Small Hydropower Development Potential in Chechen Republic

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ABSTRACT

The aim of this study is to examine the issues of energy development and hydroelectric potential utilization of the rivers in the Chechen Republic. One gives a brief description of the river network and performs the hydroelectric potential's calculations of large and small rivers. One estimates the hydroelectric potential at about 4.86 billion kWh. The share content of hydroelectric resources constitutes 3682.7 kWh/1 km^2 of the territory. We attribute special attention to the potential assessment of rivers within the mountainous part of the territory. The estimated gross potential of mountain rivers alone is 2.4 billion rubles kWh, and technical - 0.55 billion kWh. One note that the development of small hydropower is an important factor of improvement in regard to the socio-economic conditions of the population's life and territory's energy security.

Keywords: Hydropower, Potential of Small Rivers, Distributed Power Generation, Ecology, Sustainable Development, Hydroelectric Power Stations, Chechen Republic

JEL Classifications: O13, P28, P48, Q42, R11

1. INTRODUCTION

Hydropower technologies are off-the-shelf technologies and are currently applicable on a significant scale. Despite the fact that today the main role of hydropower within the global energy supply is to ensure centralized generation of electricity, one can master some technologies at the point of use, when hydroelectric power stations operate in isolation and supply autonomous systems with electricity, in many cases throughout the rural and remote areas. As long as the generating capacities and consuming facilities are geographically as close as possible, there is no need to transport energy and to build transport electric power systems. This can provide consumers and neighbors with their own energy in accordance with the reciprocation scheme, in contrast to traditional types of generation, whose energy one must deliver hundreds of kilometers away.

The attractiveness of a particular energy supply option also depends on the broader economic, environmental and social aspects, as well as on the contribution that technology makes in order to provide the appropriate energy supply (for example, peak demand for electricity) or imposes additional costs on the energy system (for example, integration costs).

In general, hydroelectric power is a recognized and highly advanced technology, but there are still possibilities for further improvement by operations optimization, mitigation or reduction of environmental impacts, adaptation to new social and environmental requirements, and implementation of more reasonable and cost-effective technological solutions (Asarin, 2013; Gaisumov and Kerimov, 2018; Russian Federation, 2012, Hydro Minds-Tool). If the energy conversion efficiency of large turbine units has already reached its maximum value, then new promising technologies have appeared in the field of small-scale power generation. These technologies include: variable speed rate technology, fish-friendly turbines, hydrokinetic turbines, and new technologies for using low (<15 m) or very low (<5 m) water pressure, previously unused for traditional technology applications.

2. CHARACTERISTICS OF THE FLUVIAL NETWORK

The territory of the Chechen Republic has characteristics with a relatively high availability of surface water resources, which are mainly concentrated in rivers, lakes and water storage basins. The distribution of surface water is very irregular throughout the territory. It is due to the nature of the terrain and the rainfall distribution, the sharp predominance of evaporation over rainfalls in steppe and semi-desert areas.

Not only the altitude, but also the direction of mountain ranges, the orientation of slopes, and the nature of landforms have a great influence on the land forms (Gaisumov and Kerimov, 2018, Russian Soviet Federative Socialist Republic, 1987). The southern part of the Republic - the mountainous regions and the Chechen sloping plain - have a widely branched and dense network of rivers and streams. Terek-Sunzha elevation and Zaterechnaya lowland, that locate to the North of the Terek, have no discharge.

The total number of rivers is 3198, the total length is 6508.8 km. The vast majority of rivers (more than 97%) are small currents of water <10 km long. The number of main rivers (more than 10 km long) is about 100 (Renewable energy and climate change mitigation 2011, Gaisumov and Kerimov, 2018). The largest rivers by length are the rivers: Terek (218 km), Sunzha (205 km), Argun (125 km), Belka (83.2 km), Dzhalka (82.5 km), Martan (61 km), Gehi (57 km), Aksai (57 km), Fortanga (34.7 km), Assa (32.4 km). Orographic, physical and climatic features influence on the formation and distribution of the hydrographic pattern. All the rivers of Chechnya belong to the basin of river Terek, with the exception of the rivers Aksay, Yaman-su and Yaryk-su, which belong to the basin of river Aktash. The rivers Terek, Argun, and Assa , as rivers of glacial nutrition, have not only spring water rises associated with melting of snow within their basins, but also a high-water season in the second half of summer, during the melting of the glaciers in the Caucasian mountain range (Figure 1).

Increased autumn rains in the mountains also cause water rises. The lowest water level in mountain rivers is in winter. The seasonal distribution of annual mountain rivers flow has characteristics of approximately the following ratio: in summer (June-August) the run-off is around 55%, in spring and autumn – 35%, in winter (December-February) – 10%. This hydrological regime of rivers is favorable for irrigation, but it makes it difficult for hydroelectric power stations to operate evenly. With the exception of Terek, Assa and Argun, all other rivers in the mountainous and foothill parts of the Republic have nourishment of spring and rain waters. The most significant of them are – Sunzha, Fortanga, Gekhi and Martan - they originate in the zone of the Rocky ridge, and

Figure 1: Map of hydrographic network in the Chechen Republic
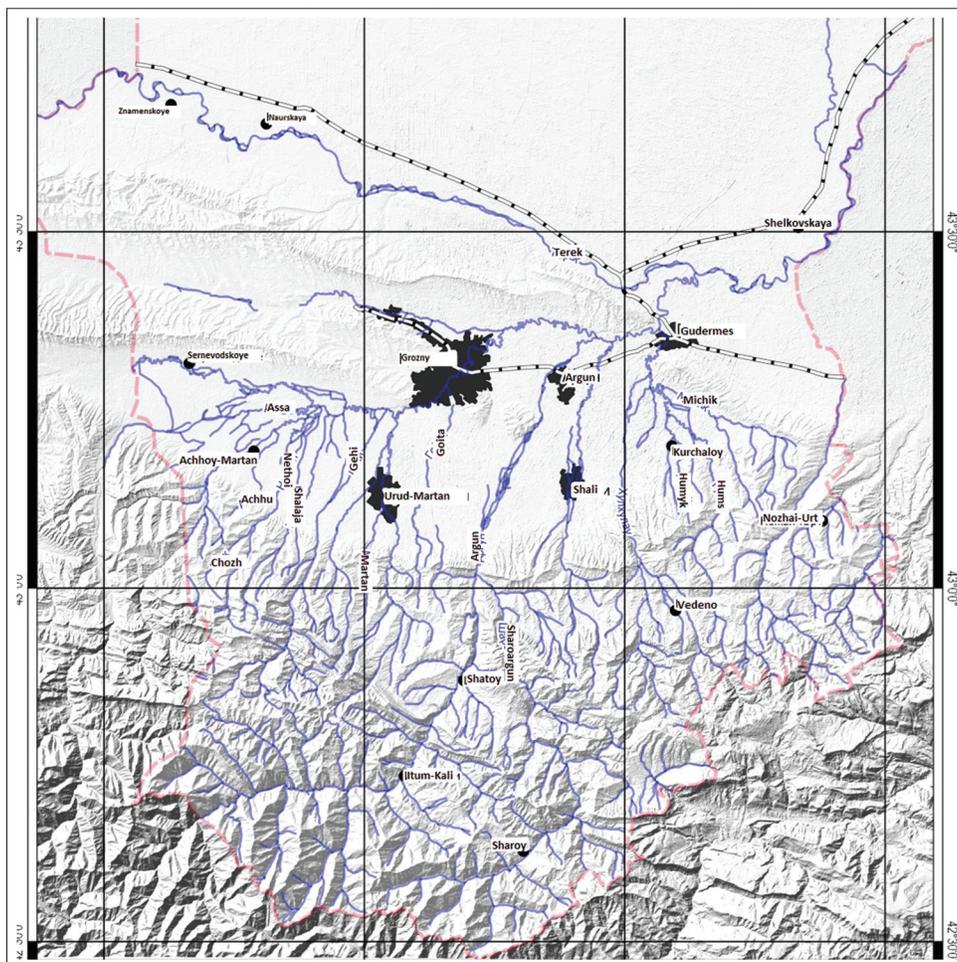
Shalazhi, Valerik, Goita, Dzhalka, Gums and others – from the springs of the Pasture mountain range and the Black mountains. Long-term hydrological observations show that the rivers with spring and rain supply become very shallow by the summer, due to the absence of a second flood. Smaller rivers of the Sunzha river basin with nourishment of the ground water, have a more stable flow. These rivers do not react well to rainfalls in the mountains or melting of glaciers in the high mountain area. The main river of Chechen Republic is Terek. The total length of river Terek is 590 km, and the basin area is about 44 thousand km², the length of Chechen Republic is 218 km. The riverbed in the territory under study is meandering, full of shoals and islands, that often change their size and shape due to washouts and aggradations. The place, where Terek receives its largest feeder is - river Sunzha, and there its lower course of a river begins. Away to the North-East, already outside the Republic, it flows into the Caspian sea (Table 1).

Sunzha river is the last right feeder of river Terek, its length from source to estuary is 265 km, its catchment area constitutes 12,200 km². The source of river Sunzha locates in the area of the Black mountains within the Western part of the forward branches of the Lesysty mountain ridge. The springs, ground water and rainfalls feed Sunzha and its feeders on the upper reaches. In the area from the town Karabulak to the city Grozny the several feeders flow into into the river Sunzha, where the largest ones are: Assa, Fortanga, Salaga, Gekhi, Martin, Goyta. From Grozny to the railway bridge that crosses river Sunzha below the city Gudermes, a number of feeders flow into it, the largest of which are rivers Argun and Belka with the feeders Hums and Hulhulau.

Argun river, the largest tributary of the Sunzha river, forms from the confluence of two rivers – Chanta-Argun and Sharo-Argun, and is a right feeder of river Sunzha. The Chanta-Argun river originates on the Northern mountain slope of the Main Caucasus mountain range, at the altitude of about 3000 m. In the upper reaches of the river on both sides there are many glaciers' feeders. The river Sharo-Argun originates in the glaciers of the Tushet mountain range at the altitude of more than 3000 m. The regime of river Argun ,as well as the rivers of its components (Chanta-Argun and Sharo-Argun), has all the features of a mountain river with mixed nutrition, with low horizons and expenditures in winter and with summer floods. It has more water than Sunzhu. The length of river

Argun reaches 148 km, the total area of the basin is 3370 km², and the average height of the basin is 1900 m. The mountain slope of the river is different: In the upper current: 0.080-0.100°; in the middle current: 0.015-0.020°; in the lower current: 0.003-0.006°.

The congealation and ice conditions of the Chechen rivers depend not only on winter temperatures, but also on the speed of their current flow. On the rivers of the highland zone (upper Assa, Chanty-Argun, Sharo-Argun), despite the relatively low winter temperatures, there is no formation of solid ice, due to the high flow speed; only in some places there are formations of ice edge around the coast (landfast ice). The average long-term river flow on the territory of Chechen Republic: Terek – 9.21 km³, Sunzha - 1.41 km³. River Argun has a regulated stream flow near the village of Duba-Yurt and in accordance with the calculations, its average flow is 0.52 km³ (Ivanov, 2015; Federation, 2009).

Rivers of Chechen Republic have characteristics of high water turbidity, due to the presence of easily eroded rocks in the river-beds. For example, the sediment runoff of river Sunzha in Grozny is 1.14 kg/m³, river Braguna is 1.67 kg/m³, river Argun in Duba-Yurt is 1.36 kg/m³, and river Michik in Gudermes is 3.55 kg/m³. One can identify the amount of sediment loads, their granulometric composition and distribution by their water regime (Table 2).

3. HYDROELECTRIC POTENTIAL

In study of the hydroelectric power of rivers, one distinguishes the following categories of hydroelectric potential:
- Gross theoretical hydropower potential, or potential hydropower resources;
- Technical hydroelectric potential, or technically usable hydroelectric resources , is that part of the gross theoretical hydroelectric potential of a river flow that can technically be under the use or is already in operation;
- Economic hydroelectric potential - part of the technical hydroelectric potential, the use of which is cost-effective.

The main hydro resources of Chechen Republic mainly concentrate within the large rivers: Terek, Sunzha, Argun, Assa and others. Rivers of the deep rock canyons make it possible to build efficient

Table 1: Characteristics of the fluvial network on the territory of Chechen Republic

Interval length, km	Number of rivers	Total length, km	Average length of rivers, km	% for the total number of rivers
Up to 1 km	1893	936.39	0.49	59.19
1-2	668	942.06	1.41	20.89
2-3	255	617.60	2.42	7.97
3-4	108	373.27	3.46	3.38
4-5	68	303.21	4.46	2.13
5-6	30	163.04	5.43	0.94
6-7	34	220.88	6.50	1.06
7-8	22	164.58	7.48	0.69
8-9	10	86.01	8.60	0.31
9-10	10	93.02	9.30	0.31
10-25	77	1164.80	15.13	2.41
25-50	13	411.90	31.68	0.41
50-100	7	484.70	69.24	0.22
Minimum 100	3	547.30	182.43	0.09
Total	3198	6508.76	2.04	100

Table 2: The average monthly usage of water consumption in m³/s of major rivers in Chechen Republic (Basins of Terek, (1987), Cadastre, S.W. (n.d.)

Rivers	Months												Annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	run-off
Terek stanitsa Kargalinskaya	130	133	166	213	324	460	538	510	349	241	198	159	285
Sunja town	1.9	2.0	2.5	3.0	3.5	4.8	2.5	2.1	2.0	2.0	1.8	1.8	2.5
Karabulak city Grozny	16.9	17.3	24.5	35.9	42.9	56.5	46.6	35.7	305	26.5	23.1	19.7	31.3
selo Braguny	43.1	42.5	58.6	83.0	11.5	156	143	112	85.5	70.2	58.2	49.2	84.7
Argun selo Duba-Yurt	16.2	15.2	18.7	30.4	55.3	85.4	91.0	71.8	50.4	36.3	25.4	19.3	43.0

hydroelectric complexes. One determines the potential hydro resources of the territory in accordance with the data of average annual expenditures and potential hydro energy (Asarin 2013; Ivanov, 2015; Polovinkin and Fomichev, 2014; Casila, 2019; Zema et al., 2016). The average long-term runoff of rivers in Chechen Republic is 12.7 million m³.

Let's examine the calculation of the theoretical hydroelectric potential for the i-th section of the river which locates between points A and B (Figure 2). One determines the hydroelectric potential of the i-th section of the river P_i (kW) by the ratio:

$$P_i = g \cdot \rho \cdot Q_i \cdot H_i \quad (1)$$

where
g - Acceleration of gravity, m/s²;
ρ - Water density, kg/m³
Q_i – The average value of the average annual water flow on the i-th section of the river, m³/s;
H_i – The height difference between the water level of water storage basin and the level of turbine's location (the fall of the i-th section of the river), m.

Approximately, the last formula, where g and ρ are constants, we can represent as follows:

$$P_i = 9.81 \cdot H_i \cdot (Q_1 + Q_2) / 2 \quad (2)$$

where
Q_1 and Q_2 – the average annual water flow at point A and point B (Figure 2), m³/s.

If there is a longitudinal profile of the entire river and data on its flow, one can determine the potential capacity from the source to the mouth of the river (control station) by the following formula:

$$P = 9.81 \cdot \sum_{i=1}^{n} Q_i H_i \quad (3)$$

The size of the technical potential depends on the amount of losses, some of which are unavoidable and more or less constant, the other (main) part depends on the hydrological, topographic and other natural conditions that form the run-off. This part of the loss is not constant, and its value can vary widely.

The limits of fluctuations in the size of permanent losses are small, and their average value may reflect the order of magnitude inherent in all hydroelectric power stations. Their value consists of head losses in supply channels, in pressure pipelines, etc. (2-10%);

Figure 2: For calculation of the hydroelectric potential
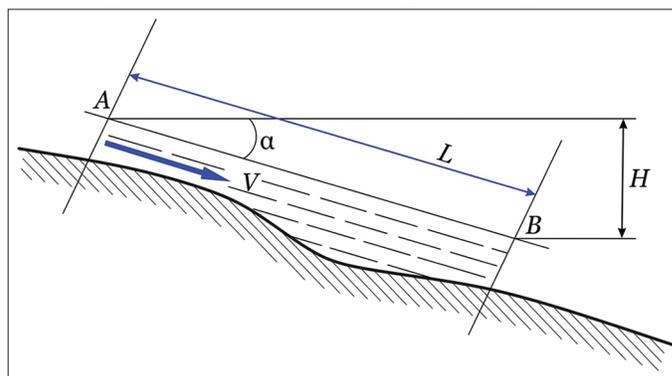
from flow losses through distributors, gates of water-retaining constructions (1%); from mechanical losses within the conversion of hydraulic energy into electrical energy (11-13%). Therefore, the upper limit on the use of gross hydroelectric potential cannot exceed 86%.

One estimates the gross hydroelectric potential of Chechen Republic at about 4.86 billion kWh. The share content of hydroelectric resources constitutes 3682.7 kWh/1 km² of the territory. The gross potential of separate mountain rivers is 2.4 billion rubles. kWh and technical – 0.55 billion. kWh.

The economic hydroelectric potential depends on the natural economic conditions of the construction in small hydroelectric power stations, and therefore, estimated by the method proposed in the studies (Asarin, 2013, Ivanov, 2015) as 0.55 of the technical potential, for mountain rivers constituted 0.302 billion rubles. kW·h. The development of only 10% of the small rivers hydroelectric potential in the mid-mountain and high-mountain zones will allow to supply up to 70% of the electricity needs in Chechen Republic (Table 3).

One can use the rich energy resources of Argun river basin in a more effective way. In 2007-2008 The Ministry of industry and energy of the Czech Republic concluded an agreement on the development of Argun HPP cascade and infrastructure facilities with the firm "RICO Group" (Republic of Slovenia). In accordance with the research data, we identified the several options for the usage of Argun river's hydroelectric potential. In accordance with the calculations results, we selected an option that includes the construction of 10 priority HPPs with such energy indicators as: the total capacity of 681 Mwatts, the annual output of the cascade up to 1.5 billion cubic meters. kWh/year (Kerimov and Debiev, 2010, Kerimov et al., 2011). Currently, we have built only the Kokadoyskaya HPP with a

Table 3: Main technical indicators of the Argun HPP cascade

No	Name of HPP	Accumulation volume, m$\geq$	Area of accumulation, ha	Volumetric water discharge, m³/s	Fall head, m.	Capacity, Mwatt	Annual output, GW
1	Chiri-Yurt	48×10⁶	255	2×60	29.3	32.2	142
2	Duba-Yurt	145×10⁶	519	2×60	44.7	49	169
3	Zones	22×10⁶	79	2×45	90	74	201
4	Nihaloy	25×10⁶	100	2×40	106.7	78	215
5	Cockadoy	25×106	145	2×35	46.8	30	87
6	Itum-Kale	210×10⁶	425	2×35	156.8	106	243
7	Ulus-Kert	33×10⁶	134	2×27.5	74.1	37.2	81.2
8	Nezhiloy-ahk	60×10⁶	132	2×27.5	116.4	58	130.3
9	Sharo-Argun	75×10⁶	210	2×25	97.2	44	87.9
10	Hima	89×10⁶	220	2×20	445	160	185.7
	Total					668.4	1542.1

capacity of 5 MW (originally there was a plan to build a HPP with a capacity of up to 30 Mwatts with a production of up to 87 GW/year).

3.1. Small Hydropower

In Russian Federation, small hydroelectric power includes damless hydroelectric power station (DHPS), whose capacity does not exceed 30 Mwatts, and the capacity of a single hydroelectric unit is <10 Mwatts. One can divide such HPPs, in turn, into: Micro-HPPs (with a capacity of 1.5-100 kW) and small HPPs (with a capacity from 100 kW to 30 MW).

Currently, there are more than 300 small hydroelectric power stations with a total capacity of about 1300 MW that operate on the territory of Russian Federation. These small hydro power plants differ by design solutions and technical level – from manually controlled to fully automated stations that operate without on-duty personnel. These HPPs provide power to individual consumers isolated from the electric power systems, but most of them have connection to the local power systems.

In order to create such capacities, technical solutions that are fundamentally different from the traditional ones developed for larger HPPs are possible, as well as:
- Construction of river intakes;
- The creation of water storage basins, the flooding of which does not exceed the maximum preflood level;
- External structural arrangement of hydroelectric power stations;
- The energy use of natural changes in the water flow.
- The required conditions for the small hydropower development:
- Decentralized, low-volume energy consumption; small industries, individual farms and enterprises, rural population;
- Low-voltage distribution network and, obviously, within the regional micro-power supply system;
- The average length of the planning period, the use of local materials and labour.

Recently, new technologies for the usage of small river flows (with a flow rate of 3-5 m³/s for small dam HPPs) have appeared. There are already hydroelectric installations that receive electricity from ultra-small flows (low-potential, from 20 l/s), with large capacity capabilities (up to 100 kW), and also from artificially created flows of so-called "kinetic hydro-ring" (Polovinkin and Fomichev, 2014;

Bjorn_Lytskjold, Astrid Vosko, 2005, Russian Federation, 2012; HydroMinds-Tool).

The new technological solutions are rapidly erected, easy to operate and use a wide range of river depths, from 0.15 m and above, with the only condition that the flow speed must be at least 0.8 m/s.

The sediment transport and their sedimentation in the reservoirs create problems that require the comprehension, as they have a number of negative impacts on the performance of HPP. That means: depletion of the reservoir storage capacity over time, increased downstream degradation, increased risk of inundation upstream from the reservoirs, production losses due to reduced Energy conversion efficiency of turbines, increased frequency of repairs and maintenance; reduced turbine service life and uninterrupted power generation. One can eventually deal with the problem of sedimentation through the use of established technologies.

The extension of the program to support the development of renewable energy after 2024 will allow the construction of small hydroelectric power plants (HPPs) with a total capacity of about 1 GW in Russian Federation by 2035 (Table 4) (Federation, 2009).

In accordance with JSC "MNTO INSET" S-Petersburg (www. inset.ru), the use of damless hydroelectric power stations (DHPS) that use water pressure is possible on the rivers Terek and Sunzha with a total capacity of up to 100 mW.

If there is a very large reservoir in relation to the size of a hydroelectric power station (or very constant river flows), HPPs can generate electricity almost continuously in the course of year, i.e. function as a base load power plant. Otherwise, if the potential of hydroelectric power significantly exceeds the storage capacity of the reservoir, then the hydroelectric power plant sometimes has name of energy-limited hydroelectric power station. An energy-limited hydroelectric power plant will use up its "fuel reserves" by continuously functioning at level of its nominal capacity during a year. In this case, the use of the reservoir capacity ensures the generation of hydroelectric power in those periods of time that are most important from the perspective of the power system, rather than in those periods of time that belong solely to the river flows. Since the demand for electricity changes during the day and

Table 4: Projects for the construction of small HPPs in the North Caucasus

Region	Name small hydro power plant	Capacity, Mwatt	Av. annual output, mln. KWh	Period of payback*, years	Stage of project's realization*
Kabardino-Balkaria	Adyr-su	24.5	92.5	9	Study of financial feasibility
	Zaragizhskaya	15.0	65.5	8	The same
	Verkhnebalkarskaya	14.7	76.0	7	The same
	Adyl-su, two-stage cascade	14.4	60.3	10	Feasibility study design*
RD	Kurminskaya	15.0	57.5	9	The same
	Shinazskaya	1.4	7.0	8	Construction and assembly operations
	Arakulskaya	1.4	6.0		
	Amsarskaya	1.0	4.0		
Republic of North Ossetia – Alania	Fiagdonskaya	4.0	22.0	6	Feasibility study design*
TOTAL		91.4	390.8		

*Calculations are preliminary and subject to clarification. Source: www.ne-fund.ru

night, during the week and seasons, the generation of electricity from a hydroelectric storage plant can refer to those periods of time when the needs of the power system are greatest. Part of this time will relate to the periods of peak demand for electricity. Operation of hydroelectric power stations in such a way as to generate electricity during periods of high demand has the name of Peak Mode (as opposed to base-load regime). However, even if there is a water storage basin, hydroelectric power generation will still have limitations by its size, the rated electric capacity of the hydroelectric power plant, as well as recreational activities or environmental protection. The production of hydroelectric power in peak mode can lead, if there is a water discharge directly into the river, to rapid fluctuations in the river flow, the area covered by water, the depth and speed of the current (Kasamba, 2015).

4. ECONOMICAL EFFECTIVENESS

The contracts for design, procurement and construction of HPP become the most popular form of the construction work in large hydropower projects. The main contractors in a number of countries face many difficulties during the construction phase of hydropower projects and it results in significant schedule delays and cost overruns. One of the reasons is the low capacity of subcontractors. An important factor for any main contractor in the implementation of hydropower projects is the subcontractor who participates in the implementation of the hydropower project.

The main contractors attempt to examine the risks associated with the identification and control of subcontractors and with the construction delay of hydroelectric power stations.

For example in (Berkun, 2010; Bui, 2019, Mai and Wang, 2017, Nogueira,1993; Sachin, 2012; Nunes and Genta, 1996), by the results' summary of international research that relate to hydroelectric projects in combination with analytical characteristics of the hydroelectric power projects development in countries with tropical monsoon, subtropical, subequatorial, temperate continental climate with forests on mountain-forest soils, with steppes turning into semi-deserts, covered with glaciers, identified the risk types of subcontractors for the process timeout of a hydroelectric project. There was a development of questionnaire with 18 risk elements, which then passed to experts in the field of hydropower project management.

In accordance with the risk model, we identified 11 main risk elements, that one can divide into 3 groups (Table 5). (Berkun, 2010; Bui, 2019; López-González, 2019; Mai and Wang, 2017; Nogueira, 1993; Sachin, 2012; Nunes and Genta, 1996).

Hydroelectric power has characteristics of the highest conversion coefficient in relation to all known energy sources (a coefficient of about 90% in transmission "from water to wires") it has a very high payback rate for electricity and is a predictable and price-competitive technology. It currently provides approximately 16% of global electricity production and 86% of all electricity from renewable sources.

The service life of small HPPs is quite long, some stations have been operating for more than 70 years, and modern small HPPs can have an even longer time of operation. Thus, they can provide electricity for a long time without harm to the environment. Numerous calculations have proved that investments in small hydropower are not subject to risks, they are reliable for several decades (Renewable energy and climate change mitigation 2011, Berkun, 2010; Federation, 2009; International Hydropower Association. (n.d.)).

The hydropower projects often require a large initial investment, but they have the advantage of very low maintenance costs and a long operational life. In general, there are two main groups of costs: construction costs, which are usually the largest costs for a hydroelectric project; and costs for electromechanical equipment.

For power plants designed for maximum power generation (base load) and/or with a certain regulation, the power coefficients range from 30% to 60%. For peak load power plants-the power factor is in the same range and for river systems-in a wide range (20-95%) in accordance with the geographical and climatological conditions, technology and operational characteristics.

According to the IBRD, with an average power factor of 44%, initial investment in the construction of small hydroelectric power plants ranges from 1,800 to 3,800 US dollars per 1 kW of capacity (for fall heads from 2.3 m to 13.5 m) and from 1,000 to 3,000 US dollars per 1 kW (for fall heads from 27 m to 350 m). At the same time, the service cost of HPP is low. The capital expenditures include: construction of dams, canals, stations; equipment for power generation (turbine, generator, transformer,

Table 5: Results of engineering, procurement and construction risks identification (EPC)

Factors	Elements of risk
Engineering	• Risk due to poor quality of technical design • Risk due to poor quality of construction plans • Risk due to negative survey data • Risk due to poor examination of technical and drawing design
Purchase	• Risk due to uncertain and unclear terms of the purchase/sale agreement • Risk due to poor purchase of materials, supplies, equipment and machinery • Risk due to poor equipment installation and commissioning
Construction	• Risk due to a quality team of construction project control • Risk due to building safety • Risks due to poor quality of investor management • Risks due to poor quality management of the EPC main contractor • Risks due to unclear circular guidance of quality management laws • Risk due to poor subcontractors • Risk due to poor construction from the EPC main contractors

power lines); development of project documentation, cost of land, commissioning.

Typically, equipment used with low fall pressure and low power generation is expensive and accounts for 40-50% of the total investment. Since we talk about the cost of civil construction, it is impossible to give exact figures with regard to the cost of each object. Dams, channels, and intake units will constitute the different percentages of the total investment for different facilities. Much depends on the topographical and engineering-geological conditions, as well as on the construction technology and the materials under use (Figure 3).

In accordance with the Ministry of Energy of the Russian Federation, the cost of 1 kW·h produced at a small HPP in Russian Federation within the centralized power system is 40-60 kopecks, within the autonomous system-1.1-2.3 rubles, respectively, the payback of the small hydro power plant is 7-8 years (Asarin, 2013; Ivanov, 2015; Federation, 2009). The costs directly related to the construction of HPP constituted 35% of this amount, while the cost of equipment for power generation – 50%.

High investment costs are the biggest barrier to large-scale development of small hydropower. However, despite this fact and a long payback period (7-10 years), small HPPs are cost-effective due to their long service life (more than 70 years) and low maintenance costs. As a rule, the cost of maintenance and repair without the replacement of expensive equipment is approximately 3 to 4% of capital investment for small and micro-hydro power.

4.1. Small Hydropower and Sustainable Development of the Region

The power plants that use fossil fuels to generate electricity are the main source of greenhouse gases (GHGs). One can effectively replace these installations by nuclear power,

Figure 3: The cost of 1 kW of capacity in accordance with the IBRD
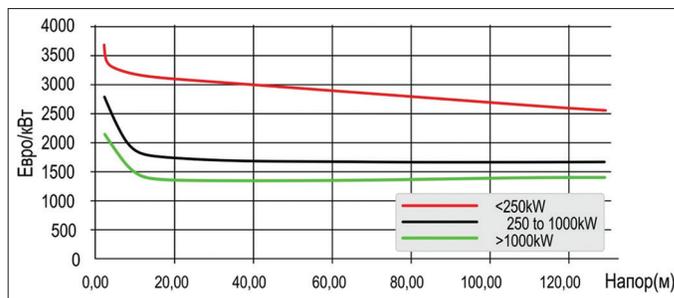
hydroelectric power, and other less important options such as biomass, hydrogen, wind power, and solar power. One must produce hydrogen either from natural gas or from electrolysis, and it can become a significant source of greenhouse gases. In accordance with the data from the International Commission on large dams (ICOLD) and the World Bank, there are ten environmental impact categories. These are impacts on the natural environment (flora, fauna, and aquatic fauna), social/economic/cultural aspects (relocation), land, dam construction, deposition of water storage basins, downstream hydrology, water quality, tidal barriers, climate, and human health (Berkun, 2010, Bui, 2019, Milton and Geiger, 2015).

The artificial reservoirs are also a source of significant pollution, especially greenhouse gases (methane and CO_2). They also cause a major political concern, especially in semi-arid areas, by the decrease of river speed and the sediment increase, that result in significant changes in the downstream regions. As the population increases and the quality of life increases, there is an additional load in relation to the social infrastructure and its intrusion into the physical resource base. However, the choice between costs and benefits is inevitable when the economy, demographics, politics, and environment meet in the same ecosystem (Berkun, 2010; Bui, 2019; Milton and Geiger, 2015).

Historically, economic development has close link with the increase of energy consumption and greenhouse gas emissions, and renewable energy can help reduce this relationship by promotion of the sustainable development. The hydropower essentially offers opportunities to promote socio-economic development, access to energy, advanced energy supply, climate change mitigation, and reduction of negative impacts on the environment and human health.

The wide range of hydroelectric power potential, its flexible nature, the ability to accumulate (if there is a reservoir) and the ability to function independently or within the networks of different sizes makes it possible to provide a wide range of services.

For example, in China, small HPPs are one of the most successful examples in agricultural electrification, with more than 45,000 small HPPs that operate with a total capacity of more than 55,000 MW and an annual capacity of 160 TWh, with consumers of more than 300 million people (International Hydropower Association. (n.d.)). The development of small hydro-power also exists in various US States (Milton and Geiger, 2015; Nunes and Genta, 1996).

Like all other options for regulation of energy consumption and water management, hydroelectric projects have negative and positive environmental and social outputs. From an environmental perspective, hydroelectric power can have a significant impact on the environment at the local and regional levels by influence on the ecology of rivers, mainly as a result of changes in their hydrological indicators and violations of the ecological process constancy in relation to sediment transport and fish migration through the construction of dams, embankments and weirs. At the same time, the degree of change in the physical, chemical, biological and ecosystem characteristics of the river depends mainly on the type of HPP. Although the projects of river HPP do not change the river flow regime, the creation of a water storage basin in order to accumulate the hydroelectric power causes serious environmental changes as a result of the ecosystem's transformation in relation to the fast-flowing river into an artificial lake with still water (López-González, 2019).

The issue of whether hydroelectric power plants can contribute to the acceleration of socio-economic development depends to a large extent on how one shares and distributes the services and income produced among the different stakeholders. HPPs can also have a positive impact on local residents and the regional economy, not only by generation of electric power, but also by support of many other water-dependent activities, such as irrigation, tourism, and others.

We should note that large power and heat stations focus on the energy supply of cities and industrial enterprises. Small settlements and farms scattered among mountain gorges have no electricity or the quality of electricity is poor. One uses approximately 80% of household electricity consumption in mountain regions for room illumination and household appliances. Currently, the main energy source materials for the population of these areas are wood, natural gas, oil products, etc.

5. CONCLUSION

Nowadays, the development of hydroelectric power, as well as small ones, is an important factor for the improvement of the socio-economic living conditions of the population in mountain regions and contributes to the solution of environmental problems in general. Despite all its disadvantages, the advantages of small HPPs over large ones are known – they have much lower financial and material costs during their construction, lower environmental risk, and proximity to the consumer, which is very significant in mountain conditions. Due to the high level of adaptability to cycling up and down demand in the network, a small hydroelectric power station is the preferred element of any integrated power system.

We should note that large power and heat stations focus on the energy supply of cities and industrial enterprises. Small settlements and farms scattered among mountain gorges have no electricity or the quality of electricity is poor. The construction of small HPP usually uses local materials and labor resources.

Surface runoff on the territory of Chechen Republic has a significant volume and the use of its hydroelectric potential will solve a number of economic and social problems. The generation of electricity and its distribution nature will support the development of productive forces in the Republic and contribute to energy security both on the territory of the Republic and at the regional level.

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