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Review of techno-economic and environmental aspects of building small hydro electric plants – A case study in Serbia

Rade M. Ciric

The Higher Education Technical School of Professional Studies, Skolska 1, 21000 Novi Sad, Serbia

A R T I C L E I N F O

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A B S T R A C T

Climate change mainly caused by increased greenhouse gases and reduced fossil fuel reserves, have launched a more intensive use of renewable energy on a global scale. One of the oldest types of the renewable sources is well known small hydro electric facility. In this paper description of small hydro plant location, selection of the turbine, sizing of the plant, connecting plant to the grid, as well as the legal aspect and environmental impact of the future facility in Serbia are presented and discussed. Besides, techno-economic analysis of future small hydro electric plant is presented and discussed. The main contribution of this paper is multidisciplinary approach to complex analysis of building, integration, economic performance and environmental impact of a small hydro-plant demonstrated on the specific site in Serbia. Finally, major barriers and threats for the growth of the small hydro-electric power capacity have been identified and proposals to increase the penetration level of the small hydro and other renewable sources into the grid in Serbia are made. To increase the contribution of the small hydro and other renewables in Serbia and South-East Europe countries, the gouverments should remove all the bariers and strongly encourage the investment in the renewable energy sector.

1. Introduction

Climate change mainly caused by increased greenhouse gases and reduced fossil fuel reserves, have launched a more intensive use of renewable energy on a global scale. According to International Renewable Energy Agency (IRENA) survey of renewable energy sources worldwide from 2017, worldwide, total installed hydropower capacity (excluding pumped hydro) was 1121 GW at the end of 2016, although its share of global renewable capacity has been slowly declining. Hydropower, large and small, remains by far the most important of the renewable energy for electrical power production worldwide providing 70% of the planet's electricity from renewable energy sources in 2016 [1]. The global weighted average for the total installed cost of a hydropower projects reached USD 1558/kW in 2017. Small–scale hydro electric plant with installed capacity of less than 10 MW (SHEP) is one of the most cost-effective and environmentally benign energy technologies which are considered for rural electrification. According to IRENA survey the weighted average levelized cost of electricity (LCOE) of hydro power projects is mostly bellow USD 0.11 $/kWh. The LCOE of small hydro plants is usually higher than LCOE of the large hydro power plants by 10%–40%, which is less than the difference in total costs for these different projects. Potential and installed capacity, technology status, as well as policy and regulatory support to small hydro project in different countries are reported in Ref. [2].

Rural hydro power renovation project implementation in China is shown in Ref. [3] where the key challenges, renovation schemes, fund management, property rights reforms and feed-in tariff improvements are presented. Current status and perspectives of small hydro power in India with total identified potential of 20,000 MW, is reported in Ref. [4]. Different aspects of small hydro-electric plants attracted researchers such as optimal site location and sizing, design, technical, economic and reliability issues, flow duration curves, economic performance evaluation, energy availability modeling, production planning etc [5–19]. Optimal installation of small hydropower plant using net present value method is presented in Ref. [5] while an overview of the prospects of small hydro and pumped –hydro power plants in the light of sustainable development is presented in Ref. [6]. Review of usage of small hydropower technology for rural electrification is presented [7] while the choice of electromechanical equipment for small hydro–electric plants is presented in Ref. [8]. Determination of site location of small hydro-electric power plants is analyzed in Ref. [9],

E-mail address: rade.ciric@aol.com.

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while probabilistic flow duration curves of small hydro power plants are presented in Ref. [10]. Optimal capacity of small hydro plants is investigated in Refs. [11–16]. Project configuration of a small hydro power plant considering various technical and economical aspects using non-linear programming method is presented in Ref. [11]. The importance of turbine type, cavitations behavior and turbine dimension in determining the installation size is reported in Ref. [16]. Object oriented modeling of run-of-river facilities is presented in Ref. [18]. Short term hydro-power production planning using stochastic programming is reported in Ref. [19]. One important aspect to consider in small hydro applications should be the use of the variable speed technology in installation sites characterized by significant head and/or flow rate variations. Since the uncertainties in the flow duration curve and in the forecast electricity prices, a risk analysis related to these aspect represent a future research challenge.

The Republic of Serbia is the country in South-East Europe with a significant hydro potential for electricity production [20], Fig. 1. Despite, the number of new small hydro electric facilities in Serbia is negligible [21]. There are more reasons for that situation but three are the most important. Firstly, the local investors do not recognize the potential benefits of such facilities in the energetic, environmental, social and financial terms. The second reason is the lack of systematic incentives for the investment in the renewable energy sector from the state except feed-in-tariff, and the third one is the high interest rate on capital investment in Serbia.

The strategy for energy development of the Republic of Serbia by 2015 envisages that the share of new renewable sources in total primary energy consumption, should reach 1.1% in the 2015th [22].

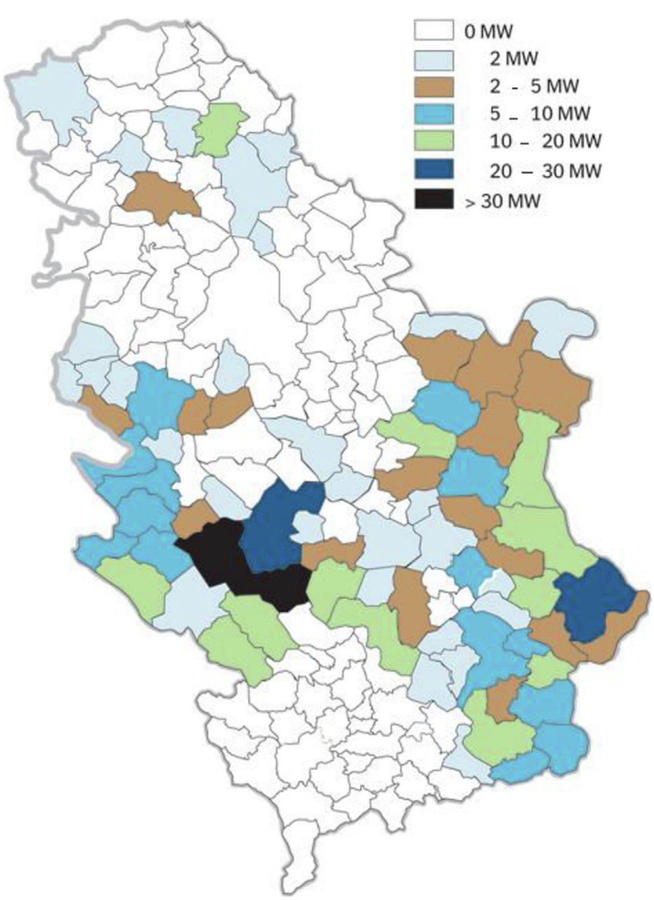

Fig. 1. Small hydro potential in Serbia.

According to agreement with the EU since 2009th, Serbia took over the obligation to increase the share of renewable energy in total energy consumption from the current 21.2%–27% to the 2020th [22].

In order to exploit existing potential of green energy, regulators, investors, financial and insurances bodies, designers, construction engineers and distribution network engineers etc need an instrument that makes the effects of application of renewable energy solutions measurable in its energetic and cost dimensions but also regarding its environmental impact. The construction of hydro-plant is a complex technical, organizational and investment venture. The first step in every investment venture is the determination of site location and techno-economic analysis whereby the value of investment has a great influence on the final evaluation of the project. However from concept to commissioning of small hydro-electric power plant is a long way. The main contribution of this paper is presenting the multidisciplinary approach to complex analysis of building of a small hydro-plant, namely its legal, technical, energetic, economic and environmental aspect.

Connecting a distributed generator (DG) to the distribution grid is an important issue. Integration aspects of DG into the distribution system are elaborated in Refs. [23–29]. In general there are four conditions that are tested when connecting DG to the distribution system, including: short-circuit power, voltage increase, flickers and higher harmonics. The last two conditions are related primarily to the DG which uses the sun and wind as primary fuel energy. The review of the selection of turbine for hydro-electric projects for available operating conditions is presented in Ref. [31] while design of high efficiency Pelton turbine for micro-hydro power plants is presented in Ref. [32]. Transient cavitating flows of a mixed flow pump as turbine at pump node are investigated in Ref. [34]. Authors in Ref. [35] investigate the pressure fluctuation intensity and vortex characteristic of a mixed flow pump as turbine at pump mode with a tip clearance. Theoretical model of energy performance prediction for centrifugal pump as turbine is presented in Ref. [36].

In this paper legal, techno-economic energetic and environmental aspects of building SHEP in Serbia are presented. Selection of the turbine, sizing of the plant, verification of the requirements for connecting small hydro-electric plant to the grid, as well as the environmental impact of the future facility are presented and discussed. Economic analysis for two case studies of future SHEP is presented and discussed.

Finally, major barriers in the growth of the small hydropower development in Serbia have been identified and proposals to increase the penetration level of the small hydro and other renewables into the grid are made.

2. Potential of renewable energy sources in Serbia

The category of privileged power producers in Serbia is defined by the *Energy Law* in 2004 [30]. A key step to begin market development of renewable energy sources in Serbia was to determine the feed-in-tariff in 2011th, respectively guaranteed purchase

Table 1
Feed-in tariff in Serbia.

type of facilities	guaranteed purchase price – feed-in-tariff (c€/kWh)
small hydro	7.8–9.7
biogas	12–16
biomass	11.4–13.6
wind turbine	9.5
solar	16–23
geothermal	7.5
waste	8.6–9.2

prices for electricity produced from renewable energy sources for 12 years from the start of production, Table 1 [30].

National Action Plan of the Strategy of the Republic of Serbia by 2015 is the key document of the energy policy [20]. Energy import dependency of Serbia in 2015 was 33.6% and it is of the utmost importance to provide safe, quality and reliable supply of energy and reduce the country's energy dependence in the future. Balance responsibility for the privileged power producers takes over the state.

Renewable energy sources are the backbone of energy independence of Serbia in the future. The general assessment is that country has significant renewable energy potential. The wind energy potential in Serbia is estimated to be 1300 MW, while the potential of small hydro power plants is estimated to be at least 500 MW [22]. However, with regard to the usage of renewable energy sources in Serbia, the current situation is far from satisfactory [21].

Apart from hydro power and the limited scope of geothermal energy and biomass, other renewable energy sources in Serbia are not used. Large hydro power plants have the installed capacity of 3009 MW with annual production around 10.3 TWh [21]. However, there are 900 potential sites of small hydro power up to 10 MW, with a potential of total production of 1800 GWh/year, while 90% of these would be less than 1 MW [22]. The total annual capacity of small hydropower is 16.7 PJ, and total technical potential of renewable energy sources in Serbia is 160 PJ/year, Table 2 [22]. In the field of biomass combustion for heat and electricity, Serbia has significant opportunities, including the use of briquettes and pellets.

3. Small hydro-electric plant Reka

3.1. Hydro-electric technology

Hydro electric plants are facilities in which the potential energy of water is converted firstly into mechanical and then into electricity. The SHEP typically include hydro-electric plants with installed capacity not exceeding 10 MW [6]. When choosing the location of hydro-electric power facility for a given water reservoir or a given height of the water drop and given flow of water masses, one should calculate how much power the turbine can be achieved. All available hydro power cannot be used, since in the process of transformation of energy are the energy losses, and the water coming out of the turbine has a residual mechanical energy.

Depending on whether SHEP have a storage pool for balancing imbalances river inflow or not, we distinguish a cross flow and accumulative SHEP. The cross flow SHEP practically work with the current flow. Changing the water flow during the year may be very large, so that the SHEP have to adapt with regard to the water flow. Scope of application of different types of turbines in hydro power plants is shown in Table 3 [31]. SHEP is recognized as one of the most cost-effective energy storage technologies currently available on a small scale because of its predictable energy characteristics, its long term reliability and its reduced environmental effects [7,8].

Table 2
Potential of renewable energy sources in Serbia.

energy source	annual potential (PJ)
biomass	100,4
small hydro (<10 MW)	16.7
geothermal	8,3
wind	7,9
solar	26,7
total potential	160

PJ = 10^{15} J.

Table 3
Areas of application of certain turbine types.

Type of turbine	n_s (1/min)	water fall H (m)	water flow Q
Pelton	2 ÷ 70	400 ÷ 2000	small
Fransis	60 ÷ 450	50 ÷ 700	average
diagonal	170 ÷ 430	40 ÷ 200	average
Kaplan	260 ÷ 1000	20 ÷ 70	large
tubular	>800	1 ÷ 20	large

The most important impulse turbine is undoubtedly Pelton turbine, patented in 1880 by Lester Allen Pelton. The Pelton turbine falls into action turbines that convert power of watercourses into the kinetic energy in the input part or in the intake nozzle [32,33]. Water flows out of the nozzle at high speed and hit the runner blades, which are constructed so that it can divert the flow of water approximately 180°, Fig. 2; The photo of the runner of Pelton turbine is obtained from Ref. [31]. The water pressure in the area of the impeller is equal to atmospheric pressure, and therefore the turbine is also called the free jet turbine [30,31]. Since most of the rare high-head installation sites have been already exploited, the great potential of small hydro power is represented by low-head sites, whose economical attractiveness is connected with an optimal design of the electro-mechanical equipment, mainly represented by turbine and generator.

The capacity sizing of a SHEP is strictly connected with flow availability and is based on the analysis of the flow duration curve [6]. The flow duration curve is a cumulative distribution of the

Fig. 2. The runner of the Pelton turbine.

stream flow rate of a site on an annual basis and shows the percentage of time that the site water flow equals or exceeds a specific value. This flow rate cannot be fully exploited, since it is established by law that a reserved flow should be released downstream to keep the ecosystem in the conditions that prevailed before the power plant construction.

3.2. Case study – SHEP Reka

The drainage area of the river Reka in South East Serbia is 6.46 km^2. Building of SHEP Reka includes damming the watercourses, the abstraction and drainage using derivation pipeline to the machinery house and returning of the abstracted water back into the river stream. Data obtained from Republic Hydrometeorological Institute, by site measurement as well as the technical characteristics of the future SHEP Reka are presented in Table 4, [37]. Selected *Pelton* turbine and generator data are presented in Table 5 [33] and Table 6 [29], respectively. Installed real power of SHEP Reka is calculated using the eq. (1) [31]:

$$P_{HE} = \eta_t \cdot \eta_G \cdot \eta_{TR} \rho\, g\, Q_i \cdot H_n = 0.87 \cdot 0.95 \cdot 0.99 \cdot 1000 \cdot 9.81 \cdot 800 \cdot 93.77 = 600\ kW \tag{1}$$

where:

$\eta_t = 0.87$ is the efficiency of the turbine,
$\eta_G = 0.95$ is the efficiency of the generator,
$\eta_{TR} = 0.99$ is the efficiency of the transformer,
Q_i is installed water flow,
H_n is net water fall,
ρ is water density, and

$g = 9.81 m / s^2$.

Turbine speed is given by eq. (2) while the generator speed is given by eq. (3), [30].

$$n_t = \left[n_s \cdot H_n \cdot H_n^{1/4}\right] / P_{HE}^{1/2} = (50 \cdot 93.45 \cdot 93.451/4)/6001/2 = 593(1/\min), \tag{2}$$

$$n_g = (60 \cdot f)/p = (3000/5) = 600(1/\min), \tag{3}$$

where

n_s is the specific turbine speed,
p is number of generator poles divided by 2 ($p = 10/2$), and.
f is rated frequency ($f = 50$ Hz).

Estimation of mean annual electricity production of the SHEP Reka, Ea is performed using the eq. (4):

Table 4
Technical characteristics of SHEP Reka.

altitude of the upper water	$K_g = 831.80$ m
altitude of the water at normal backflow	$K_z = 833$ m
altitude of the turbine working wheel	$K_s = 735.15$ m
gross water fall	$H_b = 96.65$ m
installed water flow of turbine	$Q_i = 0.8\ m^3/s$
net water fall of installed flow	$H_n = 93.45$ m
diameter of the pipeline	$D = 700$ mm
length of the pipeline	$L = 726.56$ m
installed power of HE	$P_{HE} = 600$ kW
mean annual production	$E_a = 3$ GWh

$$E_a = P_{HE} \cdot Th = 600 \cdot 5000 = 3\ GWh \tag{4}$$

where T_h is estimated number of working hours of SHEP per year.

4. Connecting hydro-electric plant to the grid

It is planned that the machinery house of SHEP Reka accommodate a power transformer 0.42/35 kV/kV of 1000 kVA to connect the generator with the 35 kV overhead distribution network, as well as the high-voltage and low-voltage block. In general there are four conditions that are tested when connecting DG to the distribution system, including: short-circuit power, voltage increase, flickers and higher harmonics. The last two conditions are related primarily to the DG which uses the sun and wind as primary fuel energy and are not interesting in case of synchronous generator.

4.1. Input data

The input data for short circuit calculation are given in the following:

- Sub-transient three phase short circuit current of the transmission network, $I_{KS}^{//}$= 5.84 kA, [38];
- The parameters of the power transformer in TS 110/35 kV are:
- transmission ratio 110/35 kV/kV,
- indicated apparent power $S_n = 31.5$ MVA,
- short-circuit voltage $u_k = 15.385\%$, and
- Copper loss $P_{CU} = 184.1$ kW.

The impedance of the transmission network is calculated based on the standards IEC 781 and IEC 909, using expression (5):

$$Z_{K110} = \frac{cU_n}{\sqrt{3} I_{KS}^{//}} = \frac{1,1 \cdot 110}{\sqrt{3} \cdot 5,84} = 11.96 \Omega \tag{5}$$

where $Un = 110$ kV is the rated voltage of transmission network in Serbia.

4.2. Criteria of allowed power

To verify this criterion the three phase short circuit power of the system at the SHEP connection point before its accession to power, and the largest generating units at the SHEP plant, must be known. Checking the criteria of allowed DG apparent power at the connection point of the grid is performed according to the expression (6) [39]:

$$S_{ngm} \le \frac{S_{KS}}{50k} \tag{6}$$

where:

S_{ngm} is the maximum power of generating units that are connected or total power if all generators are simultaneously connected to the network, S_{KS} is three phase short circuit power at the DG connection point, and
$k = 1$ for synchronous generators.

Three phase short circuit power at the SHEP connection point on the 35 kV network is determined by the eq. (7):

$$S_{ks} = \frac{(c \cdot 35)^2}{Z_e} = \frac{(1.1 \cdot 35)^2}{15.543} = 95\ MVA \tag{7}$$

where

Z_e is equivalent impedance of the network at the generator

Table 5
Technical characteristics of Pelton turbine.

diameter of turbine round	660 mm
nozzle diameter	89 mm
the width of blades	223 mm
number of blades	18
number of nozzles	5
input flange diameter	DN 600 mm
regulation	Nozzles-guided by electro-mechanical servo drives

Table 6
Characteristics of synchronous generator.

apparent power S_{ng} (kVA)	750
real power P_{ng} (kW)	600
rated voltage U_n (kV)	0.42
rated current I_n (A)	1031
power factor (cos φ)	0.8
rated frequency (Hz)	50
rated speed (o/min)	600
type of rotor	10 poles
type of excitation	brushless
voltage regulation	automatic
utilization factor	0.943
allowed overloading/duration	10%/1 h
max. ambiental temperature	40 °C

connection point (Ω).

Finally, the marginal power of generating units that can be connected to the planned location is calculated in eq. (8):

$$S_{max} = \frac{95}{50} = 1.9\ MVA \tag{8}$$

Since the future SHEP will contain one generating unit with the apparent power of 750 kVA, it is concluded that its power is less than the maximum allowed power at the SHEP connection point, and the criteria of allowed power is satisfied.

4.3. Criteria of voltage increase

Voltage increase in the 35 kV line after connecting DG is calculated using expression (9), [39]:

$$\Delta u(\%) = 100 \cdot \frac{S_{DG}}{S_{KS}} \cdot \cos(\psi_K + \phi_{DG}) \leq 2\% \tag{9}$$

where:

$\Delta u(\%)$ is voltage increase at the DG connection point (%),
S_{DG} is indicated apparent power of DG,
ψ_K is the argument of the network impedance, measured from the connection point, and
ϕ_{DG} is the argument of DG loading.

According to the considered criteria the voltage increase at the connection point must not exceed 2% of the rated voltage. Given that the maximum value of the cosine function is equal to 1, and respecting the generator apparent power $S_{DG} = 0.75$ MVA and short circuit power at the connection point $S_{KS} = 95$ MVA, the amount of corresponding voltage increase less than 1% is obtained. Accordingly the criteria of voltage increase after connecting SHEP to the grid is satisfied.

5. Economic analysis

The value of investment has a great influence on the final project evaluation. The capacity of future SHEP is 600 kW, and the mean annual electricity production is 3 GWh. The concession for this facility is issued for 30 years, with the 6.1% of the planned annual production given for the concession. Construction costs of the SHEP amount to Ci = 2800 €/kW, including construction works 50%, 20% for mechanical equipment, 10% for electrical equipment, 9% for the land, 9% for grid connection and 2% for planning activities. Cost of the SHEP Reka based on "turn key" scheme is around 1.680 million €.

Before starting the construction, there are additional costs related to preparing technical documentation, obtaining permits, as well as the cost of consultancy service (40.000 €). Further, there are additional costs that must be taken into account, such as the procurement and construction of the TS 0.42/35 kV/kV and the 35 kV overhead line (around 200.000 €). Finally, the total investment cost of future SHEP is 1.920 million €.

Stimulating (feed-in) tariffs imply a guaranteed purchase of all amounts of electricity produced from the renewable energy sources, at the predefined, fixed price for a certain period of time [40]. In accordance with the Directives of the Government of the Republic of Serbia, the price of electricity from this type of the renewable energy sources, accounts for $C_{ee} = 0.097$ €/kWh for annual production and it is guaranteed in 12 years period [41]. Planned annual income of the SHEP from the sale of electricity is 273.249 *€/year.*

In the following two case studies regarding different financing scheme of the SHEP are presented.

5.1. Case study 1

In this case the SHEP is financed from the investors own funds. This type of financing is currently the best option in Serbia, since the interest rate is very high, around 7–12% annually. By subtracting the operating and maintenance cost 9.420 €, and 20% tax, the net earnings annually will amount to 211.063 €. The return on investment would come in about 9 years which is less than period guaranteed by the contract.

5.2. Case study 2

In this case the SHEP is financed using 15 years loan with the annually interest rate 7%. Factor of capital return CRF for a period of n years and the interest rate i is calculated according to the expression (10) [23]:

$$CRF(i,n) = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{0.07(1+0.07)^{15}}{(1+0.07)^{15} - 1} = 0.1098\ {}^{1}/_{year} \tag{10}$$

The annual loan repayment A of a capital base K is calculated according to eq. (11):

$$A = K \cdot CRF(0.07;15) = 1.921.000 \cdot 0.1098 = 210.926\, {}^{Euro}/_{year} \tag{11}$$

The average cost of producing of electricity from the SHEP *CkWh* is calculated according to eq. (12):

$$C_{kWh} = \frac{annual\_\cos ts}{annual\_energy} = \frac{9420 + 210926}{0.939 \cdot 3000000} = 0.0782 \cdot \frac{Euro}{kWh} \tag{12}$$

The cost of electricity from the considered SHEP in this case (USD 0.096 $/kWh) is less than the LCOE of hydro power projects is

Europe (USD 0.11 $/kWh) [1]. Furthermore, since the guaranteed price of electricity (feed-in tariff) is 0.097 €/kWh, the project is still cost-effective. However, under these conditions the annual net profit is 52.900 € while the SHEP pays back in 36 years which is to long period for investors. Obviously the tariffs for electricity delivered as well as interest rate should be in line with the actual costs of production in order to deliver long-term profitable operation of the small hydro electric plants.

6. Environmental impact

Electricity production and consumption are among the main causes of global, regional and local warming. Small hydro-electric facilities easier fit into the environment than the large hydropower plants. Namely, small hydro electric plants do not cause the emission of dirty substances in the air and are usually located outside urban areas, so that the noise level in the machine hall is below the allowed level. Its design completely fit into the landscape, and they do not affect the change in climatic conditions due to low water accumulation.

Temporary impacts of small hydro electric facilities are typical for the period of construction and include: water and air pollution, occupation of space, visual-effects and hindered traffic around the site.

Permanent impact of small hydro plants are sedimentation and release of deposits (natural or industrial), changes in water quality due to the slowing flow, and impact on wildlife. Permanent impact of small hydro plants on wildlife especially fish and birds, water features and aesthetic landscape must be carefully analyzed. Study of the impact of the small power plant on the environment at the specific site must be performed by competent institutions, and the necessary measures must be strictly implemented in order to minimize negative environmental impact of these facilities. For example, the trout of the stream is not a migratory species and as such it is very likely to be threatened in the case of a run-off of the river flow, because the trout does not use roundabout channels. Besides even the migratory species can be in dangerous since the roundabout channels are often ousted from impurities.

The capacity of small hydropower plants must be carefully selected to avoid the situation in the summer period when a normally low water level is reaching the drying of small rivers. Such an unfavorable scenario would have very negative impact on socio-economic conditions in rural areas where the population is primarily engaged in livestock farming and rural tourism. Finally, small hydro electric plants must not be built in the nature reserves as well as at the places with protected biodiversity. In recent years due to the degradation of ecosystems the construction of small hydro power plants in the mountains in South East Serbia has evoked protests in small communities, which have caused anxiety among the general public.

7. Conclusion

The usage of renewable energy has multiple positive effects from the point of view of environmental protection, support the national economy and the development of rural areas. Despite the significant potential for the application of renewable energy, as well as the feed-in tariff, due to the unfavorable loans and complicated procedure for obtaining permission to connect DG to the grid, the number of implemented renewable energy sources in Serbia, and in other countries in South-East Europe (Montenegro, Bosnia and Herzegovina) is rather small.

The construction of small hydro electric plant is a complex technical, organizational and investment venture. The great potential of small hydro power is represented by low-head sites, whose economical attractiveness is connected with an optimal design of the electro-mechanical equipment, mainly represented by turbine and generator. Connecting small hydro-electric plant to the grid is an important issue whereby the main conditions that are checked are short-circuit power and voltage increase. Due to the construction of small power plants at locations that are far from infrastructure, the costs of grid integration can be significant. The cost-benefit analysis has shown that under reasonable interest rate conditions (3–4%), building SHEP could be cost effective project which pays back in less than the period guaranteed by the contract of purchasing electricity produced by SHEP.

Experience in Serbia shows that temporary and permanent negative impact of small hydro plants on eco system must be carefully analyzed and the necessary measures must be performed in order to minimize it. Otherwise, the cases of violating ecosystem due to construction of small hydropower plants threaten to discredit the application of this source of renewable energy.

To increase the contribution of the small hydro and other renewables in Serbia and South-East Europe countries, it is expected that the gouverments remove all the bariers, simplify the administrative procedures to obtain the permit for use, and strongly encourage the investment in the renewable energy sector [42]. It is essential that the tariffs for electricity delivered as well as interest rate are in line with the actual costs of production in order to deliver long-term profitable operation of the small hydro electric plants. After eight years of implementation of feed-in tariffs in Serbia it is time to think about introducing an auction model to finance the construction of new capacities of renewable energy sources including hydro-power. Especially, to significantly increase the contribution of small hydro plants in Serbia it would be very useful to:

- Establish a special agency for small hydro electric plants closely working with the Ministry of Energy and the Ministry of Environment Protection,
- Support projects of renovation and automatisation of existing small hydro electric plants,
- Plan adaptation of existing mills into the hydro electric facilities, and,
- Improve renewable energy education and training at all levels, since willingness of local communities to pay for renewables is observed to be correlated to socioeconomic characteristics including education, interest in environmental issues and knowledge of renewable energy sources [43].

Further, it is necessary to introduce certain incentives apart from the feed-in tariffs which would encourage the investment in the renewable energy sector such as bonuses for employment in the rural areas as well as the custom tax-free policy for renewable energy technology etc. Finally the financial and insurance sector, both international and domestic, should give their contribution approving reasonable interest rates for investment in the renewable energy sector.

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Rade M. Ciric gained Dipl.- Ing diploma from the University of Novi Sad in 1987, Master of Science degree from the University of Belgrade in 1992, and Doctor of technical science degree (PhD) from the University of Novi Sad - Serbia in 2000, all in electrical engineering. From 1987 to 2003 he was with EPS - *Elektrovojvodina Novi Sad*. Dr. Ciric was Post-Doctoral Research Fellow at the UNESP Ilha Solteira-SP, Brazil in 2001/2002 and the Visiting Professor in Power Systems and Electronics Research Group, University of the West of England (UWE), Bristol, UK in 2004/2005, through *The Leverhulme Trust* scheme. Dr. Ciric is Professor at The Higher Education Technical School of Professional Studies in Novi Sad (Skolska 1, 21000 Novi Sad, Serbia).