



Condition and development of  
small hydro power plants in Serbia

# **CONDITION AND DEVELOPMENT OF SMALL HYDRO POWER PLANTS IN SERBIA**

**DR. MECH. ENG. BRANIMIR JOVANOVIĆ**

**MSC EL. ENG. - MIROSLAV PAROVIĆ**

**December 2009**

## SUMMARY

*The term small hydropower plant in this paper applies to all hydroelectric installed power below 10 MW, regardless of the type of power plant (accumulation, flow, dam, etc.). Hydropower plants with installed capacity under 100 kW are often referred to as micro power plants, and this term will be used here despite the fact that in literature generally there is no unique classification.*

*In Serbia, approximately 10.4% of the total energy potential is in the rivers on which small hydropower plants can be built. Estimates are based on Cadastre of small hydropower plants in 1987 which described the 856 sites for the construction of SHPP, power of 90 kW up to 8.5 MW, total capacity 449 MW and 1590 GWh, with about 90% location having the technical potential for power below 1 MW. In addition to these 856 locations which are located in Serbia proper, according to the cadastre of small hydropower plants in Vojvodina there are 13 potential sites suitable for building capacity. On the territory of Kosovo and Metohija there are more sites suitable for construction of small hydro power plants, but they are not systematically processed, we cannot talk about the exact data concerning this part of the Republic of Serbia.*

*Exceptionally it is also possible to build these facilities at other locations with the approval of Ministry of Mining and approval of other relevant ministries and institutions. As particularly interesting we can distinguish in this regard sites such as the discharge for biological minimum, facilities of water supply in irrigation systems and so on.*

*The effects of construction of small hydro power plants can be measured as installed power of potentially less than 10% of the total potential, and other parameters which are becoming increasingly valuable and important, such as: preserving other existing resources - for example coal and gas, preserving environment by reducing harmful emissions, employment of local people and so on.*

*During the realization of rights for the construction of small hydro power plants, potential investors are faced with many problems such as: unclear and inconsistent regulations, discontinuity of services to give appropriate permissions and therefore different standards when issuing them, the lack of incentives in imports of proper equipment, lack of favorable credit for investment and others. All of these problems can be classified into three main groups or three aspects of the problem of construction of small hydropower plants: a legally regulated framework, technical and technological knowledge and economic and financial plan.*

*By the enactment of the Decree on incentive measures for privileged power producers from small hydropower plants, the Government of Serbia has significantly influenced the*

*investors to invest in the investment cycle with more security included. In order to solve the other two problems as well as increase incentives, the following measures are proposed:*

- further encouraging the use of energy from small hydropower plants, by special purpose loans, tax incentives, etc.*
- establishing the Agency for small hydropower plants, as a body that will deal directly with the problems, and take and propose short-term emergency and long-term strategic measures to facilitate investment in the sector*
- monitoring the use of hydro potential*
- encouraging international cooperation projects*
- considering the opportunities for education of professional staff*

## **INTRODUCTION**

Serious consideration of using the potential of small hydro power plants in Serbia started in the late eighties of last century, when Energoprojekt and the Institute Jaroslav Cherni made the Cadastre of small hydro power plants in Serbia. This document showed significant energy potential that Serbia has in small rivers. But the disintegration of Yugoslavia and long-term isolation of Serbia disabled significant use of this potential and created a large backlog of Serbia in relation to developed countries, and countries in the region. This delay and the impossibility of Serbia to address important issues related to the use of RES energy and in particular the potential of small rivers happened just at a time when awareness increased in the world of the need for faster development precisely of these potentials because of the threats of growing shortage of oil and climate change. Serbia is now on its way to EU faced with a number of binding decisions and regulations that must be fulfilled in energy sector, and therefore the responsibility of the Government and the competent Ministry of Energy to make quick and effective decisions, regulations and laws, is much greater. Bearing in mind the tendency of the energy sector in the world, and considering the fact that Serbia has significant energy resources of hydropower (it is estimated that the overall technical capacity to produce electricity is about 17.000 GWh, of which 10.000 GWh is used, and there is remaining 7.000 GWh and 5.200 GWh in large hydroelectric power stations and about 1.800 GWh in small), it is evident that the development of this sector could provide the necessary long-term energy source.

The primary purpose of this paper is to show the potential that Serbia has in small hydro power plants, the problems currently faced by investors in this area, as well as the trends and prospects of the development of the construction of small hydro power plants in Serbia.

## **BACKGROUND**

Key features of the energy sector in Serbia are low energy efficiency (both in production and consumption), obsolete technologies in the manufacturing sector, low level of investment, unrealistically low electricity prices, low share of renewable sources and the irrational consumption of virtually all forms of energy.

The structure of primary energy consumption in Serbia has been showing a constant increase since 2002 (when the country began recovery in the economic sense), however, primary consumption is still lower or at the level of consumption from the beginning of the 1990s. In 2006 the total primary energy consumption in Serbia was 609 PJ. The consumption structure shows the dominance of coal with about 55% share in the total

consumption, the share of oil consumption was about 26%, gas 13% and hydropower about 6%.

Dependence on imported primary energy sources in 2006 amounted to 40%, and already in 2007 it reached the dependence on imports of about 42%, which means projected dependence on imported energy for the year 2015. It is estimated that the total potential of renewable energy sources in Serbia is such that can cover a quarter of the energy needs. It is important to emphasize that these estimates relate to the potential of renewable natural resources and do not include assessment of economic viability of investments, which can significantly affect the real assessment.

In Serbia, the use of renewable sources is a topic that is in development, but far from the required necessary pace and intensity of monitoring and development. EU accession process already requires coordination of energy policy of Serbia and establishing targets for the share of renewables in total electricity energy (these objectives must be numerically expressed and with specified deadlines). In practice, these goals are very different, depending on the conditions in the country, and mostly on the existence of large hydro power plants. For example, Bulgaria as its goal by 2010 set 22%, Romania 30%, Belgium 6%, while Austria is aiming to reach 78%. The EU has no special criteria for the evaluation of these goals and the country seeking accession must prove that its objective is reasonable in relation to its natural wealth.

The current share of energy from renewable sources in Serbia is about 6% (including large hydroelectric power plants) and it is projected to remain steady until 2015. Energy Development Strategy by 2015 predicts that the overall share of new renewable sources (excluding large hydropower plants) in the total primary energy consumption should rise from zero to 1,1% in 2015, while the share in the total final energy consumption should increased to 1,5 - 2% in the period from 2006 to 2015.

In regard to the increase in installed capacity, Serbian hydropower plants have significant opportunities. In addition to the sites for the construction of several large hydropower plants, there are hundreds of potentially interesting sites for the construction of small hydropower plants. However, in order to use the existing potential, it is necessary to take a series of concrete measures by the state, primarily in the field of facilitation obtaining all necessary permits, and subsidies to the producers of electricity from renewable sources.

## **CONDITION OF SMALL HYDRO POWER PLANTS IN SERBIA**

Development policy of power industry after the Second World War was for a very short time focused on the study and construction of small hydro power plants. In that short period a number of small hydro power plants were built, and then the research of small waterways in order to build SHPP was neglected. The state mainly orientated to the construction of large hydropower plants such as Djerdap, Bajina Bašta and others. There is no doubt that it was the right way, but in parallel with the construction of large hydropower plants it was also necessary to explore, study and build small hydroelectric power plants, and especially the running of a large number of already existing SHPP should not have been stopped. According to the available data from 28 small hydroelectric power plants built after World War II with installed power ranging from 10 to 8800 kW, 10 of them, mostly with small power, are out of service or do not work.

In regard to the geo-morphological and hydrological conditions in Serbia, we can say that the total available water potential is far from small, and that Serbia is one of the water-rich regions of Europe.

The total hydro potential of Serbia is estimated at around 31.000 GWh per year. Most of this potential (approximately 62%) has already been used, because the construction of large production capacity is economically feasible. The rest hydro potential is usable by building small and expensive facilities, particularly mini and micro power plants. Some estimates of the potential of small hydropower plants, including mini and micro power plants in over 1.000 potential sites with the installed unit power below 10 MW, indicate that in the small water ways it is possible to achieve a total installed power of about 500MW and production of 2.400 GWh/year. Of that half (1.200 GWh/yr.) is in Užice, Niš and Kragujevac region, where it can be used in a number of small plants with the total installed power of about 340 MW, distributed in over 700 locations.

Since a significant part of our remaining unused hydro potential is in low-power range, this part is studied separately. A cadastre of small hydroelectric power plants with unit power below 10 MW has also been created. The result is expressed in the total installed capacity of 453 MW and an average production of 1.600 GWh/year in about 856 sites. The table shows the distribution of potential small rivers for the unit power of 90 kW to 8.500kW, which is possible to build with a reservoir for 1.2 billion cubic meters of water.

Republic	River (basin)	Potential (GWh/year)
Serbia	Kolubara	32
	Drina	219
	Moravica (D)	492
	J. Morava	518
	Jerma	28
	Sitnica	142
	Moravica (M)	9
	Pčinja	75
	V. Morava	38
	Pek	172
	Lepenac	22
	<b>Total:</b>	<b>1747</b>

*Table 1: Technically and economically usable hydro potential of small hydro power plants in Serbia*

Today, in Serbia there are only 31 mini-hydro power plants in operation with the total capacity of 34.654 MW and annual production of 150 GWh. Out of service there are 38 mini-hydro power plants of total power of 8667 MW and the estimated annual production of 37 GWh. These small HPP may be enabled as plants with an investment - dependent on their condition. There are significant opportunities for the installation of small hydropower plants in the existing water engineering facilities, which means much lower costs.

Table 2 presents the categories of small hydropower plants that can be put in function of raising energy capacity of Serbia. This table is interesting, because it shows that in addition to resources, which are included in the Cadastre, which shows only potential locations for the plants with power 100kW up to 10MW, there are also significant resources in other small hydro power plants that are very affordable and can be built at the discharges of biological minimum, at the water supply facilities, irrigation systems, etc. For example, only the restoration and adaptation of the locations at which mills were once built, and it is estimated that there are about 5.000 such sites in Serbia, could get about 10MW installed capacity and about 45GWh produced electricity per year.



Category SHPP	Installed power (KW)	Production (MWh/year)
1. New facilities in the cadastre of small HPP	442.632	1.544.985
2. HPP installation in water facilities	23.464	114.530
• HPP at the discharge of the biological minimum	1.064	7.500
• HPP at water supply facilities	7.000	35.000
• HPP in irrigation systems	3.000	11.000
• HPP in DTD system	10.400	54.030
• HPP at the transfer of water from basin to basin	2.000	7.000
3. Reconstruction of the existing buildings	25.769	134.000
• Reconstruction of existing SHPP	8.769	54.000
• Installation of HPP in the mills	10.000	45.000
• Revitalization of the existing HPP	7.000	35.000
<b>TOTAL:</b>	<b>491.865</b>	<b>1.793.515</b>

*Table 2: Total energy effects of small hydropower plants in Serbia*

## **EFFECTS OF THE CONSTRUCTION OF SMALL HYDRO PLANTS IN SERBIA**

As previously mentioned, according to the cadastre of small hydropower plants, in the territory of proper Serbia there are 856 locations with the technical potential for building small hydroelectric power plants from 100 kW to 10 MW, while in the territory of Vojvodina there are 13 potential sites suitable for the construction of SHPP. The total installed power of the capacity would amount to about 450 MW with an annual production of about 1.600 GWh. For this volume of electricity production in thermal power plants 2.3 million tons of coal or 400,000 m of natural gas from imports should be consumed. Small hydroelectric power plants would, in this way, save annually about 52 million U.S. dollars. To achieve this ambitious plan it is necessary for each individual location to have adequate technical documentation that includes a detailed analysis of all characteristics, in order to provide a best choice of aggregates, mechanical and electrical equipment. This would provide the best value of resources invested in equipment and construction works. Such documentation currently does not exist for these objects and it is therefore difficult to

assess the possibility of investment. However, it should be noted that a large number of sites listed in the cadastre are not economically profitable. In addition to direct economic impacts, which are due to the construction of small hydro power plants, there are many indirect effects.

Starting from the fact that SHPP use renewable energy, then each kWh of generated electricity saves 1,6 kg to 2,2 kg of coal (depending on the type and quality), or about 0,25kg of crude oil. This is in the function of sustainable development not only in terms of preserving the existing natural resources, but also in terms of protecting the environment from emissions of sulfur oxides and nitrogen, and oxides and carbon. These greenhouse gases cause global warming and threaten to cause irreversible process of climate change on Earth.

Significant economic effects of the construction of small hydropower plants can also occur due to relatively large share of domestic labor and industry, with virtually no import of equipment from abroad. Domestic participation in these small projects is much more likely and greater than in the case of large plants.

## **OBSTACLES IN THE CONSTRUCTIONAS OF SMALL HZDRO POWER PLANTS**

With the adoption of the Energy Law in 2004 and in particular the recent adoption of Ordinance on incentive measures for the production of electricity from renewable sources, Serbian government has made a significant incentive to the use of all renewable resources, especially the use of energy from small water flows. This has sent a clear signal to the investors that, both in Serbia and in the countries of the region, it is now worth investing in the construction of small hydro power plants, because, depending on the installed power, they save on average 8 to 10 euro cents per kilowatt of electricity produced. Despite these encouraging signs important tasks lie in front of Serbia in the area, and great challenges in the implementation of projects in front of the investors. The main problem still seems to be the indecision and / or the inability of the Government or the competent Ministry to set a clear legal and regulatory framework that would allow investors a transparent treatment during the process of investment. It is still necessary to obtain nearly 30 different licenses in various institutions from local to state authorities.

There is no single reference with explained procedures in cases of different degree of orderliness of documentation or different interpretations that the investor finds in different municipalities. The website of the Ministry of Mining and Energy contains instructions such as the instruction titled "Models for the construction of small

hydropower plants and the activity of electricity generation in the Republic of Serbia" which contains a legal framework for the building process and a general order of procedures that must be taken, but it does not elaborate on a number of variations which the investor faces in the field.

How important are good will and interest of the state authorities in the process of taking the investor through the project development cycle, is illustrated by an interesting case of Municipal Knjaževac, in which, in the period from 1983 to 2006, 15 micro hydroelectric power plants with power 20 up to 100 kW were built, connected to the power grid and put into operation, thanks to a positive interpretation of regulations by the competent official in the electric distribution. It is characteristic that all these micro power plants were mainly built in order to achieve large savings in investment through the actual performance. Regulation of the legal framework is certainly the biggest obstacle to a faster construction of small hydro power plants. After that, the technical - technological knowledge in the preparation and implementation of projects is a serious problem which should be considered. Because little has been built in the field of small hydro power plants in the last 30 years, there is a noticeable lack of skilled personnel, and more importantly experience, especially when having in mind the demand of investors that technology solutions should be optimal and cost-effective to the greatest extent possible. Experienced engineers and other experts that were working on state projects of large hydroelectric power plants in the former Yugoslavia in the second half of the last century did not have as a priority economic viability. This problem can be only partly solved by hiring foreign experts.

As a special issue we can include the coordination of institutions responsible for the steps required to obtain permits and exercise the right to build small hydropower plants. In addition to the Ministry of Mining and Energy, these institutions also include the Agency for Energy and Energy Efficiency, Electric Power of Serbia, Serbia Water and Serbia Forest, Vojvodina water, Vojvodina forest, etc.

## RECOMMENDATIONS

In order to improve the situation in the sector of small hydropower plants, the following important and / or emergency short-term and long-term measures can be recommended:

- **Further development of encouraging the use of energy from small hydropower plants.** With the adoption of the Regulation on stimulatory measures for privileged producers of power through small hydro power plants, the first and important step was made toward faster penetration of investments and construction of small hydro power plants, but it is also necessary to initiate other incentives such as subsidized loans, exemption from customs duties for all equipment used for construction and exploitation etc.
- **Establishment of the Agency for small hydropower plants.** It is necessary to establish as soon as possible a special body within the Ministry of Energy that would address only the problem of the construction of small hydro power plants, whose immediate task would be to coordinate existing institutions in the Republic of Serbia, responsible for exercising the right in building small hydropower plants, synchronization, i.e. simplifying and standardizing procedures for obtaining appropriate permits, as well as information and consulting for all legal and administrative details and specificity which the investor meets in the field, such as, for example, obtaining approval for the connection of SHPP to the electric network, which is currently not the same in all distribution companies in Serbia. The long-term and important task of this Agency would be working on a special regulation and related legal acts intended only to small hydro power plants, i.e. support in creating a special law on renewable energy sources. The Agency should provide valuable assistance to the Ministry of Energy, Electric Power of Serbia and potential investors when it comes to:
  - Reconstruction and rehabilitation of existing small hydropower plants
  - Automation of small hydropower plants that are functional
  - Adaptation of existing mills into small hydropower plants
  - Additional installation of new generators with installed capacity up to 10 MW within existing dams and hydropower plants, with the intention of using the full existing hydro potential
  - Construction of new small hydro power plants as independent buildings in so far unused sites

- **Monitoring the use of hydropower potential.** The main objective of this recommendation is collecting and updating data related to the hydro potential of the Republic of Serbia and how to use them. For this purpose, the existing agencies formed by the Ministry of Energy could be used, or special services could be formed. The first task of such services would be the updating of data related to the existing Land Registry of small hydropower plants, and also updating the data related to the application or direct use of these resources, regardless of their energy potential.
- **Consideration of opportunities for education of professional staff.** As investments grow in RES and particularly in small hydroelectric power plants, the need for expert staff will also grow. Bearing in mind that the adjustment of the educational system to such needs is a necessary but time-consuming task, it is necessary to also consider alternative solutions through short specialist courses in, for example, Chambers of Commerce and similar institutions, in cooperation with similar foreign institutions with substantial experience in this field. Encouragement and coordination of these activities should be the task of the proposed Agency for small hydroelectric power plants.
- **Encouraging international cooperation projects.** The use of small rivers is highly developed in some countries, and the promotion of international cooperation can provide, on the one hand, the transfer of knowledge and technology, but it can also provide funds for pilot projects valuable as polygons to acquire valuable experience as examples of good practice.

## RELEVANT LITERATURE

- [1] Small hydropower plants, Milosav Mihailović, 1995, Belgrade, Serbia
- [2] Land Registry of small hydro power plants in Serbia, Energoprojekt- Hidroinženjering, 1991, Belgrade, Serbia
- [3] The use of water power, Water management institute Jaroslav Cherni, 1990, Belgrade, Serbia
- [4] RENEWABLE ENERGY SURCES IN SERBIA, recommendations, resources and criteria; Editor: Natša Đereg; Authors: Nataša Đereg, Zvezdan Kalmar Kranjska Joviš, Iomut Apostol, December 2008, Subotica
- [5] Energy Sector Issues and Poverty in Serbia, Goran Radosavljević and Vuk Djoković, Center for Advanced Economic Studies, Belgrade, 19 June 2007.
- [6] The program of the implementation of the Energy Development Strategy of the Republic of Serbia in the AP Vojvodina (from 2007 to 2012), Jovan Petrović, Branka Gvozdenac, April 2007. Executive Board APV
- [7] Energy balance in Serbia in 2008, the Ministry of Mining and Energy Republic of Serbia, [www.mem.gov.rs](http://www.mem.gov.rs)
- [8] The Energy Development Strategy until 2015, the Ministry of Mining and Energy Republic of Serbia, 2005, [www.mem.gov.rs](http://www.mem.gov.rs)
- [9] The data of the Statistical Office of Serbia
- [10] <http://www.eia.doe.gov/> Energy Information Administration International Statistics database
- [11] Renewables Global Status Report 2006. Update, REN21, published 2007, accessed 2007-05-16; see Table 4, p. 20.
- [12] The energy potential of small rivers in Serbia, Prof. Dr. Miroslav Benišek, Dr. Miodrag Mesarović, hydropower and wind power, Energy 2005, part 5.