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Power Engineering

Water Power Resources of the Rivers in Abkhazia

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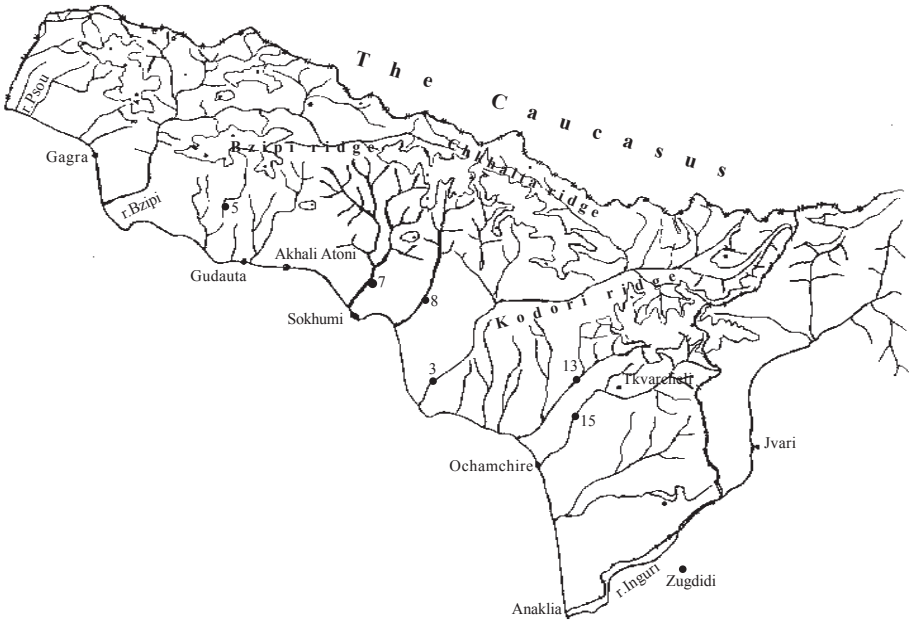
ABSTRACT. The research data of water-power resources of the rivers in Abkhazia are considered. Specific energy per unit of the catchment basin area is determined. The equation for calculation of the theoretical power is obtained. This allows the power for any required sector of the river in Abkhazia to be determined with precision up to 35%. Calculation of the power by the mentioned equation may be used in prospective work to the first approximation. *© 2007 Bull. Georg. Natl. Acad. Sci.*

Key words: *hydrographic network, hydraulic power engineering, hydrologic characteristics, power.*

The Black Sea and the southern slopes of the Great Caucasus Range bordering Abkhazia promote abundant rainfall throughout the territory, thus augmenting the hydrographic potential of the rivers (see Fig.1). The majority of these rivers flowing across the territory have their source in the southern hills of the Main Caucasus Range , which accounts for the large volume and heavy water fall causing high-energy capacity waters.



Figures over the points denote sequential numbers of rivers in Table 1:
3- Kodori,
5 – Belaya,
7 – Gumista,
8 – Kelasuri,
13- Mokvi,
15- Galidzga.

Fig. 1. Schematic map of rivers catchment basin on the territory of Abkhazia.

The above-mentioned fact provided the basis for developing small-scale hydraulic power engineering on the mentioned territory since the end of the 19th and the beginning of the 20th centuries (Gagra, Akhali Atoni, Sokhumi water-power stations) [1].

For complex and purposeful use of rivers in the mentioned region we have set the problem of studying the potential water power resources of the rivers. With this aim we chose 17 rivers. We used schematic longitudinal profiles of the rivers, diagrams of catchment area growth, the main hydrological characteristics [2].

Our purpose was to determine the power per unit of a catchment basin area for separate characteristic sectors of rivers and to establish the correlation between the water power per unit area of the river basin $\left(\frac{N}{F}\right)$ and fall of the water surface (ΔH), $\left(\frac{N}{F}\right) = f(\Delta H)$.

Longitudinal profiles of the separate rivers under study were divided into sectors. Relatively straight sectors without visible bending were chosen. The catchment area F, water surface fall ΔH, average annual consumption of water Q were calculated for each chosen sector (Table 1). Often the main hydrological characteristics *F, q, L* were unknown and so we had to use the diagrams of growth of river basins to determine the catchment areas, and to determine the water consumption we used the rate of consumption

$$K = \frac{Q}{F}, \quad \frac{\mathrm{m}^3}{\mathrm{sec} \cdot \mathrm{km}^2},$$

where Q is the average annual consumption of water, m^3/sec, F – catchment area, km^2. The values of the coefficient K were calculated and chosen from [2].

Theoretical power was calculated by the formula

$$N_{\mathrm{th}} = 9.81\, Q\, \Delta H, \mathrm{kW},$$

where ΔH is the water surface fall in the given sector.

The calculated theoretical power of sectors of 17 rivers is: sector I – 1,295,741 kW; sector II – 3,820,684 kW; sector III – 6,172,561 kW. The total power for all the rivers is 11,288,986 kW.

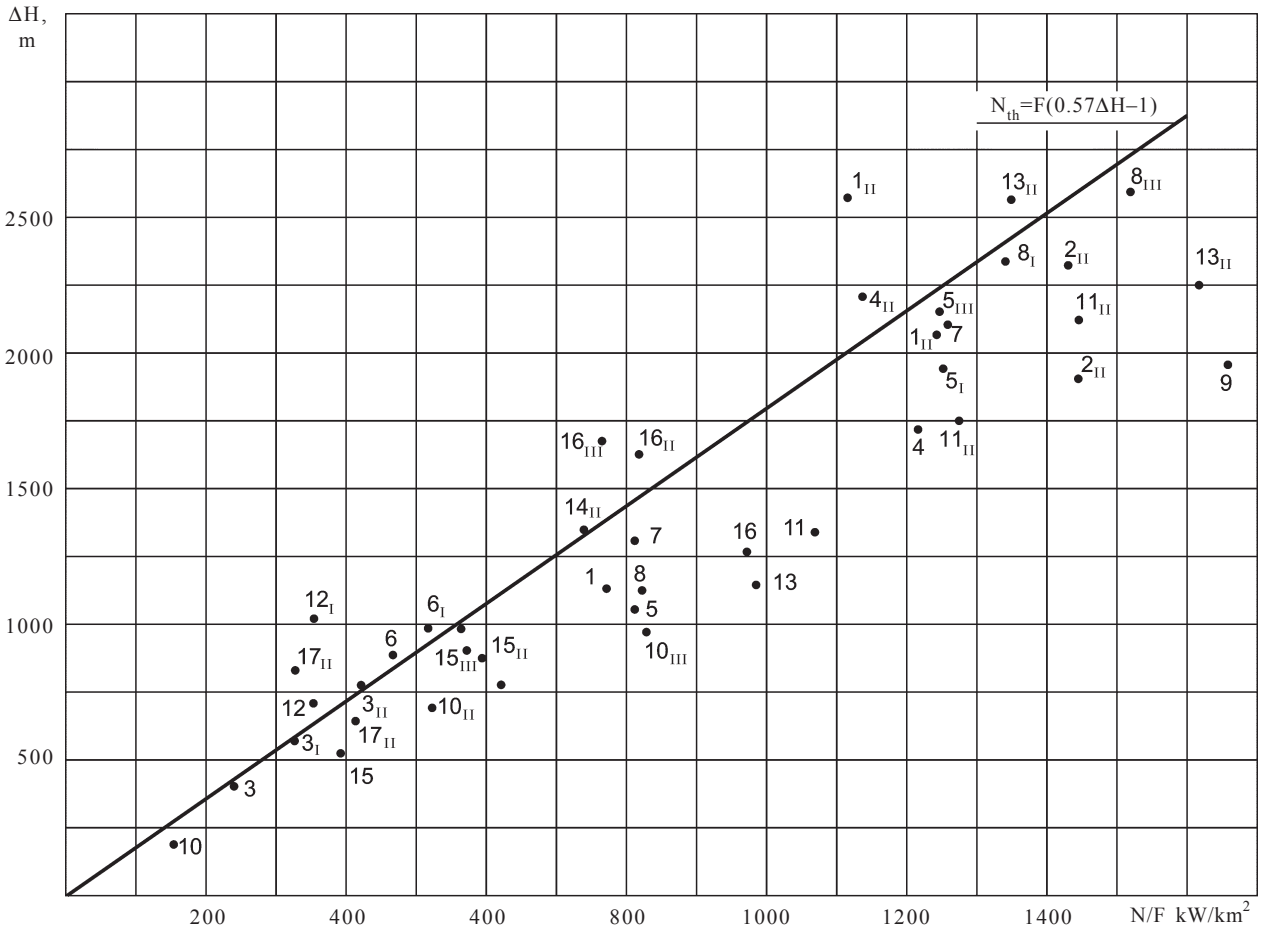


Fig. 2. Dependence of the power per unit catchment area (N/F) on water surface fall (DH). The data are taken from research results of potential water power resources of 17 rivers on the Abkhazian territory. Figures over the points denote sequential numbers of the rivers in Table 1; indices II and III denote characteristic sectors of the rivers.

Table 1

Research data on the potential water-power resources of 17 rivers on the territory of Abkhazia

№	Rivers	Characteristic sectors of the river length																		
		H, m	Sector I						Sector II						Sector III					
			H_1 m	ΔH_1 m	Q_1 m^3/sec	F_1 km^2	N_1 kW	N_1/F_1 kW/km^2	H_2 m	ΔH_2 m	Q_2 m^3/sec	F_2 km^2	N_2 kW	N_2/F_2 kW/km^2	H_3 m	ΔH_3 m	Q_3 m^3/sec	F_3 km^2	N_3 kW	N_3/F_3 kW/km^2
1	Psou	2,517	1,400	1,117	0.81	11.3	8,875	785	478	2,039	9.1	145	182,023	1,255	0	2,517	19.2	421	474,082	1,126
2	Bzipi	2,306	1,560	746	5.2	61	38,055	624	427	1,879	36.4	461	670,961	1,455	0	2,306	95.8	1,510	2,167,174	1,435
3	Kodori	740	369	371	82	1,261.5	298,440	236	185	555	92.4	1,538	502,532	326	0	740	119	2,030	863,868	425
4	Gega	2,400	689.2	1,711	6.41	89	107,578	1,208	164	2,236	27.8	422.2	609,797	1,144	-	-	-	-	-	-
5	Belaya	2,134	1,100	1,034	1.96	24.6	19,881	812	200	1,934	4.8	72.5	91,068	1,256	0	2,134	9.76	166.1	204,321	1,230
6	West Gumista	1,070	233	837	12.1	216.4	99,353	459	83.2	968.8	16.6	316	160,696	508	-	-	-	-	-	-
7	East Gumista	2,180	900	1,280	2.0	27.8	25,113	903	83	2,097	14	230	288,002	1,252	-	-	-	-	-	-
8	Kelasuri	2,580	1,500	1,082	1.2	15.3	12,737	832	300	2,280	11.3	174	252,745	1,452	0	2,580	13.2	220	334,089	1,518
9	Sakeni	2,620	696	1,924	20.6	233	388,813	1,668	-	-	-	-	-	-	-	-	-	-	-	-
10	Chkhalta	1,470	1,290.8	179	18.6	204	32,661	160	787.3	682.7	27.4	308.3	183,505	521	493.8	976.2	40.7	465	389,764	838
11	Amtkeli	2,300	981.5	1,318	9.8	109	126,710	1,077	554.7	1,745.3	11.8	159.2	202,032	1,269	200	2,100	28.1	398	578,888	1,454
12	Dgamishi	1,003	300	703	1.1	21.5	7,586	353	0	1,003	4.32	120	42,506	354	-	-	-	-	-	-
13	Mokvi	2,560	1,442.5	1,118	0.65	7.2	7,129	990	300	2,260	3.6	49.2	79,814	1,622	0	2,560	18.1	336	454,556	1,356
14	Duabi	1,380	400	980	1.49	26	14,324	551	49	1,331	6.43	114	83,957	736	-	-	-	-	-	-
15	Galidzga	960	469.4	491	11.8	142	56,837	400	100	860	23.8	335	200,791	599	0	960	29.4	483	276,877	573
16	Okumi	1,650	400	1,250	3.3	41.4	40,466	977	60	1,590	11.3	200	176,256	881	0	1,650	26.5	559	428,942	767
17	West Eristskali	800	200	600	1.9	26.3	11,183	425	1.5	798.5	12.0	296	93,999	317	-	-	-	-	-	-

H - the height of river head, H_1, H_2, H_3 - the height of sectors I, II and III respectively, ΔH_1, ΔH_2, ΔH_3 - water surface fall in the mentioned sectors;
Q_1, Q_2, Q_3 - average annual consumption of water in corresponding sectors; F_1, F_2, F_3 - catchment areas of corresponding sectors;
N_1, N_2, N_3 - water power for corresponding sectors; N_1/F_1, N_2/F_2, N_3/F_3 - water power density in corresponding sectors.

Table 2

Comparison of research results of the potential water power resources of 17 rivers on the territory of Abkhazia with values calculated by equation (1)

N	Rivers	Characteristic sectors of the rivers length								
		Sector I			Sector II			Sector III		
		N_{th} kW	N_{eq} kW	Error %	N_{th} kW	N_{eq} kW	Error %	N_{th} kW	N_{eq} kW	Error %
1	Psou	8,875	7,183	19	182,023	168,378	8	474,082	603,583	27
2	Bzipi	38,055	25,877	32	670,961	493,283	27	2167,174	1,983,264	9
3	Kodori	298,440	265,296	11	502,532	485,008	4	863,868	854,224	1
4	Gega	107,578	86,710	19	609,797	537,680	12	-	-	-
5	Belaya	19,881	14,474	28	91,068	79,850	12	204,321	201,875	1
6	West Gumista	99,353	103,026	4	160,696	174,184	8	-	-	-
7	East Gumista	25,113	20,255	19	288,002	274,687	5	-	-	-
8	Kelasuri	12,737	9,420	26	252,745	225,956	11	334,089	323,312	3
9	Sakeni	388,813	255,293	34	-	-	-	-	-	-
10	Chkhalta	32,661	20,610	37	183,505	119,663	35	389,764	258,277	34
11	Amtkeli	126,710	81,778	35	202,032	158,216	22	578,888	476,001	18
12	Dgamishi	7,586	8,593	13	42,506	68,485	61	-	-	-
13	Mokvi	7,129	4,581	36	79,814	63,330	21	454,556	489,955	7
14	Duabi	14,324	14,497	1	83,957	86,374	3	-	-	-
15	Galidzga	56,837	39,599	30	200,791	163,882	19	276,877	263,814	5
16	Okumi	40,466	29,456	27	176,256	181,060	3	428,942	525,180	22
17	West Eristskali	11,183	8,968	20	93,999	134,426	30	-	-	-
Total		1,295,741	995,616	23	3,820,684	3,428,135	11	6,172,561	5,979,485	3

N_{th} – theoretical potential power; N_{eq} – power calculated by equation (1) $N = F(0.57\ H\text{-}1)$.

Power density (power per unit catchment area) was calculated by the ratio $\frac{N}{F}$. Calculation results are presented in Table 1. Using the Table data the relation $\frac{N}{F} = f(\Delta H)$ was constructed (Fig. 2). As seen from the Figure the dependence is linear and it can be described by the following regression equation:

$$N_{th} = F(0.57\Delta H\text{-}1). \quad (1)$$

By using equation (1) it is possible to define the theoretical power for arbitrary sections of the rivers with precision up to 35%, which is wholly satisfactory for the approximate purpose.

The results of comparison of the values of powers calculated by equation (1), and those of actual ones are given in Table 2.

Thus, we can conclude:

1. The total theoretical power of 17 rivers on the territory of Abkhazia is 11,288,986 kW;

2. The obtained equation allows us to determine the approximate power for any section of rivers;

3. At designing the planner can easily determine and choose a required sector of the river to the first approximation.

ენერგეტიკა

აფხაზეთის მდინარეების ჰიდროენერგეტიკული რესურსების კვლევა

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(წარმოდგენილია აკადემიის წევრის რ. ადამიას მიერ)

სტატიაში განხილულია აფხაზეთის 17 მდინარის ჰიდროენერგეტიკული რესურსების კვლევის შედეგები. მდინარეების გრძივი პროფილები დაყოფილ იქნა მახასიათებელ მონაკვეთებად და ჩამკეტი კვეთებისათვის გაანგარიშებულ იქნა მდინარის თეორიული სიმძლავრე. გამოთვლილია წყალშემკრები აუზის ერთეულ ფართობზე ხვედრითი ენერგია, რის საფუძველზეც მიღებულ იქნა განტოლება $N_{თ}=F(0.57\Delta H-1)$ სიმძლავრის განსასაზღვრავად. ეს საშუალებას იძლევა ნებისმიერი მდინარის საინტერესო კვეთისათვის განისაზღვროს სიმძლავრე 35%-მდე სიზუსტით. აღნიშნული განტოლებით გამოთვლილი სიმძლავრე შეიძლება გამოყენებულ იქნეს პირველი მიახლოებითი საპროექტო სამუშაოებისათვის.

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