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Decarbonize Russia — A Best–Worst Method approach for assessing the renewable energy potentials, opportunities and challenges

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A B S T R A C T
Russia is known to be a country with enormous energy resources both renewables and non-renewables. Much of the country’s effort towards energy generation has been on the development of the non-renewables over the years. This study examined the opportunities and challenges in Russia’s Renewable energy (RE) sector. By coupling both interviews and literature reviews, a total of 8 main opportunities and 7 key challenges were identified and discussed. The Best–Worst-Method was used to assign weights to the various factors using inputs of 30 experienced experts in Russia’s RE sector. According to the obtained results, the most significant opportunity that the country would have to take advantage of is the opportunity to export RE outside the shores of the country, it recorded 27.7 percent. This is followed by the country’s target for the RE sector which scored 18%, hydrogen production and need to meet local energy requirements followed with 12% each. The greatest challenge which also serve as a hindrance to the development of RE in the country is the low attention given to clean technologies from government, it recorded a weight of 31.4%. This is followed by unequal playing field, and strict local content requirements which recorded 17.9% and 13.5%, respectively. The study ended with some strategic recommendations to authorities for the development of the sector.

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1. Introduction

The level of a society’s development in recent times is tantamount to the level of energy consumption. As a result energy is seen as a key input parameter for the socio-economic development of a nation (Agyekum, 2021; Agyekum et al., 2020; Agyekum and Nutakor, 2020; Mondal and Denich, 2010). The rate of energy consumption in developing countries grow by 5% whereas that of developing economies grow by 1% (Abu-Rumman et al., 2020; Muneer et al., 2005). Rising levels of carbon dioxide in the air and its associated global warming effects has led to increase in research which emphasizes the need to find more efficient and environmentally friendly sources of energy generation to meet energy demand (Agyekum et al., 2021; Agyekum and Velkin, 2020; Arsalis, 2019; Bagherian and Mehran zamir, 2020; Mehmood, 2021a,b). Renewable energy (RE) has gained much prominence in recent times as a result of its relatively less impact on the environment as well as its sustainable nature (Bagherian and Mehran zamir, 2020). The World Energy Council (WEC) as well as the International Energy Agency (IEA) has predicted that the world’s primary energy consumption may increase from 563 EJ in 2015 to between 663 and 879 EJ by close of 2050, which represents 17%–56% increment (McGlade and Ekins, 2015). It is, therefore, practically impossible to solve the existing climatic and resource depletion concerns whiles still maintaining the conventional sources of
energy where path dependency as well as interests of major economic players triumph over environmental and social concerns. Many countries across the globe have therefore developed financially sound strategies for the promotion and development of clean energy systems with RE playing a crucial role (Ermolenko et al., 2017).

Whereas, RE use around the world is increasing, its implementation in the Russian Federation has been relatively slow (Velkin, 2014). Its generation and consumption in the Russian Federation in 2010 was mainly sourced from hydropower, whiles bioenergy dominated heating in buildings and industries (including district heat generation). Hydropower in 2010 represented some 70% of Russia’s total renewable energy use of 0.6 EJ, whiles bioenergy took about 30% of the remaining. The total share of RE in Russia’s final energy consumption stood at 3.6% during that same period. Total installed renewable power generation capacity increased to 53.5 GW by close of 2015, representing about 20% of the country’s total installed electricity generation capacity of 253 GW. A large chunk of this increase was from hydropower, which took 51.5 GW followed by bioenergy with 1.35 GW. Onshore wind and solar photovoltaic (PV) amounted to 111 MW and 460 MW, respectively (IRENA, 2017).

Several researchers have conducted comprehensive studies on the various RE potentials for countries such as Ghana Gyamfi et al. (2015) and Agyekum (2020), Nepal Poudyal et al. (2019), India Rajvikram Madurai Elavarasan et al. (2020a), Jordan Abu-Rumman et al. (2020), Nigeria Aliyu et al. (2015), Bangladesh Ahmed et al. (2014), Pacific Island Weir (2018), Tamilnadu in India Jeslin Drusila Nesamalar et al. (2017), India Elavarasan et al. (2020b) and Afghanistan (Rostami et al., 2017). All these studies were either aimed at identifying the potentials, opportunities, or barriers in the various countries’ RE sector and highlight them to policy makers and decision makers for the various governments and other stakeholders in sector. Such studies are however, missing in the Russia Federation, this is however not surprising because of the abundance of fossil fuels in the country. As a result, not much attention is given to the development of the RE sector. RE usage in Russia is infinitesimal compared to other countries such as USA, China, Japan and Australia (Chebotareva et al., 2020). Chebotareva et al. (2020) assessed the various forms of state support for Russia’s RE sector. They employed an energy specific logit-model to evaluate both internal and external factors that could affect Russia’s RE development. Ermolenko et al. (2017) presented a study on measurement procedures for wind and solar PV energy exploitation in Russia taking into consideration current social and environmental limitations.

Route and Willems (2012) evaluated the political, geopolitical, economic, social, and legal opportunities and challenges that exist in exporting RE energy to the EU from Russia. According to them, a cooperation between the EU and Russia with respect to RE energy will be a win–win situation. Route (2012) analyzed the support scheme for Russia’s RE sector which is aimed at promoting RE through capacity markets. Furthermore, Shepovalova (2015) looked at the implementation of solar energy and other RES for the supply of energy in rural communities in Russia. The study took into consideration the issues related to the implementation of RES as well as the measures on energy savings in rural territories of the country. Route and Zikharev (2019) evaluated the benefits of vested interest for the development of Russia’s solar energy sector. According to the study, groups with vested interest help to overcome resistance in the RE sector especially in a country where oil and gas serve as the major source of energy.

The Russian government has indicated that it will make the development and use of RE a national priority. The government’s ambition on paper has been very high following a number of statements in that regard, one of such statements is “Russia must emerge as the leader of RE development globally”. The government in 2009 therefore announced a 4.5% electricity generation target from RE by 2020 (Route and Zikharev, 2019). In order to realize this target, the Electricity Law of the Russian Federation as amended in 2007 required the establishment of support scheme by the Russian Government (Route, 2011). However, the target for the 4.5% could not be met and has since been postponed to 2024 due to delays in the implementation of the support scheme (Route and Zikharev, 2019).

The question is why pay attention to RE in a country that is so endowed with fossil fuels? After all, the country has the largest reserves of natural gas globally, eighth largest oil reserves, second largest coal reserves and the largest exporter of natural gas globally, one of the main nuclear powers, second largest oil exporter (Overland and Kjærnet, 2013). However, with the current rate of global extraction of these hydrocarbon resources, it is projected to get exhausted in a number of decades to come: crude oil and natural gas in slightly over 50 years, and coal in 109 years (BP, 2017). These periods could however change, i.e. shortened or extended as a result of some external factors such as the development of new technologies for production, discovery and exploration of new deposits, implementation of stricter environmental legislations and the introduction of carbon tax etc. In effect, the future of fossil fuel development is not certain, and if the above estimations are accurate, then it means the world is left with about 50 years to find alternative sources of energy to meet its increasing demand (Proskuryakova and Ermolenko, 2019).

According to Overland and Kjærnet (2013), RE development and use in Russia is highly relevant for the following reasons: firstly, the country stands the chance to gain economically when RE development and use is given a priority, this is because it will improve its opportunities relative to energy exports by reducing the internal use of fossil fuels. Secondly, whereas fossil fuels are finite resources, exhaustible; RE is not, this suggests that the
development of RE will be important sooner or later. Thus, the
country being proactive in its development and use will be to its
advantage. Thirdly, the vast size of the country coupled with
the several remote and isolated communities makes RE development
the ideal and most economically feasible option and solution to
reach such areas.

The objective of this paper is to comprehensively analyze
Russia’s available RE resources, the opportunities and challenges
in the sector and provide the way forward for the development
of the sector. Whereas the few literatures on Russia’s RE sector as
reviewed supra have focused on either legal or technical aspects
of the sector, this study looks at various issues that cuts across
all sectors (i.e. political, legal, economic, and social). This gives
readers a comprehensive view of the country’s RE resources and
potential opportunities and challenges. A total of 30 experts in
the sector mainly from academia and industry were engaged to eval-
uate the various factors that were identified through interviews
and comprehensive literature review as either an opportunity or
challenge in order to rank them in the order of importance to help
policymakers during decision making. The Best–Worst-Method
which is a form of multi-criteria decision making (MCDM) ap-
proach was used for the ranking of the various factors. This study
is unique in terms of jurisdiction and the adopted approach. Other
researchers can adopt the approach to assess other sectors of the
economy both within and without Russia.

The rest of the paper is organized as follows: Section 2 presents
the energy and power situation in the Russian Federation, a
review of the various RE resources available in the country are
presented in Section 3, the methodology used for the study is pre-
sented in Section 4. Section 5 covers the results and discussion,
whilst the conclusion and future works are presented in Section 6.

2. Energy situation and level of emissions in Russia

Russia’s energy strategy aims at maximizing the use of internal
or local energy sources to sustain the growth of its economy and
drive strategic growth across the country. As part of the strategy,
the country intends to reduce its energy intensity by some 5% by
2030 (IEA, 2018). Russia comes fourth in terms of electric power
systems globally, it is led only by the United States of America,
China, and India. The country’s total capacity relative to electricity
generation has been estimated to be about 243 GW (Josefson
et al., 2019).

Although Russia has just 2% of the world’s population and 3%
of the world’s gross domestic product (GDP), it is an important
player in the world’s energy systems. It provides 16% of the
international energy trade, 5% of the world’s primary energy
consumption, and about 10% of global primary energy produc-
tion. According to reports from the BP and IEA, the country was
the largest exporter of some energy resources in 2017, these are:
number one in gas export, number two for oil exports and
number three for coal exports (Mitrova and Melnikov, 2019).
Russia also comes fourth globally — after China, United States
of America, and India relative to primary energy consumption,
electricity production and carbon emission, as a result of the use
of gas, oil, and coal for combustion-related activities. Looking at
these inputs from the country, the strategic behavior of Russia in
relation to energy transition is key to not only itself but also to the
entire world (Mitrova and Melnikov, 2019), since their activities
have the potential to affect either positively or negatively the
fight against climate change. Fig. 1 shows Russia’s total energy
supply by source.

Climate change has been one of the major challenges world-
wide due to our style of energy generation to meet demand.
It has significant effect including agriculture production, ocean
acidification and extreme natural phenomena such as rainfalls
and droughts etc. It has been said that close to three quarters of
anthropogenic carbon dioxide emissions during the past 20 years
are linked to transportation, productions, and the processing of
hydrocarbons, as well as its use to produce electricity, mechanical
energy, and heating. Russia is identified as the highest emitter of
CO₂ amid all IEA member states: the country’s carbon intensity
was more than most OECD countries in 2015: 0.47 tons of CO₂
for every $1,000 of GDP (PPP) (Proskuryakova and Ermolenko,
2019). The emissions by fuel type in Russia from 1990–2018 is as
shown in Fig. 2. According to the data from the IEA (IEA, 2021),
the volume of CO₂ emissions in Russia from fuel combustion was
highest from natural gas in 2018, measuring about 838 million
metric tons. Coal also increased significantly to 411 million metric
tons of CO₂ emissions in 2018 compared to the previous year.

2.1. The power sector of Russia

Russia’s power sector comprises of the Unified Energy System
(UES) which covers 79 regions in Russia, and some technically
remote energy systems which provides electricity for large cities in
the Far Eastern parts, and also smaller isolated and remote from
UES settlements. The total installed capacity at the beginning
of 2016 for the UES was about 235.3 GW, including technically
isolated systems resulted in a total of 243.2 GW, including 60
MW solar power plants (SPP) and 11 MW of wind power plants
(WPP), which together constituted about 0.03% of the capacity
of UES (Lanshina et al., 2018). The major fuel for the isolated
power systems is diesel, the diesel is usually transported from
other regions in the country to areas where they are required,
leading to high cost of energy (Gavrikova et al., 2019).

The country’s power grid is mainly operated and owned by
state-controlled Russian Grids public joint-stock company (PJSC).
About 2.3 million kilometers of power lines in the country are
managed by the Russian Grids PJSC, they also manage about
507,000 substations whose overall transformer capacity is over
792,000 megavolt-ampere (MVA). Over 70% of the population
of Russia get their power from the Russian Grids PJSC as well
as industrial facilities which account for more than 60% of the
country’s GDP (Josefson et al., 2019). The country’s electricity
sector is made up of generation (divided into retail and wholesale
markets), transmission and distribution. The private sector are
the major owners of Russia’s generation facilities, and such power
plants largely run on natural gas and related petroleum gas, a
significantly smaller proportion of the facilities are coal-fired. The
state controls the hydroelectric and nuclear power facilities, and
the major transmission facilities. The reforms that began in 2003
led to the current structure of the country’s power sector. Prices
in the power market in the country has in recent times seen some
form of relaxation, and as a result about 80% of Russia’s electricity
is traded at non-regulated market prices. Even though it is envis-
aged that the country’s electricity will be traded at market prices
in the future, the state-regulated prices are expected to continue
for at least a foreseeable future (Josefson et al., 2019).

2.2. Russia’s electricity companies

The Russian electricity sector is made up of the generation,
transmission, and distribution sectors. For the generation sector,
the key players in this area are the companies formed due to the
unbundling of the completely unified state monopoly RAO UES
during the 2003 reforms in the country’s power sector. The power
generation companies in the country are many but the largest
ones includes, in no particular order (Josefson et al., 2019):

- PJSC Second Generation Company of the Wholesale Electric-
ity Market (OGK-2).
- PJSC Unipro (JSC EON Russia, OGK-4).
- PJSC Unipro (JSC EON Russia, OGK-4).
In the case of transmission companies, the Federal Grid Company (PJSC Federal Grid Company of Unified Energy System) is the largest transmission company. The JSC Interregional Distribution Grid Companies Holding (Holding IDGC) is the country’s biggest distribution company. In the case of supply, the following companies are the largest for that purpose, in no particular order:

- PJSC Inter RAO UES.
- PJSC Territorial Generating Company Number One (TGK-1).
- Limited Liability Company Gazprom Energholding.
- PJSC Mosenergo (TGK-3).

The Russian electricity market has two commodities — electricity, and capacity. The trading of electricity is done via bilateral contracts in an intra-day balancing market and a day-ahead market. The bilateral contracts offers both buyers and producers of electricity the chance to negotiate price, duration of supply and quantity, directly among themselves, and independently of prevalent market conditions. The day-ahead-market is a situation whereby trades are conducted a day before actual delivery, it is a wholesale electricity market. Such trades are organized in two...
steps, i.e., firstly, a week prior to delivery, submission of technical information by power generators to the power system operators OJSC “System Operator of the Unified Power System” (SO) who estimates the consumption and select adequate production units to cover it. Secondly, a day to delivery, price offers are submitted by the power generators selected during the first step to the trading operators (OJSC) “Trading System Administrator” (ATS) who then select the optimum offers, based on the price order (Kozlova and Collan, 2016).

The capacity trade is conducted differently for both existing and planned generations (Boute, 2012; Kozlova and Collan, 2016). Facilities that are existing are subject to market-based selection. Bids are submitted to competitive capacity auctions; in this case the cheapest offers are selected by the Administrator of Trading System until the point where the needed capacity is complete for a year ahead period. The System Operator defines the required capacity (Kozlova and Collan, 2016).

3. Renewable energy resources in Russia

Despite the huge fossil fuel resources available in the country, Russia also has enormous RE resources. The country’s RE resources are comparatively evenly distributed across the entire country, whose total area is about 17 million km$^2$ (Cherepovitsyn and Tcvetkov, 2017). The vast geographical size of the country coupled with the varying climatic conditions and terrain gives Russia enormous advantage with respect to the development of any form of RE. The various RE energy potential in the country will be discussed in subsequent sections, Fig. 3, however, shows the various RE potentials in the country.

3.1. Solar energy resource

Evaluation of solar energy potential in the Russian Federation dates back as far as the 1920s. The Black sea region, north Caucasus, and the Caspian sea, Far East and Southern Siberia are identified to have the highest solar energy potential. Promising
areas for the development of solar energy in the country are in the south-western areas, these areas includes Rostov region, Volgograd region, Kalmykia, Stavropol region, Astrakhan region and Krasnodar region and in the south-eastern part of the country, these areas are also promising: Primorye, Buryatia, Altai, and Zabaykalsky. Also, the degree of insolation in certain parts of the Far East, Eastern and Western Siberia is high (Serga et al., 2016). The global horizontal irradiation of the Russian Federation is represented in Fig. 4. An estimated technical potential of the country’s solar energy potential is also presented in Table 1.

It has been estimated that, the country has a gross solar energy potential of about 2300000 million tonnes of coal equivalent (mtoe), with an economic potential of about 12.5 mtoe per year and technical potential of approximately 2,300 mtoe. The annual solar radiation for sections of Eastern and Western Siberia and the Far East is about 1300 kW/m², which is more than that in the Southern regions of Russia. Incoming solar radiation, for example in the in Irkutsk (52 degrees latitude), reaches 1340 kW/m² and Yakutia-Sakha (62 degrees latitude) 1290 kW/m² (Tsatska, 2013).

3.2. Wind energy resource

The potential for the development of wind energy varies substantially across Russia. The country has large wind energy potential, it is estimated to have a theoretical wind energy potential of about 197,477 billion kWh/year at a height of 100 m with a gross technical potential of about 21,850 billion kWh/year at same height. Most suitable areas for the development of wind farms include territories of the North West, territories of South and North Caucasus federal districts, Siberian, Ural, Far East federal district, Sakhalin Island, Kamchatka Peninsula as well as coastal areas at northeast of the country (Ermolenko, 2015). However, this potential is yet to be fully developed to the benefit of the Russian people. The place with relatively less wind speed is around East Siberia in the Lena-Kolyoma core of the Asian anticyclone. The daytime in the country experiences greater wind speed compared to what is recorded at night in Russia, this variation is however, less pronounced during the winter period. The yearly amplitude ranges from 1 m/s to 4 m/s, on average, it is between 2–3 m/s. The center of the European part of Russia, East and West Siberia (with the exception of the northern areas) have high amplitudes, and particularly the Far East where it can record an amplitude up to 4 m/s. A yearly amplitude which is less than 2 m/s is recorded in the south-east and south-west of the European section of the country as well as Central Siberia (Ermolenko, 2015). Fig. 5 shows the wind speed characteristics map of Russia.

Recent report from RAWI (RAWI, 2019), shows that as of 2019, Russia had a total of 564 wind turbines installed across the country, with installed capacity of 190.54 MW. Table 2 gives a breakdown of the installed capacity, location and number of turbines.

| Region                  | Thermal, mln. GCal | Power, mln. kWh | Thermal, tsd. GCal/ha | Power, tsd. GWh/ha |
|-------------------------|--------------------|----------------|-----------------------|-------------------|
| Russia                  | 219,402.23         | 87,972 023.23  | 0.22355               | 51.9892           |
| Republic of Adygea      | 112.44             | 26,168.76     | 0.1443                | 32.5585           |
| Republic of Bashkortostan| 2,272.08          | 528390.46     | 0.15895               | 36.9641           |
| Yamalo-Nenets           | 76,925.0           | 37,928.89     | 0.49306               | 114.666           |
| Kemerovo region         | 9,572.5            | 1,717.68      | 0.17944               | 41.7301           |

Note: mln.: million; tsd.: thousands

3.3. Geothermal energy resources

Geothermal energy (GE) exploitation in Russia has been carried out since the last 60 years. It is the second most commonly used RE in Russia (Hanson, 2019). GE is used mostly in the country for heating purposes in many cities and communities in northern Caucasus and Kamchatka. Other regions use it in their greenhouses (Svalova, 2012). Russia is endowed with high GE resources; research indicate that many regions in the country have reserves of hot geothermal fluid. The temperature of the fluid at depths between 200 to 3000 m ranges from 50 °C to 200 °C. Such areas are found in the European section of Russia (this includes the northern Caucasus with Alpine and platform areas; the country’s deepest wells exceeding depths of 5.5 km were drilled in these areas). Other areas include Siberia with Baikal rift area, Okhotsko-Chukotsky volcanic belt, western Siberia with Krasnoyarsk, Kuril-Kamchatka region and Primorsky Krai. The temperature of the thermal waters in the Kuril Islands and Kamchatka Peninsula can be in excess of 300 °C. About 385 geothermal wells have so far been drilled in the volcanically active areas of Kuril Islands and Kamchatka whose depths ranges between 170 m and 1800 m, two-phase fluids are been produced from 44 of those wells (Hanson, 2019). The graphical representation of Russia’s geothermal energy potential is represented in Fig. 6.

Russia has about 1000 geothermal heat pumps (GHP) units that are currently under operation, these pumps are spread across 6 locations in the central and western part of the country. It is estimated as follows: 110 MWt and 2185 TJ/yr for district heating, 110 MWt and 2185 TJ/yr are used for individual space heating, 4 MWt and 69 TJ/yr for agricultural drying, 4 MWt and 63 TJ/yr for bathing and swimming, 25 MWt and 473 TJ/yr for industrial process heating, 160 MWt and 3279 TJ/yr for greenhouse heating, 4 MWt and 63 TJ/yr for animal farming, 4 MWt and 63 TJ/yr for fish farming, and a projected 12 MWt and 95 TJ/yr for GHP, for a total of 433 MWt and 8475 TJ/yr (Lund and Toth, 2021).

3.4. Hydropower resources

The development and use of hydropower plants (HPP) comes with a number of merits, some of these merits includes simplicity of operations, high coefficient efficiency which varies between 92% and 94%, unlike that of nuclear and thermal power plants which is around 33%. HPPs also require relatively lesser number of personnel to man the facility, i.e. 0.25 person occupies which is around 33%. HPPs also require relatively lesser number of personnel to man the facility, i.e. 0.25 person occupies 1 MW of power, whereas that of NPPs and thermal power plants are 1.05 and 1.26 MW, respectively (Denisov and Denisova, 2017). Hydropower plays a key role in Russia’s energy sector, the country currently has about 102 HPPs with capacity of over 100 MW. The country’s total installed capacity for HPP units is about 45 million kW, whiles that of generation is also about 165 billion kWh per annum (Hydropower, 2021). The country is ranked second globally in underdeveloped HPP resources, with an estimated economic potential reaching about 852 TWh, so far only 20% of it is been used. With an estimated 80% of the country’s population and industries located in the southern and central
regions of European Russia, many of the yet to be exploited potential hydropower sites are found to be far from major load centers (IHA, 2020).

According to data from IRENA (IRENA, 2017), the country has the world’s greatest water resources. Russia’s rivers are estimated to have a total length of over 8 million km. Russia’s hydropower economic potential is projected to be almost five times the present capacity in operation, especially in the Siberia’s eastern section. According to same IRENA report, in terms of small hydropower development, the country’s largest potential is located in the eastern and central parts. Russia is currently ranked second globally after China in terms of the size of hydropower potential, approximately 852 billion kWh per year (Mikhailov et al., 2021). Table 3 presents some large-scale hydropower plants in the country.

3.5. Ocean and tidal energy resources

Tidal resources is quite significant in the northern section of Russia. The Sea of Okhotsk and the White Sea experiences some of the highest tidal ranges globally, it can reach as high as over 10 m. Some possible sites for the development of tidal power in the country includes Tugur and Mezen, which have average mean tidal range of 5.5 m. They have a combined potential power of about 22 GW, with a basin area covering over 3500 km². The total tidal generation potential has been projected to be in the order of 90 GW (IRENA, 2017).
3.6. Biomass resources

Bioenergy is seen as one of the most promising sources of energy generation for the country's economy, and some regions in the country are already developing it for use. The expediency of this sector's development is as a result of the need for waste management, the availability of decentralized energy supply zones, as well as the need to upgrade the energy sector. The development of bioenergy just like other RE sources requires a reliable resource evaluation and projections. A detail assessment of this resource and its potential has been conducted at the national level and data on the different forms of wastes used for the generation of bioenergy has been collected. Technical and economic assessment of same has since been done, maps such as that indicated in Fig. 2 has been developed for the resource for the Russian territory. There has also been an assessment of the following resources: municipal solid waste, main cultivated agricultural crops, sewage sludge and the main areas of animal husbandry at the regional level (Yu et al., 2015).

It has been said that Russia has the world’s largest biomass resources. It has been estimated that the country has about 20% of the world’s forest area as of 2010, representing about 809 million hectares. It also ranks third globally relative to arable lands, i.e. about 8.8% of arable land area globally equivalent to some 121 million hectares as at 2008 (Namsaraev et al., 2018). A study by (Namsaraev et al., 2018), identified Russia’s bioenergy technical potential to be about 2225.4 PJ. About 42% of the total potential comes from crop residues whiles 9% emanates from wastes from livestock, 23% from forest residues, biogas from sewage sludge constitute 1% and 25% from municipal solid waste. According to same study, the country currently only makes use of 12% of its bioenergy potential. Russia’s total annual agricultural organic waste is estimated to be approximately 625 million tonnes which is about 80 Mtce per year. Biogas is also estimated to be around 73.7 billion m$^3$ (2 EJ), Volga federal and South federal have half of this potential (IRENA, 2017). Russia currently use only 12% of its bioenergy potential, its forest residues potential is the most use of all (Namsaraev et al., 2018). Fig. 7 shows the country’s actual bioenergy production from different sources and the potential.

4. Materials and method

This study used an integrated approach in assessing the opportunities and challenges in Russia’s RE sector, this includes stakeholder interviews, and literature reviews. The quantitative approach was done by employing the Best–worst multi-criteria decision-making method to assign weights to the various identified factors under each criteria. The methodology used for the study is as depicted in Fig. 8.

4.1. Best–worst multi-criteria decision-making method

Multi-criteria decision-making (MCDM) is a well proven approach for solving complicated problems, particularly when multiple factors have an effect on an objective (Ali et al., 2019), it is an aspect of decision theory. MCDM problems can be grouped into two in relation to the solution space of the problem, i.e., discrete, and continuous. Discrete problems can be solved by using multi-attribute decision-making (MADM) methods, whiles that of
the continuous can use multi-objective decision-making (MODM) methods. Some examples of MCDM that have been used over the years include the Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Analytic Network Process (ANP), Elimination Et Choix Traduisant la Réalité (ELECTRE) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) among others (Rezaei, 2015).

In this study the Best–Worst Method (BWM) was used. According to (Rezaei, 2015), the BWM, is another powerful MCDM tool that can be used to analyze complex problems such as one in this paper as a result of its distinct features: (1) BWM can either be used independently or combined with other MCDM methods. (2) The consistent comparison associated with the BWM makes it highly reliable. (3) BWM uses integers to allow for convenience. (4) Unlike the AHP approach, the BWM requires a relatively less pair-wise comparison. It is for this reason, that the BWM approach was adopted in this study to assign weight to the various factors that were considered. BWM can be calculated using the following steps (Rezaei, 2015; Şan et al., 2021):

- The first step involves the creation of the decision criteria set \([C_1, C_2, C_3 \ldots C_n]\).
- The second step involves the determination of best (i.e. most desirable) and the worst criteria (least desirable).
- Determination of the favorite of the best criterion over every other criteria by assigning a number from 1 to 9. In this case, the vector for the resulting Best-to-Others would be as indicated in Eq. (1).

\[
A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn})
\] (1)
Where \( a_{ Bj } \) denotes the preference of the best criterion \( B \) over the \( j \) criterion, and \( a_{ B0 } = 1 \).

- The next step is to determine the preference of the various criteria over the worst criterion, also by assigning any number between 1 and 9. In this instance, the vector for the Others-to-Worst would be as indicated in Eq. (2).

\[
A_W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T
\]  

(2)

Where the preference of criterion \( j \) over the worst criterion \( w \) is denoted by \( a_{wj} \), where \( a_{ww} = 1 \).

- The calculation of optimal weights are done at this step \((w_1^*, w_2^*, \ldots, w_n^*)\). In assessing the optimal weight for the criteria, each pair of \( w_j/w_j \) and \( w_j/w_w \), we have \( w_{Bj}/w_j = a_{Bj} \) and \( w_j/w_w = a_{wj} \). In order to meet these conditions for the entire \( j \), it is required to identify a solution in which the maximum absolute differences \( \frac{w_{Bj}}{w_j} - a_{Bj} \) and \( \frac{w_j}{w_w} - a_{wj} \) for the entire \( j \) is minimized. This results in Eq. (3) when factoring the non-negativity and sum conditions for the weights.

\[
\min \max_j \left\{ \left| \frac{w_{Bj}}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_w} - a_{wj} \right| \right\} \\
\text{s.t.} \sum_j w_j = 1 \\
w_j \geq 0, \quad \text{for all } j
\]  

(3)

The optimal weights \((w_1^*, w_2^*, \ldots, w_n^*)\) and \( \xi^* \) would be obtained by solving Eq. (3).

For the purposes of ensuring consistency, a consistency ratio (CR) also known as the \( K_{ij} \) value is assessed using \( \xi^* \). It is obvious that, the bigger the \( \xi^* \) value, the CR, and the comparisons become less reliable. The comparison becomes more consistent when the \( \xi^* \) value is closer to zero.

The judgments for the analysis for the two main criteria i.e. opportunities and challenges in the country’s RE sector were obtained from experts comprising lecturers in top universities in the country with long standing experience in the country’s RE sector, experts from industry and some Ph.D. students who have more than 5 years’ experience in the sector. They were contacted through both emails and face to face interviews. In all, 38 experts were contacted, but 33 returned their responses out of which 30 were considered worthy to be considered for the analysis after data cleaning. Those rejected were done on the basis that, they were not fully filled to give a complete assessment of the survey.

5. Results and discussion

This section presents an overview of the opportunities and threats in Russia’s renewable energy industry, it cuts across all the sectors, i.e. social, economic, environmental, and technical aspects. The various criteria are all presented and discussed in the following sub-sections. The quantitative results were also presented in this section.

5.1. Quantitative results

The results of the BWM used to assign the various weights to the identified opportunities and challenges as presented in Table 4 are discussed in this section. A total of eight opportunities and seven challenges were identified and ranked by experts, also referred as criteria in this study. These criteria shall be discussed in detail in subsequent sections in this study.

After assessing the various inputs from the consulted experts, high export potential (O8) that is available to the country was selected as the best opportunity whereas, technology policy was identified as the least desired opportunity. Based on the preferences provided by the consulted stakeholders for each criteria provided in Table A.1 in the Appendix A, further calculations were done to ascertain the weights for the various factors. At a Kii value (CR) of 0.083 which is very close to zero, remember that in BWM the closer the CR is to zero, the more consistent the comparisons of the experts, the weights for the various criteria for the opportunities are presented in Fig. 9. It reflects the respondents views on the various identified factors which are considered opportunities in Russia’s RE sector, and which has the potential to positively affect the development of RE in the country.

According to the results high export potential was assigned the highest weight of 27.7%, followed by RE targets set by the country which was also assigned 18%. Both high market potential internally and the potential for hydrogen production recorded a weight of 12%. The country’s RE policy which experts see as key to the development of the sector and the availability of large unoccupied land in the country also recorded same weight of 7.2%, this is followed by technology policy with a weight of 3.9%. In the case of the challenges in the sector, a Kii value of 0.089 was obtained after the computation of the various rankings by the consulted stakeholders, which is also very close to zero, hence consistent and reliable. The weights for the various factors considered under the challenges in the country’s RE sector are presented in Fig. 10. The summary of the rankings from the stakeholders are presented in Table A.2 in the Appendix section. Based on the computations, a weight of 31.4% was assigned the low attention to clean technologies from government (i.e. lack of political will) which was also selected by the consulted experts as the most critical challenge facing the sector. This was followed by the unequal playing field in the energy sector, it recorded a weight of 17.9%. The country’s local content policy, high cost of RE projects, and regulation and implementation uncertainties recorded same weight of 13.5%. Unfavorable institutional design and the country’s harsh environmental conditions garnered 5.7% and 4.5%, respectively. A similar study in Nepal by (Ghimire and Kim, 2018) also identified policy and political barriers as the greatest challenge in Nepal’s RE sector. Also, a study by (Bukari et al., 2021) on Ghana found political barriers as the greatest obstacle in Ghana’s RE sector. These literature confirms the results in this current study. However, a study by (Luthra et al., 2015) on the barriers of RE technologies adoption in India found
Table 4
Factors considered under each criteria.

| Opportunities                               | Challenges                      |
|---------------------------------------------|---------------------------------|
| Renewable energy targets (O1)               | Unequal playing field (C1)      |
| Renewable energy policy (O2)                | Strict local content requirement (C2) |
| High market potential internally (O3)       | Low attention to clean technologies from government (C3) |
| Technology policy (O4)                      | Regulation and implementation uncertainties (C4) |
| Availability of large unoccupied lands (O5) | High cost of renewable energy projects (C5) |
| Need to meet local energy deficit (O6)      | Harsh environmental conditions (C6) |
| Hydrogen production opportunities (O7)      | Unfavorable institutional design (C7) |
| High export potential (O8)                  |                                 |

Fig. 10. Weights for the various criteria under challenges.

geographical and ecological factors as the greatest inhibitors to the development of RE in India as oppose to issues relating to governance and politics. Furthermore, (Reddy and Painuly, 2004) identified economic barriers as the most significant challenge followed by institutional barriers in the Indian State of Maharashtra. The differences in the results suggests that the distinct situation in every country, in relation to economic, political and geographical conditions may determine the kind of remedy that can be proposed for each country (Bukari et al., 2021; Ghimire and Kim, 2018).

5.2. Opportunities in Russia’s RE sector

The opportunities in the sector are presented in this section. These includes factors that are available in the country to help promote the development and use of RE apart from the enormous RE resources presented supra, which both investors and other interested parties can take advantage of.

5.2.1. Renewable energy targets

RE has in the few past years received significant attention from the Russian government as indicated supra at the national level. This has manifested in a number of policy documents over the years, this includes the Energy Strategy to 2030 (Nov. 2009), the Climate Doctrine (Dec. 2009), the Concept for Long-Term Social and Economic Development to 2020 (Nov. 2008) as well as the State Energy Efficiency Program (Dec. 2010). The Concept for Long-Term Social and Economic Development designed expects the country to attain “a leading position in the development of renewable energy sources”. This suggests that, policymakers in Russia acknowledge the impact of RE in terms of environmental, social, energy security and economics. The country’s energy strategy to 2030 has the following objects (World Bank Group, 2011):

- Enhancement of energy security through decentralization
- Minimization of the anthropogenic effect on climate change during generation of energy to meet demand
- Diversification of the country’s energy and fuel mix; reducing the rate of increase in transmission and distribution cost of electricity
- Maintaining both quality and good health of the country’s population.

According to information from the draft Energy Strategy for the country for the period up to 2035, the share of RE in the country’s total primary energy consumption is expected to move from 3.2% to 4.9% by end of 2035. It includes the country’s approved plan to increase the total PV, geothermal and wind capacity to 5.9 GW by close of 2024 (Mitrova and Melnikov, 2019).

5.2.2. Renewable energy policy

The Federal Law No. 35-FZ dated 26 March 2003, (hereafter, the “Federal Electricity Law”) as amended in 2007 “On the Electric Power Industry” requires the government of Russia to adopt strategic national targets towards the development of RE in the country. The policy also provides various support mechanisms for the generation of electricity from RE. The government on 8 January 2009 adopted Resolution No. 1-r “On the Main Areas of Government Policy to Raise the Energy Efficiency of Electric Power from Renewable Energy Sources for the Period to 2020” which is intended to help it realize its obligations (Tsatska, 2013). In effect, the policy stresses the relevance of efficient and clean energy production.

The Decree 449, passed in 2013, constitute the basis for the growth and transformation of Russia’s RE sector, it created the legal framework for the establishment of RE capacity system for the country. Past reforms like the 2007 amendment for electrical regulations stated earlier in this study as well as the launch of RE program to support its development in 2011 paved the way, however, Decree 449 underpins the current development and progress being made in the deployment of RES in the Russian Federation. The decree was passed to promote the development and use of RE in Russia, with special emphasis on wind and solar photovoltaics, and small-scale hydropower to a lesser extent. The terms for participating in Russia’s RE market are set out in the legislation. Energy developers under this system whose project capacity is at least 5 MW have the opportunity to bid in annual tenders for capacity supply contracts with the country’s Administrator of Trading System. Suppliers who win are paid both for the energy they supply and for the capacity they add to the energy system, for a fixed tariff based on long-term 15-year contracts (Power Technology, 2018).

5.2.3. High market potential internally

One factor most investors evaluate before taking a final decision to invest in any economy is the availability of market for whatever produce they offer. The availability of ready market in
the energy sector is crucial since large amount of energy generated cannot be stored and therefore but be used. In Russia, the consumption of electricity is estimated to be increasing at 2% per annum (EU, 2013). The development of new energy technologies in Russia is in the broader context being championed for the socio-economic development of all parts of the country. Decentralized electricity generating systems (DEGS) are considered as the optimum option for the several remote and distant regions in Russia. This is because, the extension of high-voltage electricity lines to such communities is seen as economically impracticable. The DEGS also comes as an attractive package for industrial complexes. It gives them the opportunity to become independent from national centralized power system at a relatively lower cost (Tissot, 2018).

5.2.4. Technology policy

Russia has a very sensitive policy on technology. The leadership of the country has acknowledged the risk that the country faces relative to technological development. It is the reason behind the strict requirements on the localization of equipment for RE and smart grids, as well as the several import substitution programs. Since technology policy is the key driver of the country’s interest in RE, Russia is focused on building its own RE manufacturing capacity first. As a result, the country has instituted an equally high level of local content needed to qualify for high tariff rates, which is a key component of long-term feasibility of many projects in Russia’s RE sector (Mitrova and Melnikov, 2019). The proportion of Russian-made equipment needed to prevent tariff penalties was comparatively modest during the early stages of the auction system, however, it increased to some 65% for hydro and wind farms and 70% for solar until 2020, the government has since set a long-term target of 80% for localization. It is because of these high levels that has led to numerous tenders, particularly for the development of wind farms, for which there is virtually no Russian-made equipment. These requirements have stimulated overseas multinationals to partner with manufacturers and Russian power companies. This has led to the establishment of a number of international joint ventures, this includes Fortum and state-owned technology investor Rusnano’s wind investment fund, and WRS Bashni, a corporation among Spanish developer Windar Renovables, Rusnano, and the Russian steel firm Severstal. Companies such as Lagerwey and Siemens Gamesa Renewable Energy (SGRE) are also getting themselves ready for the Russian market, Vestas Manufacturing Russia has also localized wind equipment in the region of Nizhny Novgorod (Energy Technology, 2018).

5.2.5. Availability of large unoccupied lands

The nexus between power plants (i.e. electricity systems and its accompanying networks) and the land area occupied by these components forms a key factor of their sustainability assessment (Cheng and Hammond, 2017). Decisions relating the use of land for energy generating activities are exigent concern as the need for ecosystem services, land scarcity and demands for generation of energy to meet consumption have concurrently increased worldwide (Hernandez et al., 2015). Wind and PV power plants have almost similar land use features, with impacts from disposal/recycling and materials for the manufacturing of various units. None of them need any further mining footprint. The two technologies are also characterized by the potential for dual use sites (Evans et al., 2009). Gagnon et al. (Gagnon et al., 2002) estimated a total footprint for wind power plants to be about 72 km²/TWh, without apportioning any part of this to agricultural activities. Also, Lackner and Sachs (Lackner and Sachs, 2005) also estimated that land occupation for PV power plants to be about 28–64 km²/TWh without dual purpose. In the case of hydropower plants, it varies significantly, it depends on the local topography. It has been estimated to be around 73 km²/TWh (Evans et al., 2009). In the case of geothermal power plants, their surface footprints are relatively small, with most of the components located underground (Bertani, 2005; Evans et al., 2009). A typical footprint for geothermal power plant is estimated to range from 18–74 km² /T Wh (Bertani, 2005).

Russia is considered as the largest country in the world in terms of area (Serga et al., 2016), with nearly limitless land available for the development of RE. The country has a total land area of approximately 17.1 million km², yet it is also estimated that Russia has one of the lowest population densities around the world (Study, 2021). This is positive for the development of RE technologies since it will not require extra money to relocate already settled people for its development. It also means investors will not have problems with lands for the development of their projects.

5.2.6. Need to meet local energy deficits

One major challenge in Russia’s energy sector is that about 50% of the country’s regions have power challenges, as a result, such regions purchase power from other regions. The swift economic transformation that has taken place in recent times has put lot of pressure on the country’s electricity generation capacities for governments at the regional level. The country has a high level of energy intensity, it is estimated to be about 1.5 times more than the world average, it is twice that of leading countries in Europe (Henderson and Mitrova, 2020). The complexity of increasing regional gas-consumption limits has hindered the construction of gas fired power plants and the strict sustainability rules has also limited the construction of coal and hydro-powered plants. Developing energy resources at the local level including RE sources can be a viable solution to this problem (Tsatska, 2013).

5.2.7. Hydrogen production opportunities

Russia has not striven hard to be part of the international communities and partnerships that are into the development of hydrogen technologies. The country currently does not have any national program on hydrogen, it was only in the end of 2019 when the initial attempt to synchronize various research groups as well as other interested groups appeared. Russia, however, has lot of resources and opportunities in this area for commercial purposes. There has been some design work in the area of production, transportation and storage and the use of mobile transport (Henderson and Mitrova, 2020); (Melnikov and Chugunov, 2019). Green hydrogen potential is enormous in the country and investors can take advantage of it, this is mainly because of the huge wind and solar energy potentials (Henderson and Mitrova, 2020). Russia could produce green hydrogen in commercial quantities, renewable production could be especially economically viable if sited near the Arctic Ocean or Black Sea (Caspar and Wiesholzer, 2021). Fig. 11 shows the various hydrogen production methods that a country can adopt for its development depending on the resources available.

Russia adopted two main policy documents in 2020 on its plans for hydrogen development. The first document was adopted in June 2020, this was on the country’s Energy Strategy up until 2035, it is premised on the importance of hydrocarbons for the country’s energy sector and also the need to position Russia as a major producer and exporter of hydrogen. The government has targeted to export about 0.2 million tons by 2024 and increase it to 2 million tons by 2035. The second document is about the country’s roadmap for hydrogen development until 2024, which was adopted in October 2020. Rosatom and Gazprom have been assigned with special roles in realizing this goal in the Energy Strategy. Stakeholders in the country’s energy sector are awaiting
the adoption of a comprehensive concept for the development of hydrogen, in which the country is expected to emphasize on strategic cooperation with countries such as France, Germany, South Korea and Japan (Zabanova and Westphal, 2021).

5.2.8. High export potential

The country's strategic objective for the electricity sector include the modernization of current electricity generating capacities as well as the implementation and development of capacities that are dependent on new generating technologies, which include fast-tracked RE and nuclear power development. The country also intends to strengthen the United Power System (UPS) as well as its interconnections with other adjoining countries (EU, 2013). The energy cooperation between Russia and the European Union (EU) could also be a beneficiary of the opportunities hydrogen brings. Russia is the most significant provider of energy to the EU. It accounted for 42% of coal imports, 40% of natural gas imports, and 30% crude oil imports for the EU in 2018 (Caspar and Wiesholzer, 2021). Exports of energy alone constitute about half of the country's revenues. As a result, the government of the Russian Federation sees decreasing foreign energy demand as a threat to the country’s economy. The European Green Deal, which is intended to create the way for climate neutrality by 2050 — it has stressed the need for the EU to take the energy transition and climate protection serious. It has been projected by the German Environmental Agency that Germany which is the highest domestic consumer of natural gas for instance has projected demand to fall by about 90%. In this regard, climate-friendly hydrogen exportation to the EU could be an auspicious future opportunity for the Russian Federation (Caspar and Wiesholzer, 2021).

5.3. Challenges in Russia's RE sector

This segment also looks at some key barriers that hinder the development of RE in Russia, this cuts across economics, technical and regulatory aspects.

5.3.1. Unequal playing field

One of the greatest challenges to the development of RE in Russia is the lobbying for, and traditional reliance on fossil fuels and nuclear power to meet the country’s energy demands. Whereas the share of thermal power generations as of 2018 hovered around 74% and that of RE around 26%, globally, thermal power generation in Russia during that same period was about 83% and the remaining is renewables including 16% of hydro (Rasoulinezhad et al., 2020). This is occasioned by the fact that; the country has lots of fossil fuel resources hence very little importance is given to the development and use of other energy generating resources. In effect, there is no competition in this sector, which has also affected both local and international investments into the sector's development.

5.3.2. Strict local content requirement

As stated earlier, the government introduced a local content policy to facilitate the development of RETs production in the country. This according to some experts in the industry serves as a disincentive to foreign investors although within Russia it is seen as positive. This is because the local content requirements are quite challenging for the investor community particularly foreigners, this is because it affect the Capacity Delivery Agreement (CDA) capacity price directly. Under the CDA, investors can lose as high as 55%–65% of the capacity price. As indicated earlier, the share of Russian equipment and technology in the solar energy industry for instance reached 20% in 2016. However, such equipment or technology could be more expensive and less efficient compared to foreign made technology (Vasileva et al., 2015). The emerging Russian RE markets’ inability to satisfy the strict local content requirements have left a substantial share of projects that could get support under the capacity-based renewable energy support scheme (CRESS) unclaimed (Lanshina et al., 2018). According to data from (Lanshina et al., 2018), the percentage of unclaimed projects in the 2009 original quotas included 85% for 2014, in 2015 it was 54%, and 57% and 59% for 2016 and 2017, respectively. Only quotas for solar PV were claimed virtually in full volume as a result of the presence of an integrated solar PV company in the country.

5.3.3. Low attention to clean technologies from government

Russia has not paid much attention to energy transition technologies. In an important state document, which outlines the various priorities in this sector — the state program “Energy Development” which was accepted and approved in 2014 and later amended in 2019 — the only mentioned target was “promotion of innovative and digital development of the fuel and energy complex” along with other new technologies in the production and processing of hydrocarbon; nothing was specifically said about low-carbon technologies (Stambler, 2020). It is the view of the consulted experts that, the role of government in the development of RE, particularly in a country that is predominately dominated by fossil-fuel based power plants is key. Much is expected from government beyond just policy formulation.

Fig. 11. Hydrogen production methods (Nikolaidis and Poulilikas, 2017).
5.3.4. Regulation and implementation uncertainties

Another overarching problem in Russia’s RE sector which has led to its poor development is the lack of coordination between regulations and its implementation over the years. The inclusion of RE in broad sector plans and programs instead of clearly living them as a standalone program and assigning clear cut policies for the sector can be more or less described as declaratory instead of a major push for action. For example, Russia’s energy strategy for the period up to 2030 as well as the draft up to 2035 recognize the need and certainty of the development of RES and provide for economically viable increase in the use of RES and support from government on RES. However, at the same time, the development of nuclear and fossil fuels remain a top priority in same documents. This is inconsistent and does not help in the development of the RE sector (Lanshina et al., 2018). The requirements to enable one to qualify under the RES law of Russia further worsens the risk variability for investors and regulatory uncertainty i.e., qualification is managed in Moscow centrally and takes place after the facilities are constructed. This is in contrast to ‘best practices’ internationally in this field, as a result, at the time of making their investment decisions on off-grid RES projects, investors are unable to rely on power purchase agreements and long-term regulated price guarantees. This remains a hurdle to the development of RES in Russia (Boute, 2016).

5.3.5. High cost of renewable energy projects

One other challenge which the consulted experts raised is the cost of RE projects in Russia. Although the cost of wind and solar energies have witnessed some considerable reduction in recent years, the cost of same in Russia still remain above the global average. This is partially linked to the introduction of these technologies into the country, whereas, the country’s characteristics, e.g., the vast nature of the Russian territory requires that equipment are transported over a long distance, which ultimately affect the cost of such equipment (IRENA, 2017).

5.3.6. Harsh environmental conditions

The extreme weather conditions in certain parts of the country especially during the winter period was also identified as one of the factors that affects the development of RE in Russia. Ice on wind turbines for instance could have three impact on the system, i.e., performance (wind measurement, annual energy output, and design life duration), the safety (unbalanced rotor spinning, ice throw, over-power, and fatigue), and the design (load, materials aerodynamics, and control system). It can also have an effect on the wind sensors, which will in turn render wind measuring equipment ineffective — and increase the level of noise from the system and decrease the cost-effectiveness of the turbine (Power, 2014). In the case of solar systems, locating systems such as the solar thermal in areas with severe winter conditions is mostly not a concern. Nevertheless, in the case of PV systems, cold weather conditions can have an impact on the system. The output of PV system can be reduced to nothing when the panels are covered with snow. Solar PV panels are, however, less vulnerable compared to other generation sources when it comes to extreme winter conditions because they are solid-state construction with no fluid inside it or moving parts. PV panels that are subjected to repeated freeze-thaw cycles, particularly with snowfall, are susceptible to the invasion of water, as the melted water can possibly force open little gaps in the solar panel covers, electrical connections, and mounting brackets over time. In that situations, frequent checks of on such components are key, given that the entry of water into the electrical setup can cause serious challenges (Power, 2014). In the view of the consulted experts, such situations increases the maintenance, operations and replacement cost which ultimately affects the cost of energy from such power plants.

5.3.7. Unfavorable institutional design

Notwithstanding the numerous market reforms that has taken place in the energy sector since the 1990s, Russia’s institutional framework for the energy sector is still characterized by lack of market mechanisms and high corporate concentration. Decentralization of the sector still encounters stiff opposition from both major business stakeholders and authorities. It is often seen as a threat to the reliability and stability of the country’s energy system, and to the security of the country. Low prices of energy are still seen as a ‘public good’ after three decades of command economic under the Soviet Union, as a result any attempt to increase the price of energy in the country encounters stiff opposition from consumers. The cheap energy situation in the country does not help in improving the efficiency in the sector, it also affects the modernization of prevailing systems with high fuel consumption (Stambler, 2020).

5.4. Discussion: The way forward for the country’s RE sector

It is obvious from the results discussed above that, Russia’s RE sector has a number of opportunities but also some barriers which are hindering the sectors growth which requires the attention of government. It will include a holistic approach that considers international best practices. A typical approach adopted by a number of IEA countries towards the development of their respective RE markets include the following three key steps: the adoption of relevant laws (i.e. creation of the needed market structure), adoption of RE strategy (finding the goals for the sector) and the specification of execution mechanisms (formation of rules) (IEA, 2003). Although these steps already exist in Russia, experts have expressed their dissatisfaction with some of the policies aimed at opening up the sector. As demonstrated through the BWM, experts identified the low attention from political players towards the development of the sector and the unequal playing field as the most critical barriers to the sustainable development of RE in Russia.

According to the World Bank report on Regulatory Indicators for Sustainable Energy (RISE) which compares various countries policy framework in that space, Russia was ranked 46th among other nations with a mark of 61 out of 100 in the RISE section devoted for RE (Banerjee et al., 2016). Although the report scores Russia 100 out of 100 in terms of regulatory efforts, the country got zero points on carbon pricing and monitoring mechanism due to their absence in the country’s policies. Counterparty risks and poor planning for the development of RE scored 49 and 31 points, respectively. In terms of bureaucratic procedures, Russia is known for its numerous processes (17) needed to set up a grid-connected RE power plant (Lanshina et al., 2018). All these were confirmed in the current study by the consulted experts, as they identified the country’s RE policy as an opportunity. Despite the country’s effort in terms of legal and regulatory framework as well as the huge resource potential, the RE sector has not seen the required growth. It therefore suggests that the implementation of these brilliant policies has some deficiencies due to high bureaucratic procedures in the sector as well as the lack of the needed confidence within stakeholders.

The potential to export power to European countries especially power generated from wind and hydropower was cited as the greatest opportunity relative to the development of RE in Russia. This calls for a number of measures to be taken on the part of government to enhance trade in that regard. The government will have to urgently modernize its grid system by linking the modernization plan to the country’s RE potential. Exporting electricity to Europe will require the expansion of the country’s capacity for interconnection, which creates flexibility in the electricity structure, and allow more shares of variable RE in the power sector (IRENA, 2017).
For a country to successfully develop its RE sector, it requires the institutionalization of appropriate economic measures that has the potential to affect market behavior, which will make the sector competitive relative to other conventional sources of energy generation. It is said that when there is an increase in economies of scale, the cost associated with implementing RE decreases, making it more profitable. Countries such as Germany, Denmark, USA, and Spain are benefiting from renewables. Several economic mechanisms have been adopted by countries to promote the use of renewables, some of these include, subsidies and tax-exemptions on RETs, taxes on fossil fuels, feed-in tariffs, and incentives etc. (Bellona, 2007). These are key economic mechanisms that the Russian government will have to adopt for the development of the sector.

The following recommendations are proposed:

- The RE sector in Russia has not yet been tried and tested, as a result there is a lack of information on the successes in the sector, as a result new investors are not confident to venture into innovative projects in the country. It is therefore recommended to the Russian government to take the lead in some projects by investing in the development of projects such as solar and wind power plants in order to demonstrate to possible investors the successes in the sector. This will open up the sector to both local and foreign investments.

- It is also important for the government to define the long-term role of RE in the country’s energy balance, this will enable both government and other stakeholders plan ahead to meet that target.

- Establish dedicated funds for the development of clean energy technologies. The budget for the development of conventional power plants will have to be cut drastically and diverted into the development of RE. Subsidies and incentives will play a major role in their development.

- Although the country’s Decree No. 449 of 28 May 2013 outlines the mechanism for the development of RE in both capacity and wholesale markets, it failed to provide a clear rule in competitive capacity selection relative to the generation of RE capacities (IRENA, 2017). Government will have to look at this mechanism and amend it to address this challenge.

- It is also important to increase public awareness in this sector, one issue that was raised by respondents during the interviewing process was the lack of adequate information in this area. In RE development public awareness is key, hence government and other stakeholders should institute measures that will highlight the positives associated with RE utilization among the population, some of these measures may take the form of seminars, and awareness campaigns within communities.

- When it comes to energy exports, Russia is already a major player globally especially in the fossil fuel sector, hence it has lots of experience in both intra-regional and international cooperation with other countries. RE exports have been identified by experts as a major opportunity in the sector. It is therefore recommended that the government should strengthen its international cooperation with respect to RE as well. Such cooperation will help the government to identify new energy markets and also get to know the policies implemented by some of these countries in the sector.

- RE projects are generally costly to construct and as identified by the experts, this is not different in the Russian federation. Government will therefore have to create the enabling environment that promote public–private partnerships. It will be important to encourage individuals in the country to take advantage of the numerous RE potentials in the country and invest in the sector. In this case, the government will also have to establish effective financial mechanisms to win investors’ confidence.

- Research and development (R&D) will be key to the success of RE energy in Russia, especially because of the unique weather it has compared to other countries. As indicated by the consulted experts, the harsh environmental conditions is a challenge in the RE sector, particularly wind and solar energies. It therefore suggest that foreign technologies may not be efficient in the Russia jurisdiction. It is for this reason that R&D on technologies to be used under Russian conditions need to be improved by adopting new expertise to develop new and efficient technologies capable of withstanding the weather conditions in the country. The various universities in the country will play a major role in this regard.

- Considering the large territorial nature of the country, decentralization of institutions in charge of coordinating and managing the development and promotion of RE energies will be very key. Centralizing these institutions in the nation’s capital could serve as a disincentive to the locals who will have to travel several kilometers to get documents processed. Government must take steps to decentralize some of these institutions to the regional level.

6. Conclusion and future works

Russia is a country with huge RE potentials, however, very little of it is developed and utilized. This study presented potentials, opportunities, and challenges in the country’s RE sector. The opportunities and challenges in the sector were identified through both literature reviews and experts consultations or interviews. The BWM was adopted to rank the various factors under each criteria. The results from the study shows that the opportunities in the RE sector with capacity to scale up the development of the various resources in Russia includes, the high export potential, renewable energy targets, high market potential locally, need to meet local energy deficits, hydrogen production potentials, renewable energy policy, availability of large unoccupied lands and technological policy. For the challenges in the sector, the following in no particular order were identified as the crucial factors that hinders the development of the sector: Unequal playing field, local content requirements, low attention to clean technologies from government, regulation and implementation uncertainties, high cost of RE projects, harsh environmental conditions and, unfavorable institutional design. According to the obtained results, the most significant opportunity that the country would have to take advantage of is the opportunity to export power generated from RE outside the shores of the country, it recorded 27.7%. This is followed by the country’s target for the RE sector which scored 18%, hydrogen production and need to meet local energy requirements followed with 12% each. The greatest challenge which also serve as a hindrance to the development of RE in the country is the low attention given to clean technologies from government, it recorded a weight of 31.4%. This is followed by unequal playing field, and strict local content requirements which recorded 17.9% and 13.5%, respectively. It was the view of the respondents that, since the sector is capital intensive, the role of the government in championing its development and utilization is key hence the government is encouraged to step up its commitment for the sector. The study concludes with a number of recommendations for the development of the sector.

Despite the comprehensive nature of this study, it has some limitations that must be highlighted, firstly, it focused on only one country and secondly, the number of respondents were relatively small. That notwithstanding, the paper provides valuable
insights that has the potential to affect policy direction for the country. The adopted methodology can be replicated by other researchers in other jurisdictions to assess similar projects. This study recommends a comprehensive assessment of the long-term effect of RE on the Russian economy by the use of software such as the LEAP model as future study. This will enable stakeholders assess the effect of RE on the economy and social aspects of its implementation.

CRediT authorship contribution statement

Ephraim Bonah Agyekum: Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. Nallapaneni Manoj Kumar: Data curation, Methodology, Formal analysis, Writing – review & editing, Funding, Project administration. Usman Mehmood: Formal analysis, Writing – review & editing. Manoj Kumar Panjwani: Formal analysis, Writing – review & editing. Hassan Haes Alhelou: Formal analysis, Funding, Writing – review & editing. Tomiwa Sunday Adebayo: Formal analysis, Writing – review & editing. Amer Al-Hinai: Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

See Tables A.1 and A.2

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