates, relatively equal or optimal capital structure, and profitable financial results. However, Savtickaya's scoring model indicated that currently, profitability ratios are far too low to firmly classify these organizations as ones with absolute financial stability. Next, we shall assess the main government initiatives that help in stimulating the further development of the hydroelectricity sector of Brazil and Russia, as well as analyze current industry forecasts of this key non-renewable electricity source and build a forecast of our own.

6. SUPPORTING INITIATIVES AND RESTRICTING FACTORS OF THE FURTHER DEVELOPMENT OF HYDROELECTRICITY IN RUSSIA AND BRAZIL CURRENTLY AND IN THE NEAR FUTURE

Recent developments and achievements of Brazil's hydroelectricity sector are evident: in 2020, the Itaipu plant, which is located on the border between Brazil and Paraguay, celebrated a milestone of 2.7 TWh of electricity produced since it started operations in 1984 (International Hydropower Association, www). Furthermore, Companhia Hidreletrica do Sao Francisco (CHESF, a Eletrobras-controlled company), started a pan to modernize the Sobradinho plant (1050 MW). Moreover, not only is Brazil commissioning large investment projects just in hydroelectricity, but it is also becoming one of the leaders to engage in hybrid energy projects, such as the development of a solar floating photovoltaic plant on the 52 MW Batalha hydropower project reservoir.

During the beginning of the COVID-19 pandemic, when demand levels were very low, the Brazilian regulator ANEEL had suspended disconnection due to non-payment for 90 days for residential users and essential services (this measure was adopted on March 23rd, 2020). On top of that, low-income population that paid lower tariffs under a special Social Tariff program did not have to go through periodic checks. A conditional transfer program, Bolsa Família, was reintroduced, as well as a new one, Auxílio Emergencial, was created. On April 20, 2020 ANEEL approved two measures to mitigate the payment of transmission charges by distributors and fee consumers (R$432 million), while on April 15, 2020, it had transferred R$400 million to the Chamber of Electric Energy Commercialization of Brazil (CCEE) to cover for tariff discounts that were granted to social tariff beneficiaries.

The federal government also (under Provisional Measure MP 949/2020) issued a R$900 million to ANEEL's budget so that the agency could finance this resource to the Energy Development Account (CDE), which plays out as a subsidy for authorized discounts. Earlier, on April 7, 2020, ANEEL had authorized CCEE to pass on to distributors almost R$2 billion for future charges relief, which largely helped all of the energy generation, transmission and distribution chain to meet up their payment obligations (The World Bank, www).

As seen in section five of this article, the COVID-19 pandemic had a significant impact on the financial results of Eletrobras. This was largely due to the reduction of power consumption and an increase in payment defaults. As a result, one of the most important supporting measures had been implemented for electricity utilities, the Decree №10350/2020, under which a special "COVID-Account" was created, where funds from bank loans had been deposited to support liquidity levels. In late 2020, Law №14120/2021 was provisioned and including measures to reduce tariff impacts, as well as the privatizations of power utilities in regions of the North and North-East. Under this law, renewable energy projects with authorizations after March 2022 received benefits of discounts on power transmission and distribution tariffs (Chambers and Partners, www).

When looking at Brazil, it is important to note that its' hydropower potential is huge and has no parallel worldwide (Da Silva et al., 2016). Approximately 126 GW of the total remaining hydropower potential of the country can be feasible before 2030. The growth of hydroelectricity in Brazil is also stimulated by small hydroelectric power plants, which have almost no negative environmental influence. However, though large hydroelectric power plants will increase installed capacity by 30.86 GW, while small hydroelectric power plants will increase by 2.0 GW by 2023, it is important to note that the project share of hydroelectricity for the country is set to decline by around 9.3% by 2023, which is mainly a result of the rapid development of wind and bioenergy sources.

Although the share of hydroelectricity of Brazil is expected to fall in its' renewable energy mix, industry forecasts indicate that this energy source will continue to be on top in electricity generation of the country until 2030. In 2030, hydroelectricity generation will account for 58.0% of total annual generation, with it increasing from 374.1 TWh in 2020 to 414.1 TWh by 2030 (Power Technology, www). However, these forecasts note that in Brazil, hydropower is a mature technology and perspectives for future growth are limited: as previously stated, small hydropower projects are where potential future capacity additions can be a possibility.

The growth of hydroelectricity in Brazil, as mentioned in the third section of our research, is also restricted to recurring droughts (in particular during 2014-2017 and 2021). This has made the government become more lenient towards developing other renewables, for example, in its' National Energy Plan 2030 and Ten-Year Energy Plan 2029, the main focus areas of the Brazilian Government are onshore wind and solar photovoltaic (PV). This will overall lead to a reduction of Brazil's dependence on hydropower. This is an important move as climatic and environmental variables have a serious impact on the volume of water available for the generation of energy in hydropower reservoirs (de Souza Dias et al, 2018).

According to the ''Ten Year Energy Expansion Plan to 2029'', developed by The Ministry of Mines and Energy (MME) and the Energy Research Office, an increase in total installed electricity capacity of 75.5 GW is foreseen during this ten-year period, and the majority of it will come from wind, solar and distributed generation. However, it is important to note that this is not a move of restraining further hydropower growth, it is rather a move of attempting to diversify Brazil's energy mix and mitigate drought risks, as well as using the potential Brazil has for developing Solar power, as the country has an average solar radiation that far exceeds leading countries in solar power generation (CMS, www). In terms of financial support, many renewable projects can qualify for the Special Incentive Regime for the Development of Infrastructure (REIDI): this leads to a suspension of certain taxes on goods and services which are employed in developing such projects. Some Brazilian states (in particular Rio de Janerio and Minas Gerais) grant exemptions from state ICMS tax (Tax on Commerce and Services) for distributed generation projects of up to 5 MW). Tax-incentivized infrastructure bonds are also a tool being commonly used for the financial aid of renewable projects.

Russia's hydro resource potential is one of the biggest in the world, holding a firm second place after China, and beating countries such as the US, Brazil and Canada. It has almost 9% of all hydro reserves in the world (Bogush et al., 2016). Although hydroelectricity holds an important role in the energy mix of Russia, the current conditions of it cannot be seen as optimal. PJSC RusHydro, along with many research study organizations, developed a special ''Program of hydropower development of Russia up to 2030 and visions to 2050''. According to this program, the majority of hydro resources in Russia are located in the Far East, which is why development numbers of hydro resources are currently so low at 21.5% (in Siberia, the total amount of economic hydroelectricity potential amounts to 277 TWh). During 2015-2030, a total of 50.96 TWh is expected to be developed, while in 2030-2050 a further 114.69 TWh will be implemented. Additional construction of hydroelectricity stations will help increase Russia's presence on the global hydropower market.

Although there are corporate and regional development programs for hydroelectricity, the future of this sector is yet to be integrated into the National Energy strategy of Russia up to 2035: there are no concrete directions or indicators of its' development, as well as there are no events that would stimulate the growth of this sector (RusHydro, www). What is more, there are significant differences between government strategical planning documents in how they predict growth rates for hydroelectricity development and the realization of hydro power plant construction (IMEMO, www). Along with this, there are still many unsolved problems, such as unresolved regulatory issues concerning the creation of hydro reservoirs, which are objects of Federal property. This includes an absence of requirements for holding events for preparation of flood zones of such reservoirs; of clear financial procedures necessary for such events; of determining the customers of such events and the process of accepting the results of such works. There are also regulatory problems of including planned for construction reservoirs in territorial planning schemes.

The prospective for pumped-storage power plants is also not clear, as there is no economic stimulation for their construction. Most of the minimal number of pumped-storage power plants in Russia work on the edge of bankruptcy. However, the demand in the construction of such plants is only growing year-on-year, as nuclear energy has a low-maneuverability level, and the generation of wind and sand power plants continue to be unregulated. There are also many restrictive factors in the development of small hydro power plants, such as a small volume of quotas for small hydro power plant projects in stimulating renewable programs and high and unnecessary requirements for such projects. However, RusHydro is highly interested in developing small hydro power plants, as they see them as the key driver of company growth by 2035 – total contribution to such growth is estimated to be $258 bln (Energy and Industry of Russia, www).

In terms of financial support, the Russian legal and regulatory framework installs certain rules on wholesale and retail energy trading and offers a set of incentives. In 2011, promotion of renewable energy sources through the capacity market was introduced. The scheme aimed to ensure financial profitability of investments into renewables by concluding ''Capacity Supply Agreements'' with renewable energy sources project developers. In 2013, under the governmental decree №449, this scheme was further developed. This decree established criteria for selecting new renewable energy sources projects and for their supply agreements. The capacity supply agreements obligate a distribution system operator (a grid company) to purchase electricity from renewable energy sources facilities to compensate for transmission losses. In return, such projects gained long-term tariffs, which guaranteed ROI for more than 15 years (CMS, www). There are other financial, legal and tax measures at local, regional and federal levels for renewable projects, mainly depending on the specifics of a particular project. However, it is important to note that these measures are somewhat restricted, as only projects with a certain share of the Russian technology and locally produced components that are used can qualify for a favorable pricing regime.

The Ministry of Economic Development of the Russian Federation released a governmental decree №1587 in September of 2021, which set the taxonomy criteria for sustainable development projects (The Ministry of Economic Development of the Russian Federation, www). According to the decree, sustainable energy projects, including all hydroelectricity projects (in the first variation of the decree only small hydro power plants were seen as "green" projects) can receive "green" financial aid. Such financial support includes government subsidies, as well as preferential rates for loan and tax payments (Izvestiya, www).

Industry forecasts, which are mostly based on a Net Zero Emissions by 2050 Scenario, set hydropower to have a 3% average annual generation growth rate between 2020 and 2030, which would lead total hydroelectricity generation to reach 5870 TWh of electricity. These forecasts note that in order to meet such a level, a total of 48 GW of new capacity has to be connected to the grid every year during these 10 years. The International Energy Agency highlights that stronger efforts are needed to achieve such a goal, especially in streamline permitting and project sustainability (International Energy Agency, www).

Considering current trends and using the Least Squares Method (LSM), we will build a forecast of hydroelectricity capacity net additions in 2021-2025. For this we will use previous data from 2001-2020 (Table 7).

In accordance with the Least Squares Method, we will calculate parameters of a and b from this system of equations:

$$\begin{cases} na + b\sum t = \sum y_t \\ a\sum t + b\sum t^2 = \sum y_t t \end{cases} \quad (4)$$

$$\begin{cases} 20a = 551 \\ 770b = 394 \end{cases} \quad (5)$$

From the first equation we will express a, then we will insert the value of a into the second equation to get b. By doing this, we get that a is equal to 27.55, while b is equal to 0.52. So, we get our final forecast equation of $y_{t=}$27.55+0.52t. By inserting the t values for 2021-2025 (which are equal to 11, 12, 13, 14 and 15), we predict that the next additions of hydroelectricity capacity will equal to 33 GW in 2021, 34 GW in 2022 and 2023, and 35 GW in 2024 and 2025, which is much lower than the 42 GW per year necessary to meet the Net Zero goals (Table 8). This forecast once again highlights that current trends on the hydroelectricity market indicate that not enough is being done to reach climate goals, so governments have to not forget about their targets for their relative hydroelectricity markets in the midst of rapid development of other renewables, in particular solar and wind resources. Using our forecast trend, the value of 42 GW is only feasible by 2038 (again considering current trends, if additional development initiatives are implemented, this trend will change).

Using the same method, we also forecasted the approximate impact of each leading country in hydroelectricity in net additions of total capacity (in particular China, India, Japan, Russia, Turkey, France, Norway, Canada, USA and Brazil). On average in 2001-2020, China accounted for 50.4% of total net additions of hydroelectricity capacity, Brazil – 10.1%, India – 5.3%, Turkey – 3.6%, Canada – 2.7%, Russia – 1.5%, France – 0.7%, Japan and the United States – 0.6% and Norway – 0.2%. In accordance with current market trends and our least squares method forecast, China, Brazil, Turkey, India and Norway will lead in net additions of total hydroelectricity capacity, accounting on average for 50.6%, 10.1%, 5.9%, 5.3% and 2.1% of net additions in 2021-2025, while Russia, the US, Japan, Canada and France will account for 0.8%, 0.7%, 0.6%, 0.5% and 0.3%, accordingly.

Table 7: Factual and estimated data necessary for building a trend line of hydroelectricity capacity net additions (2000-2020), GW

Year	Y_t	t	t^2	Y_t*t	Y_t=a + b*t
2001	8	−10	100	−77	22
2002	13	−9	81	−116	23
2003	20	−8	64	−162	23
2004	22	−7	49	−156	24
2005	26	−6	36	−154	24
2006	24	−5	25	−120	25
2007	31	−4	16	−124	26
2008	31	−3	9	−94	26
2009	35	−2	4	−69	27
2010	34	−1	1	−34	27
2011	31	1	1	31	28
2012	33	2	4	66	29
2013	47	3	9	141	29
2014	39	4	16	156	30
2015	36	5	25	180	30
2016	35	6	36	211	31
2017	26	7	49	181	31
2018	23	8	64	183	32
2019	16	9	81	146	32
2020	21	10	100	207	33
Total	551	0	770	394	-

Source: Compiled by the authors using data from the IRENA www.irena.org. IRENA: International Renewable Energy Agency

Table 8: Estimated net additions of hydroelectricity capacity for 2021-2025, GW

Year	t	yt=a+bt
2021	11	33
2022	12	34
2023	13	34
2024	14	35
2025	15	35

Source: Compiled by authors using data from the IRENA. IRENA: International Renewable Energy Agency

7. CONCLUSION

Current growth rates of the renewables energy market that are higher than the growth rates of the energy market as a whole highlight their increasing role. Today, the world's largest source of ''green'' energy is hydropower: though the share of this source has decreased, it still remains dominant in total renewable electricity generation, consumption and capacity. It also remains an important source to develop in order for countries to meet their net-zero goals. 2020 marked a resurgence in hydroelectricity capacity growth, largely due to capacity additions from China and Turkey. Overall investments in hydroelectricity remain low in comparison to wind and solar electricity sources, however public investments in particular remain high. The leaders on the market in terms of overall capacity are China, Brazil, US, Canada, Russia, India, Japan, Norway, Turkey and France.

Though the electricity markets of Brazil and Russia differ in aspects of ownership and regulation status, there are trends in Brazil that are aimed to make the market more liberal, as it is in Russia. Both countries are a part of the BRICS association and have somewhat similar generation and capacity values (which can become even more similar if initiatives of developing Russia's full hydroelectric potential are implemented). Hydroelectricity remains a vital part of Brazil's economy, making up 64% of all electricity generated in the country, and is a less vital, but still quite significant part of Russia's electricity mix, making up a fifth of total electricity generated. On the renewables market, hydroelectricity is dominant in both countries, though Brazil is far more diverse: this is a result of government initiatives supporting bioenergy, wind and solar development due to the recent occurrences of chronic droughts. In Russia, problems in developing its' hydroelectricity potential have to do with a weak regulatory background and weak investment values.

The calculation of bankruptcy likelihood prediction models of Altman and Ohlson for RusHydro and Eletrobras gave similar results: the EM- and O-scores of these companies indicate a high level of financial stability, however for Eletrobras, its' financial state slightly worsened during the COVID-19 pandemic in 2020, while RusHydro improved its' results. On the other hand, Savitckaya's scoring model indicated that these companies have issues when it comes to profitability ratios. Despite this, overall, they can be classified as companies with relatively no risk of becoming bankrupt, as solvency and liquidity ratios remain stable and, in some cases, higher than normative values.

During the COVID-19 pandemic, some financial measures were implemented by regulatory bodies in Brazil and Russia to support electricity markets: this includes payment transmissions to cover for tariff discounts, subsidies, loans for meeting payment obligations, the creation of a special ''COVID-Account'' (Brazil), discounts on power transmission and distribution tariffs. These measures coincide with already existing measures to support the renewables sector, such as suspension of certain taxes of goods and services, grant exemptions, tax-incentivized infrastructure bonds, government subsidies and preferential rates for loan and tax payments.

Though the potential of further growth for the hydroelectricity sector of Brazil is large, it is a mature technology with reoccurring risks in form of droughts, so government support lies within different renewable sources, though there is hope for small hydropower projects. In Russia, there is also huge potential for the development of hydroelectricity, especially in regions of the Far East, however current government initiatives are not strong enough for it to develop properly.

Our forecasts on net additions of total hydroelectricity capacity indicate that currently, trends show a slower growth than needed in order to meet climate goals. If we go by development in recent years, China, Brazil, Turkey, India and Norway are expected to stimulate this growth, though if the regulatory landscape of Russia in this sector improves, creating a more investment-friendly environment, it can also largely contribute to growth.

8. ACKNOWLEDGMENT

This paper has been supported by the RUDN University Strategic Academic Leadership Program (recipient - Oksana V. Savchina, research methodology; Dmitriy A. Pavlinov, data analysis).

REFERENCES

Altman, E.I. (2005), An emerging market credit scoring system for corporate bonds. Emerging Markets Review, 6(4), 313-314.

Apergis, N., Chang, T., Rangan, G., Ziramba, E. (2016), Hydroelectricity consumption and economic growt nexus: Evidence from a panel of ten largest hydroelectricity consumers. Renewable and Sustainable Energy Reviews, 62, 323-324.

Bogoviz, A., Lobova, S., Alekseev, A. (2020), Current state and future prospects of hydro energy in Russia. International Journal of Energy Economics and Policy, 10(3), 486-487.

Bogush, B.B., Haziahmetov, R.M., Bushuev, V.V., Voropaj, N.I., Bellendir, E.N., Vaksova, E.I., Chemodanov, V.I., Podkoval'nikov, S.V. (2016), Osnovnye polozheniya programmy razvitiya gidroenergetiki Rossii do 2030 goda i na perspektivu do 2050 goda. Gidroenergetika XXI veka: Rossiya i mirovaya integraciya, 1, 4-7.

BP. (2021), Statistical Review of World Energy-All Data, 1965-2020. Available from: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html [Last accessed on 2021 Dec 03].

Chambers and Partners. (2021), Alternative Energy and Power 2021. Available from: https://practiceguides.chambers.com/practice-guides/comparison/679/7117/11489-11498-11504-11508-11514-11525 [Last accessed on 2022 Jan 21].

Cherp, A., Vinicenko, V., Tosun, J., Gordon, J.A., Jewell, J. (2021), National growth dynamics of wind and solar power compared to the growth required for global climate targets. Nature Energy, 6(7), 750-751.

CMS Legal Services EEIG. (2020), Renewable Energy Law and Regulation in Brazil. Available from: https://cms.law/en/int/expert-guides/cms-expert-guide-to-renewable-energy/brazil [Last accessed on 2021 Dec 10].

CMS Legal Services EEIG. (2020), Renewable Energy Law and Regulation in Russia. Available from: https://cms.law/en/int/expert-guides/cms-expert-guide-to-renewable-energy/russia [Last accessed on 2021 Dec 11].

da Silva, R.C., de Marchi Neto, I., Seifert, S.S. (2016), Electricity supply security and the future role of renewable energy sources in Brazil. Renewable and Sustainable Energy Reviews, 59, 328-341.

de Jong, P., Barreto, T.B., Tanajura, C.A., Oliveira-Esquerre, K.P., Kiperstok, A., Torres, E.A. (2021), The impact of regional climate change on hydroelectric resources in South America. Renewable Energy, 173, 76-91.

de Souza Dias, V., da Luz, M.P., Medero, G.M., Ferreira Nascimento, D.T. (2018), An overview of hydropower reservoirs in Brazil: Current situation, future perspectives and impacts of climate change. MDPI-Water, 10(5), 14-15.

Eletrobras. (2021), Financial Statements. Available from: https://ri.eletrobras.com/en/information/financial-statements [Last accessed on 2022 Jan 18].

Energy and Industry of Russia. (2021), Russia's Hydroelectricity has Serious Potential for Growth (in Russian). Available from: https://www.eprussia.ru/news/base/2021/5631674.htm [Last accessed on 2021 Nov 27].

IEA Hydropower. (2000), Hydropower and the World's Energy Future-The Role of Hydropower is Bringing Clean, Renewable, Energy to the World. Available from: https://www.ieahydro.org/media/ffab53b0/Hydropower%20and%20the%20World's%20Energy%20Future%20.pdf [Last accessed on 2022 Jan 23].

Institute of World Economy and International Relations (IMEMO). (2018), Prospects of Development of Hydroelectricity in Russia in Current Economic Conditions (in Russian). Available from: https://www.imemo.ru/files/File/ru/conf/2018/21122018/PREZ/02-18-Zakharov-Velikorossov-ETC.pdf [Last accessed on 2021 Nov 28].

International Energy Agency. (2020), Explore Historical Data and Forecasts for all Renewables Sectors and Technologies. Available from: https://www.iea.org/articles/renewables-2020-dataexplorer?mode=market&region=World&product=Total [Last accessed on 2021 Nov 30].

International Energy Agency. (2021), Analysis and Forecast to 2026: Renewables 2021. Available from: https://iea.blob.core.windows.net/assets/5ae32253-7409-4f9a-a91d-1493ffb9777a/Renewables2021-Analysisandforecastto2026.pdf [Last accessed on 2022 Jan 15].

International Energy Agency. (2021), Hydropower has a Crucial Role in Accelerating Clan Energy Transitions to Chieve Countries' Climate Ambitions Securely. Available from: https://www.iea.org/news/hydropower-has-a-crucial-role-in-accelerating-clean-energy-transitions-to-achieve-countries-climate-ambitions-securely [Last accessed on 2022 Jan 04].

International Energy Agency. (2021), Hydropower Special Market Report. Available from: https://www.iea.org/reports/hydropower-special-market-report [Last accessed on 2022 Jan 10].

International Energy Agency. (2021), Hydropower. Available from: https://www.iea.org/reports/hydropower [Last accessed on 2021 Dec 18].

International Hydropower Association. (2017), 2017 Hydropower Status Report. Available from: https://www.hydropower.org/publications/2017-hydropower-status-report#:~:text=The%202017%20Hydropower%20Status%20Report,new%20capacity%20added%20in%202016 [Last accessed on 2022 Jan 12].

International Hydropower Association. (2018), 2018 Hydropower Status Report. Available from: https://www.hydropower.org/publications/2018-hydropower-status-report [Last accessed on 2022 Jan 12].

International Hydropower Association. (2021), 2021 Hydropower Status Report. Available from: https://www.hydropower.org/publications/2021-hydropower-status-report [Last accessed on 2022 Jan 12].

International Renewable Energy Agency. (2020), Global Landscape of Renewable Energy Finance 2020. Available from: https://www.irena.org/publications/2020/Nov/Global-Landscape-of-Renewable-Energy-Finance-2020 [Last accessed on 2022 Jan 09].

International Renewable Energy Agency. (2020), Renewable Energy Employment by Country. Available from: https://www.irena.org/Statistics/View-Data-by-Topic/Benefits/Renewable-Energy-Employment-by-Country [Last accessed on 2022 Jan 09].

International Renewable Energy Agency. (2021), Renewable Energy Finance Flows-Public Investment Trends in Renewables. Available from: https://irena.org/Statistics/View-Data-by-Topic/Finance-and-Investment/Renewable-Energy-Finance-Flows [Last accessed on 2022 Jan 08].

International Renewable Energy Agency. (2021), Renewable Energy Patents Evolution-Net Additions. Available from: https://www.irena.org/Statistics/View-Data-by-Topic/Innovation-and-Technology/Patents-Evolution [Last accessed on 2022 Jan 09].

International Renewable Energy Agency. (2021), Renewable Energy Statistics 2021. Available from: https://irena.org/publications/2021/Aug/Renewable-energy-statistics-2021 [Last accessed on 2021 Dec 20].

International Renewable Energy Agency. (2021), Renewable Power Generation Costs in 2020. Available from: https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020 [Last accessed on 2022 Jan 04].

International Renewable Energy Agency. (2021), Trends in Renewable Energy-Cumulative Capacity. Available from: https://public.tableau.com/views/IRENARETimeSeries/Charts?:embed=y&:showVizHome=no&publish=yes&:toolbar=no [Last accessed on 2022 Jan 03].

Izvestiya. (2021), Total Hydro Electricity Plants: Business is Asking for an Easier Access to "Green" Finance (in Russian). Available from: https://iz.ru/1158128/valerii-voronov/polnyi-ges-biznes-poprosil-oblegchit-dostup-k-zelenomu-finansirovaniiu [Last accessed on 2021 Nov 20].

Karamzadeh, M.S. (2013), Application and comparison of Altman and Ohlson models to predict bankruptcy of companies. Research Journal of Applied Sciences Engineering and Technology, 5(6), 2007-2011.

Kaunda, C.S., Kimambo, C.Z., Torbjorn, K.N. (2012), Hydropower in the context of sustainable energy supply: A review of technologies and challenges. International Scholarly Research Notices, 2012, 11-13.

Li, Y. (2019), Profitability analysis of hydropower enterprises-take GGEP as an example. IOP Conference Series Materials Science and Engineering, 612(4), 5-8.

Mikhaylova, A.A., Mikhaylov, A.S., Savchina, O.V. (2019), Macroeconomic dataset for comparative studies on coastal and inland regions in innovation space of Russia. Data Brief, 27, 104640.

Ministry of Economic Development of the Russian Federation. (2021), The Government of Russia has Accepted Criteria for Green Projects (in Russian). Available from: https://www.economy.gov.ru/material/news/pravitelstvo_rossii_utverdilo_kriterii_zelenyh_proektov.html [Last accessed on 2021 Nov 21].

Moran, E.F., Lopez, M.C., Moore, N., Müller, N., Hyndman, D.W. (2018), Sustainable hydropower in the 21st century. Proceedings of the National Academy of Sciences of the United States of America, 115(47), 11894-11896.

NP Market Advice Association. (2022), International Electricity Markets-General Information. Available from: https://www.np-sr.ru/ru/market/cominfo/foreign/index.htm#1 [Last accessed on 2022 Jan 11].

OECD. (2021), Price Level Indices. Available from: https://data.oecd.org/price/price-level-indices.htm [Last accessed on 2022 Jan 18].

Ohlson, J.A. (1980), Financial ratios and the probabilistic prediction of bankruptcy. Journal of Accounting Research, 18(1), 109-131.

Olabiwonnu, O.F., Bakken, T.H., Jnr, B.A. (2021), The role of hydropower in renewable energy sector toward CO_2 emission reduction during the COVID-19 pandemic. International Journal of Green Energy, 19(1), 52-61.

RusHydro. (2020), V Gosdume Obsudili Perspektivy Razvitiya Gidroenergetiki Rossii. Availablr from: http://www.rushydro.ru/press/news/112189.html [Last accessed on 2021 Nov 30].

RusHydro. (2021), Financial Statements in Accordance to IFRS. Available from: http://www.rushydro.ru/investors/reports [Last accessed on 2022 Jan 18].

Savchina, O.V., Pavlinov, D.A., Savchina, O.V. (2021). Financial stability of electricity companies in the context of the macroeconomic instability and the COVID-19 pandemic. International Journal of Energy Economics and Policy, 11(5), 85-98.

Savchina, O.V., Savchina, O.V., Asinovich, A.V., Kosyakov, M.A., Bobkov, A.L. (2017), Energy sector of the Russian fsederation in the context of macroeconomic instability. International Journal of

Energy Economics and Policy, 7(5), 28-33.
Savchina, O.V., Savchina, O.V., Bobkov, A.L., Sharashidze, A.Z. (2016), On the state of the mortgage market in the Russian federation in the conditions of global economic crisis. Journal of Applied Economic Sciences, 11(6), 1096-1103.
Savitckaya, G.V. (2002), Analiz Hozyajstvennoj Deyatel'nosti Predpriyatiya: Ucheb. Posobie 7-e izd., ispr. Mn.: Novoe znanie, 704 s. (Ekonomicheskoe Obrazovanie).
Schleiss, A.J. (2020), The importance of hydropower development for the energy transition in Europe. Conference: 11th ICOLD European Club Symposium, p. 7-8.
Shi, Y., Li, X. (2019), An overview of bankruptcy prediction models for corporate firms: A systematic literature review. Intangible Capital, 15(2), 114-127.
Solarin, S.A., Ozturk, I. (2015), On the casual dynamics between hydroelectricity consumption and economic growth in Latin America countries. Renewable and Sustainable Energy Reviews, 52, 1867-1868.
Statista. (2021), Electricity in Brazil. Available from: https://www.statista.com/study/61804/electricity-in-brazil [Last accessed on 2022 Jan 16].
The Platts Top 250 Global Energy Company Rankings. (2021), Top 250 Companies by Industry. Available from: https://www.spglobal.com/platts/top250/industry [Last accessed on 2022 Jan 17].
The World Bank. (2009), Directions in Hydropower: Scaling Up for Development. Available from: https://documents1.worldbank.org/curated/en/846331468333065380/pdf/490170NWP0Box31directionshydropower.pdf [Last accessed on 2022 Jan 21].
The World Bank. (2020), COVID-19 in Brazil: Impacts and Policy Responses. Available from: https://reliefweb.int/sites/reliefweb.int/files/resources/COVID-19%20in%20Brazil%20-%20Impacts%20and%20policy%20responses.pdf [Last accessed on 2022Jan 20].
von Sperling, E. (2012), Hydropower in Brazil: Overview of positive and negative environmental aspects. Energy Procedia, 18, 110-118.
World Resources Institute. (2021), Explaining the Exponential Growth of Renewable Energy. Available from: https://www.wri.org/insights/growth-renewable-energy-sector-explained [Last accessed on 2021 Dec 04].