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MASTER'S THESIS

A FEASIBILITY STUDY FOR A SMALL HYDROPOWER PLANT IN B&H

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AUTHORSHIP STATEMENT

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INTRODUCTION

During the last 800 years watermills have been in operation all over Europe, covering the needs of local habitants for mechanical power. Later, at the beginning of the twentieth century, watermills were replaced by fossil fuel (coal, oil, nuclear, etc.) fired electricity generation plants. Recently, the depletion of world oil reserves and the significant environmental degradation have revived the interest on renewable energy sources (RESs). In this context, emphasis is laid on the exploitation of wind and solar potential, with remarkable success. According to IEA (2006) hydropower is still the most widely used RES worldwide contributing almost with 18.5 % to the fulfillment of the planet electricity generation.

According to Kaldellis (2007, p. 2187) hydroelectricity as a technology started in the last decade of the 19th century, and pre-dates by many years the increasing public awareness of environmental issues. Hydropower projects can also have negative environmental consequences on a river ecosystem unless adequate mitigation measures are taken.

Most locations in Europe appropriate for the installation of large hydro power stations have already been exploited. Furthermore, there is a significant local communities' opposition towards new large power stations; hence, small hydro power stations remain one of the most attractive opportunities for further utilization of the available hydro potential. B&H and more precisely the country's mainland possesses a significant hydro-power potential which is up to now only partially exploited. In parallel, a large number of private investors have officially expressed their interest in constructing small hydro power (SHP) stations throughout the country, encouraged by the significant B&H state subsidy opportunities for renewable energy applications.

However, up to now a relatively small number of projects have been realized, mainly due to decision-making problems, like the administrative bureaucracy, the absence of a rational national water resources management plan and the over-sizing of the proposed installations. Certainly, if the above problems are suitably treated, small hydro-power plants can be proved considerably profitable investments, contributing also remarkably to the national electricity balance and replacing heavy polluting lignite and imported oil. In the context of the above mentioned issues, the present study reviews in detail the existing situation of small hydropower plants in B&H and investigates their future prospects as far as the energy, economic and environmental contribution are concerned.

The EU has a multidisciplinary and high skilled small hydro industry, which offers full range of products and services required to develop small hydro projects from the initial feasibility and design through manufacturing. According to European Commission (2011) the EU SHP industry generates an annual turnover of around EUR 120-180 million and it has maintained a leading position in the field of hydropower construction since the technology started to develop 150 years ago. It can be estimated according to European Commission (2011) about 20000 employees are working – directly and indirectly – in the EU-15 SHP sector.

The share of renewable energy in the world today is moving at about 10.5 % and their share of electricity generation ranging from a few percent or even up to 53 %. According to European Renewable Energy Council (2010) the European Union aims to have 21% of its electricity coming from renewable energy sources by 2010. This target has been formulated in the Directive 2001/77/EC on the promotion of renewable electricity. By the article of EUROPA (2011), the promotion of electricity from renewable energy sources (RES) is a high European Union (EU) priority for several reasons, including the security and diversification of energy supply, environmental protection and social and economic cohesion.

The Directive follows up the 1997 White Paper on renewable energy sources which set a target of 12% of gross inland energy consumption from renewables for the EU-15 by 2010, of which electricity would represent 22.1%. With the 2004 enlargement, the EU's overall objective became 21%. The Directive also constitutes an essential part of the package of measures needed to comply with the commitments made by the EU under the Kyoto Protocol on the reduction of greenhouse gas emissions.

European companies are currently among the world leaders in developing new technologies connected with RES electricity. The Directive aims to give a boost to stepping up the contribution of these energies while respecting the principles of the internal market.

As a different example of involvement in electricity production from renewable sources can be seen in ADEG Project (2005) Denmark (53%), Finland and Netherlands (38%), Latvia (37.5%), Czech Republic (26.4%), Germany (20.5%), Japan (16.7%), Turkey (17.6%), Austria (13.6%), etc. The world average share of electricity production from RES in total electricity production in 2006 amounts to 10.4%.

It is also important to mention the EU energy-climate package. The package, which was introduced in January 2008 and approved by European leaders in modified form in December 2008, is also known as '20 20 20 by 2020', because it aims at a 20% reduction in greenhouse gas (GHG) emissions, a binding 20% target for the use of renewable energy sources and 20% increase of energy efficiency by 2020. According to Global Environmental Change (2010) it became an opportunity for the EU to influence international environmental policy making, as it preceded the United Nations climate negotiations in Copenhagen in December 2009 that were initiated with the aim of reaching a new global climate agreement to replace the Kyoto protocol. It became clear in the run-up to Copenhagen that negotiations would not produce a binding treaty, but a nonbinding agreement was salvaged in the decreasing days of the conference, according to Climate change and African Political stability (2010*)*. From 1995 the parties to the convention met annually in Conferences of the Parties (COP) to assess progress in dealing with climate change.

Using the data provided up to now, it is quite clear that small hydroelectricity applications in B&H have a very good techno-economic performance and, therefore, a promising future. According to the available information most SHP investments present high financial efficiency if the proposed installation is properly designed in order to collaborate effectively with the existing water potential. Despite this positive situation, a relatively small number (approx. 50) of projects have been realized up to now. This unexpected evolution can be attributed to several existing problems, such as the administrative burden, the absence of a rational water resources management plan and the over-sizing of various installations encouraged by the existing subsidy scheme.

Frey and Linke (2002, p.1262) identified the following reasons to include hydropower in all Renewable Energy Initiatives. Hydropower is a renewable source of energy: hydropower uses the energy of flowing water, without depleting it, to produce electricity; therefore, all hydropower projects – small or large, run-on-river or storage – meet the definition of renewable.

Hydropower supports the development of other renewables: hydropower facilities with reservoirs offer unique operational flexibility in that they can respond immediately to fluctuating demand for electricity. Hydropower’s flexibility and storage capacity make it the most efficient and cost-effective way to support the deployment of intermittent renewable such as wind or solar power, facts available on the web page of World Commission on Dams (2000).

Hydropower fosters energy security and price stability: river water is a domestic resource and, unlike fuel or natural gas, it is not subject to market fluctuation. It offers vast potential and is available where development is most needed.

Hydropower means clean, affordable power for today and tomorrow: with an average life span of 50–100 years, hydropower projects are long-term investments that can benefit several generations. They can easily be upgraded to incorporate the latest technologies and have very low operation and maintenance costs, according to World Energy Council (2004).

Hydropower is a key tool for sustainable development: hydropower projects that are developed and operated in an economically viable, environmentally sound and socially responsible manner represent sustainable development at its best, i.e. ‘‘development that meets the needs of the people today without compromising the ability of future generations to meet their own needs.’’.

According to the World Energy Council (2007), hydropower generation is currently the largest and most easily accessible power source in the renewable energy sources due to its high energy density. In 2005, hydropower generation accounted for 87% of the total global electricity production from renewable energy sources.

In order for potential investors to invest in renewable energy, they must be convinced that such an investment is worthwhile. Therefore, the purpose of the thesis is to show that it pays off to invest in renewable energy by using the case study of constructing a small hydropower plant. Feasibility analysis of building small hydropower plant at the selected site in B&H will be performed. Also, an important aspect refers to creating the environment for change of legislation in B&H, which will be one of the obligations of B&H in the process of accession to the European Union.

Small hydro power (SHP) stations remain an attractive opportunity for further utilization of the available hydro potential throughout Europe. According to Kaldellis (2007, p.2188) SHP stations constitute remarkable energy production installations with considerably less environmental impacts, since in most cases they utilize local water resources without the need of extended infrastructure facilities and the construction of huge dams. Hence, the present analysis scope is to review the existing situation and contribute to a better development of the available small hydro potential. As already mentioned the available small hydro potential in B&H is quite high, hence there are many suitable locations for developing new stations. In this context, one may state that there is an increased investors’ interest regarding the erection of small and mini hydro power plants.

Objectives of the thesis are the following:
- to show that it is profitable to invest in renewable energy projects by using the case study of building a small hydropower plant;
- to show how significant hydro-power potential in the region, in particular in B&H can be exploited;

- to investigate environmental impacts of renewable energy projects;
- to find the location of the proposed installation based on the selection criteria;
- to investigate ownership rights of the water resources;
- to analyse the installation safety;
- to analyse legislation and to find out whether there are certain administrative barriers present;
- to explain the reasons for the small number of projects that have been realized so far;
- to investigate the reasons behind the fact that large number of private investors have officially expressed their interest in building small hydro power plants;
- to investigate the future prospects of SHPP as far as the energy, economic and environmental contributions are concerned.

The main methodology used in the thesis is a feasibility study: defining the project, technical capabilities, future trends, organizational resources, and financial aspects of the project. The purpose of the thesis is to develop a cost model of small hydroelectric power plant construction and operation. It will be applied to a particular case study involving investment project in a small hydropower plant, to check whether the model works and it is profitable to invest in certain SHP.

Also, specific indicators comprising of energy, economic and environmental aspects will be considered by the model. The present work is concentrated on the systematic investigation of the technical and economic viability of SHP stations. The study is concluded by a sensitivity analysis properly adapted for the local market financial situation, in order to enlighten the decision makers on the expected profitability of the capital to be invested. Finally, as per the sensitivity analysis carried out, the installation capacity factor, the local market electricity price annual escalation rate and the reduced initial installation cost are found to be the parameters that most significantly affect the viability of similar ventures.

The first chapter discusses renewable energy in general and its features and trends with reference to the world, EU and B&H. The second chapter inestigates energy policy, also divided into three parts listed. The third chapter of the master's thesis involves feaibility study. The most important part of this thesis is the case study, where I attempt to prove that it's worth building SHPP at selected locations in B&H, including elements of economic viability. Model inputs that are used are: dispozition of plant, hydrologic data, selection of installations flow, selected solutions, basic characteristics of the plant. Results will be obtained by Retscreen study of the facility.

1 RENEWABLE ENERGY SOURCES

Renewable energy is energy generated from natural sources such as water, sunlight, wind, rain, tides, geothermal sources and biomass sources as energy crops. Renewable energy sources are energy sources that are continually and naturally replenished in a short period of time. In contrast, fuels such as coal, oil, and natural gas are non-renewable. Once a deposit of these fuels is depleted it cannot be replenished–a replacement deposit must be found instead. Both renewable and non-renewable energy sources are used to generate electricity, for power vehicles, and to provide heating, cooling, and light.

Renewable sources of energy vary widely in their cost-effectiveness and in their availability across the world. Although water, wind, and other renewables may appear free, their cost comes in collecting, harnessing, and transporting the energy so that it can do useful work. For example, to utilize energy from water, a dam must be built along with electric generators and transmission lines.

On the other side renewables themselves are non-polluting, while the structures built to harness them can have positive or negative environmental impacts. For example, dams may affect fish migration but may also create wildlife habitat.

According to IEA (2006) hydropower is still the most widely used RES worldwide contributing almost 18.5% to the fulfillment of the planet electricity generation.

1.1 Different types of RES

Renewable energy sources (RES) are considered as water power, biomass, solar energy, wind energy, geothermal energy, and energy of sea waves. Renewable sources of energy are becoming more important in the world, due to an increasing global demands for energy and the certainty of the limited resources of fossil fuels on which today energy economy in the world is based. The EU has set targets in terms of participation of RES in total primary energy supply of EU member states. In addition to much smaller impact on the environment, renewable energy sources have another important advantage that can be applied to the construction of large power systems, and for very small systems (including households) and that can be combined with the use of fossil fuels.

A listing of the generally accepted principal RES sources and their definitions is set out below. Due to the intermittent nature of some of the RES sources (e.g., wind, most tidal, solar), a balanced RES approach to planning may need to include more than one of the sources and technologies listed. According to Moore and Smith (2007) the authors make no statement as to which resource or technology is their preference – from the perspective of an RES project developer or investor, it is clear that the 'best' or most attractive projects will be those from which the greatest returns can be made over the shortest period. This, however, has tended to be on the back of heavily subsidized tariff structures, which often favor a particular resource – generally, wind.

Governments, on the other hand, are driven more by the need to meet their international RES obligations and, increasingly, by the desire to achieve greater balance in their energy supply security positions.

1.1.1 Biomass

According to Moore & Smith (2007) biomass is, essentially, any matter which is composed of organic, biodegradable material – this can include anything from agricultural crops (some of which are specifically grown as a renewable energy feedstock) to municipal sewage. Wood, generally wood waste (e.g., sawdust, spoil, etc) from forestry processing industries, but also grown as an energy crop, can be used as a feedstock for RES projects. The most widely used process for conversion to energy is direct combustion in boilers (for heat and/or power generation), but other conversion technologies such as gasification, pyrolysis, and fermentation can also be used, dependent upon the final form of energy requirement. Biomass projects can be run on a 'base -load' (i.e., continuous operation – generally accepted as 8,000 hours per year or approximately 91% availability) generation basis.

1.1.2 Biofuels

Biofuels are, in the main, generally accepted as being those liquid fuels derived from biomass sources – these include biodiesel, bioethanol, and biogas. Whilst the principal focus to date within this category has been on the use of biofuels in the transport sector (where biodiesel and bioethanol are already in use as a blended additive for fossil fuel), such biofuels can also be used as a fuel for traditional combustion, with the generation of electricity from such a process generally meeting RES 'qualifying' criteria. The EU is one of the legislative bodies that has adopted Biofuels Directive, which establishes a road transport fuel energy content target of 5.75 per cent for renewable source-derived fuel by 2010. Biofuel plants should be capable of continuous operation.

According to Ozdemir E., Hardtlein M., & Eltrop I. (2009, p.2899) the EU has ambitious targets for biofuels, that is 10% of transport energy consumption by 2020 which are supposed to reduce the greenhouse gas (GHG) emissions from transport sector. As the provision of biofuels today is based on energy crops rather than residual materials, these targets result in the requirement of agricultural land area.

1.1.3 Biogas

According to Moore & Smith (2007) biogas is generally produced by a process of organic waste matter, such as animal manure, poultry litter, sewage, etc being decomposed by anaerobic digestion, or in landfill sites. The gas, for RES purposes, is captured and used either directly or blended with other gas for combustion, electricity generation, or upgrading to higher value fuel such as CNG (Compressed Natural Gas) for transport use. Biogas, being high in methane content, is a major GHG contributor, and RES projects which demonstrate high levels of GHG mitigation may benefit substantially from carbon credit trading. Biogas plants should be capable of continuous operation.

1.1.4 Energy from Waste – industrial and municipal

Moore & Smith (2007) emphasize a wide range of industrial, commercial, and agricultural processes generate substantial volumes of organic waste suitable for conversion to energy. MSW (municipal solid waste) also has high levels of organic matter content and, with each European generating between 0.75 kilogrammes and 1.6 kilogrammes of solid waste per day, can with some justification be categorised as ‘sustainable’. Whilst these wastes have in the past commonly been dealt with by largescale mass burn (incineration) technologies, today such an approach generally meets with substantial public resistance to the permitting of large plants, and increasingly the trend is now to seek to treat at, or near, the point where the waste is being generated (the ‘proximity principle’). A range of small-scale processes, based on established gasification/pyrolysis principles, are now becoming available on a commercial basis to address these requirements.

1.1.5 Geothermal energy

According to Moore & Smith (2007) this is any energy extracted from the earth. At its simplest, this can take the form of gathering heat from shallow-buried pipes by means of a heat pump and, at its most complex, by drilling to depths where water can be injected to return as pressurized steam for use in heating or to drive steam turbines for power generation. Geothermal power is limited to locations where geothermal pressure reserves are found. High-energy sites are suitable for electricity generation, whilst low-energy sites are suitable for direct heating and process heat applications. Geothermal plants can be considered, in respect of largescale projects, as base-load generation sources.

1.1.6 Hydro

According to Virtual Balkan Power Centre for Advance of Renewable Energy Sources in Western Balkans (2005) hydropower (large and small) contributes 17% to production of electrical energy in Europe, ranging from 99% in Norway to 3% and less in the UK and some other countries.

Because rainfall varies by region and country, hydro energy is not evenly accessible. Rainfall may also vary in time, resulting in variable annual power output. Small scale hydropower plants and small reservoirs, unlike medium and large ones, fit into the environment much more harmoniously, and cause fewer hazardous environmental impacts. Small scale hydropower plants are used for power production, municipal supply with potable and industrial water, or irrigation.

As set out above, for the purposes of this work, a small-scale hydroelectric power plant is defined to have a capacity of less than 10 MW. Hydro power is one of the oldest and most widely used forms of RES generation, using the energy from flowing water to drive a turbine. Dependent on climate and location, most mini-hydro plants can be considered as base-load generation sources (though in times of unusually low rainfall, available deliverable capacity can be severely constrained), according to Virtual Balkan Power Centre for Advance of Renewable Energy Sources in Western Balkans (2005).

1.1.7 Ocean

Moore & Smith (2007) emphasize a wide variety of technologies has been, or is being, developed to capture the energy contained in the oceans. In scale, they can vary from arrays of small-scale wave generators to large-scale tidal barrages and in location from shoreline to relatively deep-sea. The tidal barrages capture water at high tide to drive turbines in the outflow phase, tidal stream and ocean current devices, floating devices, etc. In certain locations, it may be possible to generate power from thermal gradients in seawater (Ocean Thermal Energy Conversion). The majority of ocean wave power technologies are, in theory at least, baseload energy sources, whilst tidal power projects are likely to achieve capacity factors of only some 25%. It is unlikely that any of the markets covered by this study, being all either land-locked or Mediterranean/Black Sea coast line, would be able to sustain a viable form of ocean power.

1.1.8 Solar

Solar energy has dominating theoretical potential. The amount of solar radiation intercepted by the Earth is much higher than annual global energy use. Large-scale accessibility of solar energy depends on a region's geographic position, typical weather conditions, and land availability. The proportion of the sun's rays that reaches the earth's surface is 10,000 times higher than global energy consumption. The amount of final energy will depend on the efficiency of the conversion device used (such as the photovoltaic cell applied). On average, each square meter of land is exposed to enough sunlight to produce 1,700 kWh of power every year according to Virtual Balkan Power Centre for Advance of Renewable Energy Sources in Western Balkans (2005).

In wide use throughout the world, solar heating technology is well proven and has applications in systems ranging from single dwellings to large-scale space heating and process heat. Generally, systems consist of a fluid that circulates to deliver heat elsewhere. Recent technology developments have introduced the possibility of power generation from a closed cycle fluid system, based on the use of the heat to convert fluid to gas, which drives a small turbine, the gas then cooling to re-form as fluid and recycled through the process. By definition, this is an intermittent energy source.

Based on either PV (photovoltaic) systems which convert sunlight to electricity, or thermal (Solar Thermal) systems, this resource is particularly suited to areas of high incident sunshine, de-centralised grid-connected power, and remote 'off-grid' locations. Systems that achieve thermal power generation by concentration of sunlight (Solar Thermal) may reach sufficiently high temperatures for steam to drive turbine generator sets. By definition, solar power plants are intermittent generators, although some of the latest Solar Thermal projects are capable of storing their liquid medium to give higher availability.

1.1.9 Wind

Historically, wind energy was most competitive in remote sites, far from the electric grid and requiring relatively small amounts of power, typically less than 10 kW according to Virtual Balkan Power Centre for Advance of Renewable Energy Sources in Western Balkans (2005). Wind power has been providing the driving force for water pumps and grain mills all over the world for centuries. Since the 1980s, significant advances have been made in wind turbine design and technology, with larger aerofoil blades giving rise to ever greater output ratings for landbased wind farms. Most recently, projects have been developed at offshore sites, where wind resources tend to be greater than those on land, and which could allow for higher output ratings of up to 10 MWe. Most blade and turbine designs include extremely sophisticated safety features, which prevent excessive rotation during periods of high wind speeds. By its nature, however, wind power is intermittent, with annual capacity factor in the 25–40% range, according to Moore & Smith (2007).

1.2 Cost of different RES systems

In order to illustrate the investment cost and operating and maintance cost (O&M cost) for each technology **Table 1** represents the economic parameters and accompanying plant specifications for RES technologies in the electricity sector.

Table 1: Overview on economic specifications for renewable energy sources plant

RES stype	Plant specification	Investment costs	O&M costs
		€/kW	€/(kW_{el}*year)
Biogas	Agricultural biogas plant	2,550 – 4,290	115 - 140
	Agricultural biogas plant - CHP	2,765 – 4,525	120 - 145
	Landfill gas plant	1,350 – 1,950	50 - 80
	Landfill gas plant - CHP	1,500 – 2,100	55 - 85
	Sewage gas plant	2,300 – 3,400	115 - 165
	Sewage gas plant - CHP	2,400 – 3,550	125 - 175
Biomass	Biomass plant	2,225 – 2,995	84 - 146
	Cofiring	450 - 650	65 - 95
	Biomass plant - CHP	2,600 – 4,375	86 - 176
	Cofiring – CHP	450 - 650	85 - 125
Biowaste	Waste incineration plant	5,500 – 7,125	145 - 249
	Waste incineration plant - CHP	5,800 – 7,425	172 - 258
Geothermal Eletricity	Geothermal power plant	2,575 – 6,750	113 - 185
Hydro largescale	Large-scale unit	850 – 3,650	35
	Medium-scale unit	1,125 – 4,875	35
	Small-scale unit	1,450 – 5,750	35
	Upgrading	800 – 3,600	35
Hydro smallscale	Large-scale unit	975 – 1,600	40
	Medium-scale unit	1,275 – 5,025	40
	Small-scale unit	1,550 – 6,050	40
	Upgrading	900-3,7000	40

(Table continues)

(Continued)

Photovoltaics	PV plant	2,950 – 4,750	30-42
Solar thermal electricity	Concentrating solar power plant	3,600 – 5,025	150-200
Wave energy	Wave power plant - shoreline	4,750	140
	Wave power plant - nearshore	6,125	145
	Wave power plant - offshore	7,500	155
Wind onshore	Wind power plant	1,125 – 1,525	35 - 45
Wind offshore	Wind power plant - nearshore	2,450 – 2,850	90
	Wind power plant - offshore: 5…30km	2,750 – 3,150	100
	Wind power plant - offshore: 30…50km	3,100 – 3,350	110

Source: D. Jager et al. Financing Renewable Energy in the European Energy Market. 2011.

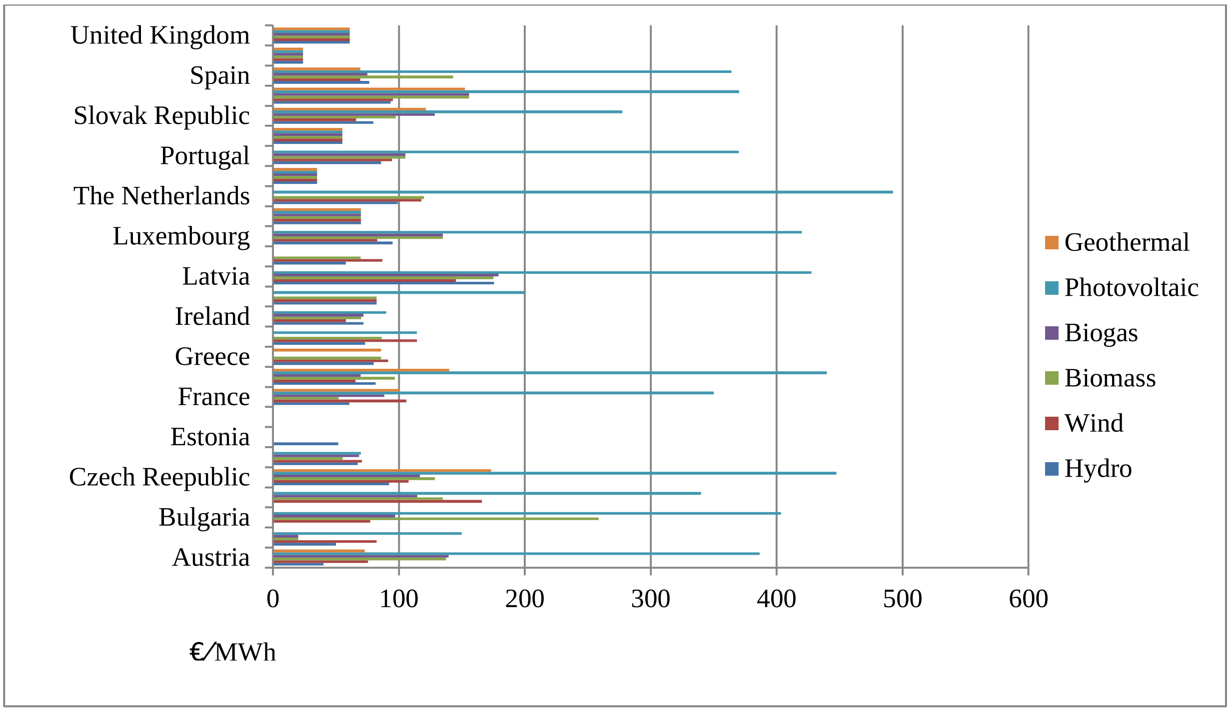
Looking at the investment costs of hydropower as electricity generation option it has to be distinguished between large-scale and small-scale hydropower plants. Within these two categories, the costs depend besides the scale of the units also on site-specific conditions and additional requirements to meet e.g. national / local environmental standards etc. This leads to a comparatively broad cost range from **850 €/$\boldsymbol{kW_{el}}$ to 5,750** €/kW_{el} for new large-scale hydropower plants. Corresponding figures for small-scale units vary from **975 €/$\boldsymbol{kW_{el}}$ to 6,050** €/kW_{el}.

Investment cost of small and large hydro are in the middle according to other plat specificition and because that hydro is competitive RES. The highest cost have geothermal and the lowest cost are cost of wind specfication.

In 2009 typical PV system costs were in the range **2,950 €/$\boldsymbol{kW_{el}}$ to 4,750** €/kW_{el}. These cost levels were reached after strong cost declines in the years 2008 and 2009.

Figure 1 shows average prices for different RES types in the EU 27 Member States.

Figure 1: Average RES prices in the EU-2009.



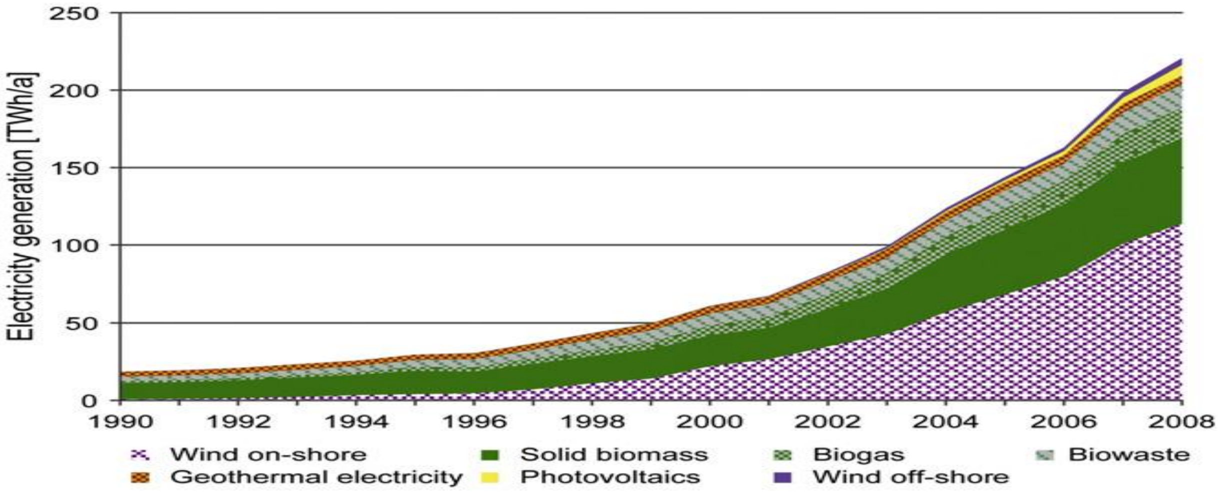
Source: European Renewable Energies Federation. Prices for Renewable Energies in Europe. 2009.

1.3 Trends in the world and the EU

According to Energotech (2011) as of 2010, about 16% of global final energy consumption comes from renewables, with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 2.8% and are growing very rapidly. The share of renewables in electricity generation is around 19%, with 16% of global electricity coming from hydroelectricity and 3% from new renewables.

The success of European promotion strategies for RES-E is depicted in **Figure 2**. An almost exponential growth took place since the beginning of the 1990s. The major success stories of this growth in RES-E in EU member states in recent years has been triggered by FIT (feed in tariffs) which are implemented in a technology-specific manner and involve rather modest costs for European citizens. The main reason for this observation is the long-term price security of the system combined with technology diversification of support. Compared to short term trading in renewable certificate markets the intrinsic stability of feed-in systems appears to be a key element for success.

Figure 2: Development of „new" RES for electricity generation in EU-27

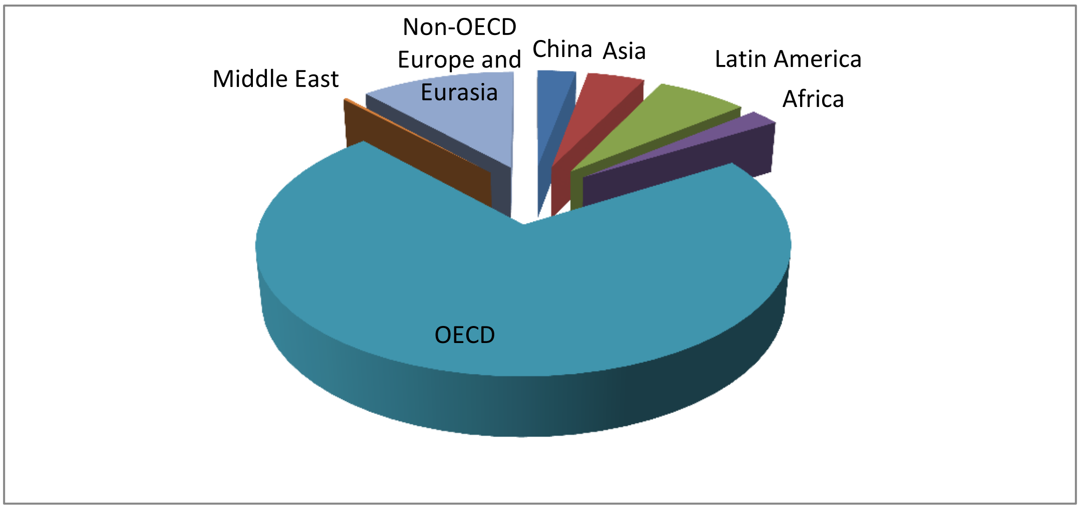


Source: R. Haas et al. Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources- Lessons from EU countries. 2011, p.2192.

OECD countries maintained constant amount of hydro production during 1971-2009 with slight increase, and it is noticeable that those countries have the biggest amount of hydro production in the world. China and Latin America had substantial growth of hydro production in the period of 2000-2009. Africa is a continent that has the lowest hydro production in the world. Non-OECD Europe and Eurasia are countries with very low and constant hydro production. Below, several figures which illustrate trends in the world and the EU are presented.

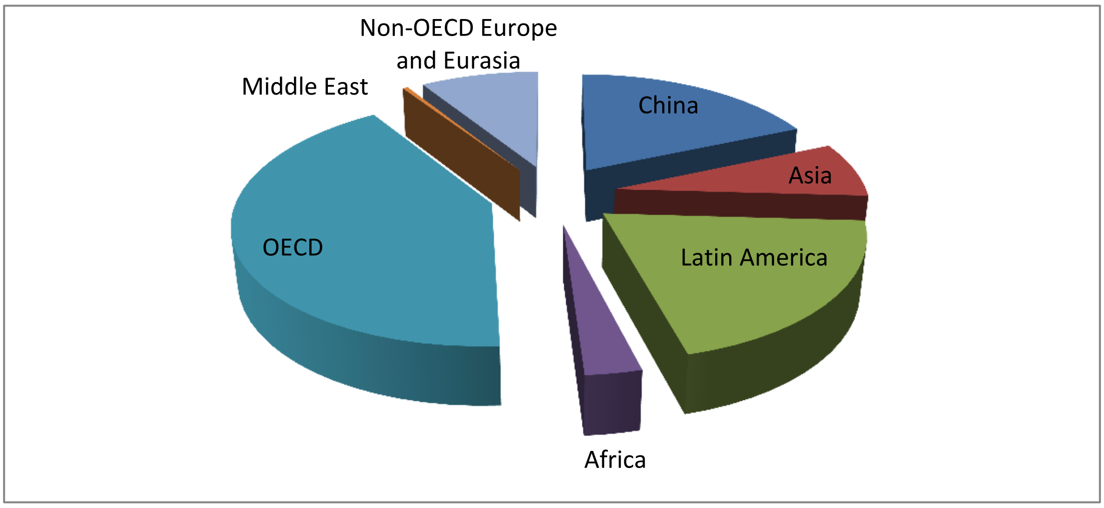
World hydro production today is almost three times higher than during 1970s. OECD countries retained the largest share of production, but it is significantly lower then before. The reason for that is the fact that other continents in the world increased their hydro production. Regional share of hydro production in 1973 compared to 2009 is shown in **Figure 3** and **Figure 4** below.

Figure 3: Regional shares of hydro production in the World in 1973 in %



Source: International Energy Agency. Key world energy statistics. 2011

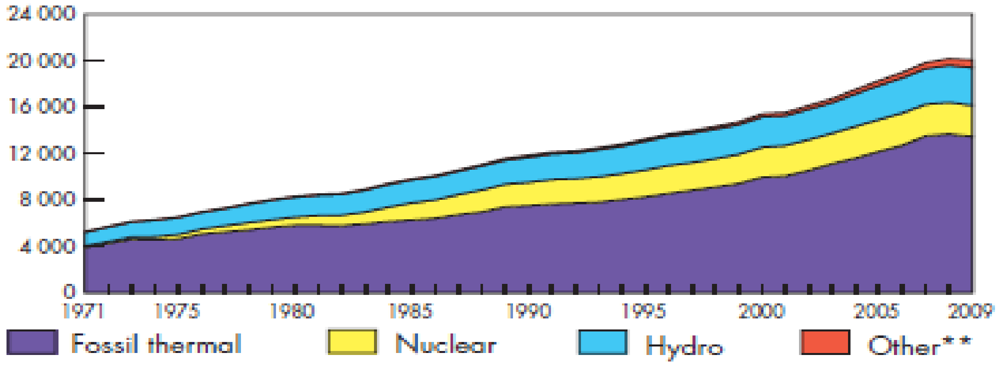
Figure 4: Regional shares of hydro production in the World in %



Source:International Energy Agency. Key world energy statistics. 2011.

Fossil fuels still remain the largest source of electricity, although hydro production did increase from 1970s till today. The growth of hydro production is noticeable, but it is not nearly enough compared to fossil production. Total production of electricity had the large growth since 1970s and it is almost quadrupled, but the negative side is the fact that in total electricity production fossil fuels remains with the largest percentage as it is shown in **Figure 5.**

Figure 5: World electricity generation by fuel 1971-2009



Source: International Energy Agency. Key world energy statistics. 2011.

According to Becerra, Bravo & Bienvenido-Bárcena (2011, p.2070) the main challenges to RES development and competitive installation are to reduce their high cost, improve the grid infrastructure, increase financing for research and infrastructures, especially large-scale facilities, develop storage mechanisms, incentivise innovation by small and medium businesses, promote competitive fossil and renewable energy systems simultaneously, train more technicians and specialists, create proper market mechanisms to build a real internal market for green power, facilitate export, simplify administrative procedures and improve institutional and economic agreements, through greater interaction between technology and politics that incentivise and improve access to RES on the power market. Social acceptance of the RES must also be improved and any local impact be reduced.

Trends in the primary production of renewable energy within the EU in 2008 was 148.1 million tonnes of oil equivalent (toe) – a 17.6 % share of total primary energy (see **Table 2.**). The volume of renewable energy produced within the EU-27 increased overall by 57.0 % between 1998 and 2008, equivalent to an average increase of 4.6 % per year.

Table 2: Primary production of RES in the EU in 2009 (in%)

	Primary production (100 toe)		Share of total, 2008 (%)				
	1998	**2008**	**Solar energy**	**Biomass & waste**	**Geothermal energy**	**Hydropower energy**	**Wind energy**
EU-27	94,343	148,144	1.2	69.1	3.9	19	6.9
Euro area (EA-16)	62,824	104,788	1.6	66.4	5.3	18.5	8.2
Belgium	678	1,806	0.5	94.4	0.2	1.9	3
Bulgaria	678	997	/	71.3	3.3	24.4	1
Czech Republic	690	2,456	0.2	91.9	/	7.1	0.9
Denmark	1,814	3,159	0.4	80	0.7	0.1	18.9
Germany	8,337	29,743	2.5	78.9	0.8	6.1	11.7
Estonia	512	755	/	98.3	/	0.3	1.5
Ireland	231	521	0.6	43	0.8	15.9	39.7
Greece	1,329	1,594	10.9	60.9	1.1	17.9	9.3
Spain	6,875	10,717	3.3	51.9	0.1	18.9	25.8
France	16,783	19,825	0.2	68.9	0.6	27.9	2.5
Italy	8,813	13,491	0.6	33	36.8	26.5	3.1
Cyprus	43	74	75.7	23	0		/
Latvia	1,756	1,782	/	84.7	/	15	0.3
Lithuania	612	883	/	94.8	0.1	4	1.2
Luxembourg	90	84	2.4	78.6	/	13.1	6
Hungary	483	1,656	0.2	91.8	5.8	1.1	1.1
Malta	:	:	:	:	:	:	:
Netherlands	1,691	3,135	0.8	87.2	0.1	0.3	11.7
Austria	6,030	8,292	1.4	56.7	0.5	39.4	2.1
Poland	3,883	5,457	0	95	0.2	3.4	1.3
Potugal	3,734	4,441	0.8	70.8	4.2	13.2	11.1
Romania	4,640	5,418	0	72.2	0.5	27.3	0
Slovenia	528	835	/	58.7	/	41.3	/
Slovakia	444	1,056	0	66	10	32.9	0.1
Finland	7,257	9,172	0	83.7	/	16	0.2
Sweden	14,206	16,051	0.1	61.9	/	37	1.1
United Kingdom	2,286	4,733	1.2	76.5	0	9.4	12.9
Iceland	1,814	3,259	/	0.1	80.7	19.2	0
Norway	11,202	13,384	0	9.8	/	89.7	0.6
Switzerland	3,969	5,190	0.6	35.9	3.7	59.7	0
Croatia	845	864	0.5	16.9	0.3	51.9	0.3
Turkey	11,481	9,360	4.5	51.9	12.3	30.6	0.8

Source: European Commision Eurostat. Renewable Energy Statistics. 2011.

Table 2 shows that among renewable energies, the most important source in the EU was biomass and waste, accounting for 69.1% of primary renewables production in 2008. Hydropower with 19% was the other main contributor to the renewable energy mix. Although its level of production remains relatively low, there was a particularly rapid expansion in the output of wind energy, which accounted for 6.9% of the EU's renewable energy produced in 2008.

The largest producer of renewable energy within the EU in 2008 was Germany, with a 20.1 % share of the EU total; France (13.4%) and Sweden (10.8%) were the only other countries to record a double-digit share. There were considerable differences in the renewable energy mix across the Member States, which reflected to a large degree natural endowments and climatic conditions. For example, more than three quarters (75.7%) of the renewable energy produced in Cyprus was from solar energy, while more than a third of the renewable energy in the relatively mountainous countries of Austria, Slovenia and Sweden was from hydropower (much higher shares were recorded in Norway and Switzerland). More than one third of the renewable energy production in Italy was from geothermal energy sources (where active volcanic processes still exist); this share rose to more than 80 % in Iceland.

The output of renewable energy in Germany grew at an average rate of 13.6% per year between 1998 and 2008, as such its share of the EU-27 total rose by 11.2 percentage points from an 8.8% share in 1998. There were also average growth rates in excess of 10% per year recorded for Belgium, Hungary and the Czech Republic, where the fastest growth in renewable energy production was recorded, averaging 14.2% per year between 1998 and 2008.

Table 3 shows renewable energy sources accounted for 9.0% of the EU-27's gross inland energy consumption in 2009. Over one third of the energy consumed in Latvia and Sweden was derived from renewables in 2009, while in Austria more than a quarter of energy consumption was accounted for by renewables.

The EU seeks to have a 20% share of its energy consumption from renewable sources by 2020; this target is broken down between the Member States with national action plans designed to plot a pathway for renewable energies in each Member State.

Table 3: Share of renewables in gross inland energy consumption

	Renewables total	Biomass & waste	Hydro	Geothermal	Wind	Solar
EU-27	9	6.1	1.7	0.3	0.7	0.1
Euro area	9	5.9	1.6	0.5	0.8	0.2
Belgium	3.9	3.6	0	0	0.1	0
Bulgaria	6.2	4.2	1.7	0.2	0.1	0
Czech Republic	5.7	5.2	0.5	0	0.1	0
Denmark	16.7	13.6	0	0.1	3	0.1
Germany	8.5	6.5	0.5	0.1	1	0.3
Estonia	13.5	13.2	0.1	0	0.3	0
Ireland	4.3	2.1	0.5	0	1.7	0
Greece	6.1	3.2	1.5	0.1	0.7	0.6
Spain	9.3	4.5	1.7	0	2.5	0.5
France	7.5	5.3	1.9	0	0.3	0
Italy	9.5	3.7	2.5	2.8	0.3	0.1
Cyprus	3.5	1.4	0	0	0	2.1
Latvia	36.2	29.2	6.9	0	0.1	0
Lithuania	10.5	9.8	0.4	0.1	0.2	0
Luxembourg	2.8	2.4	0.2	0	0.1	0
Hungary	7.3	6.7	0.1	0.4	0.1	0
Malta	0	0	0	:	0	:
Netherlands	3.9	3.3	0	0	0.5	0
Austria	27.3	15.5	10.7	0.1	0.5	0.4
Poland	6.6	6.2	0.2	0	0.1	0
Potugal	19	12.6	2.9	0.7	2.6	0.2
Romania	14.9	11	3.8	0.1	0	0
Slovenia	12.7	6.9	5.8	0	0	0
Slovakia	7.2	4.9	2.2	0.1	0	0
Finland	23.2	19.9	3.2	0	0.1	0
Sweden	34.4	21.6	12.3	0	0.5	0
United Kingdom	3	2.4	0.2	0	0.4	0
Norway	42.4	4.5	37.6	0	0.3	0
Switzerland	16.9	5.1	10.9	0.7	0	0.2
Croatia	10.9	4.1	6.6	0.7	0.1	0.1
Turkey	9.9	4.6	3.1	0	0.1	0.4

Source: European Commision Eurostat. Renewable Energy Statistics. 2011.

1.4 Balkan region and B&H

According to ADEG Project (2005) some action plans for the energy sector have been prepared, but the implementation of, even accepted plans, is very slow. The energy consumption in Bosnia and Herzegovina has been considerably reduced after the war in 1990s. As the living standard is, in a way, connected to the energy consumption, one of the main social goals in Bosnia and Herzegovina, to reduce poverty in the coming years, can be hardly achieved without increasing energy consumption. But, increasing the energy consumption must be followed closely with the reduction of the energy intensity (i.e. increasing energy efficiency), which has been increased after the war. Majority of the energy infrastructure in Bosnia and Herzegovina, especially electric energy facilities, has been reconstructed, enabling not only increase in electric energy consumption, but also to export it.

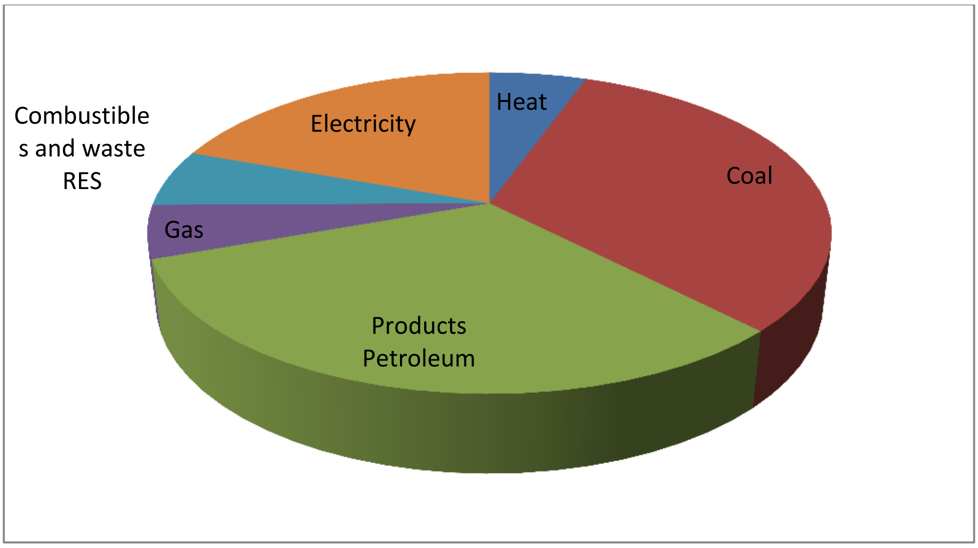
With consideration to solar irradiation, Bosnia and Herzegovina is among the more favourable locations in Europe with solar irradiation figures of 1,240 kWh/m^2/yr in the north of the country and up to 1,600 kWh/m^2/yr in the south. There is a great potential for Bosnia and Herzegovina to combine the two sources in establishing a unique central system from biomass heating plants and solar systems.

Bosnia and Herzegovina has a great potential of biomass, as the energy output is estimated at approximately 1 million m^3 per year. As many of the cities currently use combustion of crude oil for heating, serious damage to the environment could be avoided by introducing the geothermal heating.

According to *Lalić et al. (2011)* on one hand, Bosnia and Herzegovina has a huge potential of 2,500 GWh for small hydro power plants (SHPP). On the other hand, the potential of large hydro power plantsis impressive and there are big plans for the construction of several large HPP. However, large HPP can not be categorized as “renewable” due to the fact that they have serious negative environmental and social impacts, increase vulnerability to climate change and significantly crowd out funding for other renewable sources. In Bosnia and Herzegovina there have been no renewable energy projects financed by the International Finance Corporation.

Coal has the largest share in the total final energy consumption in Bosnia and Herzegovina, which was 32.2% in the year 2004 as it is shown in **Figure 6**, then petroleum products follow with the share of 31.82% in the total final consumption in the year 2004. The renewable energy sources contributed with the share of 5.73%. The largest RES share for electricity generation the largest share was from large hydropower plants as it is shown in in **Table 4.**

Figure 6: Shares of energy types in the total final consumption in Bosnia and Herzegovina in 2004 (in %)



Source: Energy Community. Report on the implementation of the acquis on renewables in the energy community contracting parties. 2011.

Table 4: Total RES electricity and heat production in Bosnia and Herzegovina in 2004

	Gross Electr.Generation (Gwh)	**Gross Heat Production (TJ)**
Municipal Waste	0	0
Biogas	0	0
Liquid Biofuels	0	0
Geothermal	0	0
Solar Thermal	0	0
Hydro	5,900	0
Solar Phovotaics	0	0
Wind	0	0

Source: Energy Community. Report on the implementation of the acquis on renewables in the energy community contracting parties. 2011.

As part of the electric energy is generated in thermal power plants, the measures for reducing environment pollution should be undertaken. The encouragement of using renewable energy resources, which are available in a significant amount in Bosnia and Herzegovina, could be helpful. Some of the European countries have shown interest in construction of renewable energy facilities in Bosnia and Herzegovina.

According to Energy Community (2011) electricity production in Bosnia and Herzegovina is highly depended on coal and hydropower. Evenvthough the electricity produced from hydropower contributes with 45.4% to the total annual production, the potential is still underutilised.

According to Energy Community (2011) due to the fact that detailed investigations for establishment of SHPP are already made and the most suitable locations identified this may be the key option for higher penetration of RES into national energy production portfolio. Energy utility companies already have plans for construction of a number of SHPP in the near future, e.g. Elektroprivreda B&H plans installation of 31 SHPP with the total installed capacity 34.19 MW and annual production of 126.6 GWh until 2008, while in the case of Republika Srpska concessions for 102 SHPP have been allocated.

Initial investigations in the southern part of the country show that there is significant potential for utilisation of wind energy. There are plans for establishment of three wind farms in the time frame from 2008 to 2012, with the total installed capacity of 128 MW. In the other parts of the country there is a need for detailed investigations on wind potential and identification of potential locations for establishment of wind farm. The basic knowledge of the necessary research and project development gained during the preparation of plans for the farms in the southern part of the country can be used as an initiative for more comprehensive research, followed by planning, that would encompass the whole country.

As already indicated geothermal energy is not being utilised neither for electricity production nor for heat production. Data on the geothermal potential is very limited, and due to the high costs of the needed research and investigations, it can be assumed that potential projects in the near future will be limited in scope and area extent. In that sense, the best option for project development is to conduct feasibility studies and market identification for utilisation of the geothermal springs at locations Bosanski Samac, Kakanj and Sarajevo.

According to Energy Community (2011) solar energy where almost none reliable data on the potential of energy utilisation exist, represents a RES that opens a great opportunity for development of research projects. These are primary preparation of “solar map”, identification of the most suitable locations where utilisation of solar energy would be cost-effective as well as identification of the best and most cost-effective technology. As the photovoltaic technology is still rather expensive, it can be assumed that solar energy would be primary used for heating and/or heating and cooling.

Apart from the projects that would increase utilisation of hydropower through SHPP, the potential for development of projects aiming at energy utilisation of biomass and waste is the most prominent in Bosnia and Herzegovina.

Due to the forest richness of the country and rather developed wood processing industry, there are important biomass resources available for energy production. In order to guarantee the sustainability of forestry and consequently sustainable energy production, a Strategy for development of forest biomass energy resource in Bosnia and Herzegovina should be prepared. Upon that, studies on the technically and economically most convenient technologies should follow, prior to establishment of biomass-fired power plants and/or cogenerations. An evaluation of the availability of other biomass sources, such as agricultural wastes and animal husbandry waste should be performed, except from the forestry. After the basic input data are gathered and analyses made, the potential locations for implementation of projects could be identified and feasibility studies on most suitable technology and market development carried out.

The utilisation of municipal waste for energy purposes has not been considered up-to-date, according to Energy Community (2011). As there are a number of technical solutions for such an utilisation available in the market, possibilities for a number of projects in that field are open in Bosnia and Herzegovina.

Primarily, one of the key issues should be to integrate energy utilisation of municipal waste into entity and national waste management strategies. Other necessary studies should encompass assessment of the quantities of wastes produced in households and industries as well as their composition. After having those basic data, feasibility studies on utilisation of landfill gas or/and waste combustion for electricity production can be conducted.

2 ENERGY POLICY AND PROMOTION OF RES

Energy is the main intermediate good for socio-economic development in any country. According to Tolo´ n-Becerra et al. (2010, p.7093) urban areas depend on commercial sources of energy and rural areas on non-commercial resources for developing countries (e.g., firewood and agricultural waste), so therefore, Omer (2008, p.2265) identified its sustainability is an important factor for consideration. According to economic theory, the strong relationship between energy use and economic activity is that energy, along with capital and labor, is a factor necessary for entering into production, and therefore, one of the main motors of economic growth. Geller and Nadel (1994, p.320) believe that, faced with the many barriers present in a given geographic area, energy efficiency policies and programs work better if they are integrated in market transformation strategies. Herring (1999, p.210) suggests that a more effective way to reduce energy consumption is by taxing it, even though this involves an economic cost to society.

2.1 Energy policy in the EU

According to Europa (2011) the European Union (EU) faces serious energy challenges concerning sustainability and greenhouse gas emissions as well as security of supply, import dependence and the competitiveness and effective implementation of the internal energy market. Each Member State is faced with a European Energy Policy, which is acknowledged as the most effective response to these challenges.

European Energy Policy will firmly commit the European Union (EU) to a low consumption economy based on more secure, more competitive and more sustainable energy. Priority energy objectives involve ensuring the smooth functioning of the internal market in energy, security of strategic supply, concrete reductions in greenhouse gas emissions caused by the production or consumption of energy and the EU's ability to speak with a single voice on the international stage.

European Council approved the so-called 20-20-20 goals, which have become the EU-27 strategic energy climate policy goals (Europa 2011):
- Increase energy efficiency to save 20% energy consumption over EU forecasts for 2020, according to the Commission estimates in its Green Paper on Energy Efficiency.
- Reduce 1990 greenhouse gas emission levels by 20% by 2020.
- Reach a minimum 20% share of renewable energies in total EU consumption by 2020.
- Increase the amount of biofuels to 10% of the transport fuel mix.

The EU attempts to manage a new industrial revolution and to develop a high efficiency energy economy with low CO_2 emissions. To succed in this it had to set a few important energy objectives, which are described in more detail in what follows.

2.1.1 Establishing the internal energy market

At the Community level an internal energy market is developed to guarantee that consumers have the opportunity to pick a supplier, at a fair and competitive price. There are barriers which continue to prevent the economy and European consumers from benefiting the advantages of opening up the gas and electricity markets, as highlighted by the Communication on prospects for the internal energy market and the inquiry into competition in the gas and electricity sectors. Establishing the effective implementation of the internal energy market hence remains important.

2.1.1.1 A competitive market and unbundling

Among the management of gas and electricity networks as well as production and sales activities must be a clear separation. According to Europa (2011) if a company controls the management of networks as well as production or sales, there is a serious risk of discrimination and abuse. A vertically integrated company has little interest in increasing the capacity of the network and thereby exposing itself to increased competition on the market and a consequent fall in prices.

In order to support companies to invest more in networks there must be a separation among the management of networks and production or sales, thereby to advance the entry into the market of new arrivals and increasing security of supply. This separation may be achieved through establishing the Independent System Operator, that is responsible for the maintenance, operation of the networks and development, which remain the property of the vertically integrated companies, or through full ownership unbundling.

2.1.1.2 An integrated and interconnected market

The internal energy market is essentially devoted on cross-border trade in energy. However, such trade is usually difficult because of the difference between national technical standards and disparity in network capacity. Effective regulation on a Community level is required. The abilities and independence of energy regulators must to be harmonised and their collaboration need to be reinforced and obliged to take into account the Community objective of realising the internal energy market. The Priority Interconnection Plan emphasizes the significance of financial and political support for implementing the infrastructures which are identified as important and nominating European coordinators for monitoring the most problematic priority projects with the objective of making the European energy network a reality.

2.1.1.3 An energy public service

The EU is determined to continue with its action against energy poverty by creating an Energy Customers' Charter. The charter will mostly encourage the implementation of aid schemes for the most vulnerable citizens when they are dealing with raising energy prices and also improve the level of information consumers receive concerning different suppliers and supply options.

2.1.2 Ensuring a secure energy supply

According to Europa (2011) minimising the EU's vulnerability concerning imports, shortfalls in supply, possible energy crises and uncertainty with respect to future supply is a clear priority. This uncertainty is all the more problematic for Member States dependent on one single gas supplier.

The new energy policy indicates the significance of measures which ensure solidarity among Member States and diversification of supply sources and transportation routes. Measures supporting strategic oil stocks must be reinforced and the possibilities for improving the security of gas supply must be explored. Increased security of electricity supply, which remains crucial, must also be guaranteed.

2.1.3 Reducing greenhouse gas emissions

Energy amounts for 80% of all greenhouse gas emissions in the EU. The EU is devoted to reduce its own emissions by at least 20% by 2020 to fight against climate change. This will also commit developed countries to reduce their greenhouse gas emissions by 30% by 2020. In addition the EU would set itself a new goal of reducing its own emissions by 30% compared with 1990 levels.

2.1.3.1 Energy efficiency

In Action Plan for Energy Efficiency (2007-2012) EU has set the objective to reduce its energy consumption by 20% until 2020. According to Europa (2011) concrete effort needs to be made to achieve this objective, in particular with consideration to energy saving in the transport sector, the development of minimum efficiency requirements for energy-using appliances, awareness-raising amongst consumers about reasonable and economic energy use, improving the efficiency of the production, transport and distribution of heating and electricity, also developing energy technologies and improving the energy performance of buildings. Certainly, reducing greenhouse gas emissions involves using less energy and using more clean energy. Through the conclusion of an international agreement on energy efficiency, the EU intends as well to achieve a common approach on a global scale for saving energy.

2.1.3.2 Renewable energy

The use of renewable energies clearly contributes to limiting climate change. Moreover, it has important role in providing energy supply and creating employment in Europe, due to the increase of the production and consumption of local energy.

Renewable energies, nevertheless, remain on the edge of the European energy mix since they still cost more than traditional energy sources. The EU in its Renewable Energies Roadmap has set itself the aim to increase the proportion of renewable energies in its energy mix by 20% until 2020 in order to increase the use of renewable energy sources.

As stated in Europa (2011) objective, mentioned above, this requires progress to be made in the three main sectors where renewable energies are used: electricity (increasing the production of electricity from renewable sources and allowing the sustainable production of electricity from fossil fuels, principally through the implementation of CO_2 capture and storage systems), biofuels, which should represent 10% of vehicle fuels by 2020, and eventually heating and cooling systems.

In December 2008, according to Klessmann et al. (2011, p.4679) the European Parliament and the Council of the European Union agreed on a new EU directive on the promotion of the use of renewable energy sources (RES), which was formally adopted in April 2009 (2009/28/EC). It sets binding targets for all EU member states to reach the European target of 20% RES share in EU gross final energy consumption by 2020. The allocation of differentiated national targets is based on a flat rate approach (same additional share for each country) adjusted to the member state's GDP. This target alocation approach does not necessarily correlate with the member states' RES potentials. The available biomass, wind, hydro, tidal, wave, and solar resource base varies importantly across different member states. The RES directive introduces''flexibility''or''cooperation''mechanism which allow those memeber states with low or expensive RES potential, to partially fulfil their RES target in other countries with higher RES potential or lower production costs, in order to account for these differences. The three intra-European cooperation mechanisms are: statistical transfer, joint support schemes and joint projects. Renewable energy, which has been produced in one member state, is ex-post and virtually transferred to the RES statistics of another member state, counting towards the national RES target of the latter member state means statistical transfer. The directive does not specify if this renewable energy is electricity, heat or fuel. Joint projects are RES electricity or heating/cooling projects that are created under framework conditions, jointly set by two or more member states; one member state may provide financial support for an RES project in another member state and count (part of) the project's energy production towards its own target. RES fuel projects are not eligible for joint projects.

2.1.4 Developing energy technologies

Energy technologies represent importan role in extending competitiveness and sustainability in the energy sector while increasing security of supply. They are also crucial for achieving the other energy objectives.

The EU, today a global leader in the renewable energy sector, intends to consolidate its position and play an equally leading role in the rapidly growing market for low carbon energy technologies. The EU must therefore develop existing energy-efficient technologies as well as new technologies, in particular those devoted to energy efficiency and renewable energies. Even if the EU considerably diversifies its energy mix, it will still be highly dependent on oil and coal and must thus also pay particular attention to low carbon-output fossil fuel technologies, especially carbon capture and storage systems.

As it emphasized in Europa (2011) investment in these appearing technologies will directly contribute to the Community strategy for increasing employment. The Commission proposes an outline for a European Strategic Energy Technology Plan which will cover the entire innovation process, from the initial research to entry onto the market. This strategic plan will support the Seventh Framework Programme for Research, which foresees a 50% increase in spending on research in the energy sector, along with the Intelligent Energy for Europe programme.

2.1.5 Considering the future of nuclear energy

Faced with increasing concerns with regard to security of supply and CO_2 emissions, nuclear energy has the benefit of being one of the low-carbon energy sources offering the most stable costs and supply. Member States make decision whether or not to use nuclear energy. However, the illustrative nuclear programme emphasizes the need to have a common and consistent approach with respect to security, safety and non-proliferation as well as concerning the dismantling of installations and the management of waste.

2.1.6 Implementation of a common international energy policy

The EU requires the involvement and cooperation of both developed and developing countries, energy consumers and producers and countries of transit because it is not able to achieve the objective of secure, competitive and sustainable energy alone. It is important that Member States and the EU are able to speak with a single voice on international energy issues to ensure efficiency and coherence.

As it is stated in Europa (2011) the EU will be a driving force in the development of international energy agreements, in particular by strengthening the European Energy Charter, taking the initiative in an agreement on energy efficiency and participating actively in the post-Kyoto climate change scheme. EU relations with consumer countries (such as the United States, India, Brazil or China), producer countries (Russia, Norway, OPEC countries and Algeria, for example) and countries of transit (such as the Ukraine) are of prime importance from the perspective of geopolitical security and economic stability. The EU will thus strive to develop energy partnerships with these countries which are transparent, predictable and reciprocal, in particular with its neighbouring countries. The EU also proposes a new partnership with Africa which will deal with a large variety of energy issues.

The EU is devoted to help developing countries in implementing decentralised energy services that are low-cost, reliable and sustainable. Furhemore this encourages countries, particularly in Africa, to immediately invest in renewable energies and the new generation of clean energy technologies.

The development of a European energy policy was at the center of the European project, with the ECSC Treaty (establishing the European Coal and Steel Community) in 1951 and the Euratom Treaty (establishing the European Atomic Energy Community) in 1957. Despite economic and geopolitical changes, it remains important today. The Energy Package is part of the movement begun by the Green Paper on a European Strategy for Sustainable, Competitive and Secure Energy in March 2006 and once again places energy at the heart of European activities, presented by the European Commission on 10 January 2007.

The actual EU energy policy seeks to reach a balance between sustainable development, competiveness and secure supply, mainly by promoting energy efficiency and the use of renewable sorces, by the application of greenhouse gas (GHG) mitigation policies and reduction of air pollution, and other directives and documents directed at the energy sector. European energy policy is in agreement with government policies implemented around the world in incorporating energy efficiency and energy savings in its work programmes for facing a series of challenges that include the perception of resource shortages, high cost of energy, secure energy supply and environmental protection. Promotion of energy efficiency is possibly the only energy policy that contributes to all of the basic EU goals in this matter, because it has a direct relationship with the reduction of GHG emissions and the mitigation of climate change, lowering the cost of consumer energy services and improvement of economic competitiveness, management of energy security.

2.2 Energy policy in B&H

2.2.1 Overview of the Energy sector

According to ADEG Project (2005*)* the main energy resources in Bosnia and Herzegovina are in coal (brown and lignite) and hydro power. There are a number of coal mines in Bosnia and Herzegovina; 14 coal mines are now in operation, 10 in Federation of Bosnia and Herzegovina (Kakanj, Zenica, Breza, Bila, Gračanica, Kreka, Đurđevik, Banovići, Tušnica i Kamengrad) and 4 in Republika Srpska (Ugljevik, Gacko, Stanari, Miljevina). Most (between 80 and 90%) of the produced coal is used for electricity generation**.**

Bosnia and Herzegovina does not have own resources in oil and natural gas. But there is an oil refinery in Bosanski Brod, Republika Srpska, using imported oil (Another refinery-Modriča is producing only motor oils and lubricants). In the last few years, the refinery is again in operation, but with a small part of the capacity (currently available capacity is estimated at 2 million tons per year), depending on the amount of imported oil and the market requirements. The company Jadranski naftovod d.d (JANAF -the same pipeline which is used in Croatia) manages transport of crude oil from the harbor at Croatian cost to the refinery. Storage capacities for oil are not sufficient for coverage of 90 days consumption.

In both entities, there are two major state–owned distributors, comprising the oil products distribution capacities, especially for motor fuels, oils and lubricants. Small private distributors cover the large share of the market, as well. Considering that the number of private petrol stations is on the increase and has reached approximately 300 stations, objective estimates suggest that the commercial capacities in B&H market are already oversized.

Natural gas is imported from Russia by the pipeline through Ukraine, Hungary, Serbia and Montenegro. The connection in Bosnia and Herzegovina is in Zvornik, at the eastern boarder of the country. This is the only connection for natural gas supply. The companies managing the import and transmission of natural gas are Energoinvest and BH Gas, Sarajevo and Gaspromet Pale (manages only a part of the transmission line from Karakaj - Zvornik -

approximately 20 km). There are two main gas distribution companies: Sarajevogas – Sarajevo (gas distribution in Sarajevo) and Sarajevogas–Lukavica (gas distribution in Eastern Sarajevo). All companies involved in the gas sector are stateowned. There are no gas storage capacities in Bosnia and Herzegovina, although some studies about the possibilities for it were done.

In the electric energy sector, there are, at present, three vertically integrated electric utility companies in charge of the generation, transmission and distribution:

- Elekroprivreda B&H (Electric Power Utility) of Bosnia and Herzegovina (EPB&H),
- Elektroprivreda (Electric Power Utility) of the Croatian Community Herzeg-Bosnia (EPHZHB) and
- Elektroprivreda (Electric Power Utility) of the Republika Srpska (EPRS).

Each electric utility is responsible for the electricity generation, transmission and distribution on its territory. The Common Electricity Coordination Center (Zajednički elektroenergetski koordinacioni centar - ZEKC), jointly owned and managed by the three electric utilities, was established in November 1998, to coordinate dispatching and ensure the integrity of the system within. The main function of ZEKC is to coordinate the management of the power supply system in a safe, effective and efficient manner and to ensure the transmission of electric power to domestic and foreign consumers.

The regulatory structure is divided along three lines:

- The State level, which encompasses the entire nation, and in the energy sector means a country-wide regulatory authority covering transmission and related issues (“SERC”);
- The Federation level, which in the energy sector means a regulatory authority covering distribution and generation for the Federation Entity (“FERC”); and
- The RS level, which in the energy sector means a regulatory authority covering distribution and generation for the RS Entity (“RSERC”).

According to ADEG (2005) despite this general division of authority in the energy sector, overlap exists. This is the combination of expected overlap resulting from splitting up the energy structure along federated lines, and overlap in the existing legislation due to lengthy negotiations involving concessions on certain issues at different times of passage. The existing intersection of jurisdictions and responsibilities is an ongoing issue. The newly created regulatory authorities and the Ministries governing the sector (three regulatory agencies; three Ministries) are confronting this and related issues as reform moves forward.

Each law creates a separate regulatory authority and each regulatory authority is in the early stages of formation. While the three regulatory authorities have issued various formation decisions, full secondary legislation, such as tariff and licensing rules, have not yet been drafted, and the regulatory authorities are not yet fully functional.

SERC has authority over transmission and transmission-related issues and jurisdiction extending over the entire country of B&H. The Bosnia and Herzegovina Parliamentary Assembly issued a decision in 2002 that acknowledged SERC as a legal entity; thus, no further registration is required. The three Elektroprivredas have pre-paid license fees, which has given SERC formation funds. SERC has the office in Tuzla and began working formally in August 2004. SERC has issued a Rule for Temporary Licenses and has required the three current integrated utilities to file for a temporary transmission license; this process has been completed, and SERC has been fully funded. Currently, work is going on developing procedural rules through public, transparent rulemaking process.

FERC has authority over distribution and generation and related issues. FERC's jurisdiction extends only to the Federation Entity. FERC has been fully funded and work formally began in August 2004. RSERC has authority over distribution and generation and related issues in the RS. RSERC has been funded and it officially commenced operations in August 2004.

The three pieces of primary legislation are:

- Act on Transmission of Electric Power, Regulator and System Operator of Bosnia and Herzegovina ("Act on Transmission"), State of B&H, Official Gazette of Bosnia and Herzegovina, 7/02, April 2002;
- Electricity Law, Federation ("Federation Electricity Law"), Official Gazette of Federation of B&H, 41/02, August 2002; and
- Law on Electricity, Republika Srpska ("RS Electricity Law"), Official Gazette of Republika Srpska, 66/02, October 2002.

Each of these laws established the respective regulatory authority. Two other pieces of integral legislation, the Transmission Company Law and the Independent System Operator Law became effective in August 2004. These laws, respectively, create the unified Transmission Company for B&H and the State-level Independent System Operator. Both of these bodies are required under the Act on Transmission.

2.2.2 Energy policy, evisaged energy sector reorganisation and development

According to Federal Ministry of Energy, Mining and Industry of B&H (2007) the Federal Ministry of Energy, Mining and Industry (FMEMI) issued the Strategic Plan and Program of the Energy Sector Development of Federation of B&H (SPP). The SPP document is made on the basis of the item 6 of the Conclusions of the Parliament of FB&H, House of Representatives from 25th July 2007 and People House from 8th November 2007. By the decision of the Minister, an Expert Group (EG) had been appointed for making the SPP.

The aim of making the document is, in the absence of the Strategy of development of energy sector B&H, to intensify activities on the reforms of the energy sector in the FB&H, secure conceptual propositions for the modernization of the already existing and the construction of new, modern energy facilities and infrastructure, with the high degree of the energy efficiency and sustainable development. The terms of references define: purpose, aim, scope and content, methodology of design, organization and dynamic plan of realization and expected results.

The purpose of developing the SPP was to make a professional analysis of the existing situation, define the requirements and possibilities of the development of energy sector in FB&H and in each subsector in whole taking into account energy sector development intensity in Bosnia and Herzegovina, region, Europe and the world. The aim is to unblock investing in this sector in FB&H and B&H, in general, and achieving the modern and sustainable development of energy sector in FB&H. The document contains the priority activities (until year 2010, see below), activities of the mid-term development (until year 2020, see below), and indicate the projection of the development in the third decade of this century (until year 2030). The SPP should have practical purpose, with the elements of the plan and program, without generally wider considerations.

Priority activities until year 2010 are:

- The concept of development and organizational aspects of the energy sector in FB&H,
- the Developing of the harmonized legislation and regulation, activities, bearers, deadlines;
- Evaluation of investments, basic technical-economical indicators of investments, including aspects of energy efficiency, environmental aspect and the lifetime of the facility.
- Preliminary realization plan for projecting, preparation works and realization of the plan and program.

Activities of the development of energy sector Bosnia and Herzegovina until year 2020 are:

- Description of activities, evaluation of investments, basic technical-economical indicators of profitability of investments, etc.
- Preliminary dynamic realization plan for projecting, preparation works for construction, putting into operation and usage of the facility, including environmental aspects in all phases of realization.

The electric power system has been rebuilt to a great extent, but the reconstruction has not been completed. The reconstruction of the 400 kV and 220 kV transmission network, including the 110kV system facilities, and particularly the reconstruction of the damaged transformer stations, enabled the reconnection and reintegration of the Bosnia and Herzegovina power grid, as well as the reconnection with the UCTE, the Balkans and Southeastern Europe systems, which was done in October 2004.

The action plan for the reconstruction and privatization of electric utilities has been prepared, but not yet fully accepted. The central issue in the action plan is the separation of three vertically integrated electric utilities into transmission, production and distribution parts. The transmission system will remain under the authority of Bosnia and Herzegovina (the transmission company will be jointly owned by the two entities), while it is planned to privatize the production and the distribution. As a first step the electric utilities will separate assets and liabilities of the different sectors – production, distribution, transmission and system management and allocate personnel to new organizations. The Joint Electric Power Coordination Center (ZEKC) will be transformed into the Independent System Operator, and electric utilities will allocate the assets and staff to it.

It is envisaged that the electricity market in Bosnia and Herzegovina shall be a single market, based on free and equal access to the transmission network and upon the principles of regulated access and applicable Directives of the European Union. The market will be opened in accordance with subsequent laws and regulations that shall define the scope, terms and conditions and time schedule of the market opening.

Bosnia and Herzegovina is in the center of Balkan and at the crossroads between some European countries and its place in connecting some of the energy infrastructure (electric and gas) may be significant. The activities in that direction and association to the regional market should help development of energy sector in Bosnia and Herzegovina. As a first step toward it, the creation of unitary electric network infrastructure company is under way and the similar approach for the gas infrastructure is foreseen. The process of privatization is in progress and the plans for privatization in some parts of the energy sector are foreseen.

There are some opinions that energy sector in Bosnia and Herzegovina, especially the electric power part of it, is considered as a prosperous one. This optimism is based on high hydropower potential, the large coal reserves, and existing power plants, on one side, and the opportunity to export electricity, and partly coal in some of the neighbouring countries, on the other side.

The Dayton Agreement, signed in Paris on 14 December 1995, retained Bosnia and Herzegovina's exterior border and created a joint multi-ethnic and democratic government. This national government based on proportional representation similar to that in existence in the former Yugoslavian state is responsible for the conduct of foreign, economic, and fiscal policy.

The Dayton Agreement also established a second tier of government, comprised of two entities – a joint FB&H (Bosnian/Croat Federation of Bosnia and Herzegovina) and the RS (Bosnian Serb Republika Srpska) – each presiding over approximately a half of the territory. The FB&H and RS governments are charged with overseeing internal functions. The Bosnian Federation is further divided into 10 cantons. Whilst the FB&H and RS governments have initiated programmes for energy sector reform and policies for the encouragement of energy efficiency and alternative sources of energy, much of the country's infrastructure remains damaged from the conflicts of the 1990s. As a consequence, in practice, most activities have been directed towards rehabilitation rather than new RES projects.

On the macro level, the government has actively pursued a policy of privatization and some 50 % of small- and medium- to large-scale enterprises have been sold to private entities. The Center for Energy at the University of Sarajevo has prepared a document as a basis for a long-term energy strategy for the Federation of Bosnia and Herzegovina. The strategy is designed to help the government to implement EU Energy Law into Bosnian Energy Law and enable acceptance and ratification of international environment protocols such as the Kyoto Protocol. According to Moore and Smith (2007) the medium-term strategy for the energy sector of Bosnia and Herzegovina developed by the Bosnian Council of Ministers has outlined the following goals:

- attracting domestic and foreign investments;
- establishing reliable energy supplies that conform with defined standards;
- developing single electricity and gas markets (Bosnia and Herzegovina is a signatory to Directive 2003/54/EC of the European Parliament and of the Council in respect of common rules for the internal market in electricity);
- improving the use of energy resources and energy efficiency;
- improving market liberalization through the introduction of competition and transparency;

- adopting international standards for environmental protection;
- protecting consumer interests;
- increasing the use of renewable energy: Bosnia and Herzegovina is a signatory to Directive 2001/77/EC of the European Parliament on the promotion of electricity produced from RES sources. Bosnia & Herzegovina is not yet a signatory to the Kyoto Protocol, but has signed and ratified the UNFCCC, with Non-Annex 1 status. Projects are eligible for CDM support consideration. The National Focal Point in the context of UNFCCC is the Ministry of Urbanism, Housing Communal Services, Civil Engineering and Ecology.

Law on the amendments to the law on electricity ("OG of FB&H" 61/09) and Law on Amendments and Modifications of Electricity Law ("OG of FB&H" 38/05) adress the following isues:
- electricity sector stimulation,
- stimulation for private domestic and foreign investments,
- more reliable supply of electricity,
- inclusion in international electricity market via unitary electricity market in B&H,
- economical and rational use of electricity,
- energy efficiency,
- implementing the transparency and competition excluding monopoly effects,
- environmental protection,
- protecting the interests of system users,
- renewable energy use.

Concerning status of compliance with EU standards, European standards are being adopted in all energy sectors since the moment of the association of the Institute for Standardization and Metrology (BASMP) with the European standardization organizations CEN and CENELEC. The number of adopted European standards by sub-sector until the end of year 2003 is as follows:
- Environment – 327 European standards
- Oil and derivatives – 256 European standards
- Gas and gas technique – 8 European standards
- Electric Energy (without Telecommunications) – 378 European standards
- Fire Protection –147 European standards.

In general, it can be said that the B&H energy-related legislation is to a high degree harmonized with the corresponding EU legislation.

2.3 Schemes to promote RES

According to Haas et al. (2011, p.2187) in 2007, the EU decided on a set of compulsory renewable energy targets for 2020: an overall 20% target. However, the intermittent nature of renewable energy sources (RES) like wind, solar and waves is one of the limiting factors for their penetration in power systems, especially autonomous systems. Apart from progress in forecasting techniques or providing information to end-users regarding management of uncertainty, energy storage applications can provide substantial help in managing intermittency.

A wide range of strategies is implemented in different countries to increase the share of electricity from renewable energy sources (RES-E). A still controversial discussion is whether quantity driven (like Tradable Green Certificates (TGCs) based on quotas) or price-driven (like feed-in-tariffs (FIT)) instruments lead to preferable solutions for society. Increasing the share of renewable energy sources for electricity generation (RES-E) has a high priority in the energy strategies of many countries world-wide.

The current discussion within EU Member States about various renewable promotion schemes focuses on the comparison of two systems, the *feed- tariff (FIT) system* in and the *quota regulation* in combination with a *tradable green certificate (TGC)* market, according to Klein et al. (2008).

2.3.1 Feed in tariff (FIT) and Quota regulation in combination with TGC

TGC-based quota system works as follows: A quantity (quota refers to a certain percentage of electricity to be guaranteed from renewable energy sources) is set by a government. The generators (producers), wholesalers, retailer or consumers (depending who is obligated in the electricity supply chain) are obligated to supply/consume a certain percentage of electricity from renewable energy sources. At the date of settlement, they have to submit the required number of certificates to demonstrate compliance. A FIT works vice versa: the price is set and the quantity finally generated is decided by the market. The system of fixed feed-in tariffs allows electricity generators to sell Renewable Energy Sources at a fixed tariff for a determined period of time. Alternatively, the feed-in tariff can be paid in the form of an additional premium on top of the electricity market price. Currently FITs are applied by 20 of the 27 EU Member States as main instrument to support the generation of RES-E and by one country (Italy) only for electricity generation from PV and certain small scale applications according to Klein et al. (2008).

According to Batlle et al. (2011) the basic feature of feed-in tariffs (FIT) is to guarantee RES-E generators a specific price per MWh that is produced. To encourage development of new RES-E capacity, FIT must be high enough to ensure long-term recovery of costs for a given technology. In most power systems, FIT apply for at least during 10 years; in some cases, support is guaranteed for as many as 30 years. According to the most recent REN21 Global Status Report, by 2010 at least 50 countries and 25 states and provinces had instituted FIT supports for RES-E generators.

The quota obligation based on TGCs is a relatively new support scheme and has replaced other policy instruments in Italy, Belgium, United Kingdom, Sweeden, and Poland and Romania in recent years. The basic element of the system is the obligation for a particular party of the electricity supply-chain (e.g. consumers, suppliers or generators) to provide a specified minimum share in total electricity consumption from renewable energy sources. Besides the quota target, a market for renewable energy certificates is established. By giving RES-E producers the possibility to sell certificates on the market, they receive financial support in addition to the electricity sales on the power market.

According to Klein et al. (2008) other policy instruments such as tender schemes, which grant financial support to projects with the lowest generation costs following a bidding round, are no longer used in any European country as the dominating policy scheme. However, there are instruments like production tax incentives and investment incentives, which are frequently used as supplementary measures. Only Finland and Malta employ these as their main support scheme.

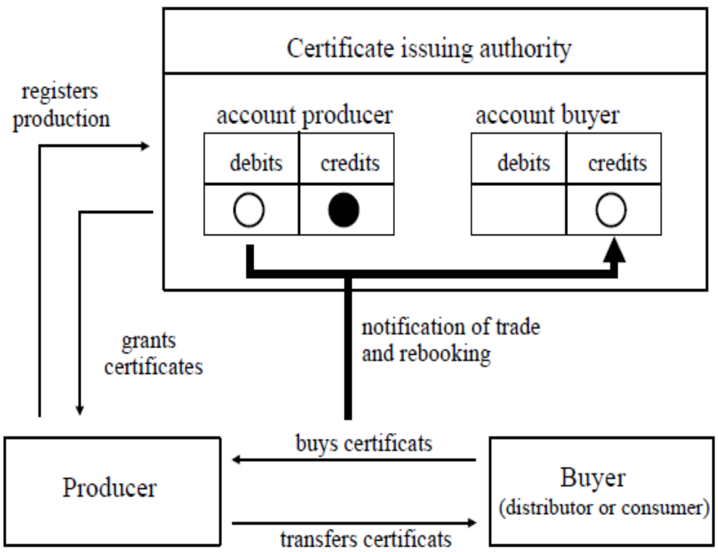
According to Ringel (2006, p.5) in order to control ecological effectiveness, i.e. to make sure that a fixed amount of ‘green’ electricity is generated, states often oblige producers, distributors or consumer to either produce or buy a certain amount of this electricity (in absolute values or quotas). These ‘fixed-quotas’ or ‘portfolio-models’ nevertheless disregard economic efficiency, as they do neither take into account the different production capacities and possibilities, nor the individual costs to fulfil these quotas.

Raising the efficiency of quantity-based model is possible by trading the quotas. Entities are free to choose either to fulfill the quota themselves or to pay another entity for covering their obligation. Producers will be obliged to meet a specified quota of renewable-based electricity in the easiest design. They have the choice whether to fulfill the quota themselves or rather buy the production of other generators with trading. If they choose less costly option, that will lead to economic efficiency. Generally, ‘green’ electricity is produced by those generators that can do so at least cost.

Green certificates are a comparatively new, advanced version of tradable quotas. Despite of its recent use, the model has achieved popularity in many EU member states since its introduction in the Netherlands at the end of the 1980s. Ringel (2006, p.7) emphasizes that the model obliges a group (again producers, but more usually consumers or distributors) to hold a certain share of their overall electricity consumption/sales in 'green' electricity in a certain time period (usually one year). In a tradable quota-model they would prove the fulfilment of their obligation by showing that they have bought the respective amount of electricity generated by renewables (contract certificate).

Electricity consumption is divided from the need to fulfill the quota obligation in the green certificate model. The production of 'green' electricity is measured and certified (e.g. one certificate per MWh) by an independent, usually state-controlled certificate issuing authority. This process works as a bank account on which the production of renewable-based electricity is saved as credit (see **Figure 7**).

Figure 7: Functioning of green certificate model.



Source: M. Ringel. Fostering the use of renewable energies in the European Union: the race between feed-in tariffs and green certificates. 2006.

The producers thus generate a certain stock of green certificates which prove that they have produced the respective amount of physical electricity by renewable energy sources. By means of the green certificates, it is possible to separate the market for electricity (physical commodity) from the market for the certificates. The certificate market can be referred to as a service market for the ecological benefits resulting from the use of renewable energies (eco-services like e.g. the reduction of emissions and the conservation of fossil resources).

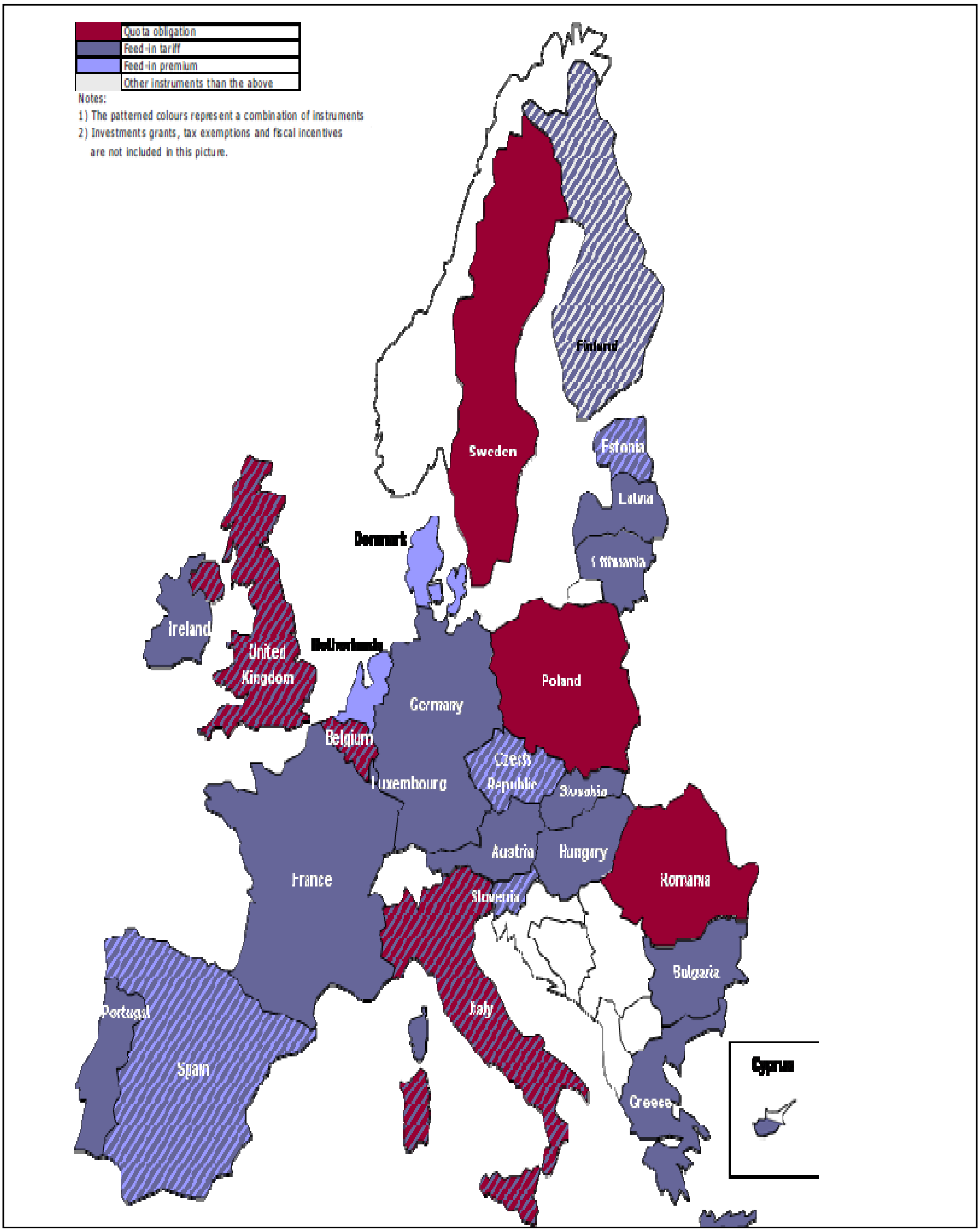
A producer has two different sources of income with the separated markets. First, he can sell his electricity on the physical market, at standard market price. As his product will compete with electricity generated by coal, nuclear or others, he is due to the cost disadvantage of renewables likely to incur a loss. To make up for this loss, the producer may then turn to the eco-service market and sell his green certificates at a price that covers his loss.

The sale of the certificates is monitored and followed by the issuing authority through the means of double bookkeeping on the certificate market. Each distributor or consumer can achieve his share, either by producing the required amount of 'green' electricity by himself or he can buy the equivalent amount of green certificates, in order to create a demand for the certificates. This total separation of the two markets adds an increased flexibility to the model.

According to Ringel (2006, p.10) in the EU the Netherlands has the largest experience with green certificates. The current Green Certificaten model has evolved out of a voluntary tradable label system. It has been the blueprint for tradable quota systems in several other European countries, which all recur to the tradability of certificates in spite of their differing in-detail regulations.

Ringel (2006, p.10) explained that energy storage is also set as one of four pillars of the EU Post Carbon Society. Efficiently designed financial schemes for storage systems may contribute to EU energy policy 20–20–20. The available options for energy storage and integration of different energy and resources flows that could help solve intermittency problems in the islands energy systems have been proposed using the Renewislands methodology. Case studies and calculations for pumped hydro and hydrogen have in many cases been proposed or have been recently implemented, or are under final construction, like on Ikaria Island in Greece. Efficient management of batteries in small island power systems with increased RES penetration can provide both economic and operational benefits for the power systems operators for the island of Kythnos. **Figure 8** shows representation of support mechanisms for energy production from renewable energy sources in EU countries. As it is shown feed-in tariff is the most represented support mechanism in EU.

Figure 8: Map of EU countries according to their support mechanisms for RES-E



Source: International feed in Corporation. Recent experiences with feed-in tariff systems in the EU. 2010.

2.3.2 Objectives of promotion schemes

Haas et al. (2011, p.2190) provides the following basic reflections which are of core relevance with respect to the choice of the most proper strategy:

1. The core objective of a promotion scheme for RES-E must be to increase its market deployment;
2. It is of core relevance to bear in mind that actually all these systems rely on a command & control approach of a planned economy. In one case the price is set, in another case the quantity is set;
3. Yet on the other hand all of these systems are market-based: the goods are produced in a competitive market (private or public). Companies decide whether to invest or not. Only if the proper incentives are provided the proper investments will be made on a "free" competitive market. And it is important to note that this market in all cases is created by some kind of artificial demand. Hence, in both cases an artificial market is created.
4. What should be the economic target of a support system for RES? As it is based on an artificial market and not on the voluntary decisions of the consumers/voters the objective should be to minimize the overall additional costs for thise group to finally reach a maximum of support/acceptance possible.

2.3.3 Comparison of both schemes with respect to ecological effectiveness and economic efficiency

According to Ringel (2006, p.12) in order to compare instruments, economic theory usually draws on the criteria of ecological effectiveness (in this case the question 'is a certain share of renewable energy used at a given point in time?') and economic efficiency (the question: 'is this aim reached at socially least cost?').

Feed-in tariff schemes are generally presumed to reach the goal of achieving a certain amount of renewable energy in electricity production (i.e. the criterion of ecological effectiveness). In general, a trial and error-process is necessary to find the price which is associated with a certain amount of renewable energy use. However, as it depends on all entities to react to the price signals, it is unclear when the aim will be reached. This instrument is not able to provide for the desired amount of renewables in a timely manner when prices are set too low. On the other hand, when prices are set too high they offer windfall gains to power producers, at the expense of the end users, which constitutes an efficiency loss for the economy.

The quantity-based green certificates are fully in accordance with the objective of ecological effectiveness in the aspect of timeliness. Hence, for a policymaker, quota models would be desirable as they do not only assure the fulfilment of the renewable energy objective, but also make sure that this objective is met. Ecological effectiveness is not a crucial motivation for transposing to quota models combined with green certificates. Considering the economic efficiency, literature is uncertain that feed-in tariffs are able to meet this criterion.

Politicians have an interest in setting high fixed prices to protect the ecological effectiveness. International tariff comparisons show that e.g. Germany works with comparatively high tariffs. However ecologically viable results with far lower tariffs are reached in France and Denmark. This indicates that the exhaustive assistance leads to efficiency losses for the economy as a whole. Furthermore, prices on electricity markets are different according to season, daytime and according to the reliability of power supply. As TSO must ensure that a stable grid voltage is held, they will pay the highest prices for rapidly available power sources with a high reliability (in Europe mostly gas-fired power plants or pump storage plants). The feed-in tariff scheme with its fixed prices for each MWh produced ignores the differences of the markets and thus probably diverge from economic efficiency also from this point of view.

Green certificate models promise a high degree of economic efficiency by recurring to two separate markets. The market price of the commodity market is determined by supply and demand only. On the certificate market, too, only the most efficient production facilities contribute to achieve the ecological aim. However, this feature has repercussions to ecological effectiveness in the sense of reaching a high diversity of renewable energy sources.

To conclude the discussion, it can be said that both models have their respective advantages and disadvantages with regard to ecological effectiveness and economic efficiency. The workability of each support mechanism depends fundamentally on the political and economic context. As far as the European Union is concerned, a particular framework is given by the single market for electricity.

2.3.4 Guarantees of origin (GO)

According to Ragwitz et al. (2009, p.300) the European Commission has proposed a new Renewable Energy Directive which includes flexibility provisions allowing the cost-effective attainment of the ambitious target for renewable energy of 20% of energy consumption, which has been set for the year 2020, as it is mentioned earlier in this work. One of the flexibility provisions currently being considered is to allow countries to reach their individual targets by buying their renewable electricity deployment deficit from other countries with a surplus (i.e., with a renewable electricity deployment above their targets). This trade is likely to take the form of an exchange in guarantees of origin (GOs). According to Ragwitz et al. (2009, p.301) GOs are currently implemented in Member States to fulfil the Renewable Electricity Directive requirement that each country has a system that allows the tracing of the source of each kWh of renewable electricity and informs on this source. Although the recent and tiny literature on the analysis of GO trading has focused on trade between firms, the exchange of GOs between governments has not received a comparable attention.

GOs, which are issued by Member States, ensure that electricity has been produced from RES sources. They specify the energy source from which the electricity was produced and serve to enable RES-E producers to demonstrate that the electricity they sell is produced from RES.

According to Ragwitz et al. (2009, p.301) the European Commission (2007) states that GOs are compatible with existing support schemes. However, it would be more appropriate to say that this depends on the type of GO system implemented, i.e., on the specific design elements of the scheme. Particularly, a government-based GO trade scheme would be more compatible with the existing support systems than a company- based one. Another conclusion explained Ragwitz et al. (2009, p.302) is that a government-based trading system of GOs would have some advantages regarding several assessment criteria compared with company- based trading. This is particularly so with respect to effectiveness in encouraging RES-E generation, the avoidance of windfall profits, dynamic efficiency and transaction costs of implementing the GO trading scheme. Moreover, as government-based trading is more compatible with existing national promotion schemes and provides a more direct connection between the costs of RES-E promotion and the local benefits, it is thus more politically feasible than company-based trading, whose implementation is likely to face strong opposition by some governments and companies. Hence, introducing company-based trading is not advisable, as it is currently being proposed by certain policy circles within the EU.

2.4 Promotion scheme in B&H

According to Lalić, Popovski, Gecevska, Popovska Vasilevska and Tesić (2011) B&H has the highest energy intensities in Europe, i.e. much more energy is used for the production of a unit of work here than in any European country. Nonetheless, very little investment and priority are being given to the increase of the efficiency. On the other hand, B&H has a high potential for developing energy production from renewable energy sources (RES): water, wind, biomass, and geothermal energy. However, these potentials are not studied and exploited enough and the present situation for their utilization is not so good. Although energy is a critical foundation for economic growth and social progress of B&H, there are many constraints for RES development (political, technological, financial, legislative, educational, etc.). Obviously, defining development strategies and new support measures is necessary since renewable energy sources can make an important contribution to the regional energy supply and security.

Lalić et al. (2011) explained that for all of the Western Balkan countries it can be summarized that:

- Partial engagements for defining the concrete strategies for development are present. None of the countries has a concrete strategy for particular RES development that is officially accepted and supported by measures that would enable its implementation;
- None of the countries have developed a suitable legal background allowing easy access to permissions, concessions, funds, etc., enabling application of RES;
- None of the counties have defined sufficient and sustainable programs and solutions for particular measures for supporting development of concrete RES;
  Only some of the countries (i.e. Croatia) have allocated funds for supporting the development of RES.

Last but not least, none of the countries have enough data and information essential for the determination of the market for particular RES at their disposal. This should be one of the most important directions of the future engagements in RES development, if the desired level of development is to be achieved.

The definition of renewable energy within the Bosnian regulations governing electricity differs from the EU directive on the promotion of electricity from renewable energy sources in the internal electricity market. Furthermore, the sections on “national indicative targets” and “guarantee of origin of electricity produced from renewable energy sources” stated in the EU directive are not taken into account in the regulation adopted by B&H.

Discussions are therefore in process to produce feed in tariff directive that would be standard for the whole of B&H and in conformance with the EU policy. In 2002, the Government adopted a resolution to promote the generation of electricity from renewable energy sources., where electricity suppliers or grid operators are obliged to accept electricity from renewable energy sources in their grids and to pay a fixed rate for it. The level of remunerations for the in-feed of electricity from renewable energy sources with a maximum installed capacity of 5 MW is coupled to the amount of the medium-voltage tariff.

In the spring of 2004, the South East European Enterprise Development (SEED) Program of the International Finance Corporation (IFC) launched a program to promote renewable energy

through certificate trading. The goal of the SEED program is to support companies and institutions in BH to switch to renewable energy sources thereby reducing GHG emissions.
All the countries have Energy Laws, similar to those in the EU, developed to modernize the structure of the energy sector, promote RES, to separate the current monopolies and to open the sector to competition.

For completion of the legal framework for RES it is important to adopt:
- Decree on the minimum share of RES and cogeneration;
- Regulation on RES and cogeneration utilization;
- Regulation on fees for electric energy generation from fossil fuels;
- Tariff system for electricity production from RES and cogeneration;
- Regulation on the criteria for acquiring the status of eligible producer;
- Grid code and other regulations from the transmission and distribution domain;
- Sub-acts stipulated by the Law on Production, Distribution and Supply of Heat.

After this RES legislative framework has been created it is necessary to prepare and implement corresponding secondary regulations and sub-acts that are comparable with the EU practice and are easily implemented. The goal of this legislation is to simplify the administrative procedures and to speed up the issuing of necessary permits for construction and RES utilization. Administrative barriers are among the most serious and ubiquitous barriers, originating from non-aligned regulation, non-defined or overlapping responsibilities, timely procedures, etc. Administrative barriers are different for each type of RES; they can, despite the huge potential, hinder or delay a project development.

Subacts should define institutional organization that enables project development based on entrepreneurs' initiatives, including authorization procedures, support system functioning, contracting arrangements, rights and obligations of renewable producers. The whole framework is still pending, and even if adopted, it will take time for new relationships to be established and institutional arrangements to become effective.

For now, the only type of subsidies in B&H are guaranteed prices Guaranteed prices (GC) means the price payable to producers of electricity from RES for the duration of the contract on purchase of electricity. Guaranteed price depends on the reference price and the tariff coefficient. Reference price(Rc) for 2010 is 12.26 pf / kWh.

For each subsequent year Operator determines Rc no later than 31 October of the current year so that Rc for the current year is corrected for inflation (producer price index for the E: Electricity, gas and water, which is establishesed by the Federal Bureau of Statistics).

Guaranteed price is obtained by multiplying the reference price and the related tariff coefficient for a certain type of RES:

$$G_C = R_C \cdot C$$

Where:
G_C- guaranteed price
C – tariff coefficient
$C = 1.01$ for SHPP in B&H.

Regulation on using renewable energy resources and cogeneration (“OG of FB&H” 36/2010) lays down:

- how to use renewable energy and cogeneration facilities (herein after referred to RES),
- the minimum share of electricity produced from plants using RES in total energy consumption,
- encouraging the production of electricity from RES,
- testing the potential of RES,
- establishing the Register of RES projects,
- RES plant construction, purchase and compensation, RES plants access on the grid,
- the certification of origin of electricity produced from RES,
- the establishment of institutional structures for the operationalization of the system for supporting the electricity production from RES, as well as other issues of importance for RES utilization.

The use of RES is of general interest for the FB&H. The aim of this Regulation is to stimulate greater production and consumption of electricity from RES in the internal electricity market and the development of regulatory and technical infrastructure for the RES, particularly in terms of:

- removing barriers to increase use of RES, including administrative barriers,
- reduce the impact of using fossil fuels on the environment,
- approaching the Kyoto targets,
- encouraging, introducing, applying and developing new equipment and technologies, and the domestic economy as a whole,
- job creation and entrepreneurship development in the energy sector,
- long-term energy security, efficient use of energy, including energy efficiency and savings,
- quality of waste disposal.

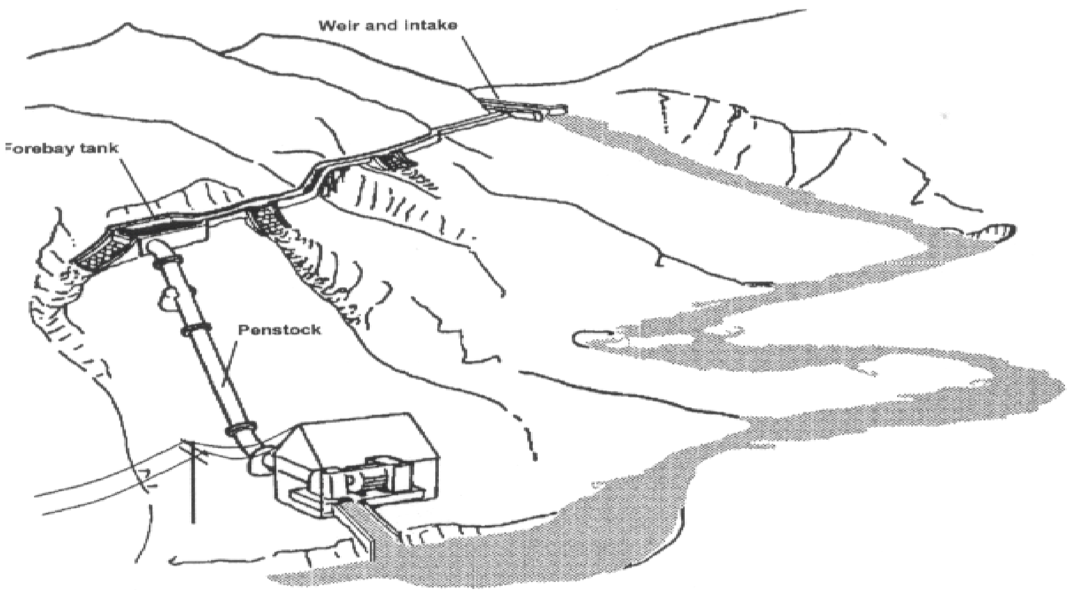
3 SMALL HYDROPOWER PLANTS (SHPP)

Kaldellis (2007, p. 2187) explained that hydroelectricity as a technology, started in the last decade of the 19th century, and pre-dates by many years the increasing public awareness of environmental issues. Hydropower projects can indeed have negative environmental consequences on a river ecosystem unless adequate mitigation measures are taken.

According to the World Energy Council (2007), hydropower generation is currently the largest and most easily accessible power source in the renewable energy sources due to its high energy density. In 2005, hydropower generation accounted for 87% of the total global electricity production by renewable energy sources**.**

Figure 9 shows that this SHPP requires no water storage but instead diverts some of the water from the river which is channeled along the side of a valley before being 'dropped' into the turbine via a penstock. In **Figure 9**, the turbine drives a generator that provides electricity for a workshop. The transmission line can be extended to a local village to supply domestic power for lighting and other uses.

Figure 9: Appearance of small hydro power plant



Source: Wikipedia. How to Plan a Micro Hydro power Plant. 2011.

3.1 Small hydro power plants in the world

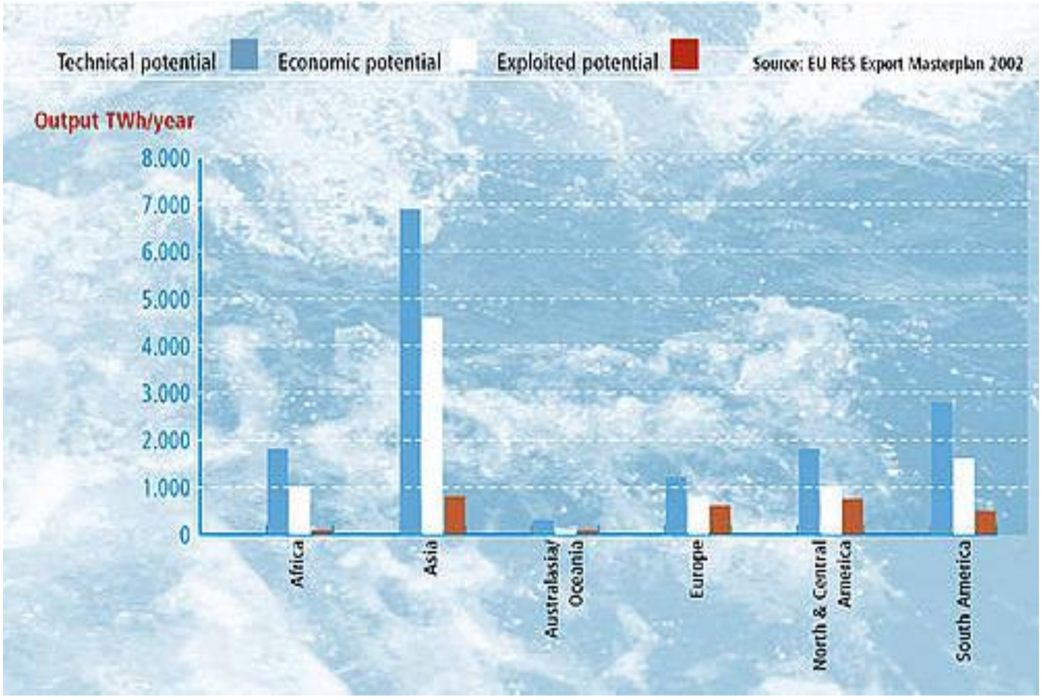
According to The Europan Small Hydro Power Association (2007) approximately 70% of the earth's surface is covered with water, a resource that has always been central to human development. The use of hydropower has been characterised by continuous technical development, and it is currently the second most used renewable energy source in the world, just behind solid biomass. Hydro supplies the vast majority of renewable electricity, generating 16.6% of world supply and 92% of total renewable energy electricity according to *IEA (2003).*

There is no international consensus on the definition of small hydropower (SHP). In China, it can refer to capacities of up to 25 MW, in India up to 15 MW and in Sweden small means up to 1.5 MW. However, a capacity of up to 10 MW in total is becoming the generally accepted norm by ESHA, the European Commission and UNIPEDE (International Union of Producers and Distributors of Electricity).

Asia, especially China, is set to become a leader in hydro-electric generation as it is shown in **Figure 10.** Present developments in Australia and New Zealand are focussing on small hydropower plants. Canada, a country with a long tradition in using hydropower, is developing small hydropower as a replacement for expensive diesel generation in remote off-grid communities. Markets such as South America, the former Soviet Union and Africa also possess great, untapped potential.

The World Energy Council (WEC) estimates that under current policies, installed capacity of small hydro will increase to 55 GW by 2010 with the largest increase coming from China. In the year 2000 the world-installed capacity of small hydropower was about 37 GW. All regions of the world are experiencing significant increases in small hydro capacity, with China again showing the greatest increase.

Figure 10: Total hydropower potential by continent



Source: The European Small Hydro Power Association. SHP in the world. 2011.

3.2 Small hydro power plants in the EU

It is important to mention that small hydro power plants (SHPP) are the most prosperous way for additional hydro power penetration in European electricity market, considering that most large-scale opportunities have either been already exploited or face serious contradictions by local societies as environmentally unacceptable. On the other hand, SHPP usually operate as‘‘run-of- river’’ systems, thus any dam or barrage used is quite small, not really disturbing the water flow rate. Although to date there is no internationally agreed definition of SHPP size, the official size in the local electricity generation market is equal to 10MW maximum.

According to Directive 2009, Renewable energy world (2009), by 2020, a fifth of all energy consumption in European Union (EU) member countries must come from renewable sources – hydro, wave, solar, wind, and biomass. This mandate, which EU leaders signed in March 2007, is part of a proposal designed to cut greenhouse gas emissions by 20% (compared with 1990 levels). This mandate translates to significant growth in development of new capacity and in upgrading of existing facilities throughout Europe for hydroelectric power.

Several new conventional hydroelectric projects entered commercial operation in the past few years. Examples of new projects include: Sonna in Norway (270 MW), Glendoe in the United Kingdom (100 MW), and Blanca in Slovenia (42.5 MW).

According to Renewable energy world (2009) Europe also is an established leader in research and development of new technologies – ocean, wave, and hydrokinetic. Thirty years ago, the United Kingdom had the most aggressive wave power research and development program in the world. This commitment to research and development, as well as to commercialization of new designs, continues today throughout Europe.

The emphasis in Western Europe is retrofitting hydro plants with modern equipment, usually upgrading the capacity of the plant. In Eastern Europe, the focus is rehabilitating aging plants that often were allowed to deteriorate during the era of the Soviet Union.

For small hydro (less than 10 MW), development opportunities are important. Provided the mandate by EU member countries is implemented on a timely basis, the European Small Hydropower Association (ESHA) estimates that installed small hydro capacity could reach 16,000 MW by 2020 – a more than 4,000-MW increase over current levels.

Pumped storage is another area of significant growth for the hydropower sector in Europe, especially in the central region of the continent. In addition to supplying additional electricity during times when demand for power is highest, pumped storage's ability to balance power production and regulate the transmission network, in light of increased use of intermittent renewables, particularly wind, is attractive.

As many as ten pumped-storage facilities are under construction, including 178-MW Avce in Slovenia, 540-MW Kopswerk 2 in Austria, 480-MW Limberg 2 in Austria, and 141-MW Nestil in Switzerland. Several more potential projects are being investigated.

Total of approximately 179,000 MW hydropower is installed in Europe. European countries with the largest amounts of hydro include France, Italy, Norway, and Spain. Maintaining and, in many cases, upgrading, this existing infrastructure continues to be an important focus throughout Europe.

Numerous utilities are committing significant resources to upgrade entire portfolios. For example, in France, national utility Electricite de France (EDF) is investing more than 2 billion euros (US$2,5 billion) as part of France's economic stimulus program, including spending on modernization of hydroelectric projects. Recently, EDF has issued several solicitations for hydropower equipment and other work for its many projects, including up to 50 turbine-generators over five years.

3.3 Small hydro power plants in B&H

Most locations in Europe appropriate for the installation of large hydro power stations have already been exploited. Furthermore, there is a significant local communities' opposition towards new large power stations; therefore, small hydro power stations remain one of the most attractive opportunities for further utilization of the available hydro potential. B&H and more precisely the country's mainland possesses a significant hydro-power potential which is up to now only partially exploited. In parallel, a large number of private investors have officially expressed their interest in constructing small hydro power stations throughout the country, encouraged by the significant B&H state subsidy opportunities for renewable energy applications. Nevertheless, up to now a relatively small number of projects have been realized, mainly due to decision-making problems, like the administrative bureaucracy, the absence of a rational national water resources management plan and the over-sizing of the proposed installations. Certainly, small hydro-power plants can be proved considerably profitable investments, contributing also remarkably to the national electricity balance and replacing heavy polluting lignite and imported oil if the above problems are suitably treated. In the context of the above mentioned issues, the present study reviews in detail the existing situation of small hydropower plants in B&H and investigates their future prospects as far as the energy, economic and environmental contribution are concerned.

Using the data provided up to now, it is quite clear that small hydroelectricity applications in B&H have a very good techno-economic performance and, hence, a promising future.
According to the available information most SHPP investments present high financial efficiency if the proposed installation is properly designed in order to collaborate effectively with the existing water potential. Despite this positive situation, a relatively small number (approx. 50) of projects have been realized up to now. This unexpected evolution can be attributed to several existing problems, like the administrative bureaucracy, the absence of a rational water resources management plan and the over-sizing of various installations encouraged by the existing subsidy scheme. Bosnia and Herzegovina is one of the few European countries where the use of hydropower potential as the most attractive renewable source of energy is less than 40%.

Hydropower potential of small hydro power plants in B&H, given that until now has not been fully explored, can be based only on previous estimations. In countries that have investigated the potential advantage of small and large streams, proportion of the potential of small streams was slightly over 10% of the technically usable potential. The estimated hydropower potential in Bosnia and Herzegovina, according to some sources, was about 2,100 GWh.

Due to the construction of roads, settlements and facilities in river valleys, the potential can only be used by small hydro power plants that require much less or almost no sinking of the surrounding area. **Table 5** shows a list of small hydro plants in operation until 2004.

Table 5: Small Hydro Power Plants in B&H till 2004

SHPP name	Location/River
Una Kostela	Bihać/Una
Krušnica	Bosanska Krupa/Krušnica
Bihać	Bihać/Una
Modrac	Lukavac/Spreča
Osanica	Goražde/ Osanica
Hrid	Sarajevo/Water supply system
Snježnica	Teočak/ Rastošnica
Bastašica	Drvar/Unac
Bogatići	Trnovo/Željeznica
Vlasenica	Vlasenica/Jadar
Mešići	Rogatica/Prača
Tišća	Vlasenica/Tišća
Štrpci	n/a.

Source: ADEG. Napredni decentralizirani sistemi proizvodnje energije u zemljama zapadnog Balkana. 2005

Based on the scheduled tender concessions for construction SHPP in Bosina and Herzegovina during the period 2004-2008 constructed SHPP are shown in **Table 6.**

Table 6: List od SHPP from 2004-2008

SHPP name	Location	Installed power (kW)	Electricity produced (June 2008) kWh	Produced (January-June 2008) kWh
Botun	Zenica	1,000.00	156,800.00	1,832.28
Majdan	Zenica	2,802.00	427,480.00	4,414.68
Jezernica	Zenica	1,376.00	288,880.00	2,001.08
Mujakovići	Zenica	805.00	404,080.00	3,166.24
Bila Voda	Zenica	50.00	23,884.00	139,831.00
Mošćani	Zenica	805.00	145,620.00	1,471.19
Prušac 1	Zenica	805.00	224,640.00	1,508.42
Pogledala	Zenica	500.00	169,000.00	1,367.26
Jelići (group of 3 SHP)	Zenica	2,992.00	630,096.00	5,481.54
Torlakovac	Zenica	452.00	92,958.00	428,704.00
Pršljanica 1	Zenica	200.00	84,749.00	84,749.00
Osanica 4	Zenica	630.00	4,841.00	113,805.00
Total		12,417.00	26,530.28	788,331.69

Source: ADEG. Napredni decentralizirani sistemi proizvodnje energije u zemljama zapadnog Balkana. 2005

The highest concentration of SHPP, of 202 contracts on concessions, are in the two cantons as it shown in **Table 7** and their status is "under construction".

Table 7: SHPP under construction

Number	Federation of Bosnia and Herzegovina Canton	Number of SHPP	Installed power (MW)
1	Srednjobosanski	69	46.89
2	Zeničko.dobojski	47	36.72
Total		116	83.61

Source: *Internal data from JP Elektroprivreda B&H*

4 FEASIBILITY STUDY OF BUILDING SMALL HYDROPOWER PLANT (SHPP)

In this chapter indicators that show whether or not it is worth investing in project are explained.

4.1 Model construction

SHP Raševik is the plant on the river Vrbas, which uses 5.5 m of gross decline. Concrete bulkheads-dam consists of overflow and non overflow part. Location of SHP Raševik is downstream of the town Jajce, i.e., accumulation begins immediately below the second downstream, under the bridge, over the river Vrbas in the town of Jajce. Line accumulation extends over a length of 1,562 meters. SHPP Raševik is the hydroenergetic plant on the river Vrbas with concrete barriers.

For this level of development of project solutions, the analysis was conducted for the range of installed water flows, variously: 15, 30, 46 and 60 m^3/s. For each analyzed variant of installations flow investment calculation was made. Comparison of alternative investments was done without a network connection. On the basis of investments and possible production for each size installations flow was calculated as the ratio of investment (pf BAM/kWh). **Table 8** provides an overview of the results.

Table 8: Investments for each size installations flow

Investment	**Unit**	**Installed flow (m^3/s)**			
		15	30	46	60
Total investment cost	BAM	7,318,321.00	7,983,994.00	8,621,241.00	10,436,354.00
Total investment cost	€	3,741,798.11	4,082,151.31	4,407,970.53	5,336,023.07
Possible production	MWh	5,993	7,224	10,256	11,487
Investment ratio	BAM/kWh	1.22	1.105	0.881	0.91

Source: Internal data from JP Elektroprivreda B&H

Table 9: Initial investment costs for chosen SHPP

	Cost type	Amount (in BAM)	Amount (in €)
Investment cost	Construction works	4,459,688.00	2,280,202.26
	Hydro-mechanical equipment (overflow)	961,553.00	491,634.24
	Electro-mechanical Equipment	3,200,000.00	1,636,134.02
	Total	**8,621,241.00**	**4,407,970.52**

Source: Internal data from JP Elektroprivreda B&H

Based on the size of the investment ratio given in **Table 8** it can be concluded that installed flow of 46 m^3/s represent optimal solution for the hydropower facility and as such is adopted for further design of the SHPP.

For the adopted size of installated flow of 46 m^3/s investment optimization was perfomed. Initial investment costs are shown in **Table 9.**

4.2 Decision criteria

According to Brigham and Daves (2010) capital budgeting is the decision process that managers use to identify those projects that add to the firm's value, and as such it is perhaps the most important task faced by financial managers and their staffs. First, a firm's capital budgeting decisions define its strategic direction because moves into new products, services, or markets must be preceded by capital expenditures. Second, the results of capital budgeting decisions continue for many years, reducing flexibility. Third, poor capital budgeting can have serious financial consequences. If the firm invests too much, it will waste investors' capital on excess capacity. On the other hand, if it does not invest enough, its equipment and computer software may not be sufficiently modern to enable it to produce competitively.

Also, if it has inadequate capacity, it may lose market share to rival firms, and regaining lost customers requires heavy selling expenses, price reductions, or product improvements, all of which are costly. A firm's growth, and even its ability to remain competitive and to survive, depends on a constant flow of ideas for new products, for ways to make existing products better, and for ways to operate at a lower cost. Consequently, a well-managed firm will go to great lengths to encourage good capital budgeting proposals from its employees. If a firm has capable and imaginative executives and employees, and if its incentive system is working properly, many ideas for capital investment will be advanced. Some ideas will be good ones, but others will not.

Six key methods are used to evaluate projects and to decide whether or not they should be accepted: (1) net present value (NPV), (2) internal rate of return (IRR), (3) modified internal rate of return (MIRR), (4) profitability index (PI), (5) payback, and (6) discounted payback.

4.2.1 Payback period and discounted payback period

The PB method of financial appraisal, used to evaluate capital projects, calculates the return per year from the start of the project until the accumulated returns are equal to the cost of the investment, at which time the investment is said to have been paid back. The time taken to achieve this payback is termed the payback period (PBP).

According to Lefley (1996) under the PB method the required payback period sets the hurdle rate (threshold barrier) for project acceptance. While there is a considerable amount of literature on the determination of the discount rate used in the Discounted Cash Flow methods, there is very little evidence to show how the hurdle rate, as used in the PB method, is arrived at. It appears that in many cases the determination of the required payback period is based on subjective assessments, taking into account past experience and the perceived level of project risk. The typical payback period expected by management appears to be in the region of two to four years, explained Lefley (1996). The PB method indicates how quickly the cost of an investment is recovered but does not measure its profitability.

Brigham and Daves (2010) explain that the payback period, defined as the expected number of years required to recover the original investment, was the first formal method used to evaluate capital budgeting projects. The basic idea is to start with the project's cost, determine the number of years prior to full recovery of the cost, and then determine the fraction of the next year that is required for full recovery, assuming cash flows occur evenly during the year:

$$\text{Payback} = \text{Number of years prior to full recovery} + \frac{\text{Unocovered cost at start of year}}{\text{Cash flow during full recovery year}}$$

The two most serious disadvantages of the PB method of financial appraisal are: (i) it does not take any regard of returns after the payback period and, (ii) it ignores the timing of the returns.

According to Brigham and Daves (2010) some firms use a variant of the regular payback, the discounted payback period, which is similar to the regular payback period except that the expected cash flows are discounted by the project's cost of capital. Thus, the discounted payback period is defined as the number of years required to recover the investment from discounted net cash flows.

Although the discounted payback period (DPP) method still ignores the returns after the payback period, and is therefore not a substitute for profitability measurement, it is an improved measure of liquidity and project time risk over the conventional PB method. The discounted payback approach corrects the first flaw of the regular payback method because it considers the time value of the cash flows. However, it too fails to consider cash flows occurring after the payback year, and, as with regular payback, there is no relationship between discounted payback and wealth maximization. According to Brigham and Daves (2010) the payback methods have serious faults as ranking criteria, but they do provide information on how long funds will be tied up in a project. Thus, as long as other things hold constant, the shorter the payback period, the greater the project's liquidity. Also, since cash flows expected in the distant future are generally riskier than near-term cash flows, the payback is often used as an indicator of a project's risk. Because of these reasons, other methods of capital budgeting like net present value, internal rate of return or discounted cash flow are generally preferred.

4.2.2 NPV and IRR

Santolin, Cavazzini, Pavesi, Ardizzon and Rossetti (2011) explain that the Net Present Value and the Internal Rate of Return are undoubtedly, among the indices available in literature for an economic appraisal of an investment, the most used in the field of the hydropower plants.

The Net Present Value (NPV) is an indicator of the value or magnitude of an investment and takes into account the initial cash outflow for the plant purchase and the annual revenues (the cash inflows) of the plant (R), discounted back to their present value.

The initial cash outflow, to simplify the analysis, is assumed to be equal to the investment cost (C). The cash inflows of the plant are mainly due to the selling of the energy production to the national electric grid. The selling price from a clean energy production, i.e., from renewable energy sources, is typically subsidized by state regulations and incentives according to the EU directives. For example, in Italy the Electric Service Manager (GSE) buys the green energy at an all-inclusive feed-in tariff within long-term (15 years) contracts.

According to Brigham and Daves (2010) the net present value (NPV) method is based upon the discounted cash flow (DCF) technique. To implement this approach, we proceed as follows:

1. Find the present value of each cash flow, including the initial cash flow, discounted at the project's cost of capital.
2. Sum these discounted cash flows; this sum is defined as the project's NPV.

$$NPV = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ ... + \frac{CF_n}{(1+r)^n} = \sum_{t=0}^{N} \frac{CF_t}{(1+r)^t} \quad (1)$$

Here (1) CF_t is the expected net cash flow at period t, r is the project's cost of capital, and n is its life. Cash outflows (expenditures such as the cost of buying equipment or building factories) are treated as negative cash flows, for several years before operations begin and cash flows turn positive.

Brigham and Daves (2010) explain that the rationale for the NPV method is straightforward. NPV of zero signifies that the project's cash flows are exactly sufficient to repay the invested capital and to provide the required rate of return on that capital. If a project has a positive NPV, then it is generating more cash than is needed to service the debt and to provide the required return to shareholders, and this excess cash accrues solely to the firm's stockholders.
The IRR is the project's expected return, defined as the discount rate that forces the NPV to equal zero (2):

$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+IRR)^t} = 0 \quad (2)$$

According to Brigham and Daves (2010) the NPV and IRR methods will mathematically always lead to the same accept/reject decisions for independent projects. This occurs because if NPV is positive, IRR must exceed r. However, NPV and IRR can give conflicting rankings for mutually exclusive projects.

The Retscreen model calculates the net present value (NPV) of the project, which is the value of all future cash flows, discounted at the discount rate, in today's prices. Under the NPV method, the present value of all cash inflows is compared against the present value of all cash outflows associated with an investment project. The difference between the present value of these cash flows, called the NPV, determines whether or not the project is generally a financially acceptable investment. Positive NPV values are an indicator of a potentially feasible project. In using the net present value method, it is necessary to choose a rate for discounting cash flows to present value. As a practical matter, organisations put much time and study into the choice of a discount rate. The model calculates the NPV using the cumulative after-tax cash flows.

4.2.3 WACC

According to Fernadez (2012) WACC is the cost of each capital component multiplied by its proportional weight and then summing (3):

$$WACC = \frac{E}{V} \cdot R_e + \frac{D}{V} \cdot R_d \cdot (1 - T_c) \quad (3)$$

Where:
Re = cost of equity
Rd = cost of debt
E = market value of the firm's equity
D = market value of the firm's debt
V = E + D
E/V = share of equity financing
D/V = share of debt financing
Tc = corporate tax rate

According to Pierrua and Babusiaux (2010, p.240) weighted average cost of capital (WACC) relies on the assumption that every year the interest cost immediately generates a proportionate tax shield. **Table 10** shows the shares of equity and debt financing of the project.

Table 10: Share of equity and debt financing

Element	Share in (%)	Amount (in €)
Project equity	20	881,594
Project debt	80	3,526,376
Total		**4,407,970**

Source: Internal data from JP Elektroprivreda B&H

WACC is calculated to estimate the value of investment projects for companies listed on the stock market and then using formula (4):

$$\boldsymbol{WACC = wd * KD + we * KE * (1-T)} \quad (4)$$

And $KE = Ro + Rf + B(Rm - Ro)$, where:

W_d-weight of debt,

KD-cost of debt,
We-weight of equity,
KE-cost of equity,
Ro-risk free paper,
R_f-the country risk premium.
B-beta risc factor,
R_m-required average market rate of return.
T –tax rate.

The cost of capital is based on the opportunity cost for investor in the sense that the required rate of return of risky projects is always greater than the required rate of return in a safer and risk-free projects and instruments. Ro in B&H is 4.12%, Rf according to the European Bank for B&H is 7%, Beta for Elektroprivreda B&H is 0.728 for the period up to 2009 year.

Beta is taken from the companies in the German market. Rm is the required return by investors, which should reflect the opportunity cost, which means that if the interest rate on deposits in some banks (ProCredit for example offers 6%), then the required return by investors must be greater because it is known that the savings in B&H is the safest in the investment banks, so the assumption is taken that the minimum required market return Rm is 7%.

So the **cost of capital** can be calculated as:

$$KE = 4.12\% + 7\% + 0.72(7\% - 4.12\%) = 13.22\ \%$$

The cost of debt is usually necessary to calculate based on the average interest rate at which the company borrows specifically for a period over one year, but since I do not have it I will take market interest rate on term loans and published by the Central Bank Bosnia and Herzegovina, for 2010 it was 10.92%. So we have a KD = 10.92% (1-Tc). Tc is the corporate tax rate, and $1 - Tc$ is a tax shield. Income taxe in B&H in both entities is 10%. Now it is easy to calculate the WACC in my example. Therefore, **cost of debt** equals to $KD = 9.83\ \%$.

Taking into account the capital structure where wd= 80% of debt and we = 20% equity, the nominal WACC can be calculated as follows:

WACC (nominal) = 13.22 * 20% + 10.92 * (1-0.1) * 80%= 10.50%.

Since feasibility study is performed for estimated cash flows in constant prices, nominal WACC is furthermore adjusted for inflation. The real WACC is obtained using the following formula:

WACC (real)=(1+WACC)/(1+i)-1.

where i denotes inflation rate of 4.00%. Hence:

WACC (real)=(1+10.5%)/(1+4.00%)-1=6.25%.

4.2.4 Debt and equity financing

Debt vs. equity financing is one of the most important decisions facing managers who need capital to fund their business operations. Debt and equity are the two main sources of capital available to businesses, and each offers both advantages and disadvantages.

Debt financing takes the form of loans that must be repaid over time, usually with interest. Businesses can borrow money over the short term (less than one year) or long term (more than one year). The main sources of debt financing are banks and government agencies. According to E notes (2011) debt financing offers businesses a tax advantage, because the interest paid on loans is generally deductible. Borrowing also limits the business's future obligation of repayment of the loan, because the lender does not receive an ownership share in the business.

Nevertheless, debt financing also has its disadvantages. New businesses sometimes find it difficult to make regular loan payments when they have irregular cash flow. In this way, debt financing can leave businesses vulnerable to economic downturns or interest rate hikes. Carrying too much debt is a problem because it increases the perceived risk associated with businesses, making them unattractive to investors and thus reducing their ability to raise additional capital in the future.

Equity financing takes the form of money obtained from investors in exchange for an ownership share in the business. The main advantage to equity financing is that the business is not obligated to repay the money. Instead, the investors hope to reclaim their investment out of future profits. The involvement of high-profile investors may also help increase the credibility of a new business.

The main disadvantage to equity financing is that the investors become part-owners of the business, and thus gain a say in business decisions. Managers face a possible loss of autonomy or control as ownership interests become diluted. In addition, an excessive reliance on equity financing may indicate that a business is not using its capital in the most productive manner.

Both debt and equity financing are significant ways for businesses to obtain capital to fund their operations. Deciding which to use or emphasize, depends on the long-term goals of the business and the amount of control managers wish to maintain. Ideally, experts suggest that businesses use both debt and equity financing in a commercially acceptable ratio. This ratio, known as the debt-to-equity ratio, is a key factor analysts use to determine whether managers are running a business in a sensible manner.

Some experts recommend that companies rely more heavily on equity financing during the early stages of their existence, because such businesses may find it difficult to service debt until they achieve reliable cash flow. But start-up companies may have trouble attracting venture capital until they demonstrate strong profit potential. In any case, all businesses require sufficient capital in order to succeed. The most prudent course of action is to obtain capital from a variety of sources, using both debt and equity, and hire professional accountants and attorneys to assist with financial decisions, according to E notes (2011).

4.3 Case study of building SHPP

In this chapter the analysed Case study of building SHPP is explained by using Ret screen software.

4.3.1 Ret screen study of the facility

The previous section presented a case for a viable and cost-effective installation in a particular economic scenario. Opportunities for implementing commercially viable, energy efficient and renewable energy technologies (RETs) are often missing these days, because many planners and decision-makers still do not routinely consider them as critically important at initial planning stage, even though technologies such as small hydropower installations have proven their reliability and cost-effectiveness in similar situations elsewhere. According to Alonso-Tristán (2011) specific procedures regarding design and economic viability studies of small hydropower plant projects have been developed, in order to address and integrate at a pre-feasibility, planning stage, perspectives that consider all the potential obstacles that can arise.

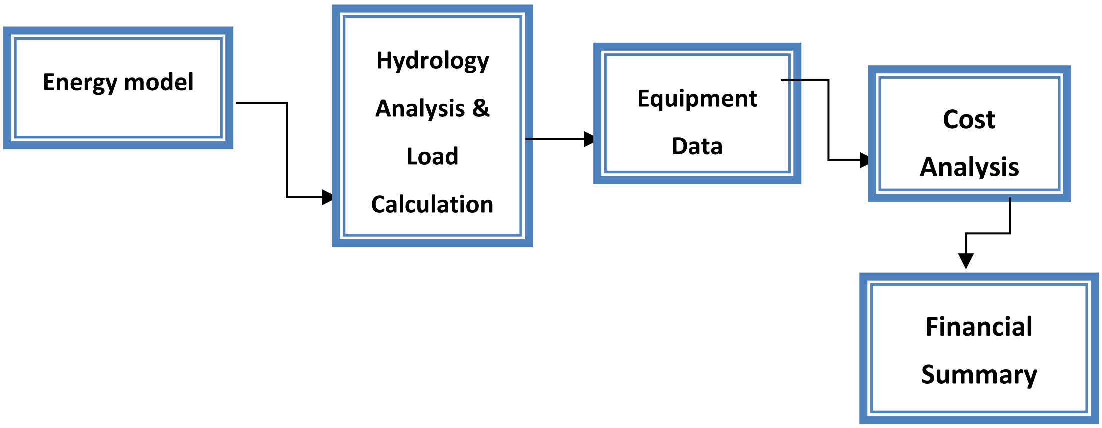
RETScreen software is capable of assessing RETs viability factors such as energy resources available at the project site, equipment performance, initial project costs, “base case” credits, on-going and periodic project costs, avoided cost of energy, financing, taxes on equipment and income (or savings), environmental characteristics of energy displaced, environmental credits and/or subsidies and decision-maker defined cost-effectiveness. Moreover, the RETScreen software integrates a series of databases that help to overcome the costs and difficulties associated with gathering meteorological data, product performance data, etc. Hence, worldwide meteorological data has been incorporated directly into the RETScreen software. This meteorological database includes both the ground-based meteorological data and NASA's satellite-derived meteorological data sets. The RETScreen's hydroelectric model can be used anywhere in the world, but the only available hydrological data is from Canada.

However, the user can introduce data from any other source. According to Houri (2006) in his work „Solar water heating in Lebanon: Current status and future prospects" the software has been widely used to study all types of renewable energies including: small hydropower, photovoltaic power, solar water heaters, wind and small wind projects, combined heat and power facilities, hybrid systems, among others. The application of this tool for the proposed case study will demonstrate its capacity to perform pre-feasibility studies anywhere in the world and will expand the study for application in other design options and financing as well as different economic scenarios. Seven worksheets are provided in the small hydro project workbook file:

- Energy model;
- Hydrology analysis and load calculation;
- Equipment data;
- Cost analysis;
- Greenhouse gas emission reduction analysis;
- Financial summary;
- Sensitivity and risk analysis.

Figure 11 presents a flow diagram of the computerized RET's assessment tool that is used in this work. Greenhouse gas emission reduction and sensitivity and risk analyses are optional.

Figure 11: RET SCREEN model flow diagram



Source: C. Alonso, et all. Small hydropower plants in Spain: A case study. 2011.

4.3.2 The energy model

The first step, referred to as the "energy model", requires the user to collect basic information concerning the site conditions as may be necessary: latitude and longitude, available head, or drop in elevation. These data are presented in **Table 11** in relation to this case study. Small hydro power plant „Rasevik" has gross head 5.50 m. Maximum tailwater effect is 5.00 m. Residual flow in order to meet the legally prescribed minimum discharge of water in the natural riverbed is 0.05 **m**^{3}/s. Firm flow is 9.95 **m**^{3}/s. Peak load is 2,021 kW. Energy demand is 10,559 MWh. Detailed calculation can be found in Appendix, **Table A 1.**

Table 11: Energy model

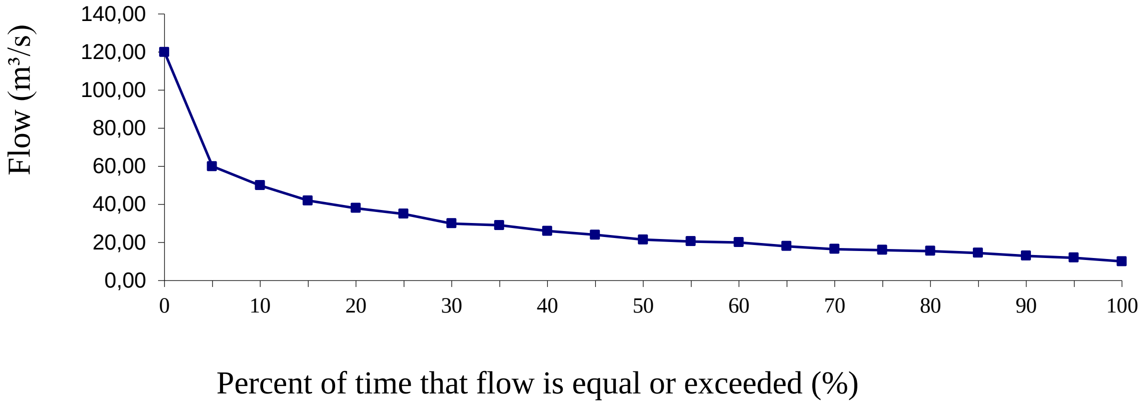
Site Conditions	Units	Estimate
Project name	Small hydro	
Project location	Rasevik	
Latitude of project location	˚N	13.83
Longitude of project location	˚E	-89.73
Gross head	m	5.50
Maximum tailwater effect	m	5.00
Resiudal flow	m^3/s	0.05
Firm flow	m^3/s	9.95
Peak load	kW	2,021.00
Electricity generated (max)	MWh	10,559.00

Source: Retscreen software

4.3.3 Hydrology analysis and load calculation

RETScreen calculates the estimated renewable energy delivered for SHPP projects, based on the adjusted available flow (adjusted flow–duration curve), the design flow, the residual flow, the load (load–duration curve), the gross head and the efficiencies/losses. The flow–duration curve of the River Vrbas in the facility site has been calculated from data compiled by the JP Elektroprivreda B&H, the results of which are presented in **Figure 12.** It also includes the design flow of the turbines and the biological indicators of the river flow.

Figure 12: Flow-Duration curve for the river Vrbas



Source: Retscreen software

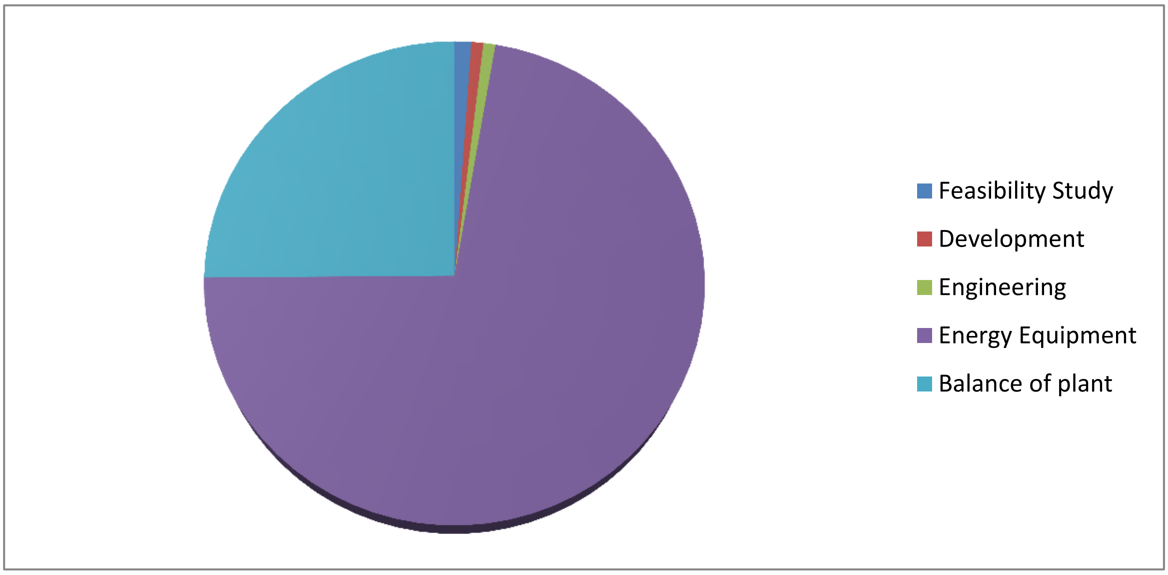
4.3.4 Equipment data

The data on small hydro turbine efficiency can be entered manually or can be calculated by RETScreen. Turbine performance is calculated at regular intervals on the flow–duration curve. Plant capacity is then calculated and the power–duration curve is established. Available energy is simply calculated by integrating the power–duration curve. In the case of a central-grid, the energy delivered is equal to the energy available. The calculation involves comparing the daily renewable hydro-energy available to the daily load–duration curve for each of the flow–duration curve values. Estimated (maximum) electricity generation in this case annualy is 10,559.00 MWh.

4.3.5 Cost analysis

As part of the RETScreen Clean Energy Project Analysis Software, the Cost Analysis worksheet is used to help the user estimate costs associated with a small hydro project. These costs are addressed from the initial, or investment, cost stand point and from the annual, or recurring, cost standpoint. Figure 13 presents the distribution of initial expenses. Operating costs are furthermore shown in Table 12, while detailed cost analysis from Retscreen software can be seen in Appendix, Table A 4.

Figure 13: Share of investment cost



Source: Retscreen software

Table 12: Operating cost

Annual Costs (Credits)	Unit	Quantity	Unit cost	Amount
O&M			in €	in €
Land lease	project	1.00	14,101.00	14,101
Property taxes	%	0.00	4,407,971	
Water rental	kW	1,917.00	/	
Insurance premium	%	0.40	4,407,971	17,632
Transmission line maintenance	%	5.00	/	
Spare parts	%	0.50	4,407,971	22,040
O&M labour	p-yr	2.00	35,000.00	70,000.00
GHG monitoring and verification	project	0.00	/	
Travel and accommodation	p-trip	6.00	1,000.00	6,000.00
General and administrative	%	10.00	129,772.00	12,977.00
Other O&M	Cost	0.00	/	
Constingeinces	%	10.00	142,750.00	14,275.00
Annual Cost-Total				**157,025.00**

Source: Retscreen sofware

4.3.6 Estimated revenues

The following **Table 13** shows the distribution of revenue per year. As already mentioned, constant prices are assumed in revenue calculation.

Table 13: Estimated revenues

Periods	Annual production (kWh)	Price of electricity energy (€/kWh)	Annual revenue (€)
1	7,736,259.53	0.0780	603,428.24
2	7,736,259.53	0.0780	603,428.24
3	7,736,259.53	0.0780	603,428.24
4	7,736,259.53	0.0780	603,428.24
5	7,736,259.53	0.0780	603,428.24
6	7,736,259.53	0.0780	603,428.24
7	7,736,259.53	0.0780	603,428.24
8	7,736,259.53	0.0780	603,428.24
9	7,736,259.53	0.0780	603,428.24

(Table continues)

(Continued)

10	7,736,259.53	0.0780	603,428.24
11	7,736,259.53	0.0780	603,428.24
12	7,736,259.53	0.0780	603,428.24
13	7,736,259.53	0.0780	603,428.24
14	7,736,259.53	0.0780	603,428.24
15	7,736,259.53	0.0780	603,428.24
16	7,736,259.53	0.0780	603,428.24
17	7,736,259.53	0.0780	603,428.24
18	7,736,259.53	0.0780	603,428.24
19	7,736,259.53	0.0780	603,428.24
20	7,736,259.53	0.0780	603,428.24

4.3.7 Financial summary

Financial Summary worksheet is provided for each project evaluated. This common financial analysis worksheet contains five sections: Annual Energy Balance, Financial Parameters, Project Costs and Savings, Financial Feasibility and Yearly Cash Flows. The Annual Energy Balance and the Project Costs and Savings sections provide a summary of the *Energy Model, Cost Analysis* and *GHG Analysis* worksheets associated with each project studied. In addition to this summary information, the Financial Feasibility section provides financial indicators of the project analysed, based on the data entered by the user in the Financial Parameters section. The Yearly Cash Flows section allows the user to visualise the stream of pre-tax, after-tax and cumulative cash flows over the project life.

One of the primary benefits of using the RETScreen software is that it facilitates the project evaluation process for decision-makers. The *Financial Summary* worksheet, with its financial parameters input items (e.g. avoided cost of energy, discount rate, debt ratio, etc.), and its calculated financial feasibility output items (e.g. IRR, simple payback, etc.), allows the project decision-maker to consider various financial parameters with relative ease.

A number of different economic and financial feasibility indices were calculated such as the year-to-positive cash flow, In ternal Rate of Return (IRR), return on investment (ROI), and Net Present Value (NPV). The results are presented in Figure 15 in ehich the calculated

RETscreen accumulated cashflow results over 20 years. Detailed financial analysis from Retscreen software can be seen in Appendix **Table A 5.,** and manual calculation of NPV in **Table 20. Table 14** summarises these results.

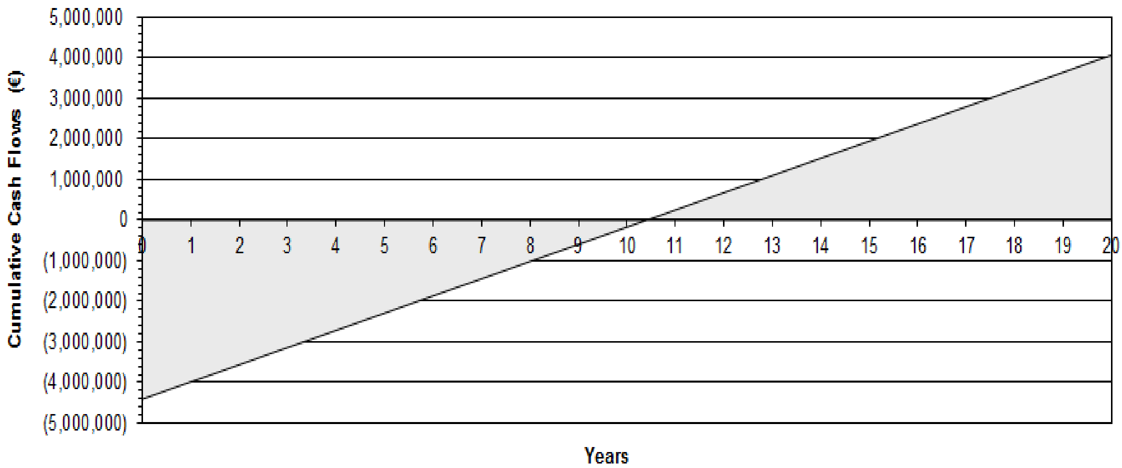
Table 14: Financial Feasibility

Decision criteria	Units	Value
IRR	%	7.24
PB	yr	10.8
NPV	Thousands €	**355,877.98**
Benefit-Cost (B-C) ratio	⁄	1.40

Source: Retscreen software

The RET screen calculations result in 7.24% after-tax IRR assets and a payback over 10.8 years, NPV amounts to € 355,877.98. Project is acceptable because the NPV is greater than zero, IRR is greater than the real WACC (6.25%), and the payback period and discounted payback period is considerably shorter than the expected life of the generating plant.

Figure 14: Cumulative cash flows



Source: Ret screen sofware

4.3.8 Sensitivity analysis

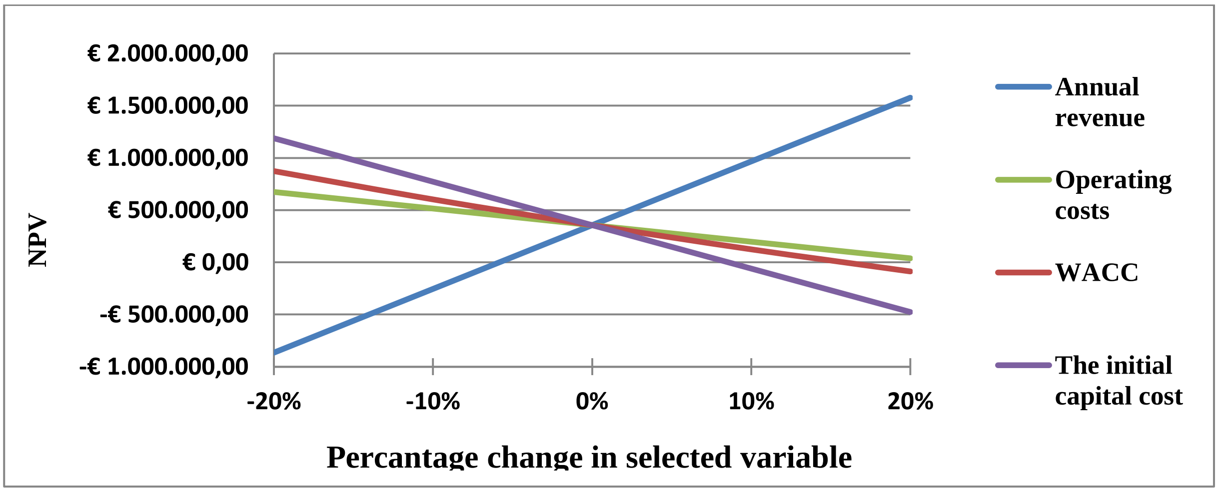
As part of the RETScreen Clean Energy Project Analysis Software, a Sensitivity Analysis worksheet is provided to help the user estimate the sensitivity of important financial indicators in relation to key technical and financial parameters.

Selection can be made from three options in the drop-down list with respect to the financial indicator to be used for both the sensitivity and risk analyses. Modifying the selection in this cell will change the results in the worksheet.

Entries of the sensitivity range in (%) define the maximum percentage variation that will be applied to all the key parameters in the sensitivity analysis results tables. Each parameter is varied by the following fraction of the sensitivity range : -1, -1/2, 0, 1/2, 1. In this paper is chosen 20% sensitivity range. The sensitivity range entered by the user must be a percentage value between 0 and 50%.

Sensitivity analysis is a tool aimed at monitoring the changing NPV taking into account the change of one variable, while everything else is presumed ceteris paribus (Brigham and Daves, 2010). **Figure 15** shows how the NPV is affected by changes in the following variables: investment cost, annual operating cost, annual revenue and WACC. It can be established that NPV increases when revenues are increased, while increase in investment cost, operating cost or WACC are associated with a decrease in NPV. It can also be observed that estimated NPV is the most sensitive to changes in revenues and investment cost and somewhat less sensitive to changes in WACC and operating cost.

Figure 15: Sensitivity analysis of NPV



CONCLUSION

Bosnia and Herzegovina is in the center of Balkan and at the crossroads between some European countries and its place in connecting some of the energy infrastructure (electric and gas) may be significant. The activities in that direction and association to the regional market should help development of energy sector in Bosnia and Herzegovina.

B&H possesses a significant hydro-power potential which has been up to now only partially exploited. In parallel, a large number of private investors have officially expressed their interest in constructing small hydro power stations throughout the country, encouraged by the significant B&H State subsidy opportunities for renewable energy applications. However, up to now a relatively small number of projects have been realized, mainly due to decision-making problems, like the administrative bureaucracy, the absence of a rational national water resources management plan and the over-sizing of the proposed installations. Certainly, if the above problems are suitably treated, small hydro-power plants can be proved considerably profitable investments, contributing also remarkably to the national electricity balance and replacing heavy polluting lignite and imported oil. In the context of the above mentioned issues, the present study reviews in detail the existing situation of small hydropower plants in B&H and investigates their future prospects as far as the energy, economic and environmental contribution are concerned.

The legislative and legal framework to introduce the RES into existing electric energy network in Bosnia and Herzegovina is enacted through the Energy Law (2002) and establishment of the State Energy Regulatory Commission (2002). The further work with respect to RES penetration is required because the questions of tariff, subsidizing, taxing, etc. is not yet fully solved.

There is no financing of RES installations in B&H through the state's authority. In B&H, the Ministry of Energy would be the start force to promote RES installations. We hope that through the EU's different programs B&H can start with RES penetration into own energy network. In this way we should make hard job, taking into consideration the standards and rules, information support and promotion of RES, financial incentives for private investments in RES, investment in RES from public sector and funds, etc.

All actions regarding RES should be set up in accordance with EU and national laws and the constitution of Bosnia and Herzegovina. The results of the several researches that have been conducted with the aim to decrease pollution in area of B&H and to promote the RES penetration into B&H energy network show and promise good business for investors.

The licensing procedures for RES installations in B&H go through the Ministry of Energy, Industry and Mines of B&H Federation, then through the local community, which gives the permission for installing RES in its territory (building and communally permissions). In the future, the requested license will be the subject of the Regulatory Energy Commission on the base of collected permission for building RES power plant.

There are number of reasons to make the legal framework for RES in the B&H. These reasons can be numbered as follows: reduction of pollutants from thermal power plants, introduction of the new and clear technologies, enlargement the number of work-places, change in the structure of the existing work-places, improvement the quality and reliability of energy supply at the rural and isolated regions, decentralization of the energy demands, stimulation of the local economy.

In general, there are no barriers to the development of RES in B&H. But, due to the past war, B&H is late for the many subjects; one of them is RES penetration into energy networks. We think that firstly must be designed the appropriate legislative framework based on the best EU practice. That means the B&H government should subsidize the start of RES projects (through the taxes), and to apply the feed-in-tariff and green certificates to improve and accelerate RES penetration into the current energy system. However, the Regulatory Energy Commission should devise the framework for future investors into RES installations, so as to make the RES penetration process transparent and efficient. The overall RES installations should be publically acceptable. At same time, one should enhance the public awareness of importance of RES for community. It can be done only with the continually and practical systems of information and education.

A cost model of small hydroelectric power plant construction and operation is developed. The model shows that it is profitable to invest in certain SHPP. Location SHP Raševik is downstream of the town Jajce, ie accumulation begins immediately below the second downstream, under the bridge, over the river Vrbas in the town of Jajce. Line accumulation extends over a length of 1562 meters. A number of different economic and financial feasibility indices are calculated such as the year-to-positive cash flow, Internal Rate of Return (IRR) and Net Present Value (NPV). Based on real WACC of 6.25% and calculated RETscreen accumulated cashflows over 20 years IRR of 7.24% after-tax is obtained, NPV amounts to € 355,877.98 and payback period is estimated to be 10.8 years. All the above estimated indicators therefore confirm that investment in SHPP is justified.

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APPENDIXES

TABLE OF APPENDIX

Table A 1: RETScreen Energy Model

RETScreen® Energy Model - Small Hydro Project — Training & Support

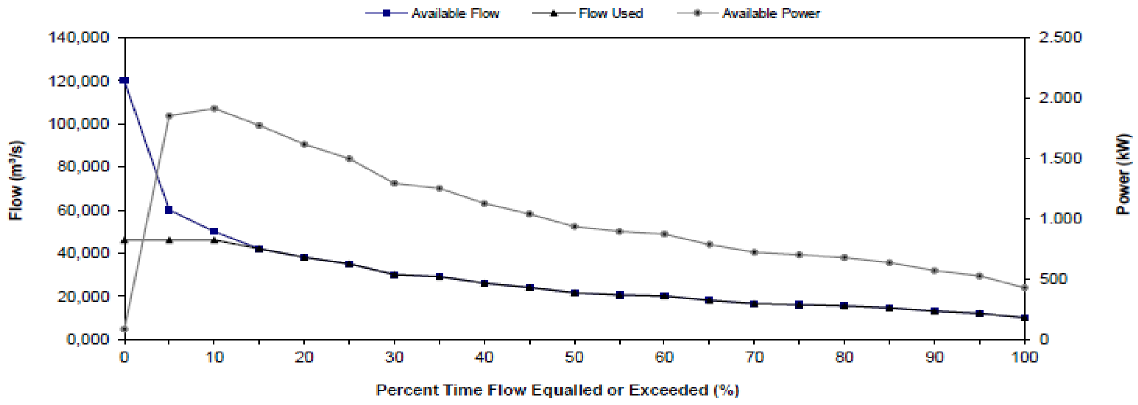
Units: Metric

Site Conditions		Estimate	Notes/Range
Project name		**Small Hydro**	See Online Manual
Project location		**Rasevik**	
Latitude of project location	°N	13,83	-90.00 to 90.00
Longitude of project location	°E	-89,73	-180.00 to 180.00
Gross head	m	5,50	
Maximum tailwater effect	m	5,00	
Residual flow	m³/s	0,05	Complete Hydrology & Load sheet
Firm flow	m³/s	9,95	
Peak load	kW	**2.021**	
Energy demand	MWh	**10.559**	

System Characteristics		Estimate	Notes/Range
Grid type	-	Isolated-grid	
Design flow	m³/s	46,000	
Turbine type	-	Kaplan	Complete Equipment Data sheet
Number of turbines	turbine	2	
Turbine peak efficiency	%	88,6%	
Turbine efficiency at design flow	%	88,2%	
Maximum hydraulic losses	%	5%	2% to 7%
Generator efficiency	%	95%	93% to 97%
Transformer losses	%	1%	1% to 2%
Parasitic electricity losses	%	2%	1% to 3%
Annual downtime losses	%	4%	2% to 7%

Annual Energy Production		Estimate	Notes/Range
Small hydro plant capacity	kW	1.917	
	MW	1,917	
Small hydro plant firm capacity	kW	**426**	
Available flow adjustment factor	-	1,00	
Small hydro plant capacity factor	%	52%	40% to 95%
Renewable energy available	MWh	8.805	
Renewable energy delivered	MWh	**7.416**	
	GJ	26.697	
Excess RE available	MWh	**1.389**	

Flow-Duration and Power Curves



Complete Cost Analysis sheet

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Source: Retscreen software

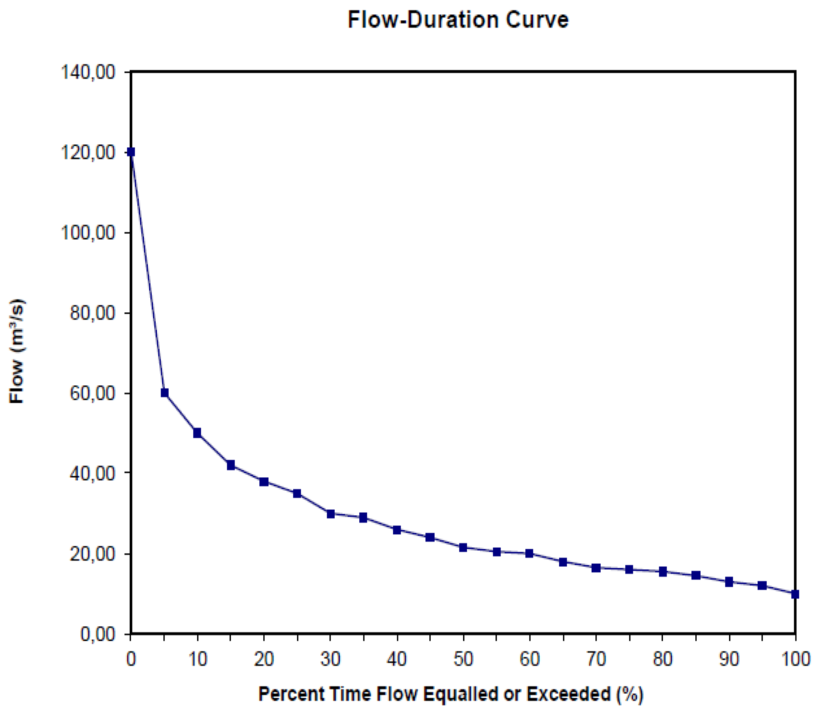
Table A 2: Retscreen Hydrology Analysis and Load Calculation

RETScreen® Hydrology Analysis and Load Calculation - Small Hydro Project

Hydrology Analysis		Estimate	Notes/Range
Project type		Run-of-river	
Hydrology method		User-defined	
Hydrology Parameters			
Residual flow	m³/s	0,05	
Percent time firm flow available	%	100%	90% to 100%
Firm flow	m³/s	9,95	

Flow-Duration Curve Data

Time (%)	Flow (m³/s)
0%	120,00
5%	60,00
10%	50,00
15%	42,00
20%	38,00
25%	35,00
30%	30,00
35%	29,00
40%	26,00
45%	24,00
50%	21,50
55%	20,50
60%	20,00
65%	18,00
70%	16,50
75%	16,00
80%	15,50
85%	14,50
90%	13,00
95%	12,00
100%	10,00



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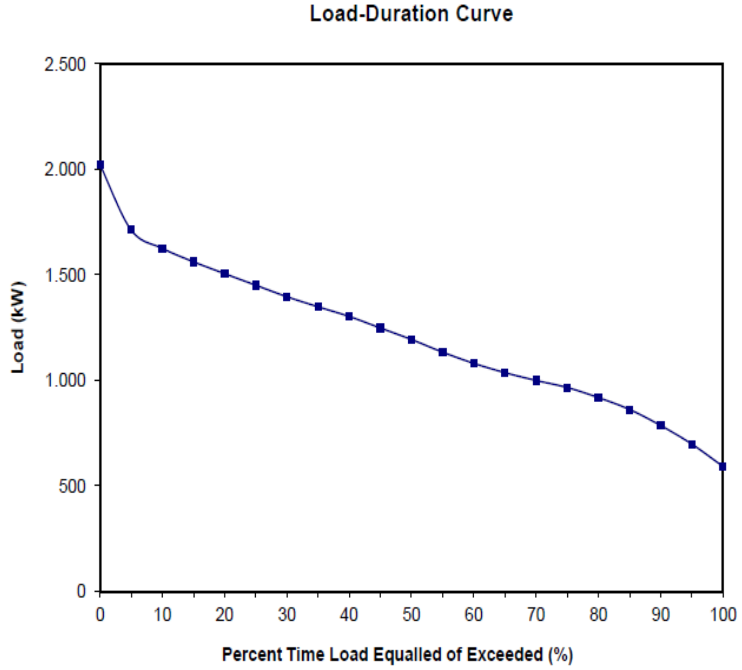
Load Characteristics		Estimate	Notes/Range
Grid type		Isolated-grid	
Load Conditions			
Load-duration curve		Typical	
Peak load	kW	2.021	

Load-Duration Curve Data

Time (%)	Load (kW)
0%	2.021
5%	1.712
10%	1.624
15%	1.561
20%	1.504
25%	1.450
30%	1.395
35%	1.347
40%	1.301
45%	1.247
50%	1.192
55%	1.132
60%	1.079
65%	1.035
70%	998
75%	965
80%	917
85%	861
90%	785
95%	697
100%	591



		Annual	Daily
Energy demand	MWh	10.559	28,9
Average load factor	%	60%	60%

Return to
Energy Model sheet

Source: Retscreen software

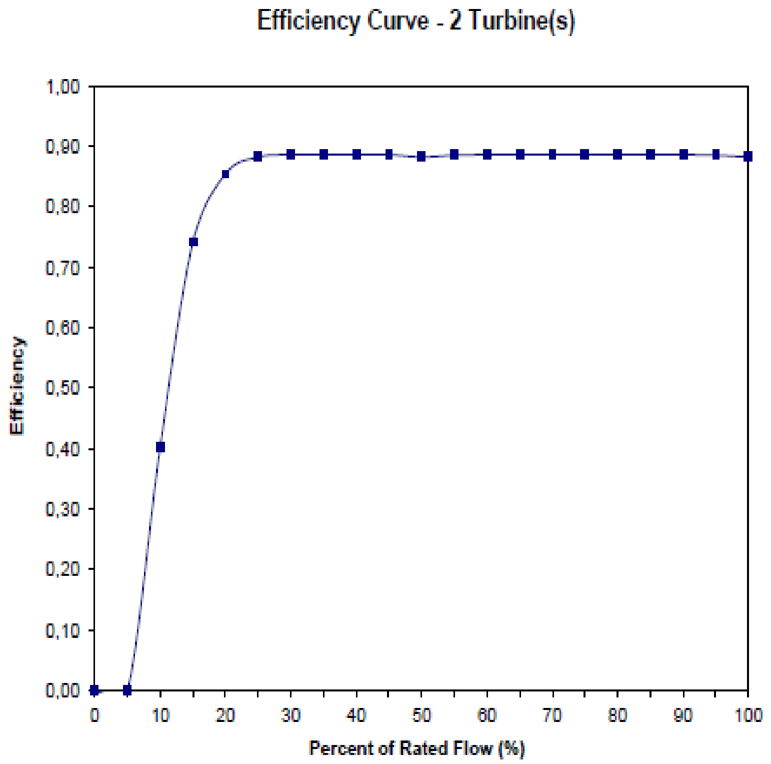
Table A 3: Retscreen Equipment data

RETScreen® Equipment Data - Small Hydro Project

Small Hydro Turbine Characteristics		Estimate	Notes/Range
Gross head	m	5,50	
Design flow	m³/s	46,000	
Turbine type	-	Kaplan	See Product Database
Turbine efficiency curve data source	-	Standard	
Number of turbines	turbine	2	
Small hydro turbine manufacturer		ABC Ltd.	
Small hydro turbine model		model XYZ	
Turbine manufacture/design coefficient	-	4,5	2.8 to 6.1; Default = 4.5
Efficiency adjustment	%	0%	-5% to 5%
Turbine peak efficiency	%	88,6%	
Flow at peak efficiency	m³/s	34,5	
Turbine efficiency at design flow	%	88,2%	

Turbine Efficiency Curve Data

Flow (%)	Turbine efficiency	Turbines running #	Combined turbine efficiency
0%	0,00	0	0,00
5%	0,00	1	0,00
10%	0,00	1	0,40
15%	0,07	1	0,74
20%	0,40	1	0,85
25%	0,61	1	0,88
30%	0,74	1	0,89
35%	0,81	1	0,89
40%	0,85	1	0,89
45%	0,87	1	0,89
50%	0,88	1	0,88
55%	0,89	2	0,89
60%	0,89	2	0,89
65%	0,89	2	0,89
70%	0,89	2	0,89
75%	0,89	2	0,89
80%	0,89	2	0,89
85%	0,89	2	0,89
90%	0,89	2	0,89
95%	0,89	2	0,89
100%	0,88	2	0,88



Return to
Energy Model sheet

Source: Retscreen software

Table A 4: Cost Analysis

RETScreen® Cost Analysis - Small Hydro Project

Search Marketplace

Costing method: Detailed | Currency: Euro symbol | Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Site investigation	p-d	1.0	€ 10,000	€ 10,000	0.2%	-	-
Hydrologic assessment	p-d	1.0	€ 10,000	€ 10,000	0.2%	-	-
Environmental assessment	p-d	1.0	€ 7,000	€ 7,000	0.2%	-	-
Preliminary design	p-d	1.0	€ 8,000	€ 8,000	0.2%	-	-
Detailed cost estimate	p-d	1.0	€ 3,000	€ 3,000	0.1%	-	-
GHG baseline study and MP	project	0	€ -	€ -	0.0%	-	-
Report preparation	p-d	1.0	€ 1,000	€ 1,000	0.0%	-	-
Project management	p-d	1.0	€ 5,000	€ 5,000	0.1%	-	-
Travel and accommodation	p-trip	10	€ 2,000	€ 20,000	0.5%	-	-
Other - Feasibility study	Cost	0	€ -	€ -	0.0%	-	-
Credit - Feasibility study	Credit	0	€ -	€ -	0.0%	-	-
Sub-total:				€ 64,000	1.5%		
Development							
PPA negotiation	p-d	1.0	€ 2,000	€ 2,000	0.0%	-	-
Permits and approvals	p-d	1.0	€ 3,000	€ 3,000	0.1%	-	-
Land rights	site	1	€ 2,000	€ 2,000	0.0%	-	-
Land survey	p-d	1.0	€ 2,000	€ 2,000	0.0%	-	-
GHG validation and registration	project	0	€ -	€ -	0.0%	-	-
Project financing	p-d	1.0	€ 25,000	€ 25,000	0.6%	-	-
Legal and accounting	p-d	1.0	€ 6,000	€ 6,000	0.1%	-	-
Project management	p-yr	1.00	€ 6,000	€ 6,000	0.1%	-	-
Travel and accommodation	p-trip	1	€ 2,000	€ 2,000	0.0%	-	-
Other - Development	Cost	0	€ -	€ -	0.0%	-	-
Credit - Development	Credit	0	€ -	€ -	0.0%	-	-
Sub-total:				€ 48,000	1.1%		
Engineering							
Design and tender documents	p-yr	1.00	€ -	€ -	0.0%	-	-
Contracting	p-d	1.0	€ -	€ -	0.0%	-	-
Construction supervision	p-yr	1.00	€ -	€ -	0.0%	-	-
Other - Engineering	Cost	1	€ 50,000	€ 50,000	1.1%	-	-
Credit - Engineering	Credit	0	€ -	€ -	0.0%	-	-
Sub-total:				€ 50,000	1.1%		
Energy Equipment							
Turbines/generators, controls	kW	1,917	€ -	€ -	0.0%	-	-
Equipment installation	%	0%	€ -	€ -	0.0%	-	-
Transportation	%	0%	€ -	€ -	0.0%	-	-
Other - Energy equipment	Cost	1	€ 3,243,971	€ 3,243,971	73.8%	-	-
Credit - Energy equipment	Credit	0	€ -	€ -	0.0%	-	-
Sub-total:				€ 3,243,971	73.8%		
Balance of Plant							
Access road	km	0.0	€ -	€ -	0.0%	-	-
Clearing	ha	0.0	€ -	€ -	0.0%	-	-
Earth excavation	m³	0.0	€ -	€ -	0.0%	-	-
Rock excavation	m³	0.0	€ -	€ -	0.0%	-	-
Concrete dam	m³	0	€ -	€ -	0.0%	-	-
Timber crib dam	m³	0	€ -	€ -	0.0%	-	-
Earthfill dam	m³	0	€ -	€ -	0.0%	-	-
Dewatering	%	0%	€ -	€ -	0.0%	-	-
Spillway	m³	0	€ -	€ -	0.0%	-	-

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	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Canal	m³	0	€ -	€ -	0.0%	-	-
Intake	m³	0	€ -	€ -	0.0%	-	-
Tunnel	m³	0	€ -	€ -	0.0%	-	-
Pipeline/penstock	kg	0	€ -	€ -	0.0%	-	-
Powerhouse civil	m³	0	€ -	€ -	0.0%	-	-
Fishway	m lift	0.0	€ -	€ -	0.0%	-	-
Transmission line	km	0.0	€ -	€ -	0.0%	-	-
Substation	project	0.0	€ -	€ -	0.0%	-	-
Transportation	%	0%	€ -	€ -	0.0%	-	-
Other - Balance of plant	Cost	1	€ 1,000,000	€ 1,000,000	22.7%	-	-
Credit - Balance of plant	Credit	0	€ -	€ -	0.0%	-	-
Sub-total:				€ 1,000,000	22.7%		
Miscellaneous							
Special equipment	project	0	€ -	€ -	0.0%	-	-
Contractor's overhead	%	0%	€ 1,000,000	€ -	0.0%	-	-
Training	p-d	0.0	€ 10,000	€ -	0.0%	-	-
Contingencies	%	0%	€ 4,405,971	€ -	0.0%	-	-
Interest during construction	10.0%	0 month(s)	€ 4,405,971	€ -	0.0%	-	-
Other - Miscellaneous	Cost	1	€ 2,000	€ 2,000	0.0%	-	-
Sub-total:				€ 2,000	0.0%		
Initial Costs - Total				€ 4,407,971	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Land lease	project	1	€ 14,101	€ 14,101		-	-
Property taxes	%	0.0%	€ 4,407,971	€ -		-	-
Water rental	kW	1,917	€ -	€ -		-	-
Insurance premium	%	0.40%	€ 4,407,971	€ 17,632		-	-
Transmission line maintenance	%	5.0%	€ -	€ -		-	-
Spare parts	%	0.50%	€ 4,407,971	€ 22,040		-	-
O&M labour	p-yr	2.00	€ 35,000	€ 70,000		-	-
GHG monitoring and verification	project	0	0.00	€ -		-	-
Travel and accommodation	p-trip	6	€ 1,000	€ 6,000		-	-
General and administrative	%	10%	€ 129,773	€ 12,977		-	-
Other - O&M	Cost	0		€ -		-	-
Contingencies	%	10%	€ 142,750	€ 14,275		-	-
Annual Costs - Total				€ 157,025	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Turbine overhaul	Cost	20 yr	€ 30,000	€ 30,000	-	-
				€ -	-	-
				€ -	-	-
End of project life	Credit	-	€ -	€ -		Go to GHG Analysis sheet

Source: Retscreen sofware

Table A 5: Financial Summary

RETScreen® Financial Summary - Small Hydro Project

Annual Energy Balance

Project name		Small Hydro	Peak load	kW	2,021
Project location		Rasevik	Energy demand	MWh	10,559
Renewable energy delivered	MWh	7,416			
Excess RE available	MWh	1,389			
Firm RE capacity	kW	426			
Grid type		Isolated-grid			

Financial Parameters

Avoided cost of energy	€/kWh	0.0780	Debt ratio	%	80.0%
RE production credit	€/kWh	-	Debt interest rate	%	4.0%
			Debt term	yr	10
			Income tax analysis?	yes/no	No
Avoided cost of excess energy	€/kWh	-			
Avoided cost of capacity	€/kW-yr	-			
Energy cost escalation rate	%	5.0%			
Inflation	%	2.5%			
Discount rate	%	6.3%			
Project life	yr	20			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	1.5%	€	64,000	O&M	€	157,025
Development	1.1%	€	48,000			
Engineering	1.1%	€	50,000	Debt payments - 10 yrs	€	434,770
Energy equipment	73.6%	€	3,243,971	**Annual Costs and Debt - Total**	€	**591,795**
Balance of plant	22.7%	€	1,000,000			
Miscellaneous	0.0%	€	2,000	**Annual Savings or Income**		
Initial Costs - Total	100.0%	€	**4,407,971**	Energy savings/income	€	603,428
				Capacity savings/income	€	-
Incentives/Grants		€	-			
				Annual Savings - Total	€	**603,428**
Periodic Costs (Credits)						
Turbine overhaul		€	30,000	Schedule yr # 20		
		€	-			
		€	-			
End of project life - Credit		€	-			

Financial Feasibility

			Calculate energy production cost?	yes/no	No
Pre-tax IRR and ROI	%	7.9%			
After-tax IRR and ROI	%	7.2%			
Simple Payback	yr	9.9			
Year-to-positive cash flow	yr	10.8	Project equity	€	881,594
Net Present Value - NPV	€	355,878	Project debt	€	3,526,376
Annual Life Cycle Savings	€	31,660	Debt payments	€/yr	434,770
Benefit-Cost (B-C) ratio	-	1.40	Debt service coverage	-	1.09

Yearly Cash Flows

Year #	Pre-tax €	After-tax €	Cumulative €
0	(4,407,971)	(4,407,971)	(4,407,971)
1	446,403	423,803	(3,984,168)
2	446,403	423,803	(3,560,365)
3	446,403	423,803	(3,136,562)
4	446,403	423,803	(2,712,759)
5	446,403	423,803	(2,288,957)
6	446,403	423,803	(1,865,154)
7	446,403	423,803	(1,441,351)
8	446,403	423,803	(1,017,548)
9	446,403	423,803	(593,746)
10	446,403	423,803	(169,943)
11	446,403	423,803	253,860
12	446,403	423,803	677,663
13	446,403	423,803	1,101,466
14	446,403	423,803	1,525,268
15	446,403	423,803	1,949,071
16	446,403	423,803	2,372,874
17	446,403	423,803	2,796,677
18	446,403	423,803	3,220,479
19	446,403	423,803	3,644,282
20	446,403	423,803	4,068,085

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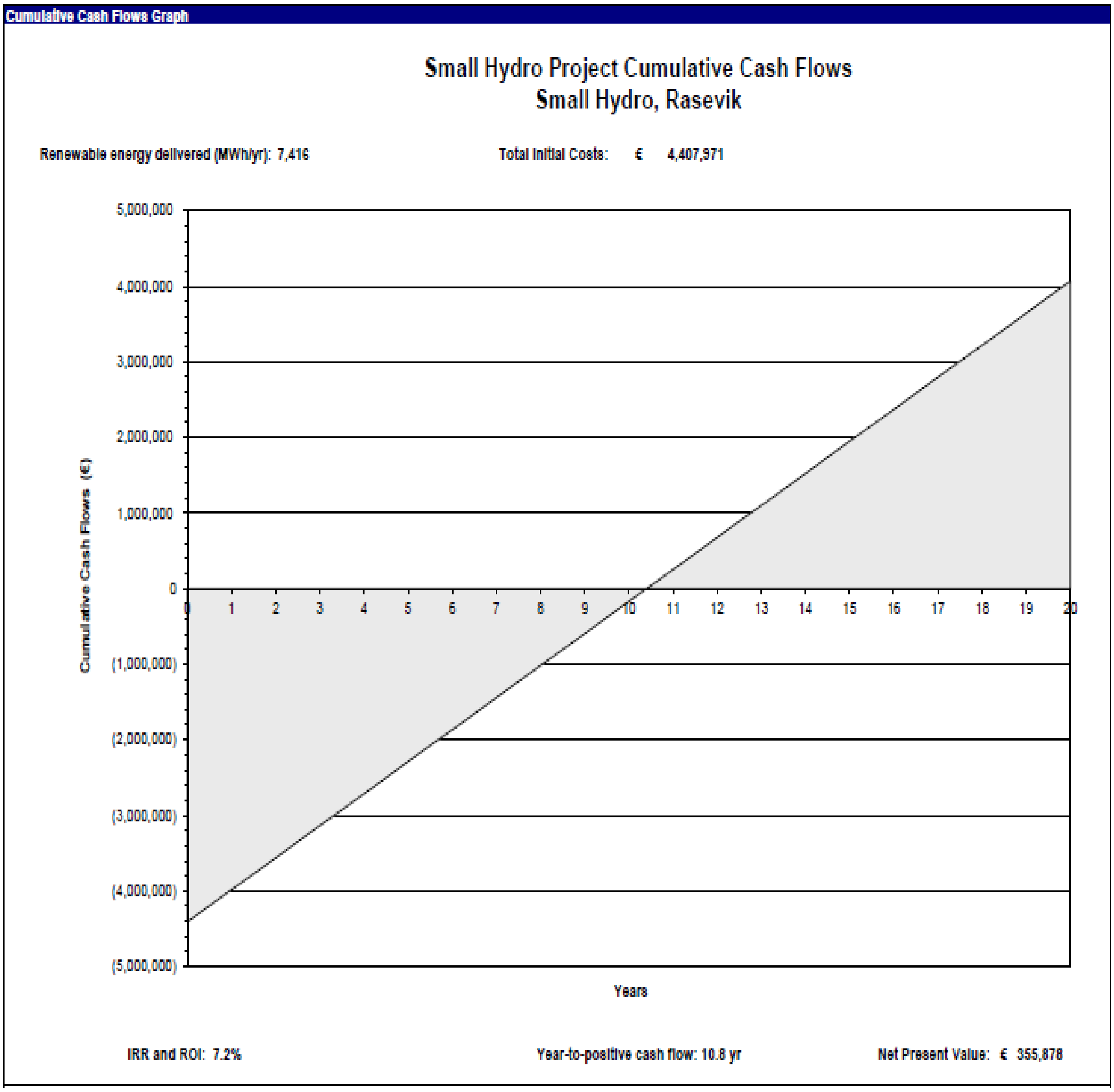
RETScreen® Financial Summary - Small Hydro Project



Source: Retscreen software

Table A 6: Calculation of EBIT

Periods	Annual revenue (€)	Operating costs (€)	Depreciation (€)	EBIT (€)	Tax on profit (10%)	EBIT after tax (€)
1	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
2	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
3	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
4	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
5	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
6	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
7	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
8	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
9	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
10	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
11	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
12	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
13	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
14	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
15	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
16	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
17	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
18	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
19	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
20	603,428.24	157,025.00	220,398.53	226,004.72	22,600.47	203,404.25
	12,068,564.87	**3,140,500.00**	**4,407,970.53**	**4,520,094.34**	**452,009.43**	**4,068,084.90**

Table A 7: Manual NPVcalculation

Periods	NCF (€)	Discounted NCF (€)	Cumulative NCF (€)	Cumulative discounted NCF (€)
0	-4,407,970.53	-4,407,970.53		-4,407,970.53
1	423,802.77	398,873.20	-3,984,167.76	-4,009,097.33
2	423,802.77	375,410.07	-3,560,364.99	-3,633,687.27
3	423,802.77	353,327.12	-3,136,562.22	-3,280,360.14
4	423,802.77	332,543.17	-2,712,759.44	-2,947,816.97
5	423,802.77	312,981.81	-2,288,956.67	-2,634,835.16
6	423,802.77	294,571.12	-1,865,153.90	-2,340,264.04
7	423,802.77	277,243.40	-1,441,351.13	-2,063,020.64
8	423,802.77	260,934.97	-1,017,548.36	-1,802,085.67
9	423,802.77	245,585.85	-593,745.59	-1,556,499.82
10	423,802.77	231,139.63	-169,942.81	-1,325,360.19
11	423,802.77	217,543.18	253,859.96	-1,107,817.02
12	423,802.77	204,746.52	677,662.73	-903,070.50
13	423,802.77	192,702.61	1,101,465.50	-710,367.89
14	423,802.77	181,367.16	1,525,268.27	-529,000.73
15	423,802.77	170,698.50	1,949,071.04	-358,302.23
16	423,802.77	160,657.41	2,372,873.82	-197,644.81
17	423,802.77	151,206.98	2,796,676.59	-46,437.84
18	423,802.77	142,312.45	3,220,479.36	95,874.61
19	423,802.77	133,941.13	3,644,282.13	229,815.74
20	423,802.77	126,062.24	4,068,084.90	355,877.98

Table A 8: Manual calculation for Sensitivity analysis

Summary table				
% Deviation	NPV at Different Deviations from Base			
	Annual revenue	Operating costs	WACC	The initial capital cost
-20%	-€ 865,056.30	€ 673,591.33	€ 873,548.75	€ 1,187,923.32
-10%	-€ 254,589.16	€ 514,734.66	€ 602,455.69	€ 771,900.65
0%	**€ 355,877.98**	**€ 355,877.98**	**€ 355,877.98**	**€ 355,877.98**
10%	€ 966,345.13	€ 197,021.31	€ 123,983.27	-€ 60,144.69
20%	€ 1,576,812.27	€ 38,164.64	-€ 87,516.84	-€ 476,167.36
Range	**€ 2,441,868.57**	**€ 635,426.69**	**€ 961,065.59**	**€ 1,664,090.68**

Table A 9: Calculation of Net Cash Flow, discounted and cumulative NCF

Periods	EBIT after tax (€)	CF (€)	The initial capital cost (€)	NCF (€)	Discounted NCF (€)	Cumulative NCF (€)	Cumulative discounted NCF (€)
0			**4,407,970.53**	-4,407,970.53	-4,407,970.53	-4,407,970.53	-4,407,970.53
1	203,404.25	423,802.77		423,802.77	398,873.20	-3,984,167.76	-4,009,097.33
2	203,404.25	423,802.77		423,802.77	375,410.07	-3,560,364.99	-3,633,687.27
3	203,404.25	423,802.77		423,802.77	353,327.12	-3,136,562.22	-3,280,360.14
4	203,404.25	423,802.77		423,802.77	332,543.17	-2,712,759.44	-2,947,816.97
5	203,404.25	423,802.77		423,802.77	312,981.81	-2,288,956.67	-2,634,835.16
6	203,404.25	423,802.77		423,802.77	294,571.12	-1,865,153.90	-2,340,264.04
7	203,404.25	423,802.77		423,802.77	277,243.40	-1,441,351.13	-2,063,020.64
8	203,404.25	423,802.77		423,802.77	260,934.97	-1,017,548.36	-1,802,085.67
9	203,404.25	423,802.77		423,802.77	245,585.85	-593,745.59	-1,556,499.82
10	203,404.25	423,802.77		423,802.77	231,139.63	-169,942.81	-1,325,360.19
11	203,404.25	423,802.77		423,802.77	217,543.18	253,859.96	-1,107,817.02
12	203,404.25	423,802.77		423,802.77	204,746.52	677,662.73	-903,070.50
13	203,404.25	423,802.77		423,802.77	192,702.61	1,101,465.50	-710,367.89
14	203,404.25	423,802.77		423,802.77	181,367.16	1,525,268.27	-529,000.73
15	203,404.25	423,802.77		423,802.77	170,698.50	1,949,071.04	-358,302.23
16	203,404.25	423,802.77		423,802.77	160,657.41	2,372,873.82	-197,644.81
17	203,404.25	423,802.77		423,802.77	151,206.98	2,796,676.59	-46,437.84
18	203,404.25	423,802.77		423,802.77	142,312.45	3,220,479.36	95,874.61
19	203,404.25	423,802.77		423,802.77	133,941.13	3,644,282.13	229,815.74
20	203,404.25	423,802.77		423,802.77	126,062.24	4,068,084.90	355,877.98
	4,068,084.90	**8,476,055.43**	**0.00**	**4,068,084.90**	**355,877.98**		

Table A 10: List of abbrevations

Mark	Meaning
EfW	Energy from Waste
MSW	Municipal solid waste
IEA	International Energy Agency
SHP	Small Hydro Power
RES	Renewable Energy Sources
MW	Megawatt
kW	kilowatt
GW	gigawatt
TW	terawatt
kV	kilovolt
kWel	Kilowatt Electric