

# **NATIONAL BACKGROUND REPORT ON ENERGY FOR MONTENEGRO**

**Prepared in the frame of the WBC-INCO.NET project by**

**Prof. dr Igor Vušanović**  
**University of Montenegro, Faculty of Mechanical Engineering**

**Prof. dr Gojko Joksimović**  
**University of Montenegro, Faculty of Electrical Engineering**

**Podgorica, March 2012.**

## **Executive summary:**

This report is developed in March 2012 in the content of EC funded project WBC-INCO.NET under the WP7 – Priority setting to structure participation in FP.

The report provides a brief overview of the research in energy field in Montenegro with the scope to define and set priorities in term of sub-areas of common regional interest for the enhancing of FP participation. It covers the most important issues, themes and sub-themes in energy research on national level. It is based on official documents of research institutions in this area (their strategies, studies ...), official state documents (strategies, agendas ...) as well as on experience of expert team that prepared this background report.

The focus is put on the identification of national strengths thus enabling the definition of potential national priorities.

## Table of contents:

Introduction.....	4
1. Purpose of the national background report and methodology/summary of the consultation process.....	5
2. The Energy S&T system in Montenegro.....	5
2.1 The Montenegro and Energy policy framework.....	5
2.1.1 The overall Energy policy framework.....	6
2.1.2 The elements of Energy research policy making.....	7
2.2 Overview of Energy research activities.....	8
2.2.1 Energy research projects.....	8
2.2.2 Key competencies in Energy research fields.....	9
2.2.3 Energy research infrastructure.....	9
2.3 Key drivers of Energy research.....	11
2.3.1 Main Energy sector trends in <i>Montenegro</i> .....	13
2.3.2 Main socio-economic challenges in <i>Montenegro</i> .....	14
3. Integration of <i>Montenegro</i> in the European Research Area in the field of Energy.....	14
4. SWOT analysis of the Energy research capacity in <i>Montenegro</i> .....	15
4.1 Strengths.....	15
4.2 Weaknesses.....	16
4.3 Opportunities.....	16
4.4 Threats.....	17
5. Energy research priorities for <i>Montenegro</i> .....	17
5.1 Energy Research priorities on the basis of the country's readiness.....	18
5.1.1 Renewable electricity generation (Activity Energy.2) .....	18
5.1.2 Innovative Integration of Renewable Energy Supply and Energy Efficiency in Large Buildings (Area Energy 2.8.).....	19
5.1.3 Renewables for Heating and Cooling (Activity Energy 4.).....	19
5.1.4 Solar energy.....	19
5.2 Energy research priorities on the basis of the future potential.....	20
5.2.1 Coal for cogeneration.....	20
5.2.2 Fossil fuels from domestic sources.....	20
5.2.3 Cogeneration and gas.....	20
5.2.4 Energy efficiency in building sector.....	21

## **Introduction**

In the field of energy sector, world is already faced with rapidly increasing demand for energy supply on one side and how to decrease negative influence of energy sector on environment. In most of scenarios it was predicted radical structural change among energy supply technologies, and most high developed countries invest large amount of money for new energy technologies and for technologies for environmental protection as well. It was recognized that development of sustainable energy sector is main condition for sustainable economy development, and it has great influence on national and political stability of every country in with world.

Montenegro as small country and economy has minor influence on global processes in energy sector. The key task in energy sector in near future will be how to solve high energy deficit using its great potential both in hydro and thermal power sector. Potential in hydro sector is more than 80% unused so far, so Montenegro can became important energy factor in this part of Europe. For this ambition task it was recognized that it's impossible to achieve it without investment in education, science and technology and research and development.

As Mediterranean and EU candidate country Montenegro has great chance to show its competitiveness just in energy sector. Toward this goal in last decade Montenegro adopt a few strategically important documents as *Strategy of Energy Sector until 2025*, *Strategy of Energy Efficiency*, and other important laws related to energy sector. In these documents it was recognized that research and development in energy sector is missing part for future development in this area.

## **1. Purpose of the national background report and methodology/summary of the consultation process**

The purpose of this report is twofold: firstly, to give a short overview of the energy sector in Montenegro, together with description of energy policy framework, research policy making, energy research activities and energy research infrastructure; secondly, to recognize the energy research priorities for Montenegro, based on country readiness as well as on future potential. These priorities are generally based on official documents of research institutions in this area (their strategies, studies ...), official state documents (strategies, agendas ...) as well as on experience and subject feeling of expert team that prepared this background report.

## **2. The Energy S&T system in Montenegro**

In the field of energy, the most of the countries in the world are focused to the three main goals:

- Energy independence of country,
- Energy efficiency in production and consumption,
- Environmental protection, economical sustainability in energy sector and developing of the new energy technologies.

Developed countries invest large amount of money both from private and public sources for developing of new technologies. Many international research and development projects in the field of new energy technologies are already started. Public sector of IEA countries today invest about 10 billions of US\$ per year (about 0,03 % of GDP, and Japan even 0,08%), and most of them (around 50%) are related to the nuclear energy. Private sector invest even more: around 40 to 60 billions of US\$ per year.

The dynamic development of science and technology in the field of energy in the world is linked to the development and application of new materials and the huge financial investments. It is clear that Montenegro, as a small state, can not be one of the key players in the field of science and technology related to energy. What we see as the main target of Montenegro in this area is to be up to date with modern developments, to form a competent professional staff in this area and that, as far as possible, apply the latest scientific achievements in practice.

### **2.1 The Montenegro and Energy policy framework**

The most important laws that regulate Education, Science and Research in field of Energy in Montenegro are:

- *The Law on Scientific and Research Activity of Montenegro* (Official Gazette of Montenegro no. 80/10) is adopted in December 2010, taking

into account that the research environment has changed significantly and that there is a need for introducing and defining the quality in research, parameters for funding on competitive base, quality assurance as well as all kind of promotion and recognition of quality in research.

- *The Law on the Montenegrin Academy of Sciences and Arts* (Official Gazette of the Republic of Montenegro no. 14/2002, and new Law adopted recently this year) which regulates the activities of the Montenegrin Academy of Science and Arts.
- *The Law on Higher Education* (Official Gazette of the Republic of Montenegro 60/03). Amendments of the Law on Higher Education were adopted in Parliament on July 27, 2010. Major updated of the new Law include: an integrated university system; three-cycle education system; introduction of the European Credit Transfer and Accumulation (ECTS) system; introduction of a Diploma Supplement; creation of a Council of Higher Education; and improved quality assurance (internal and external);
- *The Strategy of scientific research activities (2008-2016)* is adopted with a view of priority setting, stimulating and monitoring of scientific research activity. The Strategy determines in particular:
  - priorities in scientific research activities;
  - plan of stimulating young researchers with scientific title of doctor and master of sciences in priority development areas;
  - framework for financing programmes of public interest;
  - plan of investment on annual financial resources for scientific research activities;
  - necessary scientific research infrastructure;
  - research information system;

It is brought by the Government based on the proposal of the Council for Scientific Research Activity. The Strategy will be revised till the end of year 2012.

### **2.1.1 The overall Energy policy framework**

In last decade Montenegro as state made significant progress in creation of systematically foundation of establishing legal, institutional and regulation framework for sustainable development of energy sector. Regulations for a favorable investment climate in the energy sector include tax system, property rights, water management, spatial planning, environmental protection and others.

Reforms in the energy sector in Montenegro started with new Law on Energy in 2003, and a series of sub laws that gives more details in the energy sector. With this law, independent energy regulator is established, all energy subjects are licensed and it's obligatory that tariffs must cover the costs. Additionally, law provides framework for the establishment of energy market and introduce

competition in the energy sector. In April of 2010, the new law of Energy is adopted, and beside system issues it regulates field of electric energy, gas and renewable energy sources. Also, new Law on energy efficiency is adopted for the first time.

So far, it was observed that there is an incomplete harmonization of national legislation with the EU in the energy sector, insufficiently developed regulatory process and incomplete independence of regulatory bodies. Also, there is a lack of protection of consumers in terms of quality and security of supply of electric energy and other energy sources.

Montenegro, as candidate for EU in recent future, should perform next steps:

- To adopt laws that are in line with EU legislations in the field of energy and environmental protection.
- Montenegro needs to fulfill following conditions:
  - *Legislative*: Inclusion of the *Acquis Communautaire* into the national legislation;
  - *Institutionally*: Continuous monitoring of the institutional framework in order to increase energy efficiency, with a clear separation of responsibilities between national, regional and local authorities;
  - *Financially*: To have defined strategy of financing of necessary administrative structure.
- It is essential in the act of concession for the building of energy facilities to ensure higher representation of the grantor (the concession provider) in the ownership structure of the concession company;
- Higher level of service requires that the tariff system include indicators of quality of supply (supply interruptions, voltage conditions, etc..).
- It is necessary to develop legislation for the "green engineering" which is regulating the development of new materials, products, processes and systems that are safe for human health and the environment.

### **2.1.2 The elements of Energy research policy making**

The Government of Montenegro established *National Council for Scientific-Research Activities* as a body, and prepared *Strategy for Science and Research of Montenegro* (2008 – 2016) with the aim to define annual budgetary increase, as a % of GDP allocated to research and development.

As one of the themes *Energy* is recognized as one of the priorities. In accordance with Strategy, research should be primarily focused on the new energy resources, renewable energy sources, as well as improving energy efficiency, bearing in mind that we are, in this field, among the last countries in Europe.

## **2.2 Overview of Energy research activities**

Under the instructions of the Council for Scientific-Research Activities, Ministry of Science as a main body related to Science and Technology and Research and Development has adopted priorities in fields of Energy for near future (2012 – 2014). In accordance with their announcement main priorities are:

- Development of the technological solutions toward the more economical, eco-friendly and reliable production of energy;
- Increasing of efficiency of energy conversion and decreasing of costs of electric energy production from renewable energy sources (RES) as hydro potential, wind, thermal solar and biomass;
- Development of new technological solutions which assume increased energy efficiency and more energy savings;
- Research and development toward the improvement and publication of new strategic documents in field of energy;

Ministry of Science announced call for financing national projects in 2011 year and many of projects related with energy and energy efficiency are on way to be accepted and realized through the internationally recognized teams and researchers. More results from these projects will be known by the end of this and next year.

### **2.2.1 Energy research projects**

#### International projects:

Currently is underway one international project financed by European Commission under the FP7 horizontal action SEE-ERA.NET PLUS. The name of the project is Monitoring of Wind Turbine Generator Systems (MONGS). In this project the operation of wind turbines is investigated to identify possible fault indicators based only on the sensors already available in the power inverter. The research covers the whole electrical power conversion process: from the control algorithms for optimal adaptation to dynamic changing wind speeds to considerations on how the system energy efficiency is reduced by emerging fault conditions of different components and to a practical verification of the detection system on a reduced scale generator system.

Project participants are: Vienna University of Technology (coordinator), Faculty of Electrical Engineering and Information Technology, Institute of Energy Systems and Electrical Drives, Professor Thomas Wolbank; University of Zagreb (partner), Faculty of Electrical Engineering and Computing, Department of Control and Computer Engineering, Professor Nedjeljko Perić; University of Montenegro (partner), Faculty of Electrical Engineering, Professor Gojko Joksimović;

#### National projects:

Just accepted for funding by the Ministry of science over the next three years:



- University of Montenegro – Faculty of Mechanical Engineering  
Prof. dr Petar Vukoslavčević  
„The research of phenomenon of transient processes in the hydraulic and aero-mechanical systems”
- University of Montenegro – Faculty of Electrical Engineering  
Prof. dr Sreten Škuletić  
„Alternative energy sources - the possibility of their use in Montenegro“
- University of Montenegro – Faculty of Mechanical Engineering  
Prof. dr Igor Vušanović  
“Numerical and experimental investigation of the possibility of using geothermal energy for the heat pumps“

### **2.2.2 Key competencies in Energy research fields**

In accordance with current regulation in political system in country, key role in shaping R&D policy have:

- *The Parliament of Montenegro* as the highest legislative body - preparation and adoption of the legislative acts dedicated to research activities goes through its Committee on Education, Science, Culture and Sports;
- *The Government of Montenegro* as the highest executive body for preparation and implementation of research policies. It prepares and proposes programs, laws and policies to the Parliament through its ministries or through inter-ministerial and expert working groups;
- *Ministry of Science (MoS)* –It is the main ministry responsible for science and R&D on the operational level and for funding of national R&D projects and development of research infrastructure;
- *Council for Scientific Research Activities* is the main advisory body of the Government for R&D. The Council is obliged to make its opinions, recommendations and conclusions, and in this area accessible to the public;
- *Ministry of Economy* is supervising for the Energy sector in Montenegro, and has key role in developing of new renewable energy sources, energy efficiency programs and implementation of new regulation in field of Energetic generally.

### **2.2.3 Energy research infrastructure**

Currently in Montenegro there is a lack of modern research infrastructure for energy research projects and followed laboratories and equipment, which hampers its engagement in research activities and research cooperation with the EU.

*Montenegrin Research and Education Network (MREN)* has been established in 2005. It is collection of all networking services and facilities, which support the communication and information requirements of the education and research community in Montenegro. MREN aims to create, promote, offer,

participate in and preserve the requisite bases for effective use of modern telecommunication technologies in the education and research in Montenegro. The main mission is to connect MREN to GEANT- multi-gigabit pan-European data communications network, reserved specifically for research and education use, via fiber optic with high speed. The MREN's target is to support the substantial use of the Pan-European and world research networks by Montenegrin researchers, scientists, lecturers and students, as well as to facilitate the integration of Montenegrin educational, research and cultural resources in the international information space. Since October 2010 MREN is successfully connected to the European Academic Network (GÉANT).

*Centres of Excellence (CoEs):* - The new Law on Scientific and Research Activity presents the qualifications of a center of excellence – showing that “a scientific research institution or a group of researchers which has, by the originality, significance or actuality of achieved results in the scientific research activity in the period of five years, realized highest level and internationally recognized outputs in its area of science, can be granted the status of a Center of Excellence”. The 2008-2016 Strategy sets out as an objective to modernize Montenegro's scientific research infrastructure, through the development of an organization of laboratories with the establishment of multi-disciplinary centers, which would “gather internationally recognized researchers, and have the critical mass of competencies for mentorship to young PhD students, as well as easier access to the European funds for research.” Technological parks are also seen as one of the comparative solutions.

In order to improve research infrastructure in Montenegro, Ministry of Science conducted in 2011 two feasibility studies:

- Feasibility study for the establishment of Centers of Excellence in Montenegro, and
- Feasibility Study for setting up a Science and Technology Park in Montenegro.

The first Centre of Excellence (CoE) will be funded through the project called “Higher Education and Research for Innovation and Competitiveness” (HERIC), funded from the World Bank's loan. The anticipated duration of the project is from March 2012 up to April 2017.

*Science and Technology Park (STP):* Ministry of Science with Ministry for information society and telecommunications funded Feasibility Study for setting up a Science and Technology Park (STP). It is clear that the development of the STP directly responds to the set goals and that it contributes (directly and indirectly) to the development of the SME sector, and by that to the general development of the Montenegrin economy. In order to conduct the detailed planning and establishment of the STP, during 2012 will be prepared business plan which should consist of the following three points:

- elaboration of a detailed strategic concept;

- Development of a suitable framework concept and execution of a detailed cost calculation and financial plan.

Government of Montenegro, at the session on 29 September 2011, adopted the feasibility study for setting up Science and Technological Park. The Study gave strategic guidelines and defined the cornerstones of the Science and Technology Park profile. Thematic focus of the Park, that should include characteristics of a technology park, an incubator and a business park, should be: energy efficiency and green energy, agriculture and food processing, information and communication technologies, medical technologies, wood processing and interdisciplinary research, as well as setting up of Center for development of young scientists. The STP shall foster both academic and industrial R&D and build the basis for academic-industrial interaction and provide both infrastructure and a broad range of services.

After the development of the business plan is period for the implementation and the architectonic planning. After this the building-up of infrastructure and organizational structure should be conducted within a year, after which the STP should start with its work. Estimation is that after about three years of planning and implementation, the STP could start with its work.

There are two technology/innovation centers (European Information and Innovation Centre Montenegro –EIICM and R&D Service Centre at the University of Montenegro). Also, two business incubators are established, in Bar and Podgorica, developed in the partnership between local authorities and international organizations. Business incubator in Podgorica is directed toward innovative information technologies.

Specialized agencies for technology transfer have not been established yet.

### **2.3 Key drivers of Energy research**

Key drivers of energy research in Montenegro are:

1. Montenegrin Academy of Sciences and Arts and
2. University of Montenegro.

To be more precise, just so-called technical faculties of University of Montenegro are involved in energy research in different fields of interest: Faculty of Electrical Engineering, Faculty of Mechanical Engineering, Faculty of Civil Engineering and Faculty of Architecture. Beside aforementioned, Hydro Meteorological Institute of Montenegro as state owned institution also have active part in field of hydro energy and wind resources as a part of renewable Energy research.

*Montenegrin Academy of Sciences and Art* performs scientific research in energy sector by itself or in cooperation with other scientific institutions, through its natural science department. The results of recent research in this area are summarized in four editions of Academy: “New energy technologies” (2000), B.Đorđević, M.Šaranović, “Hydropower potentials of Montenegro” (2007), B.Đorđević, G.Sekulić, M.Radulović, M.Šaranović, “Hydro potentials of Montenegro” (2010) and I.Vujošević, “Energy” as a part of the project “Montenegro in XXI century – in the era of competitiveness“, (2010). It should be also recognized the importance of the Academy activities in this area by organizing a biennial conference „Alternative energy sources and the

future of their application“, starting from 1998. The usual venue of the Conference is Budva. The conference is recognized in the region and very well attended. Additionally, the Academy recently organized three prominent symposia dedicated to new energy technologies: „New energy sources in Montenegro“ (2004), „Renewable energy sources and energy efficiency“ (2011) and „Nuclear Energy - Global Trends and Perspectives in South-East Europe“ (2011).

*University of Montenegro* is the oldest and largest higher education and research institution in Montenegro founded 1974. It is the only state University in Montenegro. Today it is consisting of 20 faculties and 3 research institutes with 1170 employees (372 with academic and scientific titles, 286 associates, 106 expert staff, 406 technical collaborators and administrative staff) with more than 20.000 students. At the University of Montenegro, mainly four different Faculties take some part in the energy research.

*Faculty of Electrical Engineering*, its Department of Power Engineering and Automatics, Electrical machines research group have a lot of experience in area of wind generators, primarily from electrical generator aspect, modeling, control and diagnosis of different fault conditions. It was first laboratory in South East Europe that had developed and used cycloconverter, very rare and very complicated power electronics apparatus dedicated to supplying of double fed generators as part of wind generators. Currently is underway one international project financed by EU commission under FP7 frame, horizontal action SEE-ERA.NET PLUS, dedicated to monitoring of wind turbine generator systems. The name of the project is Monitoring of Wind Turbine Generator Systems (MONGS).

*Faculty of Mechanical Engineering*, Department for Energy and Thermal Science, performs research in field of energy efficiency both in residential (buildings) and industrial sector, in field of hydro power plant systems, in field of modeling and development of ground source heat exchangers (GSHE) for heat pumps (HP), in modeling of ventilation and energy supply for traffic tunnels, in field of measurement in heat, mass transfer and fluid flow. Regarding the energy efficiency Faculty performs specialized courses for energy auditors, for future energy auditing and labeling of all buildings.

*Faculty of Civil Engineering* performs research towards hydro potential of Montenegro and efficient way of use of such power is conducted.

*Faculty of Architecture*, research towards energy characteristics of buildings, energy efficiency and renewable energy sources impact on different architecture concepts are underway.

*Hydro Meteorological Institute of Montenegro* collects daily a lot of meteorological data through the Montenegro. Beside many other activities of the institute is the creation of hydrological grounds that are necessary for design of hydropower dams as well as mapping the winds

and solar radiation on the territory of Montenegro required for the proper design of wind generators and solar or photovoltaic panels.

### **2.3.1 Main energy sector trends in Montenegro**

In accordance with data obtained in project of “*Montenegro in XXI century – in the era of competitiveness*“ (2010), current condition of energy sector in Montenegro can be as follows:

- overall energy consumption in Montenegro in 2006 was about 1,1 Mten, or 0,009% of overall world consumption in primary energy (PE), while the population of country is 0,01%;
- Montenegro exploits brown coal, lignite, wood for heating, hydro energy and wood industrial waste, which results in about 54% of energy independence;
- In overall state energy balance in primary energy (PE) oil derivatives are dominant (32,3%), and they followed by coal (30,1%), hydro energy (19,6%) and wood for heating (10%);
- Montenegro has imported in 2006 year about 0,35 Mten of oil, more than third of electric energy (1,7 TWh), while the export of energy was negligible;
- Consumption of final energy (FE) in 2006 was about 0.82 Mten, with highest ration of oil derivatives (43%), and electric energy (40%);
- In final energy (FE) balance industry sector takes ratio of 31.6%, transport sector is 14.1%, household sector 14%, services (administration, tourism, etc.) is 6.5%, agriculture (0.7%) and construction sector (0.7%);
- Producers of electrical energy in Montenegro are:
  - HE Piva & Perućica 1.7 TWh;
  - TE Pljevlja 1.2 TWh;
  - Small hydro power plants 20 GWh.
- Consumption of electric energy in 2008 was 4,6 TWh, separated between distributive consumers (1,9 TWh or 41,5%) and direct consumers (1,955 TWh 42,6%) as aluminum industry (KAP), steel industry (Željezara Nikšić) and state railway (Željeznica CG);
- Montenegro has about 1.250 km of transmission network which has mostly radial structure on every of 3 different voltage levels (110kV, 220kV and 400kV) which is not well connected to the closer electro energetic systems (EES);
- Electrical distribution system is composed from about 20,000 km of overhead and cable lines gather with transformer stations at three different voltage levels: 35kV, 10kV and 0.4kV;
- Liquid petrol gas (LPG) is present in Montenegro in form of small bottle packages for the industrial purposes mostly, service sector and households as well;
- The heat as final energy produces mostly in industrial sector and one public heat producing facility. In 2004 it was produced about 0,07 Mten of heat, where 88% was in industry of lights metals;

### 2.3.2 Main socio – economic challenges in Montenegro

In recent past Montenegro is faced with electrical energy deficit (around 30%) due to the lack of new energy sources (last was built in 1983) and constant rise of electrical energy consumption mainly in non-industrial sector. This trend is the main threat of energy sustainability of country and need to be considered as one of the main state priorities.

It was recognized on state level that investment and developing of energy sector in Montenegro can be a chance to increase GDP, open the work position on market and to increase our competitiveness in recent future. This goal of course can't be achieved without strong investments in research and development in energy sector.

One of the key problems that Montenegro has is the current structure of our industrial sector which is extremely energy intensive due to the existing of two big metal processing sectors (aluminum and steel industry).

Parallel overview of the GDP variations and energy consumption for the period from 1989 trough 2003 (1989-basic year) is shown on Figure 1 (*EE Strategy of Montenegro, 2005*).

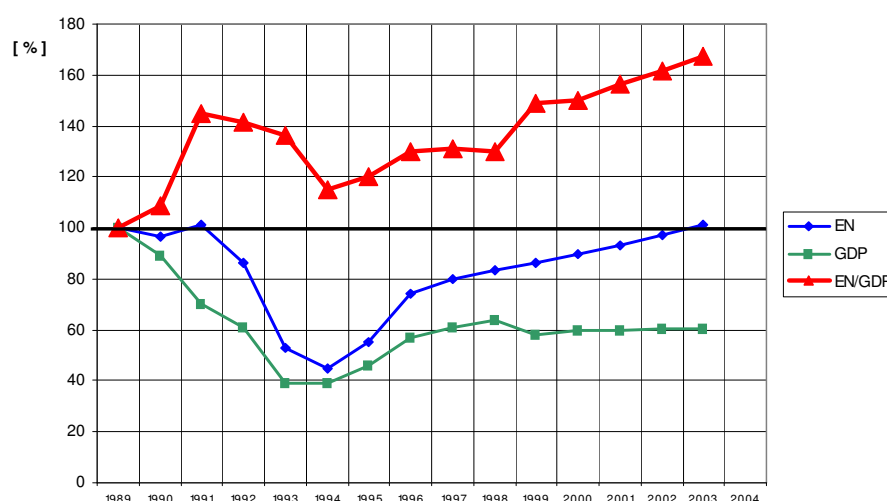


Fig. 1. Energy consumption and GDP variations in Montenegro (1989-2003.)

In the previous period shown relation between end-supply energy and GDP had growing trend up to 45% until 1991. From 1991 trough 1994, this index of energy inefficiency falls down to 15% and after 1995 has permanent increase, so for the year 2003 it gets higher for 67% in compare to basic year, 1989. That means that energy consumption per unit of the gross product has been decreased for 67% in the recorded period of time. We had completely opposite process in developed countries, which illustrates very disturbing situation in this field and risk that energy sector in Montenegro becomes unsustainable.

### 3 Integration of Montenegro in the European Research Area in the field of Energy

As it can be seen from this Report, in Montenegro is currently underway only one international project in energy area - more specifically, the monitoring of

wind turbine generator systems. Montenegro, ie. Faculty of Electrical Engineering in Podgorica is involved in this project as a partner, along with another partner, the University of Zagreb. Coordinator of the project is Technical University of Vienna. This project will last two years and it is funded by the EU through the horizontal action of FP7 programme, known as SEE-ERA.NET PLUS.

Funding obtained by the EU Commission, make it possible to employ a young research student on the project who working towards his MSc thesis. Networking and intensive communication with other project partners, learn about their way of working, their labs, joint research, writing and publishing papers in international conferences and in international journals is the added value of this project. Generally, participation in projects of this kind is a huge benefit for Montenegrin small scientific community.

As previously mentioned, Montenegro is a country of small potential, in area of research in energy, that it could appear as the coordinator of some projects in the field of energy. However, we believe that our scientific community has enough capacity to be a very successful partner in the projects financed from EU funds.

Besides the obvious efforts of state institutions towards successful participations of Montenegro in all research programs which are financed from EU funds, primarily FP7 funds, it is essential existence of the aspirations and wishes of the researchers themselves to establish contacts with colleagues from foreign universities. To this end, Montenegro also has to make some steps, because it is well known that all institutional networking, however, is mainly based on the good contacts between individuals with these institutions.

## **4 SWOT analysis of the Energy research capacity in Montenegro**

### **4.1 Strengths**

- Traditionally good and quality education at technical faculties and faculty of natural sciences provides a solid foundation for graduates to do research in the field of energy;
- Lack of interest in high school students to enroll in technical faculties and faculty of natural science is the current weakness of the system but also can serve as an advantage in the sense that this interest in the future, as a result of economic developments, will undoubtedly grow. For example, we are witnessing of intensified interest of students to enroll the Power Engineering at the Faculty of Electrical Engineering in the last few years, at the expense of the study of electronics, telecommunications and computing;
- Significantly increased the availability of mobility for final-year students, postgraduates and doctoral students. Practically not a single month passes that some interesting opportunity for scholarships from reputable foreign universities does not appear. An example is currently two open calls: one from International Renewable Energy Agency (IRENA) for graduate studies at the prestigious University of Masdar, Abu Dhabi, UAE, in collaboration with the Institute of Technology from Massachusetts, USA. Other one is UNESCO/ISED call in area of sustainable energy

development. Whoever is in the areas of technology, know well that the MIT in the technical sciences is match of Harvard and Yale in the field of social sciences. Such calls for researchers from South East Europe, decade ago were just a dream!

- Establishment of a separate Ministry for science, instead of past sector in the Ministry of Education and Science, is a clear sign that the State recognizes the scientific work and research as precondition for its future comprehensive development;
- A new and ambitious cycle of funding of national projects by the Ministry of Science;
- Not well used natural resources, water streams, solar and wind energy are an additional impulse for qualitative research in this area;
- Actual financial crisis may be an additional motive to individuals and small and medium enterprises in Montenegro for the research, and above all, the use of unused energy resources and their economic valorization;

#### **4.2 Weaknesses**

- Lack of interest of high school students to enroll in technical faculties and the faculty of natural science;
- Noticeable lack of motivation of a number of technical students. The impression is that some of them studied for study, showing no desire to acquire practical knowledge and its application in practice;
- Lack of students and young researchers motivation to learn foreign languages and to change their place of education and gain new working and life experiences, despite the many scholarships offered to them;
- Low number of research projects in area of energy, at national as well as at international level;
- Obsolete equipment in the laboratories of technical faculties, except a few shining examples;
- Lack of funds for the purchase of scientific research equipment, which is usually very expensive;
- Greater orientation of scientific staff to mobility instead to purchase of laboratory equipment, which is partly a result of pronounced mobility policy of the European funds at the expense of scientific research equipment procurement;

#### **4.3 Opportunities**

- Already formed public opinion that investing in science and science itself is prerequisite for overall social and economic state development;
- Insufficient quantities of electrical energy, the need for imports, highly expensive oil products, have formed a public opinion on the need for savings, rational utilization of energy and the need for research and development of new energy sources, on a first place, renewable energy sources;
- Increasing funding for scientific research at national level as well as wider opportunities for funding of research through different international sources, primarily from different EU funds;



- Increased number of bilateral agreements between Montenegro and other countries (Austria, China, France, Bosnia and Herzegovina, Croatia, Slovenia) and consequently, increased opportunities for researcher networking;

#### **4.4 Threats**

- As a result of present economic crisis, possible threat is that our top students, who are the basement of any future research activities in Montenegro, leave the country and reside at more developed countries, especially at countries that are part of European Union;
- Significant threat is quite poor state of our economy. Poor production results of companies as a result of the global economic crisis and subjective and objective weakness of our economy may have resulted in significantly reduced issuance of state for science;
- Insufficient promotion of technical sciences and insufficient promotion of the fact that the real economy can be based only on production, i.e. on the creation of new values. In this process the natural and technical sciences are a priority as well as energy in its different forms, its production and its rational use;

### **5 Energy research priorities for Montenegro**

In accordance with *Strategy of energy development sector until 2025* energy sector in Montenegro will be focused on the following strategic goals:

- Implementation of international obligations in the energy sector and environmental protection;
- Improving of energy efficiency (EE) in processes on the level of the mid developed EU countries;
- Decreasing of energy dependence of imported energy, with improving of energy supplying;
- Improving of sustainability of the energy sector.

In the long term period research in Energy sector must follow European and world trends in the following fields:

- Improvement of technology of electric energy production with so called de-carbonization;
- Substitution of petroleum products in transport;
- Low energy building construction;
- The development of smart electric grids;
- Joint research programs and technological development in cooperation with EU countries;

It is essential in next period to fund specific research programs in energy and environment, run the research and development centers (ENEKO in the frame of Montenegrin Academy of Science and Art (MASA)) and similar programs at universities and industry, as well as inclusion of domestic scientific capacities in the EU, OECD and other energy research projects.

## 5.1. Energy research priorities on the basis of the country's readiness

### 5.1.1 Renewable electricity generation (Activity Energy.2)

- **Hydro energy** (Area Energy 2.7.) Montenegro's hydropower potential has not yet been used near the degree of utilization of what is in the developed countries. Specifically, of the total hydroelectric potential on the main water streams, currently is commercially exploited only 17%. In addition to this potential on the main water streams there is a significant potential of small streams that can be used by building small hydropower plants. The process of preparing the construction of several small hydropower plants is under way. This area of renewable energy sources is particularly important for Montenegro. Regarding possible themes for research in this area, we primarily see further research in the field of meteorological analysis, research in the field of synchronous and induction generators, research in the field of connection of distributed sources of electricity in the power system, and implementation of new solutions in the field of water turbines primarily for small hydro power plants, for example, analysis of possible applications of matrix turbines.
- **Wind** (Area Energy 2.3.) – Wind turbines in recent decades become one of the major renewable energy sources. Unfortunately, in Montenegro there is still no one of installed wind turbine. Areas of research related to wind turbines are numerous: ranging from aerodynamic research, design of new forms of wind turbines, the analysis of mechanical loads, vibrations, research in the field of electromechanical energy converters and so on. One possible area of research is in the domain of electrical generator that is part of the wind turbine, his control, optimization, fault-tolerant control, where Faculty of Electrical Engineering at University of Montenegro has many years of experience.
- **Photovoltaic** (Area Energy 2.1.) Research in photovoltaic area is coupled with the high technologies which are not available to Montenegro. It is a highly sophisticated technologies and materials that are tested and developed in a highly technologically developed countries, and corporate laboratories. For Montenegro, the research interest in this area are primarily in the area of application of photovoltaic cells, their implementation, the different modes of connections, the management and control.

### **5.1.2 Innovative Integration of Renewable Energy Supply and Energy Efficiency in Large Buildings (Area Energy 2.8.)**

#### **Renewables for Irrigation**

- The fattest soil in Montenegro is also the most sunlit areas in Montenegro. On this territory there is a significant number of private farmers that supply Podgorica and the Adriatic coast, as the most densely populated areas, with their products. Intensive agricultural production raises the need for irrigation with an expenditure of energy for the irrigation pumps. As one of the priorities in the use of renewable sources of energy we see photovoltaic cells and small wind power turbines to be used as small electric power stations for irrigation purposes. Also, windmills that directly, via a mechanical gear, drew water from wells could be interesting solution for these purposes.

### **5.1.3 Renewables for Heating and Cooling (Activity Energy 4.)**

- One of the key problems in the energy sector in Montenegro is the problem of insufficient diversification of energy sources. The energy sector has relied on the (insufficient) production and use of electricity in all areas of social activity, as well as the use of (mostly imported) fossil fuels and the use of firewood to heat the rooms. In addition, there is no gas infrastructure in Montenegro. Finding alternative ways for heating would significantly relax primarily Montenegrin electrical energy system. One possible way is the intensive use of solar panels for water heating and space heating and the use of small power wind turbines that would be used primarily for heating of rooms during the winter months. For this purpose it is necessary to intensify research in this area primarily by performing a pilot plants in order to obtain more specific indicators of how this would be an effective way of heating. One way for better using of electric energy for heating is massive use of heat pumps that use air, water and solid as heat source. In this field there is a lot of potential for research of using soil and ground water for heat pumps. Initial project in this field is already underway at Faculty of Mechanical Engineering.

### **5.1.4 Solar energy**

- Solar energy is significant renewable energy potential in Montenegro. The area of Montenegro is exposed to the direct sunlight about 1500-2500 hours per year, which is approximately 17-18% of overall year time. Especially, seaside of Montenegro is highly exposed to the direct sunlight with average solar flux of 4.45 kWh/(m<sup>2</sup>day). In the past (before 1990) solar energy was used in many public objects as hotels and landlords facilities. The total sum of installed solar collectors was about 11,000m<sup>2</sup> with approximately installed power around 5,500 kW. Due to the bad maintaining in the period of mid 1990 - ties and UN sanctions current using is below this level. In the tourism sector using of solar energy for hot water supply and heating can be one of the

strategic projects in future in terms of energy efficiency and decreasing of electric energy consumption.

## **5.2 Energy research priorities on the basis of the future potential**

### **5.2.1 Coal for cogeneration**

- According to the existing conceptual project, in the electrical energy production sector the main energy efficiency potential regarding the coal using is cogeneration potential of Thermal Power Plant Pljevlja which is about 78 MW of thermal energy. This energy can be used for heating of municipality of Pljevlja. To release this potential, it is necessary to implement the Program of Reconstruction and Modernization of thermal power plant Pljevlja into Thermal – Heat facility, and to build an appropriate infrastructure in the city. For this highly profitable and ecologically acceptable program, significant investments from EPCG (or future TE owners) and Pljevlja municipality are needed;
- Another possibility of using coal from Pljevlja is to gasification as a way to cleaner energy source, and using for another block of thermal power plant. New facility should solve the problem of current high and unacceptable air pollution in Pljevlja. This strategic plan is a great chance to introduce a research in new Carbon Capture Storage Technologies (CCS).

### **5.2.2 Fossil fuels from domestic sources**

- Montenegro is highly dependable country regarding the fossil fuels using especially for oil derivatives where 100% is imported. In the future some spots on the seaside of country will be explored in terms of possible using of gas and oil. Using of gas can be very attractive in industrial sector in aluminum and steel industry to replace heavy oil for heat purposes. Also, there are some plans for gas based electric power plants that can use both natural and liquid oil gas.

### **5.2.3 Cogeneration and gas**

- Heat as final energy is most dominant in energy consumption in residential and many industrial sectors. Combine production of electric energy and heat (Cogeneration) is well known technology today but in Montenegro there are no much applications of it. In the sector of services (Tourism) and for hospitals there are a lot of possibilities of combine using electric energy and heat, due to the high energy demand for heat as final energy. Knowing that in recent future there is a plan for introducing a natural gas (so called "South line") possibilities of using cogeneration will be wide open.

#### 5.2.4 Energy efficiency in building sector

- In the building sector in Montenegro there is significant potential for energy savings and it was stated as one of the priorities in the recent future in terms of different energy efficiency programs. Decreasing of energy consumption in this sector is very important, because it's non-profit character (do not participate in the creation of GDP). According to official study of *Energy Efficiency* (2005) almost two thirds of the necessary heat in households (heating, cooling, hot water and cooking) is covered by electricity, 18% by wood as fuel, and 11% of coal. The dominant share of electric heating is the real potential for different measures of energy efficiency (EE), either by the substitution or energy or conservation. Among other measures, such as insulation to prevent heat loss through walls and windows, heat pumps are one of the most effective technical solutions for energy efficiency in the production of heat as the final form of energy. According to earlier studies, replacement of electric heaters for 10% with heat pumps gives energy savings of about 75 GWh per year. Some previous estimates indicate that existing installations of solar panels meet only 5% of all requests for sanitary hot water. However, the above amounts must be verified" through" market studies for each sector.