

Part 8

RENEWABLE ENERGY SOURCES

8.4. Small hydro power plants

8.4.4. Overview of development of small HPPs as of 2014

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ABSTRACT

In Russia all hydro power plants (HPPs) are referred to renewables, but small hydro and non-conventional are those with capacity less than 30 MW_e. The word “non-conventional”, taken from the national standards GOST R 54100-2010, GOST R 51238-98, etc., is not absolutely correct for small HPPs; by the middle of XX century in the former USSR some 6600 small HPPs were in operation, later on almost all of them were dismantled [1]. We can speak of the “second birth” of small hydro, which happened in the world and in our country during the last 20 years. Big hydro for a long time is a separate branch and in this article only small HPPs are considered.

The most impressive results in the share of small hydro capacities and power output in Europe is achieved in the Netherlands (8,5 % of power output), Austria (6,9 %), Sweden (3,15 %). In RF total potential of small hydro sector is higher than the potential of such renewables as wind, solar and biomass all together; economic and technical potential is evaluated of 205...372 bln kWh per year [1] or from 1/4 to 1/3 of power consumption in the world. At the time being in RF power generation by small hydro constitutes some tenths of percentage in the power production balance.

The article includes the materials from the first version of section 8 “Renewables” of the Informational System of Moscow Power Engineering Institute (<http://osi.ecopower.ru>), prepared by JSC ENIN [3] and recent materials got available later.

1. SMALL HPPS

Brief description. According to the national standard GOST R 51238-98 [2] small HPPs are those which installed capacities are in the range from 100 to 30000 kW. This very standard classifies small HPPs in a way water flow comes to hydro turbines:

- dam-type (water duct and hydro turbine are placed in the dam body);
- river-bed type (water duct and hydro turbine are installed in the river-bed);
- dam-storage power plant (water flow from the upper reservoir is forwarded to a turbine installed before the bottom reservoir by water-duct pipeline);
- diversion (part of the river water flow via by-pass water duct is directed to the turbine);
- without a dam;
- free flow;
- mixed.

Small hydro can be grid connected (united with a power system) and autonomous.

Types and capacities of energy equipment at which it is recommended or possible to implement the technology under consideration.

As it is clear from types of small HPPs indicated above, the choice of a reasonable option depends on local conditions and they vary a lot.

According to the national standard GOST R 51238-98 the following types of turbines at small HPPs can be implemented:

- reactive;
- scoop;

- active, transverse-jet;
- reactive, front;
- reactive, auger;
- reactive, rotor;
- free flow.

The most wide spread according to [2] are:

- active scoop-type turbine with tangential water feed of high-speed jet to the wheel, which is equipped with blades of special configuration;
- reactive turbine with axial water feed to the blades of the wheel; revolution takes place due to pressure difference between the turbine inlet and the outlet.

Manufacturers of equipment.

In 1990's because of decrease in construction of large-scale hydro power plants in Russia some companies partly turned to produce equipment for small hydro; among them JSC “LMZ” (www.power-m.ru) and JSC “NPO CKTI” (www.ckti.ru) from St. Petersburg; JSC “Tiazhmash” (www.tyazhmash.com) from Syzran, etc. At the same time some small business companies and enterprises producing equipment for small hydro power plants appeared (some in the framework of military conversion of industry). Among them the most well-known are JSC “MNTO Inset” (www.inset.ru) and NPC “Rund” (www.rund-n.spb.ru) from St.Petersburg; JSC “Napor”, JSC “NIIES” (www.niies.rushydro.ru) and JSC “Energomash” (www.npoenergomash.ru) from Moscow. Among suppliers of equipment one should name regional entities which earlier were branches of All-Union Design and Research Institute “HydroProject”. At the time being in Russia factory-assembled hydro turbines with automated control systems for grid-connected and autonomous HPPs can be manufactured; they are designed for water heads from 1 m to 250 m; they can as well produce non-standard hydro-mechanic and lifting equipment, head pipelines, inlet doors, transformer substations, electric distribution appliances and other components necessary for small hydro power plants. For small HPPs with static heads hydro turbines of the following types are applicable: radial-axial, propeller, scoop, slant- and transverse-jet, front configuration. For small HPPs with use of speed heads hydro turbines of “Darie”, “Wells”, “Savonius” types, etc. are applicable. Generators for small HPPs are produced by JSC “Electrosila” (St. Petersburg), JSC “UralElectroTiazhmash”, JSC “Privod” (Lysva), JSC “SEGPO” (Sarapul), JSC “SEZ” (Safonovo), etc. [4]. Below is information on small HPP turbines of megawatt capacities and their technical parameters from JSC “MNTO Inset” [5].

Hydro turbines for small HPPs:

- aggregates with axial turbines (GA-1, GA-8, GA-8M, GA-14, Pr-15, Pr-30) with capacity up to 1800 kW;
- aggregates with radial-axial turbines (GA-2, GA-4, GA-9, GA-11) with capacity up to 5600 kW;
- aggregates with scoop-type turbines (GA-5, GA-10, GA-10M, 200K) with capacity up to 5200 kW.

As an example in Table 1 parameters of hydro aggregates with radial-axial turbines GA-2, GA-4, GA-9 and GA-11 with capacities from 950 kW to 5600 kW each are presented.

Range of applicability:

- head for small HPPs of megawatt capacity must be over 25...30 m;
- it is desirable that small HPPs of megawatt capacity are built at mountain rivers which has no fish value or HPPs are of diversion type;
- some small HPPs cannot be operational in winter time.

Table 1. **Hydro aggregates with radial-axial turbines**

Parameters	GA2	GA4	GA9	GA11
Capacity, kW	up to 950	550	3300	5600
Head, m	30...100	25...55	70...120	100...160
Consumption, m ³ /sec	0,35...0,9	0,4...1,0	0,8...3,2	1,5...4,0
Rotor revolution speed, rpm	1000; 1500	1000	600; 750; 1000	750; 1000
Nominal voltage, V	400; 6000	400; 6000	6000; 10000	6000; 10000
Nominal current frequency, Hz	50	50	50	50

Restrictions on implementation of technology.

Restrictions are possible because of environmental reasons (protection of fish resources) or social (necessity in resettlement of some people as a result of flood from the upper reservoir).

Advantages and disadvantages.Advantages:

- general advantages characteristic for all of the renewables (no emissions of pollutants and almost absence of GHGs emissions, organic fuel savings, diversification of energy sources, company's image increase aspects, etc.) and besides:
- minimal operational costs;
- high level of automation;
- lifetime of the main equipment – over 40 years; period between capital maintenance works – 5 years;
- domestic equipment manufactured by high level technological producers is available.

Disadvantages:

- high specific capital cost for some small HPPs which are sited at places with disadvantaged relief (may be over 2000 USD/kW);
- some negative impact may be on fish resources.

References in RF.

Main resources of small hydro in Russia are concentrated at Northern Caucasus, in Far-East region, at the North-East of the European part of the country (Arkhangelsk, Murmansk, Kaliningrad regions, Karelia Republic), at Altai, Tuva, Yakutia, Tumen regions. There is a great number of facilities where small HPPs are introduced, located in many regions of the country.

Information on existence/absence of author's rights on the implemented technology, developers and/or legal owners of the technology

In the process of creation and improvement of equipment of small HPPs some units and technological components are protected by authors' rights (RF patent 2277182, USSR patent 62742, etc.).

2. MICRO HPPS

Brief description. Micro HPPs according to the national standard GOST R 51238-98 [2] are power plants with installed capacities up to 100 kW. This very standard classifies small HPPs in a way water flow comes to hydro turbines:

- without a dam;
- free-flow;
- floating;
- submersible;
- sleeve-type.

Micro HPPs in most cases are implemented as an autonomous power source.

Types and capacities of energy equipment at which it is recommended or possible to implement the technology under consideration.

There are many micro HPPs and the variety of related equipment. For instance, the range of turbines made by JSC "MNTO Inset" is presented by the following aggregates [5]: with propeller-type of a wheel

- capacity up to 5 kW (MGES-5Pr) designed for the head 2.0...4.5 m and water consumption 0.07...0.14 m³/sec;
- capacity up to 10 kW (MGES-10Pr) designed for the head 4.5...10 m and water consumption 0.10...0.21 m³/sec;
- capacity up to 15 kW (MGES-15Pr) designed for the head 4.5...12 m and water consumption 0.10...0.3 m³/sec;
- capacity up to 50 kW (MGES-50Pr) designed for the head 2.0...10 m and water consumption 0.3...0.9 m³/sec;
- capacity up to 100 kW (MGES-100Pr) designed for the head 6...18 m and water consumption 0.5...1.2 m³/sec.

with diagonal-type of the turbine wheel

- capacity 20 kW (MGES-20PrD) designed for the head 8...12 m and water consumption 0.08...0.17 m³/sec.

with scoop-type of the turbine wheel

- capacity up to 100 kW (MGES-100K) designed for the head 40...250 m and water consumption 0.015...0.06 m³/sec;
- capacity up to 180 kW (MGES-200K) designed for the head 40...250 m and water consumption 0.025...0.1 m³/sec.

Table 2. **Parameters of micro HPPs with diagonal- (D) and scoop-type (S) of turbines**

Parameter	HPP 20Pr (D)	HPP 100K (S)	HPP 200K (S)
Capacity, kW	10...20	до 100	до 180
Head, m	8...18	40...250	40...250
Water consumption, m ³ /sec	0,08...0,17	0,015...0,060	0,015...0,100
Revolution speed, rpm	1500	600; 750; 1000; 1500	
Nominal voltage, V	230, 400	230, 400	
Current nominal frequency, Hz	50		

Range of applicability:

- all over the country where it is possible to provide the head over 1...2 m and sufficient water consumption;
- formally as classified by national standard the capacity is up to 100 kW.

Restrictions on technology application: practically absent.

Advantages and disadvantagesAdvantages:

- low operational costs;
- domestic equipment for micro HPPs made by highly technological manufacturers is available;
- the technology can be applied by small-scale companies and even by private persons;
- long-term lifetime of HPPs;
- there is practically no impact on environment.

Disadvantages:

- low single capacities of micro HPPs, not enough for many production enterprises.

Where in RF the technology is applied.

Quite a lot all over the country.

Information on existence/absence author's rights on the implemented technology, developers and/or legal owners of the technology

In the process of creation and improvement of equipment of small HPPs some units and technological components are protected by authors' rights.

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