# FINAL PROGRESS REPORT

**PROPOSAL / CONTRACT N° : FP6-509161**

**ACRONYM : RISE**

**TITLE : RENEWABLES FOR ISOLATED SYSTEMS – ENERGY SUPPLY AND WASTE WATER TREATMENT**

**PROJECT CO-ORDINATOR: Institute of Communication & Computer Systems (ICCS/NTUA)**

**PARTNERS :**

- **National Power Utility AD Elektrostopansto na Makedonija (AD MEPSO)**
- **Bioengineering, Doo (BIG)**
- **SOLTECH, Ltd, Zagreb (SOLTECH)**
- **Istrabenz Energetski Sistemi (IES)**
- **Institute Ruger Boskovic, Zagreb (IRB)**
- **Research Center for Energy, Informatics and Materials (ICEIM-MANU)**
- **Instituto de Engenharia de Sistemas e Computadores do Porto (INESC Porto)**
- **Association pour la Recherche et le Developpement des Methodes et Processesriels Industriels (ARMINES/CENERG)**
- **University of Manchester (UM)**
- **University of Ljubljana, Faculty of Electrical Engineering (ULJ)**
- **University of Belgrade, Faculty of Electrical Engineering (UB)**
- **University "Sts Cyril and Methodius", Faculty of El. Eng. (UKIM)**
- **University of Tuzla (UTU)**

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# Part 1: Publishable Final Report
# (Non Confidential)

## 1.1 Executive summary

The scientific and technical objectives of this project concern the investigation of the possibilities offered by Renewable Energy Sources, mainly solar, wind and biomass, as well as biogas as a by-product of wastewater treatment, for energy supply in isolated areas, focusing on:

- The sustainable development of the countries, with a special emphasis to regions affected by the war crisis
- The demonstration and reinforcement of the usage of renewable energy potentials by helping the local industries.
- The reinforcement of WB's countries research potential.
- Developing and improving tools for operation and control of stand-alone electricity supply systems
- Contributing to the PV, wind, biomass and biogas technology for production of electricity.
- Dissemination of the know-how for the potential implementation of Renewable and DG sources for energy supply and waste water treatment.

These targets dictate collection of data, their analysis and identification of the needs for the following developments:

- Low-cost innovative RES technologies and applications. Innovative decision support and operational tools for a wide implementation of RES in isolated regions for energy supply and wastewater treatment need to be developed.
- Case studies in remote regions, non-connected to the electrical grid, that have been particularly affected by the war and also physical islands must be selected. In these reagions the innovative decision support and the operational tools need to be applied.
- The results of these applications will be projected to a large scale implementation of RES on a wider scale of isolated regions in these countries.

The results will be used as follows:

- Large scale implementation of RES on a wider scale of isolated regions in these countries in order to contribute to sustainable development of the region, especially in alleviating the consequences of the war in the environment and health.
- Increasement and re-establishment of the collaboration among industry and research /academic institutions of the WB countries and such have positive effect on the overall future development of the region.

## 1.2 Publishable synthesis report

The main objective of the project was the investigation of the possibilities offered by Renewable Energy Sources, mainly solar, wind and biomass, as well as biogas as a by-product of wastewater treatment, for energy supply in isolated areas. To achieve its goals the Consortium investigated the application of low-cost innovative RES technologies and developed innovative decision support and operational tools for a wide implementation of RES in isolated regions for energy supply and wastewater treatment. These tools have been applied to the design of selected study cases from four Western Balkan countries, namely Serbia & Montenegro, Croatia, FYROM and Bosnia-Herzegovina. . The following results were achieved and the respective main conclusions were drawn:

- All the relevant existing studies and information on solar and small hydro potential in specific regions in Croatia and FYROM, were collected and reviewed. Generally, with few exceptions for some months at some locations, there was a good agreement of the values from the regional solar maps and the measured data. Metronome-calculated data also generally agree well with predictions from the maps. The exceptions were locations for which there is no sufficient density of meteo-stations in the vicinity of the selected location
- Based on measured wind data the regional map with mean wind speed was generated that includes the orography database and assumes homogeneous roughness length of 0.03m. This map allows for more precise siting procedure in the same region to calculate the wind potential at any specific place.
- Data for the choice of the technology for anaerobic WWTP was derived. In cooperation with UKIM, BIG analyzed the appropriate usage of biogas as an alternative source of energy, the possible re-usage of the effluent (purified) water from the WWTPs for irrigation, as well as calorific value of the biogas and biogas production dynamics.
- In the Tuzla Canton of Bosnia and Herzegovina an extensive list of a total of 13 municipalities was compiled. The results of this analysis gave information on quantity, quality and availability of the biomass form the resource analyzed, and represent incoming data for possible technologies that can be applied at the energy isolated regions. The list of distributed available biomass through out of municipalities of Tuzla Canton as compiled by the UTU and IES was used as basis for visualizing the biomass potential in relevant sites of Tuzla canton of Bosnia and Herzegovina.
- Three types of thin films of Cuprous oxide were produced and investigated their structural, morphological and optical properties. Followingly the production was focused on Cu2O Schottky barrier solar cells using the Cu2O thin films. The performance of the Cu2O Schottky barrier solar cells were found to depend on the starting surface material, the type of the junction, post deposition treatment and the ohmic contact material.
- The investigations of the University of Belgrade were focused on the possibility for development of a low energy consumption measuring system for wind technologies, and comparative testing of two measuring methods, further investigations of plasma processing equipment and equivalent circuit and mathematical modeling of DFIG generator.
- The pilot WWTP system consisted of two tanks. In the first one, the anaerobic fermentation was carried out, with the production of biogas. The second tank was filled with bacterial bio-carriers, where the final biooxidation of the organic matters will be accomplished. The experiments concluded that the best microbial enzyme for biogas production of 500 $cm^3$, is the combination of cellulase and pectinase.
- The most promising way of exploiting biogas in isolated, but also in grid connected systems is Combined Heat and Power Plants (CHPP), where the effectiveness may reach nearly 80 %. Biogas, as the burnable methane produced in digesters, can be used to generate electricity (there are some cases where electricity price equivalent of 6 cents per kWh is reached), heat

farm buildings and keep the digesters at operating temperatures. The residue from biogas production has little odor and retains all the fertilizer value of manure.

- A model for decision support tool (RISE-DSS) was developed that was used for investment analysis in selected cases. The work was focused on setup of supporting analyses structure, definition of main external factors, selection of analysis criteria / attributes (Supply Reliability, Economics, Environment), investigation of key uncertainties and comparison and selection of risk indicators, selection of adequate multi criteria decision aid/system, choice of risk assessment model and comparison of different risk management options. The results were a set of equations, suitable for programming of the RISE-DSS.
- Detailed analysis of two Study Cases in Croatia quantitatively demonstrated the advantages of wider implementation of PV, while the obstacles to wider implementation of RES and PV in particular were identified, such as the high initial costs of PV devices and the low level of knowledge -technological, practical, financial, environmental and, particularly, about financing opportunities;
- The proposed PV systems in FYROM, were designed to supply the needs of the isolated locations. Main findings of the analysis included: The pay-back period of the systems is rather long (15 – 25 years, depending on the energy escalation rate ), but still, since the estimated (and even guaranteed) lifetime of PV solar cells/modules is rather long at the end of the life-time balance is still positive. The uncertainties of fuel and electricity prices and changes in equipment prices have big effect on the economic performance of the projects, emphasizing the importance of such analyses.
- The waste water treatment itself has immense significance in dealing with waste and preserving the environment, taking into account that the locations were situated in the National Park *Mavrovo* and the surroundings. The analyses showed that these types of systems allow significant annual reduction of GHG emissions compared to the reference scenarios - 7.7 tons of CO2 spared each year for Study Case in *Fezlievo Bacilo*, for example.
- The eco house in Serbia consisted of residential house, workshop house, mechanical house with the equipment for water supply, artesian well, water pull and the garden. The electricity needs were fulfilled by the wind and solar photovoltaic conversion. Biomass was the dominant heat source. In addition, solar heating was used and a small amount of electricity for security reason and for air conditioning during the summer. The analysis shown that management of energy consumption can reduce the size of electricity storage system, through the categorization of consumers, regulation of energy consumption profile and optimal peak-demand management.
- After reviewing all aspects (technical, ecological, economical, job opportunities, etc.) of possible fuels, based on wood residues, pellets were selected as the optimal biomass source in Bosnia Herzegovina. The selection procedure that ensures the optimal electricity supply architecture was developed. It is preferable to use the selected technology (Stirling machine) that works in CHP (cogenration) mode so that provides both the heat and electricity to the isolated objects.
- ARMINES has investigated the application of time-series analysis and mainly artificial intelligence techniques for short-term RES and Load Forecasting issues with respect to the systems considered in the project.
- ICCS/NTUA developed functions to optimize the scheduling and operation of isolated systems with RES, including the application of battery energy storage systems for static and spinning reserve, based on the forecasted consumption and RES production. Furthermore provided the functional specifications of the Control Tool demo, based on the analysis of the economic scheduling functions which was analyzed in the project
- The usage of the new WWT technology called Anaerobic-Aerobic Granular System (AAGS) was tested. The advantages of this type of WWTP compared to the others were: the capability to simultaneously purify municipal wastewaters and organic waste materials from agricultural and

industrial nature, produce biogas, eliminate the nitrogen and phosphorus compounds present in the wastewater, small amount if sludge production, and high level of purification.

- The geographic assessment for energy resources and potential consumption for a wide area of Balkan Countries was essential in order to create input maps and scenarios for the economic, environmental and social evaluation of potential for Renewable Energy Technologies (RET). These maps revealed potential consumer characteristics, maps with wind, solar, biogas, and biomass resources, as well as a detailed characterization of technologies, social and environmental barriers and distance to the electric grid.
- GIS functions were developed in order to evaluate electric network expansion or reinforcement costs to supply new load locations and load growth.
- GIS tools developed to evaluate visual impact of wind farms, based on visibility functions over a digital terrain model, using potential locations of wind farms for targets and populated places for observers sensitive to the impact. The methodology was applied for wide areas in Croatia case studies. It was also developed a geocomputational model to quantify emission from the several technologies based on the geographical density of consumption and based on typical emission of each technology. By applying the methodologies the final maps of impacts and benefits were created and quantified by country.
- The analysis of the Isolated Electrical Systems based on Renewable Energy Sources were has shown that on each target location there were social benefits that were tightly connected to the economic benefits. PV is the most competitive RES especially in low population isolated regions and professional DC applications. Feed-in tariffs proposed are 0.6euro/kWh and government subsidies in the order of 80% for PV to be competitive. The social benefits to be expected from RES installations could be improvement of quality of life, social cohesion and stability, decrease of rural migration, reduce the conflict consequences. These benefits are tightly connected to the economic benefits, mainly recognized in the following: Reduce the unemployment rate; Open new business opportunities; Provide sufficient income for sustainable development.
- The Policy Strategies for Western Balkan Countries for the integration of RES in order to achieve previous results are: Existence and activity of an energy agency to coordinate efforts; Government policies should consider feed-in tariffs of more than 0.6euro/kWh; New installations need investment subsidies (80%), rebates and tax incentives in order to overcome high initial cost of the systems; Use of diesel generators as a source of power supply with high environmental impacts, in remote areas can be removed, with environmental externalities in calculations in favour of RES, compared to grid connected system; Communicating the benefits of RES should be the prime target and the audiences should be identified; Non Governmental Organisations (NGOs) and non-profit organisations can be useful allies in awareness-rising campaigns; Apart from local businesses that can be subsidised from the government, the tourist sector can benefit from RES and environmentally friendly tourism (ecotourism and agrotourism); Citizen participation and awareness rising, education; Evolution of energy standards in buildings and efficiency; Green electricity labels of locally produced electricity from RES;

# Part 2: Detailed Final Report
# (Publishable)

## 2.1 Objectives and strategic aspects

The main aims of the project are in accordance with the objectives of the INCO specific measures in "Integrating and strengthening the European Research Area". These are:

*To help European researchers, businesses and research organisations in the European Union and in the countries associated with the Framework programme to have access to knowledge and expertise existing elsewhere in the world, and*
*To help ensure Europe's strong and coherent participation in the research initiatives conducted at international level in order to push back the boundaries of knowledge or help to resolve the major global issues.*

The project has as its main objective the promotion of the RTD cooperation among leading Research Institutions and Universities in the EU and Balkan countries and reinforcement of the Community science and technology capacities, in particular in the fields of dispersed and renewable generation. At present, this is particularly needed in the field of power industry in order to meet the goals of sustainable development.

The science/technology forces from the Balkan countries not in the pre-accession phase have to be recruited to adapt developments in the power industries of their own countries and wider. For that reason it is important to reduce the isolation of the scientists from these countries and to enable their work at the Community level.

RISE enhanced their abilities, involving them in cooperative programmes and transferring the knowledge and managing of project know-how. The science potentials of these countries, that are important, can then contribute to the common objectives if they are properly involved in the community science cooperation. RISE supposes close cooperation and exchange of ideas in all the proposed working packages, thus leading to an effective solution of the related problems.

RISE support to the scientific excellence within the wider international framework. The achievement of the science/technical goals specified contribute significantly to the Community and the world science thus pushing back the boundaries of knowledge:

- Researchers from the Community had the chance to access the scientific and technological knowledge available in the key Universities and Research Centers of the co-operating Balkan countries.
- European Researchers expanded their research experience and gained knowledge about the particular problems, activities and priorities of the Western Balkan countries enhancing the competitiveness and presence of the Community industry.

RISE contributed to the following policy developments:

Next to isolated inland regions, islands were a further target of the project. RISE permits the increase of the RES penetration in isolated systems and as a result, the increasing electrical demands in the islands will be met in an economical, ecological and socially accepted way. This is an important contribution, taking into account that:

In some of these islands in Croatia, there is a special island environment and an important tourism and service sector whose development is in direct conflict with any additional burden on the environment posed by an increase in fossil fuel use. Reliable and secure power supply is a basic factor in offering tourist services of high standards and is considered generally as a basic factor of everyday quality of life.

The installation of additional intermittent RES capacity will also cause short and long term employment effects during manufacturing, installation and operation phases in these countries. Moreover, the wide penetration of RES in isolated regions will cancel or delay interconnections via power networks and future installations of conventional units.

Finally, the objectives of RISE are also in line with the main European policies regarding sustainable growth. The promotion of Renewable Energy Sources (RES) and ecologically clean technologies to reduce Greenhouse Gas (GHG) emissions is a key policy of the European Commission, as expressed in the "White paper on RES" and the Directive 2001/77 on the "Promotion of Electricity from RES in the internal electricity market".

RISE will contribute to the following social objectives:

Quality of life: RISE will contribute to the regional sustainable socio-economic development in pilot rural regions. Many of these regions are now uninhabited and/or comprise regions of unique natural beauty and cultural inheritance. RISE will allow the revival of these areas and their social development and such contribute to more uniform development of the whole region.

- In FYROM there are mostly mountainous regions, relatively far from the existing electricity grid, with favourable natural preconditions for sheep breeding. The sheepfolds need electricity, not only for lighting and heating, but for their production process, particularly for introduction of modern technologies for milk pasteurization, centrifuge and vacuum milking. That would facilitate the quality of current products increasing their competitiveness on the market. Other isolated regions need authentic reconstruction and activities for protection of natural and cultural rarities, as well as a revitalization of the villages for summer and winter tourism. RISE will allow the revival of these areas and their socio-economic development.

- In Croatia a small village in the remote mountain area is selected as case study (*Busevic*), as an representative of desolated, war-ravaged regions were living conditions are at so low level that many former inhabitants are still reluctant to return. A stand-alone system for households in such place would mean much more than satisfying the needs for electricity - it would do enormous impact on helping people in alleviating the consequences of war, helping create elementary living conditions and bringing hope, and also encouraging others to return to their homes.

- In Serbia, a rural area called Rošijana, located inside the special nature reserve Delibaltska Peščara which is the largest sand dune region in Europe, was considered as the target site for designing an eco green house powered by RES. This eco house Rošijana is supposed to meet the most critical rules of environment protection which are mandatory in special nature reserve. The conservation and upgrading of sandy area special nature reserve include the protection measures regarding forestry policy, agricultural use, water resources management and sand exploitation. The development of urban infrastructure, tourism, hunting and water supply require energy sources which, concerning the ecology, should be of renewable nature. By constructing a wind turbine the wind energy will be used for the electricity production and water supply helping all the activities in special nature reserve and promoting the sustainable use of RES, energy efficiency, new recyclable material application and WWT.

Contribution to the employment:
Based on regional wind climate of Rošijana, Serbia, the municipalities surrounding the nature reserve are expected to change their economy towards electricity production from wind. Rošijana eco house is planned to be the center of enormous importance for the demonstration of RES use, dissemination of related knowledge and the education of people that has to change their own job and to go to the wind related activities. Some project related research activities will also be performed in Rošijana house. The selected site is of primary importance concerning the main project objectives and the results dissemination.

Preservation of the environment and natural resources: The maximum penetration of RES may cancel or delay future installations of conventional units.

## 2.2. Scientific and Technical description of the results

***Workpackage 1: Collection and Analysis of Data in WB Countries***

**OBJECTIVES**

The outcome of this workpackage is το provide a solid input for the succeeding workpackages, intending to attain, investigation of the potentials of RES in WBC, giving emphasis in solar and biogas energy in FYROM and Croatia, while wind energy in Serbia and biomass in Bosnia-Herzegovina.

**ACHIEVEMENTS AND MAIN RESULTS**

### T1.1 Exploring the solar and small hydro potential

The first basic goal of this task is to make an overview of the solar energy potential in Croatia and the FYROM, providing also visualized information in a form of regional solar maps. ICEIM-MANU and IRB collected and reviewed all the relevant existing studies and information on solar and small hydro potential in specific regions in Croatia and FYROM. In absence of measured solar data, both partners agreed to use the software tool MeteoNorm in order to calculate solar radiation data for some locations, being initially considered as possible target regions for RES installations in Croatia and FYROM. With regards to the small hydro potential, both countries provided the maps with locations considered favourable for construction of small hydro power plants.

**Methodology**
In order to estimate and visualize the solar energy potential the following activities have been performed:

• Collection, digitalization, processing and critical reviewing of the available data from all meteo-stations that measured global solar radiation (measured data).
• Calculation of data for global solar radiation and its components (direct and diffuse) and temperature (medium, and both extremes) for the selected target locations by making use of the software tool Meteonorm.
• Compilation of regional solar maps based on the 10 year averages of solar radiation, which show expected global solar radiation for each month.
• Development of GIS based solar maps (GIS-RISE solar maps)
• Checking the accuracy of the solar maps, comparing the values derived from the maps to calculated and/or measured values for the solar radiation for 17 selected locations, as well as to the solar radiation values from the database of Photovoltaic Geographical Information System (wherever available)

### Conclusions

Generally, with few exceptions for some months at some locations, there is a good agreement of the values from the regional solar maps and the measured data. Meteonorm-calculated data also generally agree well with predictions from the maps. The exceptions are locations for which there is no sufficient density of meteo-stations in the vicinity of the selected location. The level of the accuracy of few % (in all cases lower than 8%) can be accepted as satisfactory since it is sufficient for meaningful and reliable simulations of solar devices, for optimization of sizing of parts solar devices and for calculations of performance and costeffectiveness of off-grid PV devices.

***Detailed description of the solar maps for Croatia and FYROM is given in Deliverable D1.1 entitled: "Regional solar maps with data on solar potential".***

**Small hydro potential overview**

The second goal of this task was to make an overview of the small hydro potential in the FYROM and Croatia, considering the most favorable sites for construction of small hydro power plants.

The lists of candidate small hydro power plants as compiled by the FYROM Power Utility and Croatian MAHE were used as basis for visualizing the small hydro potential in both countries.

For each site the following set of data was collected:
• Location name
• Plant name
• Geographical coordinates (latitude, longitude)
• Mean annual water flow (m3/s)
• Capacity (MW)
• Annual energy production (GWh)
• Capacity factor (h/year)
• Status (preliminary design, main design, detail design, feasibility study; including dates)

***Deliverable D1.4 "Regional Small Hydro Maps with Data on Small Hydro Potential" contains information about the small hydro potential in the FYROM and Croatia.***

## T1.2 Exploring the wind potential

UB performed preliminary estimation of the global wind energy resources, on a basis of the existing meteorological data placing particular emphases on the rural areas of Serbia and Monte Negro (Vrsac, Dolovo, Deliblatska Peščeara, Vlasina, Kopaonik, Bjelasica, Zlatibor), not connected to the grid, or having low-performance grid.

Furthermore, measurement equipment was purchased and installed, enabling measurements, extensive research, and analysis aimed at defining a regional map concerning the average annual speed of the wind.

Researches were directed to region identification and overseeing the technical wind energy potential of Serbia with an emphasis on rural regions with a large number of isolated consumers of electric energy.

For realization of this task different types of data were used such as standard meteorological wind speed measurements for a time period of several years taken from the measurement stations in Serbia, and also dedicated measurements for a time period of one year on 40m anemometer post installed in periphery of the target region of Deliblatska Pescara.

**Performed Activities**
In order to estimate, analyze and visualize the wind energy potential the following activities have been performed:

• Acquisition and analysis of existing data of wind energy potential of Balkan Countries and Serbia.
• Collection of meteorological data for wind speed measurements at meteorological station in Serbia for 7 years period (1999. to 2005.)
• Development of Global wind potential map of Balkan Countries.
• Regular time interval touring and checking the measuring points in Vojvodina region and their modelling (obstacle and roughness models).

• Creation of vector topographic maps for Vojvodina region. The maps created according to data from Shuttle Radar Topography Mission (SRTM) and software Global Mapper.
• Creation of vector terrain roughness maps for Vojvodina region. Satellite images from Landsat 7 in resolution of 30m and panoramic images in resolution of 30m were used.
• Acquisition of measured wind speed data at 40m above ground from an anemometric post installed in targeted location Dolovo which is located in wider area of targeted region of Deliblatska Pescara.
• Identification and filtrating of bad data (caused by icing) and standardization for WAsP applications.
• Creation of wind energy potential map for 50m above ground level for Vojvodina region. The map was created using the methodology from European Wind Atlas and WAsP software.
• Creating a detailed 3D digital orography map of selected site based on 1:25000 topography maps
• Analysis of wind speed altitude profile and determination of the roughness rose at the measuring point.
• Creation of high resolution (200x200)m wind resource map of target region Deliblatska Pescara by WAsP using field measurements.
• Climatological correction of wind potential map of target region.
• Analysis of daily and annual wind velocity variations in Delibatska Peschara region.
• Identification and GPS location of isolated households (consumers) in targeted region.
• Analysis of wind resources on micro locations of isolated households (consumers) in targeted region and creation of adequate database.
• Digitalization of measured anemometric wind speed and wind direction data from the measuring point Banatski Karlovac.
• Analysis of correlation between conventional hydrometeorologyical and anemometer mast measurements (based on comparison of the average ten minutes wind speeds data)
• Analysis of annual electricity production of perspective small wind-plant in the region of Deliblatska Pescara.

Moreover, methods for the estimation of wind power potential for electricity production were developed and methods for wind velocity measurements were developed and applied. Many visits were made to the candidate sites and to a selected site and surroundings during two years work on the project and the travelled distance was over 6700km.

The following steps were performed during this project task realization:

• Identification of the reference met stations in Sought Banat
• Collecting the wind data and creating the regional wind rose map
• Inspection and modeling of the reference met stations
• Validation of wind data time series
• Formation of the regional orography, roughness and obstacles databases
• Calculation of the regional wind potential in order to select the candidate sites for the wind mast installation
• Visiting the candidate sites and selection of one site for the wind mast mounting
• Creating a detailed 3D digital orography map of selected site based on 1:25000 topography maps and GPS measurements at the site
• Geo-mechanical investigations
• Selecting and ordering the wind station equipment
• Laboratory testing of all the equipment
• Programming data logger and Internet communication via GMS
• Testing the telecommunication signals at the site
• Meteorological inspection at the site for specifying the orientation of sensors and solar panels
• Design and manufacturing of solar energy powered accumulator station
• Terrain civil works
• Wind mast and measuring equipment transportation and installation
• Testing of wind station operation at the site
• In office testing of remote internet communication and data acquisition
• Data processing
• Wind potential assessment by computer calculations based on WAsP modeling
• Generation of regional wind map

Using wind, orography and obstacles databases the wind characteristics at Zagajičko brdo site were calculated inside WAsP computer program. The homogeneous regional roughness length 0.03m was included in calculations. After all candidate sites inspection the location Zagajičko brdo was selected for the wind mast installation. The site inspection and geo-mechanical investigations provided data for the wind mast installation.

On the wind mast the following equipment was mounted after in office testing:
• 4 cup anemometers
• 2 wind vanes
• temperature sensor
• humidity sensor
• pressure sensor
• data logger
• modem with emission antenna for remote data sending using GSM communication and ISP
• lightning protection
• power supply with two solar 5W panels for data logger and remote sensing system
• accumulator station with 25W solar panel for supplying the air traffic signalization light designed and manufactured inside this project.

**Results**

The data were collected during the measurement campaign from 7th May 2006 to 14th October 2006. For data analyses the manufacture's software and a licensed WAsP computer program were used. The performed measurement and corresponding databases are the most informative source of wind related parameters collected in the target region from the period of campaign. Based on measured wind data the regional map with mean wind speed was generated that includes the orography database and assumes homogeneous roughness length of 0.03m. This map allows for more precise siting procedure in the same region to calculate the wind potential at any specific place.

The following results were achieved:

• Global wind potential map of Balkan Countries developed by ARMINES
• Global wind potential map of Serbia using methodology from the European Wind Atlas and standard meteorological data for period 1971 – 1999
• Wind potential map of perspective Serbian Region Vojvodina is estimated usingn WAsP and methodology from the European Wind Atlas and standard meteorological data for period 1999 – 2005
• High resolution (200x200)m wind resource map of target region Deliblatska Pescara is estimated by WAsP using field measurements on 40m anemometer post andmeteorological data (climatological correction);
• Correlation between conventional meteorological data and field measurements on anemometer post is analyzed;
• Seasonal variation of wind speed based on field measurements and power at target site is analyzed.

***Full results are provided in Deliverable D1.2:" Regional Wind Maps with Data on Wind Potential"***

## T1.3 Exploring the potential of biogas from wastewater

BIG provided a preliminary report related to the biogas potential from various wastes in Croatia and FYROM. Data for the choice of the technology for anaerobic WWTP was derived. In cooperation with UKIM, BIG analyzed the appropriate usage of biogas as an alternative source of energy, the possible re-usage of the effluent (purified) water from the WWTPs for irrigation, as well as calorific value of the biogas and biogas production dynamics.

***Full results are provided in Deliverable D1.6 "Report on possibilities for usage of the technology for anaerobic WWTP and biogas production"***

## T1.4 Exploring the potential of biomass

### Introduction

The basic goal of this task was to make an overview of the biomass potential in the Tuzla Canton of Bosnia and Herzegovina, and its neighboring Central Bosnia Canton, considering the most favorable sites for biomass fueled energy isolated objects.

### Methodology and Results

In the Tuzla Canton of Bosnia and Herzegovina an extensive list of a total of 13 municipalities was compiled. The results of this analysis gave information on quantity, quality and availability of the biomass form the resource analyzed, and represent incoming data for possible technologies that can be applied at the energy isolated regions. The list of distributed available biomass through out of municipalities of Tuzla Canton as compiled by the UTU and IES was used as basis for visualizing the biomass potential in relevant sites of Tuzla canton of Bosnia and Herzegovina.

For each site the following set of data was collected:

• Municipality name
• Plant name (soft wood, hard wood, mixed wood)
• Geographical coordinates (latitude, longitude)
• Bruto timber mass (m3)
• Sawdust intended for pellets (app. 10% of the timber mass) – m3
• Sawdust intended for pellets (kg); Density of prepared pellets is 250 kg/m3)
• Total Heat Value (MJ), (specific heat value of pellets at wet of 0% is amounted to 19 MJ/kg) (GWh)
• Annual energy production (MWh)
• Payment of heat & electricity obtained by means of biomass based boilers (70% efficiency; 0,14 euro/kWh) (euro)

***Full results are provided in Deliverable D1.3 "Regional Map with Data on Biomass Potential"***

## T1.5 Defining the most suitable locations for RES installation

WB Partners provided a preliminary list of target locations in the respective WB countries, elaborating the economic, social and environmental aspects of the possible RES installations.

***Full results are provided in Deliverable D1.7 " Report on target locations in the WB countries together with load identification, environmental, economic and social aspects of each location"***

## T1.6 Defining the technical requirements with respect to security, reliability and power quality

The UM has defined the technical requirements that are directly related to operational, engineering, design and assessment aspects of the isolated electrical systems based on renewable energy sources
Overall, this WP advances according to the Contract schedule. Good progress has been made on all tasks.

***Full results are provided in Deliverable D1.8 "Technical requirements for isolated electrical systems based on renewable energy sources"***

***Workpackage 2: Investigation of Low-Cost Innovative RES and Wastewater treatment solutions***

## OBJECTIVES

The objective of this Workpackage was:

A) To investigate promising, but not fully established, technologies and solutions

B) To investigate usage of new technologies for waste water treatment in rural areas

C) To assess and validate the new technologies

## ACHIEVEMENTS AND MAIN RESULTS

### T2.1 State of the art on low-cost innovative RES technologies

The state-of-art of Renewable Energy Sources (RES) technologies that could be particularly adapted to WB countries was reviewed. Robust technologies with particular characteristics suitable for isolated systems were considered with special attention to the RES technologies included in this project i.e. PV, wind, biomass and biogas technologies.
The main characteristics of commercially available RES technologies and their costs were comparatively described. Hydro sources, fuel cells, Stirling engines, power converters and other emerging technologies were also discussed.

***Full results are provided in Deliverable D2.1 : "Report on the state of the art on low-cost RES technologies"***

### T2.2 Investigation on PV materials, components and technologies

Three types of thin films of Cuprous oxide were produced and investigated their structural, morphological and optical properties. The Cu2O thin films were deposited on three different substrates: copper, glass coated with tin oxide (SnO2) and glass coated with indium tin oxide (ITO). Followingly the production was focused on Cu2O Schottky barrier solar cells using the Cu2O thin films.

**Methodology and Conclusions**

• The performance of the Cu2O Schottky barrier solar cells are found to depend on the starting surface material, the type of the junction, post deposition treatment and the ohmic contact material.
• The parameters of the produced solar cells, such as the open circuit voltage (Voc), the short circuit current density (Isc), the fill factor (FF), the diode quality factor (n), serial (Rs) and shunt resistance (Rsh) and efficiency were determined from the volt-current characteristics. Also the barrier height (Vb) was determined from capacity-voltage characteristics.
• The current-voltage characteristics of the best ITO/Cu2O/C, Ni/Cu2O/Cu and SnO2/Cu2O/C solar cells have been recorded in darkness and under 100 mW/cm2 illuminations, point by point
• The serial resistance *Rs* and shunt resistance *Rsh* for all types of the cells were evaluated from I-V characteristics.
• The diode factor was evaluated from the logarithmic plot of the dependence of *Isc* versus *Voc*, which were measured for different illumination.
• The capacitance-voltage characteristics were also plotted. The dependence 1/C2 versus reverse bias voltage for all this types of cells is straight line. The intercepts of the straight line with x-axis correspond to the barrier height *Vb*.
• From the capacitance-voltage characteristics, the values of barrier height *Vb* was determined for all type of cells.
• The future activities will be directed to depositing gold instead of Ni or C (graphite paste) because we expect that the performance may be improved by decrease of *Rs*.

**Publications**

Some of the results have been published in two papers:
*1) "Structural, Morphological and Optical Properties of Electrodeposited Films of Cuprous Oxide for Solar Application"* Balkan Power Conference, Ohrid, June 2006
*2) "Current-voltage Characteristics of the Copper (I) oxide Solar Cells"* Physica Macedonica 55, (2006) p.35-42.

***Full results are provided in Deliverable D2.2 : " Report on the outcomes of research on PV technologies"***

**T2.3. Investigation on Wind technologies**

This task includes several sub-tasks related to development of wind technologies: wind velocity measurements, possibility of low energy consumption measuring system, development of power converter for DFIG (Double Fed Induction Generator), possibility of low-noise, wear resistant gears for wind turbine gear box development by plasma technology and mathematical modeling of DFIG.

**Methodology**

The wind velocity measuring system was delivered and in-house tested together with data processing system and wireless communication. The wind mast, 50 m in height, has been delivered and completely prepared for mounting. By inspection of the local areas around the target site for wind mast mounting and nearby meteorological stations, the roughness maps were made together with the obstacles modelling. The measurements of the terrain configuration, geological investigations, mast positioning and designing of overall measuring system were finished. Two sensor types for wind velocity and direction measurements were analysed: the old type cup anemometer and the hot-wire anemometer were both mounted on the Vinca Institute 40 m height tower.
The experiment with a 5.5 kVA double fed machine (DFM) coupled with a speed controlled dc machine instead of wind turbine operated in the Power Converters Laboratory of the Faculty of Electrical Engineering, University of Belgrade (UB). An algorithm for control of a doubly fed machine installed in the experimental set up prepared for testing was developed.
The experiments with pulse plasma discharge intended for surface treatment of gears for wind turbine gearbox were performed at UB. The properties of the diode configuration glow discharge like glow-to-arc-transition instabilities, hollow cathode effect, transition region analysis, unhomogeneity due to glow discharge spreading over the cathode and the life time of the active species were considered. The surface layer properties of plasma treated steel samples were analysed by the optical microscopy, scanning electron microscopy, X-ray analysis, Raman spectroscopy, infra red (IR) spectroscopy and microhardness testing.
Mathematical modeling of the wind generator (DFIG) was carried out by UM in DigSilent Power factory. Also different voltage control strategies that can be applied to DFIG controllers to improve the transient stability of the wind turbine were investigated.

**Realized Activities**

- One year measurements at the target site, the analysis of the possibility of developing a low energy consumption measuring system and a comparative testing procedure of two measuring methods were completed.
- The development of the converter and the corresponding control logic which provide the required quality of the electric power supplied to an isolated consumer was completed.
- The development of a mathematical and logical control model of DFIG which provides the maximum efficiency of the turbine and maintenance of the frequency and rms voltage value across the load under real conditions of the wind speed variation and variation of power consumption including an asymmetric operation was completed.
- The development of the dynamic mathematical model of DFIG for the purpose of analysis of transients (short circuits, abrupt load relaxations, and similar) was completed.

- The research on several plasma technologies as the candidates for low noise, wear and corrosion resistance gear box development was completed and described in D2.3.4 report.
- The additional special report on Transient responses of distribution network cell with renewable energy sources was included.
- Additional work on comparative test of sensors, mathematical modeling of DFIG operation and plasma research was performed as well as on sollar cells and biogas production.

**Conclusions**

The investigations of the UB were focused on the possibility for development of a low energy consumption measuring system and comparative testing of two measuring methods, further investigations of plasma processing equipment and equivalent circuit and mathematical modeling of DFIG generator.

The research related to the wind measuring equipment was performed at few locations. The automatic measuring station installed at 40m wind tower at the Vinča Institute location was of great importance, conserning the fact that at this location measurements were taken with different sensor types. These measurements include 10 years wind measurements with 1st and 2nd generation of cup anemometers and 5 years wind measurements with hot wire anemometer supplied by the Institute of Physics.

It was found that the cup anemometer and wind vane sensor on the same shaft, with included sensor shaft heating, suffered from low reliability in the case of icing weather conditions and in the case of the wind speed less than 1m/s this sensor type also suffered from low measurement accuracy. On the other hand, the hot-wire anemometer has shown excellent performances, high reliability and wind peak measurements ability, but their cost is much higher.

The influence of measuring tower or measuring mast on sensor readings was also investigated. It was found, that in the case of measurements taken at two 36m telecommunication towers located in Vršac region with two cup anemometers located at the same height, the sensor readings differ up to 40% depending on the predominant wind direction. Even in the case of measuring mast located at Zagajičko brdo location, two cup anemometers show different readings up to 5% in the case of higher wind speeds (Figure 2).

Taking everything into account, the wind speed measurements were sensitive to the direction at which the sensors are mounted on the wind mast or tower. Concerning the possibility of low noise, wear and corrosion resistance gear box development by using plasma technology it was found out that with the combination of plasma nitriding and PACVD process, the developed layer resistance to wear, corrosion and fatigue can be improved. On the other hand, from previous investigation it is known that plasma nitriding lowers the noise acoustic level of the gears.

***Detailed information about the Wind technologies are contained in Deliverable D2.3 "Report on the outcomes of research in Wind technologies".***

**T2.4 Investigation on wastewater treatment with production of biogas**

The pilot WWTP system consists of two tanks. In the first one, the anaerobic fermentation was carried out, with the production of biogas. The second tank was filled with bacterial bio-carriers, where the final biooxidation of the organic matters will be accomplished. This was the final version of the planned pilot system design which was going to be altered according to the potential research planned in the future actions.

The aims of the experiments conducted by BIG, ICEIM-MANU and UKIM were:

- Optimal chemical composition of the WW for higher biogas production
- Optimal dry mater concentration of the WW for higher biogas production
- Optimal conditions (temperature) for optimal fermentation and high biogas production (psychrophylic and mesophylic conditions)
- Conduction of mesophilic anaerobic wastewater (WW) fermentation with the usage of one group of hydrolytic enzymes.
- Influence of the temperature over the biogas production velocity
- Usage of cellulolitic bacterial cultures in anaerobic mesophilic fermentation.

**Methodology**

To conduct tests 0.5 and 1 dm3 Zeykus serum chambers were used, as well as conventional and UASB reactors with a working volume of 3 lt. The extracted biogas was accumulated in graduated cylinders, previously filled with an acidic saturated solution of NaCl. The chemical analyses were conducted in accordance with the APHA (American Public Health Association) standard.

The following parameters were monitored: total dry, organic and mineral matters, total nitrogen, COD, BOD5, nitrite, nitrate and ammonium nitrogen, phosphates, K, Ca, Mg, heavy metals etc.

*Anaerobic mesophylic fermentation of water with 0.5%, 1% and 5% dry matters* From the results it was concluded that the water with 1 d.m. is most suitable for conducting of anaerobic fermentation.

*The effect of a previously adapted anaerobic starter culture on the speed and productiveness of the anaerobic fermentation.*
For each following test 20% of the inoculum from the previous test was left behind, and 80% fresh substrate was added. The increased production of biogas in the tests compared to the controls for both of the substrates clearly points at the positive effect that the anaerobic mixed bacteria culture has on the anaerobic fermentation.

*Anaerobic fermentation of water with 1% and 5% d.m. at a temperature of 18-22ºC and 30ºC* In order to determine the influence of temperature on the anaerobic methanogenesis, a 62 day fermentation was conducted at ambient temperature of 18-22ºC and 30ºC. Parallel to the psyhrophylic fermentation, a mesophylic fermentation on the same substrate was conducted as well, with a duration of 21 and 72 days.

The final design of the laboratory pilot wastewater treatment plant is the following:

The anaerobic laboratory pilot digester is assembled from glass. It is consisted from one anaerobic reactor. The reactor has double glass walls for the purpose of temperature control.
The released biogas was collected in a biogas collector.
The influent enters in the lower part of the reactor, than the water passes trough a layer of microbial biomass, and at the end the effluent leaves the reactor from the top side of the reactor. The effluent is then collected in a sedimentation tank.
The final water purification is conducted in an aerobic reactor.
The reactor was assembled from glass and it was consisted of one aerobic cylinder in which the nitrification of the water is taking place (with diffuser) and one anoxic cylinder where the denitrification is taking place.

**Conclusions**

- It was found that the WW with 1 % d.m. is the most suitable one for anaerobic fermentation. With the usage of previously activated anaerobic microbial culture, the biogas production is increased. For every next experiment it is necessary to use 20 % of the WW from the previous test, and the other 80 % need to be from fresh substrate.

- From all the previous experiments we concluded that the best microbial enzyme for biogas production of 500 $cm^3$, is the combination of cellulase and pectinase.

- The utilization if organic matters compared to the control (43 %) is highest with the enzymes pectinase and cellulose and with "BIG" – compound combination is 61 %.

***Detailed information about the pilot WWTP with production of biogas are contained in Deliverable D2.4. "Report from the pilot WWTP with production of biogas".***

**T2.5 Research on exploitation of biogas**

The research was focused on

- Studying and analysis of different techniques for conversion of biogas in order to obtain the highest exploitation of energy;
- Estimation of the energetic potential, quantity and velocity of production as an influent to the cost-effectiveness of the particular biogas sources;
- Recommendations for applications in WBs countries;

**Methodology**

Firstly a preliminary investigation on the benefits of anaerobic digestion (AD) technology, the possibilities for production of electrical energy from biogas has been completed and studied some other applications of biogas.

Secondly investigations on the biogas production and its use for thermal and electrical energy conversion were based on the two pilot projects for small settlement and small sheepfold with cheese production facility were performed, as well as the investigation on the available software resources for:

- biogas utilisation,
- cost/benefits of a biogas plant,
- economic calculations with different interest rates
- payback time.

**Development of mathematical model of a biogas plant**

**Major findings and recommendations**

The utilization of biogas and anaerobic digestion (AD) technology offers variety of different kinds of benefits and advantages, such as: Waste Treatment Benefits, Energy Benefits, Environmental Benefits and Economic Benefits.

There are also some disadvantages: costly initial investment, proper care and feeding the digester, required technical knowledge, maintenance of the equipment, chemical processes that lead to ammonia or nitrates.

In general, the obtained benefits and advantages surpass the disadvantages.

**Mathematical model**

The main task of the mathematical model is estimation of the potential of biogas. Two basic approaches are implemented: estimating the available material and the solid fraction of the material or estimation based upon the number and kind of animals.

**Recommendations**

The most promising way of exploiting biogas in isolated, but also in grid connected systems is Combined Heat and Power Plants (CHPP), where the effectiveness may reach nearly 80 %. Biogas, as the burnable methane produced in digesters, can be used to generate electricity (there are some cases where electricity price equivalent of 6 cents per kWh is reached), heat farm buildings and keep the digesters at operating temperatures. The residue from biogas production has little odor and retains all the fertilizer value of manure.

The following recommendations for estimated biogas quantity and necessary installed power should be taken into consideration when analyzing different biogas sources and different types of consumers. Energy estimates are for animals kept in a stable all year, and are reduced by 20% for taking into account the biogas process heat.

Calculation of the number of animals for different types of consumers

| Type of the consumer | Installed power (kW) | Biogas volume ($m^3$) | Cows (appr. number) | Pigs (appr. number) | Sheep (appr. number) | Chicken (appr. number) |
|---|---|---|---|---|---|---|
| Isolated single house | 5 | 20 | 12-15 | 90-95 | 230-280 | 1300-1400 |
| Isolated village, 10 houses | 50 | 200 | 120-130 | 920-950 | 2350-2850 | 13000-13500 |
| Small city | 1000 | 4000 | 2400 | 18500-19000 | 50000 | ~270000 |

***Detailed information about the research on exploitation of biogas is contained in Deliverable D2.5. "Report on cost-effective technology for usage of biogas".***

***Workpackage 3: Development of advanced Decision Support Methodologies for dimensioning of RES in isolated grids***

## OBJECTIVES

The outcomes of this workpackage are:

- Development of decision support system (DSS) including methodology and tools for investment decisions in RES in isolated regions
- Providing DS for Comparison of different RES systems configuration and comparison with other modes of electricity supply
- Computer simulation of the system operation and forecasting of the produced energy
- Economic and environmental analysis
- Security of supply
- Risk assessment

## ACHIEVEMENTS AND MAIN RESULTS

### T3.1 Survey of state-of-the art of DSSs for energy systems in isolated regions

The aim of this Task was to provide a state of the art search of decision support systems (DSS) for energy systems especially designed for stand-alone systems. A special care in the survey was to be given to modeling of characteristics of individual RES technologies: wind, biomass, biogas and other technologies addressed in the case studies of this project. ICCS/NTUA has surveyed of the state of the art.

***Detailed information about the Survey of state-of-the art of DSSs for energy systems in isolated regions is contained in Deliverable D3.1. "Summary of existing DSS".***

### T3.2 Development of decision support methodology for investment decisions in implementation of RES in isolated regions

The objective of this task was the development of a model for RISE-DSS that will be used for investment analysis in selected WP4 cases. The work was focused on setup of supporting analyses structure, definition of main external factors, selection of analysis criteria / attributes (Supply Reliability, Economics, Environment), investigation of key uncertainties and comparison and selection of risk indicators, selection of adequate multi criteria decision aid/system, choice of risk assessment model and comparison of different risk management options. The results were a set of equations, suitable for programming of the RISE-DSS.

#### Methodology

The List of Inputs that needed to be measured at the selected sites in WP4 in order to enable for calibration of RISE-DSS, was provided. Partners took responsibility to prepare technology/energy source modules of the Model. An overall model concept was prepared including modules for demand, supply (seven sub-modules for Photovoltaics, Wind Generation, Small Hydro Generation, Biomass, Fossil Fuel Generation, Storage and Economic Dispatch), a Reliability module, a Financial Module, an Environmental Module and an MCDM (MultiCriteria Decision Making) Module

#### Achievements

Data dictionary and User's Manual has been compiled, along with a set of pre-defined examples of solved simulations.
To ensure the usability of the RISE-DSS program, an Additional Deliverable, D3.5 entitled "Report on DSS tools: User Manual" has been set up. The report was aimed to enhance the impact of the WP 3, improving the resulting program package and make it more usable to the target beneficiaries.

***Detailed information about the development of decision support methodology for investment decisions in implementation of RES in isolated regions is contained in Deliverable D3.3. "Report of DSS Methodology and tools".***

#### Decision Support System

According to the functional specification, the decision support system conceived (RISE-DSS) comprises the following modules:

#### Overall Model Concept
The first task that was worked on by ULJ and IES was overall model concept**.**

**Demand Module**
The demand module was completed by INESC and ULJ. Its purpose was to identify the demand to be supplied by the system. This information was essential to conceive the energy supply system and evaluate the required reliability. The objective of DAM was to provide daily demand curve for the entire system planning horizon to the Supply Module. The daily demand curves have hourly resolution and contain information about demand level and its uncertainty.

**Supply**
This module contains seven sub-modules, Photovoltaics (PV), Wind Generation (WG), Small Hydro Generation (HPP), Biomass (BM), Fossil Fuel Generation (FFG), Storage (STG) and Economic Dispatch (ED).

**Supply - Photovoltaics**
UM and ARMINES have developed a model of PV plant suitable for decision support analysis. The developed "solar module" enables estimation of hourly contribution by PV generation. A simplified formula for modeling of PV generation together with an Excel document containing program written in VBA for an estimation of hourly contribution by PV generation during one year period was prepared to test the proposed model setup.

**Supply - Wind**
Wind Generation submodule developed by ARMINES and UM provides wind production curves according to the selected generation architecture. There are two major steps to calculate the production curves. Generation of wind speed data series and Modeling the wind turbine to obtain production curves. The submodule produces a generation curve based on uncertain wind availability.

**Supply - Hydro**
The hydro module was completed by IES and INESC. The task of this submodule was to calculate the supply curve of small run-of-river hydro power plant (HPP). The HPP supply curves are created using next two steps:

Preparation of a set of $N_{sc}$ hydrologies for different hydrological conditions (provided by User). Optional:

User can use Monte-Carlo simulation to simulate hydrologies.

Modeling of turbine (conversion of hydro energy to electricity).
The submodule produces a generation curve based on uncertain hydrology.

**Supply - Biomass**
The Biomass Submodule based on a model of a thermal power plant run on biomass was developed by IES and ULJ. The thermal power plant was a steam turbine power plant. The parameters of the plant, such as ramp up and ramp down times, are used in economic dispatch submodule as optimization constraints.

**Supply - Fossil**
The fossil submodule developed by ARMINES and ULJ provides generation parameters of different types of fossil fueled generators, diesel generators in particular. The generation parameters, such as ramp up and ramp down times, are used in economic dispatch submodule as optimization constraints similarly as with biomass submodule.

**Supply – Economic Dispatch**
The Economic Dispatch submodule was developed by ULJ and IES. Based on a set of simulated uncertain fuel availability scenarios, each of the three fuel-uncertainty dependent RES sources, PV, WG and HPP are scheduled. The remaining three fuel uncertainty independent modules, BM, FFG and STG were then dispatched according to the demand. In this submodule, their dispatch was optimized in ED, aiming for minimum fuel costs and minimal emissions.

**Storage**

The Storage submodule was developed by UM and ARMINES. A suitable methodology to dimension storage devices to compensate for the intermittence of RES in isolated systems with intermittent RES/Hybrid was proposed. A storage model that could be used in evaluation of RES system operation in isolated regions was developed, and that can be dispatched according to the demand.

**Reliability Module**

ULJ and IES also developed reliability module which calculates reliability parameters such as healthy state probability p(H) of the system and energy not served probability ENSP for different reliability groups. The module calculates the reliability indices of the selected Supply Architecture for all investigated Supply Scenarios.

**Financial Module**

IES and ULJ together also developed financial module which calculates key economic parameters such as investment costs, price of electricity, internal rate of return IRR and net present value NPV. Based on the actual supply curves and the annual energy produced, it calculates the financial parameters of the current Supply Architecture under various uncertain scenarios.

**Environmental Module**

Environmental module for calculation of emissions was developed by IES and ULJ. The module analyzes the $CO_2$ emissions arising from the current dispatched supply and the avoided $CO_2$ emissions.

**MCDM Module**

The Multicriteria decision making module structure was developed by ULJ and IES. The module was the envelope of the RISE-DSS. The first of its two sub-modules, the Input sub-module, provides for the input of all user-supplied parameters, featuring drop-down menus with pre-determined selections of typical generation units. This way, the user can assemble a Supply Architecture to simulate in the next scenario run. The Reporting sub-module is presenting the results of economic optimization and sensitivity analysis in graphical and tabular fashion for the user to appraise the feasibility and suitability of the current Supply Architecture to match the reliability, environmental and economic requirements. The User can then modify the Supply Architecture and run the simulation again.

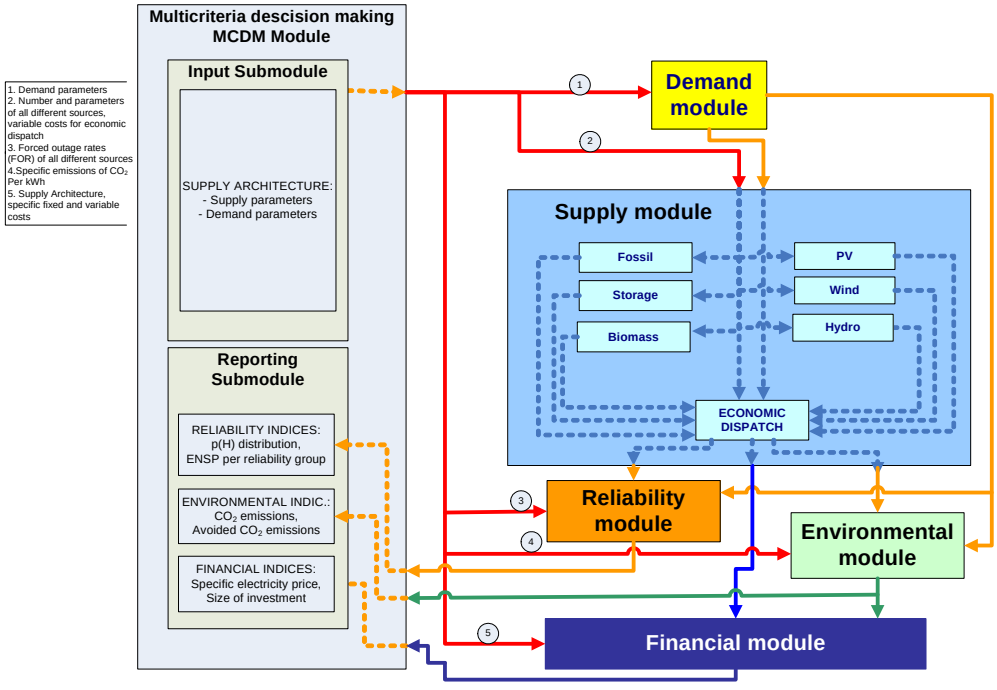



Figure 3.2.1: Overall model concept

***Detailed information is contained in Deliverable D3.5. "Report of DSS Tools: User Manual".***

### T3.3 Development of web-based DSSs

**Introduction**
In this task, the RISE-DSS tool, defined has been programmed. The RISE-DSS model integrates simulation of operation of various RES technologies and technologies in hybrid systems. The tool ease investment decision in isolated systems using RES in the pre-feasibility phase. The key criteria considered in the Multi-Criteria Decision Making are economics, supply reliability and environmental impacts of given technology source combinations.

**Methodology**
The RISE-DSS model integrates simulation of operation of various RES technologies and technologies in hybrid systems. Modern techniques for forecasting, modelling and simulation, based on artificial neural network techniques applied for complex RES and hybrid systems in isolated regions. ANN techniques were used for forecasting and modelling uncertainties such as electricity demand load, availability of resources like hydrology and wind and for simulation of the system operation for various system configurations and technologies. In the frame of investment decisions an analysis optimal operation modes was accounted. A special care was given to complex configuration and careful modelling of load shape characteristics. An adequate model for risk assessment to compare different risk management options for such projects was developed. The tool eases investment decision in isolated systems using RES in the pre-feasibility phase.

The key criteria considered in the Multi-Criteria Decision Making are economics, supply reliability and environmental impacts of certain TSCs. It should enable:

- comparison of RES technologies,
- determination the optimal size of the given technology source combinations (TSCs),
- assessment of economic benefits of the alternative solutions,
- simulation of system operation and forecasting of energy production,
- assessment of environmental benefits,
- calculation of security of supply
- risk management factors.

**Achievements**

All modules of the decision support tool (RISE-DSS) were prepared and programmed by all partners according the agreement, using the concepts of advanced Decision Support Methodologies for dimensioning RES, developed in T3.2. The assessment and quantification of uncertainties was done as well.

Since the web-based application would pose problems regarding the processor power and hosting of the web-application after the project end, it was decided to develop RISE-DSS as a web-available standalone application.

After the initial investigations, the ANN have proven not to possess the sufficient qualities required to conduct the necessary analyses and modeling tasks according to the chosen modeling approach, so it was decided to use scenario analysis approach based on Monte Carlo method coupled with linear programming optimization instead.


Fig. 3.3.1: User interface of Demand Data Sheet

***Detailed information about the Development of web-based DSSs is contained in Deliverable D3.4. "Web-based DSS Modules".***

***Workpackage 4: Application to selected target Sites***

## OBJECTIVES

The outcomes of this workpackage are:

- Optimal Design of RES installations at the Selected Sites
- Assessment of economic benefits
- Assessment of environmental benefits
- Life cycle analysis of the proposed installations
- Comparison with other methods of electricity supply

## ACHIEVEMENTS AND MAIN RESULTS

### T4.1 Application to the study cases of Croatia

**Introduction**

The main area of the research was the application of photovoltaics (PV) for electricity production at isolated places at two types of locations that are not connected to the national grid: a location on a Croatian islands and a location in the continental, remote, war-devastated region. The main criterion in the process of location selection was that the cost for grid installation was too high to be economically feasible, and that the proposed design of solar devices would have a high replication potential at other off-grid locations.

**Methodology**

1. Potential locations, candidates for study cases, were visited during the summer/fall months. The main criterion in selection was that the locations were not connected to national grid, that the cost for grid installation was most probably too high to be economically feasible, and that the potential of the proposed design would have a high replication potential at other off-grid locations. Specifics of selected locations were determined, like: the orientation of the object, inclination of the plane on which the PV modules would be installed, possible local shadings or shading of the whole area (higher neighboring hills etc). For maritime locations distance from the sea was determined related to the salty environment that the RES have to withstand, which in turn should have impact on the life-cycle analysis. Extensive photo-documentation was made.
2. Initial contacts with the potential users have been established. The input data regarding the environmental, techno-economic and social impact that the RES installed on the selected sites could have on the local community and on the further development of the area were collected.
3. Priorities of needs of inhabitants at selected sites for specific loads (electricity) were collected (supplied to WP1-T.1.5). Detailed estimates of the expected electricity consumption (expected load) were estimated based on the most important needs and habits (including daily electricity consumption/load throughout the year and hourly distribution of the consumption during the day/night). The form for target sites provided by NTUA (as Task Leader of T1.5) was used for organizing data on loads as averaged monthly values given in hourly time intervals. Initial List of input data related to PV (global radiation and loads – electricity consumption), was prepared in accordance with the requirements in WP1, WP3 and for the RETScreen computer simulation program.
4. Initial contacts established with some local authorities provided information about some sites/villages/households without electricity, while HEP (Croatian Electricity Dispatcher Company, HEP) provided prices of connecting to the grid for some of these locations – an important input parameter. These contacts were also very important for the dissemination phase of the project.
5. RETScreen computer program, a standardized and integrated RES project-analysis-software was prepared for the use for pre-feasibility, quantitative analysis of various PV systems at selected locations. We started to create a Database of various Input data relevant for Croatia concerning PV solar systems and system components that are available at the Croatian market. That would enable

realistic simulations in order to optimize size/price ratio of PV solar systems and determine optimal relative size of components. Data were organized in the RETScreen-adapted format.

**Test Sites Characteristics**

- General Characteristics
  The test-site for island location was a restaurant with a small marina and few rooms to rent on the *Island Zut*, in the *Kornati archipelago*, in Zadar-Sibenik region of the Croatian coast, described in detail WP1 in (location and Load in D.1.7, solar potential in D.1.1, as well as in a paper cited in WP1).

- Technical characteristics and optimal design at the selected island location
  PV system was designed to satisfy basic electricity needs taking into account daily and monthly variations. Optimization of the PV-system sizing was done by maximizing solar-covered fraction of the Load, and minimizing unused PV- produced electricity. Design was versatile so that was applicable on numerous similar locations (modularly scalable to smaller/larger load); PV installation, particularly PV modules selected to be robust, reliable and resistant to humid, salty, maritime atmosphere. Detailed optimization of the PV-system components, calculation of performance and cost-effectiveness of particular PV system was done by PVSYST and RETScreen programs.

- Costs and economic aspects
  For direct purchase (without loan) and with no incentives, the initial cost was estimated. The return of investment was 15 years. By using subsidies and incentives that were available for RES installations at islands the cost of a PV system, the price of electricity and the effect of incentives for long-term loans were analyzed.

- Environmental & social aspects/benefits
  The effective reduction of CO2 by the PV electricity production in this case study was analyzed and a computer program for the life-cycle analysis of PV systems was developed and used to optimize selection of components in PV system. Social aspects have been also analyzed.

**Results**
The Major Achievements were:

- Optimized PV system design
- Conditions for economic viability were devised/identified (economic viability, including Sensitivity and Risk analysis, etc)
- Quantitative environmental impact/benefits determined (including Life-Cycle-Analysis)
- Social impact/benefits determined in terms of job creation, sustainable development of small islands and remote, war devastated mountain regions
- Recommendations were given for wide-scale application of PV at off-grid locations in Croatia

**Additional important features** were:
- Very realistic simulations for optimization of PV system using several state-of-the-art softwares (Meteonorm, RETScreen, PVSyst and DSS-RISE (developed in WP3); with the goal to maximize part of electricity Load covered by PV AND to minimize waste of PV- produced energy
- A computer program developed for Life Cycle Amalysis (LCA)
  Croatian partners influenced new by-laws with feed-in tariffs through the activities in Chamber of Commerce of Croatia.Quantitative potential for each RES in Croatia was determined and present status (installed capacities) of each RES in Croatia were listed.

**Conclusions**

- Detailed analysis of two Study Cases quantitatively demonstrated the advantages of wider implementation of PV
- Obstacles to wider implementation of RES and PV in particular were identified:
  - ❖ Initial costs of PV devices are still very high and appropriate investment financing schemes are essential to bridge them; with end-of-the-project huge positive cash-flow result

- ❖ the other important obstacle was found to be a low level of knowledge -technological, practical, financial, environmental and, particularly, about financing opportunities; recommendations were given how to optimally resolve them

- After removing/alleviating these obstacles PV could enable economic development, especially of tourism, with minimal environmental damage both at island and mountain locations without grid

***Detailed information about the Application to the study cases of Croatia is contained in Deliverable D4.1. "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of Croatia".***

**T4.2 Application to the study cases of FYROM**

**Introduction**

The task's activities were related to data collection and examination of RES potential for the target locations, while a suitable electricity supply system for the selected target locations was designed.

**Performed activities**

The selected locations were visited during summer months. Also possibilities for installation of measuring equipment at different measuring points at the selected locations were investigated, in order to complete the list of input data. Meanwhile additional data through other relevant institutions in the country were collected.

The possibility for further use of the pre-feasibility studies was promoted, which would be created in the framework of this project to local community or interested companies/institutions.

The visit to the selected locations was essential for gathering on-site information. It allowed to check the site conditions (site orientation, latitude, longitude and height; site exposure to sun and wind; distance from existing network; connections to nearest settlements (telecommunications and roads); etc.); to compare the results with the data already collected; to identify possible consumers and check the possibilities to install measuring equipment.

Efforts were made to collect as much relevant information for the locations as possible. Some data were obtained from the on-going project for the new wind atlas for FYROM and some information was obtained in collaboration with MEPSO.

The compiled data for RES potential and electricity requirements for the target locations have been analyzed. Based on those analyses, the decisions for selection of most suitable RES applications for each of the locations have been made.

The selection and sizing of the RES applications for the target locations were made using the software tool RETScreen. Several designs, using different available technologies have been examined for each of the locations.

Using available parameters, characteristic for the country, the economic aspects of the proposed designs have been inspected. Cumulative cash flow analyses were performed and compared. For each case, direct purchase and possibilities for obtaining loans were considered and return of the initial investment was assessed. It was concluded that the year to positive cash flow varies, but usually it takes more than 10 years to return the initial investment. For successful evaluation of the economic aspects, the socio-economic benefits should be also considered.

Environmental aspects for the proposed applications were also examined. RETScreen enables assessment of $CO_2$ reduction when RES application would be installed instead of other electricity supply system. As base case, replacement of diesel generators with RES application was examined.
The proposed designs were compared to base case scenarios where diesel generators were used for electricity supply. This is justified, as use of diesel aggregates is the most common way for covering electricity needs in isolated locations. The comparison to grid extension was being examined in collaboration with MEPSO.

**Methodology**

In FYROM three locations were selected as test-sites for Study Cases, of which two were sheepfolds – *Fezlievo Bacilo* and *Belanca*, while the third one was the village *Kicinica*, a cultural monument with specific rural architecture form the 19th century; all locations being in *National Park Mavrovo*.

For each of the target locations, an off-grid PV system was anticipated and proposed systems were compared to different reference scenarios for electricity supply: particularly with grid extension and with (presently used) diesel generators. For each of the target locations, an appropriate Waste-Water-Treatment (WWT) system was proposed.

The WWT systems as foreseen for the target locations in FYROM were based on anaerobic digestion, conducted in a biogas plant. To test assumed processes a Laboratory WWT system was built. The anaerobic laboratory pilot digester was assembled from glass. It consists of one anaerobic reactor with 3L volume capacity. The released biogas was collected in a biogas collector while the effluents were collected in a sedimentation tank. The final water purification was conducted in an aerobic reactor. The reactor was assembled from glass and it consisted of one aerobic cylinder in which the nitrification of the water took place (with diffuser) and one anoxic cylinder, where the de-nitrification took place.

**Conclusions**

The proposed PV systems were designed to supply the needs of the isolated locations. Main findings of the analysis include: The pay-back period of the systems is rather long (15 – 25 years, depending on the energy escalation rate ), but still, since the estimated (and even guaranteed) lifetime of PV solar cells/modules is rather long at the end of the life-time balance is still positive. The uncertainties of fuel and electricity prices and changes in equipment prices have big effect on the economic performance of the projects, emphasizing importance of such analyses. In this stage of PV market development incentives are needed to attract investments in these types of projects and to bridge the problem of large initial investment.

The waste water treatment itself has immense significance in dealing with waste and preserving the environment, taking into account that the locations were situated in the National Park *Mavrovo* and the surroundings. The analyses showed that these types of systems allow significant annual reduction of GHG emissions compared to the reference scenarios - 7.7 tons of CO2 spared each year for Study Case in *Fezlievo Bacilo*, for example.

The added values of the proposed solutions were recognized in the social and environmental benefits. These projects would allow job openings and stimulation of local economy, which is of vital importance for the region in which the economical situation has worsened in the past 10-15 years, as several smaller companies that existed in the area have been closed. The census showed that 28% of the population in the municipality is economically active, of which 61.6% are unemployed!
The proposed off-grid electricity system and WWT plant would help in the development of rural tourism, while protecting the environment as well. Job openings are expected for management and maintenance of the tourist facilities and operation and maintenance of the electricity and WWT systems.

Benefits can be expected at the sheepfold locations, too. The electricity supply would improve the working conditions of the sheepfold staff and help the company produce cheese and diary products with high quality. These products would have better chance for success in the competitive market than the products they already produce.

***Detailed information about the Application to the study cases of FYROM is contained in Deliverable D4.3. "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of FYROM".***

## T4.3 Application to the study cases of Serbia

### Introduction

Two locations were analyzed in detail, the old forestry house, *Rosiana* and an *isolated household*, both located in Nature reserve *Delibatska Pescara* in Serbia.

The old forestry service house Rošijana, located in Special Nature Reserve Deliblatska Peščara was selected as the target site for study case of RES application in Serbia. The eco house was powered by RES since no grid connection existed in this rural region and the most critical rules of environment protection which are mandatory in special nature reserve were to be satisfied - conservation and upgrading of sandy area special nature reserve including the protection measures regarding forestry policy, agricultural use, water resources management and sand exploitation. The eco house consists of residential house, workshop house, mechanical house with the equipment for water supply, artesian well, water pull and the garden. The electricity needs were fulfilled by the wind and solar photovoltaic conversion. Biomass is the dominant heat source. In addition, solar heating is used and a small amount of electricity for security reason and for air conditioning during the summer.

### Methodology

The electricity load was assessed; either by foreseeing activates and related electricity consumption (*Rosiana*) or by measurements of the electricity of a household similar to *isolated household* but which is not connected to the grid
Wind potential for *Rosiana* was assessed from measurements at near-by *Zagajičko Brdo*, where a wind mast with measuring equipment was erected through the RISE project. For *isolated household* the wind potential was assessed through the combination of computer simulation (WAsP) and measurements at wider region. In addition, the high-resolution map (200x200 m) of wind potential of the whole target region (35x35 km) was devised.

### Conclusions

It is shown that management of energy consumption can reduce the size of electricity storage system: through the categorization of consumers, regulation of energy consumption profile and optimal peak-demand management a considerable reduction of the storage capacity of the accumulator (battery) was envisioned, providing maximal economy with minimal discomfort in using wind-produced electrical energy.

The cost analysis of connection to public distribution network of either of analyzed isolated consumers shown that it would be more expensive than providing electricity with the wind turbine.

It is shown that, besides direct ecological benefit due to much lower $CO_2$ emissions, RES installations at the selected sites are providing symbolical benefit and impulse to ecological societies in this region for the preservation of natural environment. For chosen RES installations, life cycle analysis was conducted considering projected life cycle of 25 years.

Despite different approaches of analysis of two selected objects (eco-house *Rosiana* and *isolated household*) results and conclusions in two reports were amazingly similar: 1 kWh to produce from wind would cost 0.24 and 0.22 Euro/kWh, respectively.

Besides additional work in analyzing in detail two instead of planned one Test Site in Serbia, the benefits in the form of implementation of results are already felt: experimental data of measuring campaign close to *Rosijana* site were already used for pre-feasibility study of a 106 MW wind farm in *South Banat* region. The RISE results of D4.2 are particularly important for the neighbouring region of *South Banat* where relatively large wind farms are planned in the future.

***Detailed information about the Application to the study cases of Serbia is contained in Deliverable D4.2. "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of Serbia".***

### T4.4 Application to the study cases of Bosnia Herzegovina

#### Introduction

The public mountain house for vacationing, leisure and recreation was selected as the target site for study case of Renewable Energy Sources (RES) application in *Tuzla Canton*, in Bosnia and Herzegovina. The house was planned to be equipped by an ecologically neutral energy source.The suggested RES has low level of maintenance. Building of real instalation based on selected Study case would help in rising the awareness of people regarding new technologies and opportunities for the new job positions.

#### Methodology and Conclusions

The biomass **data** in the view of forest (hard and soft wood) and wood processing residues (sawdust) were collected from all *Tuzla Canton* municipalities that are potential resource for providing the sawdust to feed the house's device. The data were collected from Ministry of forest and forest processing companies.

The sawdust as a byproduct of wood processing can be transformed in pellets through the one of thermal processes. It is a promising energy resource to equip remote objects such as houses and villages that are not connected to power grid. Regarding **technical aspects**, the comparative study of the different machines that can be powered by pellets has been conducted. For each of them the detailed technical, technological, economical, and ecological study has been performed. Machines powered by pellets, the Stirling machine, ORC based machine, Inverse gas turbine cycle, Hot air turbine cycle (indirect gas turbine cycle), and Steam screw-type engine process are compared. Using Analytical Hierarchical Approach the Stirling machine has chosen as the most promising one.

A software was also developed as a tool for decision-makers to choose from various RES technologies and analyze their different aspects.

In analysis of **techno-economic aspects** four types of costs are identified:
Capital costs (depreciation, interest costs),
Consumption based costs (fuel, auxiliary energy, consumables),
Operation-based costs (personnel costs, costs for maintenance),
Other costs (administration, insurance).

Several analized fuels that are based on wood processing residues have been considered, in order to find the most appropriate biomass fuel source: bark, pellets, and forest wood chips. At the same time, the other factors such as possibilities to gather forest and wood processing residues have been included in to process of estimation of key uncertainties.

After reviewing all aspects (technical, ecological, economical, job opportunities, etc.) of possible fuels, based on wood residues, pellets were selected as the optimal biomass source in Bosnia Herzegovina. The selection procedure that ensures the optimal electricity supply architecture was developed. It is preferable

to use the selected technology (Stirling machine) that works in CHP (cogenration) mode so that provides both the heat and electricity to the isolated objects.

In study of *Environmental aspects/benefits* including *life cycle analysis*, various biomass-related RES configurations are assessed, and compared both among themselves and with and diesel aggregate and with bring the grid. Based on all these analyses *the Recommendation on application of RES in isolated objects* was given.

***Detailed information about the Application to the study cases of Bosnia Herzegovina is contained in Deliverable D4.4. "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of Bosnia Herzegovina".***

## *Workpackage 5: Design of Operational Tools*

### OBJECTIVES

The objectives of this WP was to study control and operation of RES supplied isolated regions, to prepare a software tool for control of RES supplied isolated regions, to optimize operation of RES supplied isolated regions and to apply the operational tool developed on the selected sites

The outcomes of this workpackage are:

- To provide a survey of the control and management tools developed within other EU and national projects, as well as tools currently used in isolated systems, like islands, microgrids, etc.
- To start preparing short-term load and renewable forecasting functions for operational planning purposes
- To start preparing functions for optimal scheduling based on the forecasted consumption and RES production
- To start designing a new system and technology for biological WWT and production of biogas.

### ACHIEVEMENTS AND MAIN RESULTS

#### T5.1 Survey of the state of the art tools for operation and control of RES supplied isolated systems

ICCS/NTUA has performed a survey of the control and management tools developed within other EU and national projects, as well as tools currently used in isolated systems, like islands, microgrids, etc.

***Detailed information about the Survey of the state of the art tools for operation and control of RES supplied isolated systems is contained in Deliverable D5.1. "Survey of State of the art tools for operation andcontrol of RES supplied isolated regions."***

### T5.2 Development of Short-Term RES and Load Forecasting functions

ARMINES has investigated the application of time-series analysis and mainly artificial intelligence techniques for short-term RES and Load Forecasting issues with respect to the systems considered in the project.

Example case studies were taken that can be considered as representative. Data from these cases were used to illustrate the particularities related to prediction. These particularities were mainly due to the small size of the systems. Due to the lack of data from the case studies of the project, the size of the Task is reduced. Some resources are transferred in WP1 for the realisation of the wind and solarmmaps for the Western Balkan countries.

***Detailed information about Development of Short-Term RES and Load Forecasting functions is contained in Deliverable D5.2. "Theoretical background, flowcharts and preliminary results of forecasting algorithms."***

### T5.3 Development of Optimal Energy Scheduling Functions

ICCS/NTUA developed functions to optimize the scheduling and operation of isolated systems with RES, including the application of battery energy storage systems for static and spinning reserve, based on the forecasted consumption and RES production.

The functions optimize the operation of:

- RES with variable energy output (wind, solar);
- RES with constant energy output (biogas);
- Conventional, thermal units like diesel.

The possibilities of battery energy storage systems and their use in hybrid systems for static and spinning reserve in isolated grids have been considered.

***Detailed information about Development of Short-Term RES and Load Forecasting functions is contained in Deliverable D5.3. "Theoretical background, flowcharts and preliminary results of energy scheduling algorithms."***

### T5.4 Development of Integrated Optimal Operation Tool

In this task, ICCS/NTUA provided the functional specifications of the Control Tool demo based on the analysis of the economic scheduling functions which was analyzed in task 5.2 and 5.3.

The control of a remote site with Renewable Energy Sources requires data exchange between the central control site and the remote site. This is schematically described in the next figure:

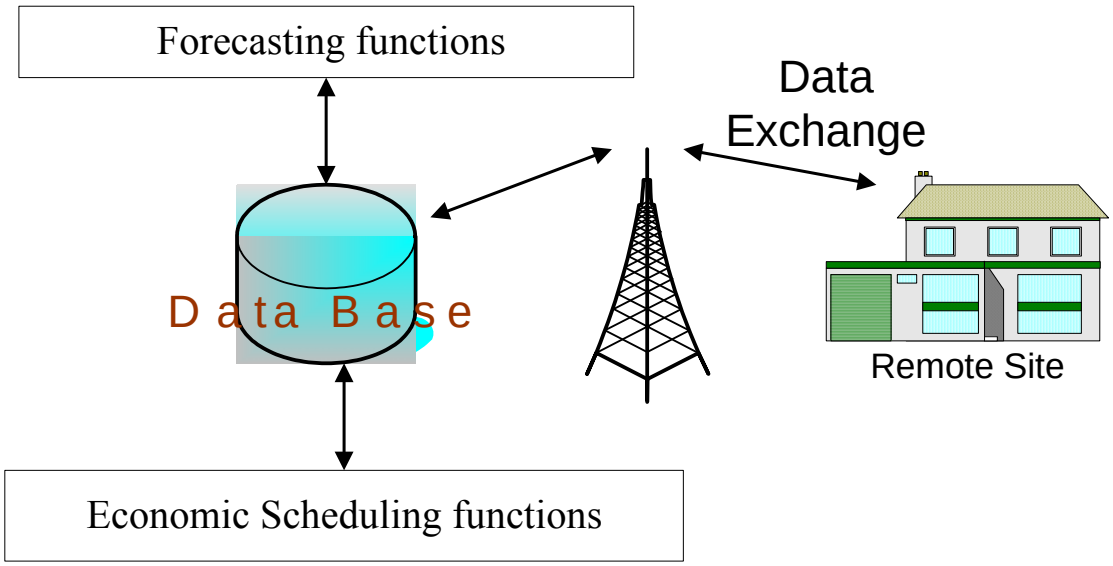



*Figure 5.4.1: The typical layout for the optimal control of a Remote site*

The DataBase (DB) of the Integrated Control Tool interacts with the forecasting functions of both load and Renewable Energy Sources (RES) production. The outputs of the forecasting functions are kept in the DB and are used by the Economic Scheduling functions described in detail in Deliverable D5.3 to provide the optimal operation schedule. The other inputs required by the economic scheduling functions such as technical characteristics of the units, fuel prices etc are also kept in the DB. The outputs of the Economic Scheduling functions are kept in the DB in order to be transmitted to the remote site in a proper format depending on the available equipment at the remote site.

Some information should be exchanged from the remote site to the DB in order to be used as inputs to the forecasting functions and the Economic Scheduling functions. The data exchange between the remote site and the DB of the Integrated Tool depend on the complexity of the functions used, the capabilities of the local controllers and the telecommunications cost.

The integrated software for optimal control for remote sites should be modular enough in order to provide flexibility in developing different functions and methodologies for both forecasting and economic scheduling functions. This helped in using and testing software from different partners. The modules and the requirements that the developed tools should have were described in this document with emphasis on the economic scheduling functions.

***Detailed information about Development of Integrated Optimal Operation Tool is contained in Deliverable D5.4. "Demo of integrated operational tool."***

**T5.5 Design of WWT system**

## Introduction

The main goal of this task was to design a WWT system which will collect the treatment of the wastewaters from the chosen target location and process it to a combined anaerobic system. The provided results from the research will be used for the design of the new system and technology for biological WWT and production of biogas. In this task, experts for WWTP design included. This task was accomplished by BIG, given the provision of necessary input data from the participating countries.

**Methodology**

Anaerobic digestion is a process by which a complex mixture of microorganisms transforms organic materials under oxygen-free conditions into biogas, soluble nutrients, and additional cell matter, leaving

salts and refractory organic matter [2], figure 5.1. Raw biogas typically consists of methane (60%) and carbon dioxide (40%), water vapor and trace amounts of hydrogen sulfide. As much as 90% of the biodegradable organic fraction of manure can be stabilized in anaerobic treatment by conversion to methane gas. The major benefits of anaerobic digestion for dairy farms include:

- ❖ Waste stabilization
- ❖ Odor control
- ❖ Energy production
- ❖ Pathogen reduction
- ❖ Weed seed inactivation
- ❖ Nutrient conservation and mineralization
- ❖ Fiber by-product production
- ❖ Compliance with impending air emission regulations
- ❖ "Green" image and improved societal acceptance.

From the process engineering point of view, anaerobic digestion is relatively simple even though the biochemical processes involved are very complex. Since the process uses a "mixed culture" enrichment of ubiquitous organisms, no sterilization steps are required and product separation is obviated as the biogas separates itself from the aqueous phase. Also, since the methane produced is relatively insoluble, it does not accumulate to inhibitory concentrations in the fermentation mixture.

The main items of equipment required for dairy manure digestion per se are the reactor vessel, or digester, and a manure separator. The type of digester used varies with the consistency and solids content of the feedstock, with capital investment factors, and with the primary purpose of digestion. Higher organic loading rates optimize volumetric methane productivity, while lower organic loading rates maximize treatment efficiency. Anaerobic digestion applications have been performed under ambient (15-25oC), mesophilic (30-40oC), or thermophilic (50-60oC) temperatures. Typically, farm digesters are operated at mesophilic temperatures.

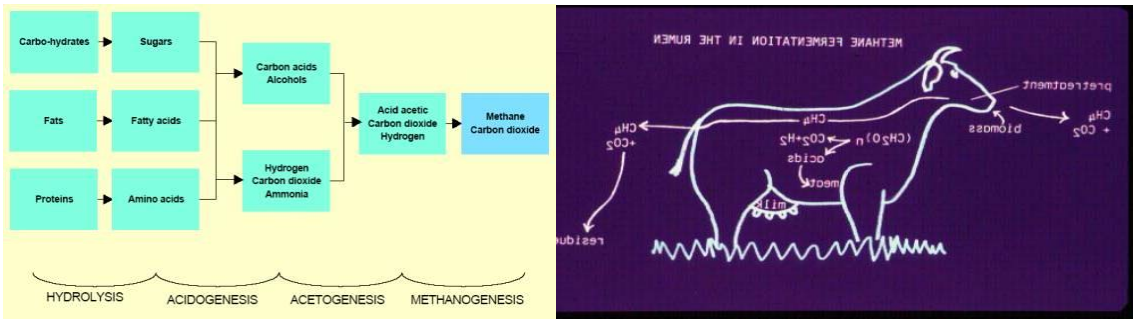



*Figure5.5.1. Description of the anaerobic digestion process*

**Selected biogas production technology description**

So based on the previously mentioned facts we can give the basic description of the chosen biogas production technology for the prototype WWTP:
The prototype waste water treatment plant WWTP consisted from one anaerobic reactor, and one aerobic reactor
The released biogas collected in a biogas collector. The influent enters in the WWTP by the force of gravity, than the water pass trough a layer of microbial biomass, and at the end the effluent leaves the reactor and then collected in a sedimentation tank.
The final water purification conducted in an aerobic reactor. The reactor consisted of one aerobic pool in which the nitrification of the water will take place (with diffusers) and one anoxic pool where the denitrification took place.

The design of the prototype of the WWTP was based on the design of the laboratory pilot WWTP system design , described in WP2.

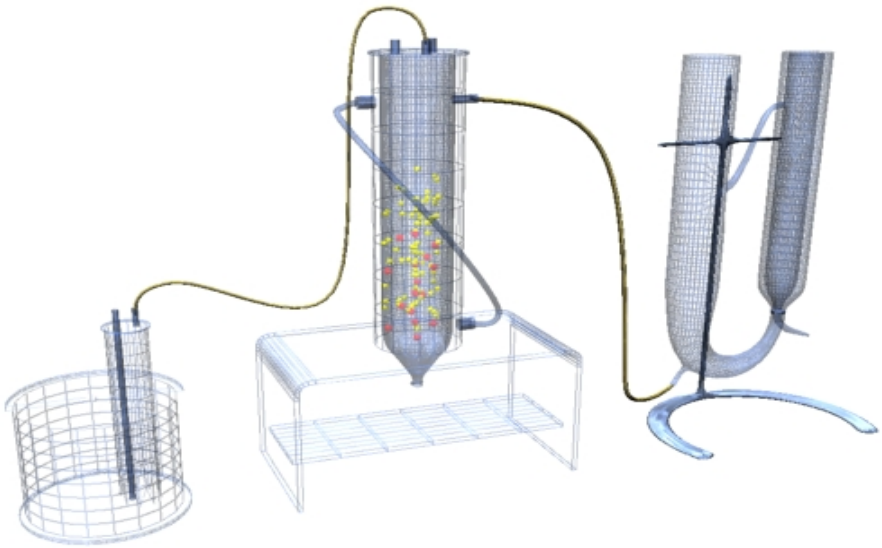


*Figure 5.5.2 Final description and design of the prototype WWTP*

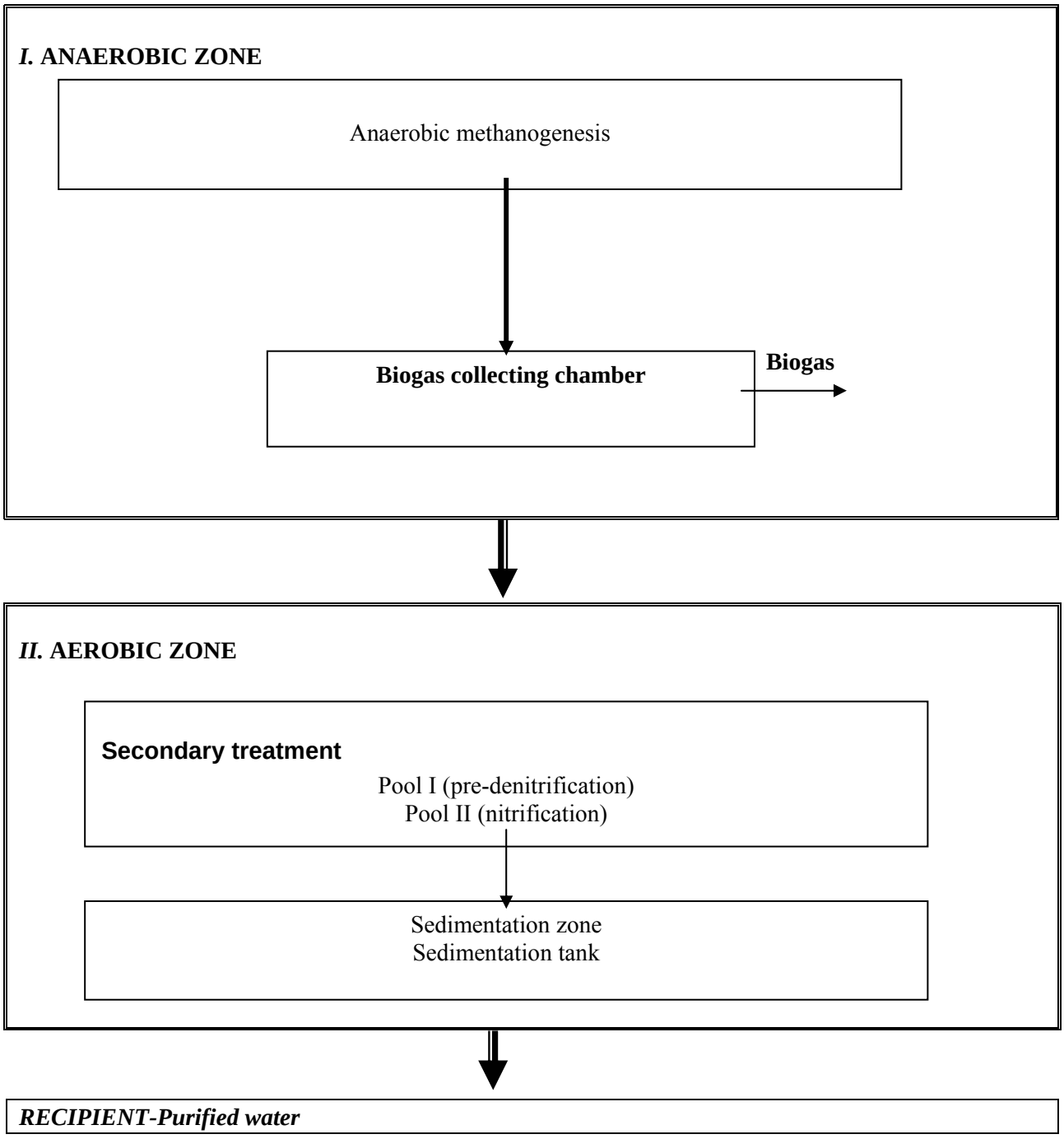
**Conclusions**

The usage of our new WWT technology called **Anaerobic-Aerobic Granular System (AAGS)** also means quality, economically acceptable, easy to maintain and very effective system for wastewater treatment. The end result from this wastewater treatment system is biogas and purified water which will not endanger the environment.

The functioning of the process is graphically shown on figure 5.5.2. The WWTP can be used in small rural areas, small agricultural production capacities etc. The brut volume of the WWTP can vary with few $m^3$, to several hundred thousand $m^3$, depending on the capacity of the rural area or industry. The WWTP was constructed from poly-plast.

The advantages of this type of WWTP compared to the others is: the capability to simultaneously purify municipal wastewaters and organic waste materials from agricultural and industrial nature, produce biogas, eliminate the nitrogen and phosphorus compounds present in the wastewater, small amount if sludge production, and high level of purification.

The WWTP was consisted of **anaerobic zone**, where the anaerobic methanogenesis was performed and two aerobic process zones: **biological zone**, consisted of two pools (pool I and II) in which pre-denitrification and nitrification was carried out, and **sedimentation zone**, equipped with a sedimentation tank.




***Detailed information about Development of Design of WWT system is contained in Deliverable D5.5. "Design of prototype WWTP."***

***Workpackage 6: Projection to future large-scale integration of RES in isolated regions – economic and environmental aspects***

## OBJECTIVES

The aim of the Work was to define a roadmap for a large scale integration of RES in isolated regions of the WB countries.

For this purpose, other specific objectives should be reached, including:

- Estimation and size optimisation of RES Installations in a large scale
- Selection of technologies and components
- Assessment of economic and environmental benefits
- Assessment of social benefits
- Investigate feasibility of large-scale RES installations in isolated regions.

## ACHIEVEMENTS AND MAIN RESULTS

### T6.1 Development of a GIS tool for the Identification and Design of large-scale integration of Renewable Sources in Isolated Systems of WB countries

#### Introduction

The aim of this Task was to maps energy resources and evaluates the economical potential of Renewable Energy Technologies (RET), through the GIS tools for RES capacity estimation planning, based on geographical analysis of RES technology potential. The inputs for these economical potential modules are maps with potential consumer characteristics, maps with wind, solar, biogas, and biomass resources, detailed technologies characterization, social and environmental barriers, distance to the electric grid. The outputs are regional maps with number of systems, size, location, electricity production cost

The task was divided in two parts. The first one consisted in the evaluation of maps for a wide countries region for solar, hydro, wind, biomass and hydro energy resources. The second subtask was related with the economic evaluation potential for each technology, based maps of levelized electricity production costs.

### Methodology and Results

The geographic assessment for energy resources and potential consumption for a wide area of Balkan Countries was essential in order to create input maps and scenarios for the economic, environmental and social evaluation of potential for Renewable Energy Technologies (RET). These maps revealed potential consumer characteristics, maps with wind, solar, biogas, and biomass resources, as well as a detailed characterization of technologies, social and environmental barriers and distance to the electric grid.

The wide area mapping for energy resources was carried out for solar, wind, small hydro and biomass resources. For solar resource maps, ARMINES applied methodologies which extensively Earth Observation data provided by meteorological satellites, from a database called HelioClim. This approach creates maps which contain results for global radiation per month. For wind resource maps, ARMINES created a regional wind map for the Balkan countries, retrieved from the ECMWF meteorological analyses. Regarding hydro resources for Croatia and FYROM, all the potential hydro locations including information about water flow, drop, potential power to be installed, potential energy production, and other characteristics. For biomass, INESC Porto used the "Global Land Cover 2000 database" to map the forest

biomass resources. Biomass resources for hardwood, softwood, and others were widely mapped for all countries. The methodology was based on GIS spatial analysis model calibrated by biomass statistics from the Tusla Canton municipality.

The second important geographic achievements were the characterization of consumptions and trends and also the characterization and quantification of potential users for isolated renewable energy technology.

At the same time, the energy potential was characterized concerning the status, actual plans and targets for the several renewable energy technologies in WB countries. This evaluation was based on maps for resources and potential users.

***Detailed information about Development of a GIS tool for the Identification and Design of large-scale integration of Renewable Sources in Isolated Systems of WB countries, is contained in Deliverable D6.1. "Report with a mapping of RES potential and associated demand in wide areas of WB."***

## T6.2 Development of Functions to assess the Economic Benefits of alternative solutions (isolated vs. interconnected mode of operation)

### Introduction

The main goal of this task was the development of GIS functions in order to evaluate electric network expansion or reinforcement costs to supply new load locations and load growth.

### Methodology

The methodology included economic comparison of traditional electric grid solutions with stand alone systems. The task was internally organized in the following four sub-tasks:

- Development of GIS spatial network methodologies to evaluate incremental costs to supply isolated areas from the existing electric network.
- Characterization and quantification of potential users for isolated renewable energy technology. Other issue of this subtask was the energy characterization concerning the status and actual plans and targets for the several renewable energy technologies in WB countries.
- Develop a GIS methodology for multi-criteria evaluation of the potential for development of Renewable Energy Technologies (RET). This methodology aggregates the economic, environmental and social criteria, based on maps covering all the countries, and produces maps of potential for development for each technology.
- Develop a GIS tools including geocomputation intelligence to simulate the time and spatial dynamics of RET development and integration.

### Achievements

Several GIS spatial analysis modules have been developed. GIS spatial analysis methodologies were developed for electric RES technical and economic evaluation. These include the evaluation of solar PV systems and small wind systems (several scenarios for isolated and grid-connected stems) as well as an economic evaluation for big wind farms.

The most complex methodology developed in this task is the GIS spatial network methodology. The goal was to evaluate incremental costs that are necessary in order to supply with energy isolated areas from the existing electric network. Finally, based on simple conditional GIS spatial methodologies, a wide-scale

geographic analysis was made in order to enable the economic comparison of several energy solutions as well as mapping areas with high potential.

In order to evaluate LEC maps for PV systems, four different system scenarios have been studied: conventional grid-connected systems mounted on buildings; grid-connected BIPV; isolated, supplying AC loads; isolated small professional applications. In order to compare both micro-generation alternatives, the same scenarios of PV have been used for small wind.

To evaluate LEC of the electric grid expansion, the sum of three components: the cost of MV virtual network, the cost of LV substation and LEC for the electricity price, was considered. The LEC was very high for loads far from the existing grid, especially if they were small loads. LEC for LV transformer was higher if it was a potentially low load. The wide-scale result for overall WB region was computed and correspondent maps created.

In order to compare several electrification solutions, LEC solutions for isolated alternatives (PV systems and small wind systems) and for a system connected to the nearest electric network was compared.

Scenario comparisons were the following:

- Areas with electric grid;
- Areas without electric grid, but with domestic potential consumption;
- Areas without electric grid: compare LEC to extend the electric network;
- Isolated areas with domestic potential consumption, that could only a few and small potential applications;
- Remote areas without domestic potential consumption, that could only a few and small professional applications.

LEC for wind farm generation was computed based on typical 2 MW wind turbine power curve at 90 m high. Important conclusions have been reached for wind potential and its inclusion in the country energy planing.

***Detailed information about Development of Functions to assess the Economic Benefits of alternative solutions is contained in Deliverable D6.2. "Report with a comparative economic analysis among solutions with traditional approach and different mix of technologies. The solutions will be evaluated by cost."***

### T6.3 Development of Functions to assess the Environmental Benefits of alternative solutions

#### Introduction

The objective of this task was to develop GIS functions to asses positive or negative environment impacts of each RES technology and conventional energy solutions, based on the technology compute land occupations, quantitative emissions, qualitative indices for visual impact and noise impact. The GIS tools were developed by INESC Porto but the preparation of inputs and model parameterization for application to BC countries was done by ICEIM-MANU. The inputs and parameterization included indicators for environmental impacts of each technology, information about environmental sensibility of the region and local populations.

#### Results

INESC Porto developed a GIS tools to evaluate visual impact of wind farms, based on visibility functions over a digital terrain model, using potential locations of wind farms for targets and populated places for observers sensitive to the impact. The methodology was applied for wide areas in Croatia case studies.

It was also developed a geocomputational model to quantify emission from the several technologies based on the geographical density of consumption and based on typical emission of each technology.
By applying the methodologies the final maps of impacts and benefits were created and quantified by country.

***Detailed information about Development of Functions to assess the Environmental Benefits of alternative solutions is contained in Deliverable D6.3. "Report with trade off analysis on selected solutions and traditional grid interconnected solutions regarding visual impacts and pollutant emissions. The solutions will be evaluated environmental impact."***

**T6.4 Assessment of Social benefits from wide-scale integration of RES in isolated regions**

**Introduction**

Based on geographical maps and geostatistics the main objective was to asses the social benefits of the estimated RES integrations. (employment, quality of life improvement, etc.). The approach used was based in three different perspectives, with concrete objectives of quantifying and qualifying the social benefits for:

a) Individual consumers, with specific characteristics (isolated or grid connected, different reliability requirement, different type of applications)
b) Community applications (schools, health facilities, etc.)
c) The perspective of each Renewable Energy Technology service quality

Elaboration of social aspects from a wide-scale integration of RES in isolated regions in WB countries, in particular seen as possible contribution towards the mitigation of the war consequences, as well as to the life quality improvement.

**Conclusions**
The most important aspects achieved in terms of assessment of socio-economic benefits of the analysed Isolated Electrical Systems based on Renewable Energy Sources (IESRES) were:

- Review of the actual socio-economic conditions in the WBC.
- Detailed information on socio-economic conditions in the target locations and clear identification of specific socio-economic issues, as basis for assessment of the expected benefits from IESRES.
- The report has shown that on each target location **social benefits** should be expected and that all of the effects could be systemized in several main benefits:
    - Improvement of quality of life;
    - Social cohesion and stability;
    - Decrease of rural migration;
    - Reducing the conflict consequences.

These benefits were tightly connected to the **economic benefits**, mainly recognized in the following:

- Reducing the unemployment rate;
- Opening new business opportunities;

- Providing sufficient income for sustainable development.

***Detailed information about Assessment of Social benefits from wide-scale integration of RES in isolated regions is contained in Deliverable D6.4. "Report on the socio-economic aspects of the RES applications in the WB countries."***

## T6.5 Development of a policy report (roadmap) for a wide-scale integration of RES in isolated regions in WB countries

### Introduction

The work done in this task is an assessment of expected economic, environmental and social benefits of a wide-scale integration of RES (particularly in isolated regions) and policy suggestions. After researching the already existing policies in Western Balkan countries and the situation concerning electrical energy production, distribution and consumption, some policy suggestions are formulated, to create a realistic roadmap for Western Balkan countries.

The major aspects studied and presented in the policy report are the following:

**a) Existing Energy Policies in Western Balkan Countries**
The existing energy policies in Serbia, Croatia, Bosnia & Herzegovina and FYROM, were investigated. Electricity production, distribution and consumption were discussed, along with existing RES integration and renewable sources potentials.
Data derived from WB partners.

**b) RES Competitive Economical Potential for Western Balkan Countries**
Competitive technologies were compared (PV, small wind and grid connection) as found in D6.2. PV is the most competitive RES especially in low population isolated regions and professional DC applications. Feed-in tariffs proposed are 0.6euro/kWh and government subsidies in the order of 80% for PV to be competitive.

**c) RES Socio-economic benefits for Western Balkan Countries**
The socio-economic benefits were discussed as found in D6.4 for Serbia, Croatia, Bosnia & Herzegovina and FYROM. The social benefits to be expected from RES installations could be improvement of quality of life, social cohesion and stability, decrease of rural migration, reduce the conflict consequences. These benefits are tightly connected to the economic benefits, mainly recognized in the following: Reduce the unemployment rate; Open new business opportunities; Provide sufficient income for sustainable development.

**d) Guidelines for Wide Scale Integration of RES in Western Balkan Countries**
Policy Strategies for Western Balkan Countries for the integration of RES in order to achieve previous results:

- Existence and activity of an energy agency to coordinate efforts;
- Government policies should consider feed-in tariffs of more than 0.6euro/kWh;
- New installations need investment subsidies (80%), rebates and tax incentives in order to overcome high initial cost of the systems;
- Use of diesel generators as a source of power supply with high environmental impacts, in remote areas can be removed, with environmental externalities in calculations in favour of RES, compared to grid connected system;
- Communicating the benefits of RES should be the prime target and the audiences should be identified;

- Non Governmental Organisations (NGOs) and non-profit organisations can be useful allies in awareness-rising campaigns;
- Apart from local businesses that can be subsidised from the government, the tourist sector can benefit from RES and environmentally friendly tourism (ecotourism and agrotourism);
- Citizen participation and awareness rising, education;
- Evolution of energy standards in buildings and efficiency;
- Green electricity labels of locally produced electricity from RES;

***Detailed information about Development of a policy report (roadmap) for a wide-scale integration of RES in isolated regions in WB countries is contained in Deliverable D6.5. "Policy Report aiming to a wide-scale integration of RES in isolated regions in WB countries."***

## *Workpackage 7: Results Dissemination*

### OBJECTIVES

The aim of the Workpackage was to to disseminate achieved knowledge and developed methodologies produced in order to:

- Promote early and broad application of the new technology
- Show feasibility of RES installation in isolated regions (to target SMEs)

Specific project objectives for the last 12 months period were:

- To set-up a web-site in order to highlight all the information relative to the research activities within the project and to attract all the interested parties
- To prepare and publish an electronic Newsletter every 6 months

### ACHIEVEMENTS AND MAIN RESULTS

**T7.1 Web-site**
A web site http://www.rise05.net has been developed and maintained by AD MEPSO with the help of ICCS/NTUA for disseminating information of the project to general public. This site includes information about the project and is used for project results dissemination. The site also includes a work-space with access limited to the partners to facilitate exchange of information (reports, minutes etc) among the partners.

**T7.2 Newsletter**
An Electronic version of the Project's Newsletter has been developed by AD MEPSO and published periodically, on 6 months bases, with the relevant Project's information and results.

**T7.3 Publications and presentations at regional and international conferences**
The results of the project have been presented through a number of publications and presentations at regional (Balkan Power Conference BPC) and international Conferences (PMAPS). A list of them is given in the References Section at the end of the report.

**T7.4 Workshops**

The 1st VBPC-RES Decision Makers Workshop held in Ohrid, FYROM, focusing on technical and other project level aspects of implementation of RES BAT in WB countries. The partners of RISE project have attended the workshop in Ohrid and presented the current status of research within the RISE project.

The workshops for Decision Makers has facilitated exchange of information on establishing incentives for promotion of RES and experiences with harmonization with EU legislation in EU, AS and WB countries. Prominent WB energy policy makers, other Governmental officials, decision makers from business community (from utilities and SMEs from different European countries), consultants involved in preparation of regulatory framework and other stakeholders have been invited to two special workshops.

The workshops were aimed to further discuss the issues addressed in the project VBPC-RES in the wider circle of experts and stakeholders. At first, to provide a necessary feedback to research community to focus the further common research projects on the most relevant issues. Secondly, to disseminate the VBPC-RES coordinated projects achievements to wider public, to inform the responsible DM in the region with the latest achievements relevant for future for RES penetration.

In addition, AD MEPSO in cooperation with all partners and mainly UKIM and ICEIM-MANU have organized a workshop in Belgrad.

## 2.3 References

Conference presentations relating to the project have been given or will be given in the following Conferences:


- Popović, V. Zlatanović, A. Kunosić and M. Zlatanović "Modeling of diode configuration glow discharge impedance connected to pulse power supply", Surface and Coatings Technology, Volume 200, Issues 5-6, pp 1659-1663, 2005

- M.Kayikci and J. V. Milanović, "DFIG modelling and the relevance of model simplification", *CD Rom of the CIRED 2005, 6-9 June 2005, Turin, Italy.*

- M.Kayikci, O.Anaya-Lara, J. V. Milanović and N.Jenkins, "Strategies For DFIG Voltage Control During Transient Operation ", *CD Rom of the CIRED 2005, 6-9 June 2005, Turin, Italy,*

- M.Kayikci and J. V. Milanović, "Contribution of DFIG based wind plants to power quality and stability of local network", *CD-Rom of the 13th International Symposium on Power Electronics,Ee'05 , Novi Sad, Serbia & Montenegro, 2-4 November, 2005, Paper T7-1.4*

- *"Structural, Morphological and Optical Properties of Electrodeposited Films of Cuprous Oxide for Solar Application"* Balkan Power Conference, Ohrid, June 2006

- M. Rakic, Dunja Desnica-Frankovic and U. V. Desnica, *Potential for off-grid PV applications on Croatian islands*, Proceedings of Int. Conference *Energy and the Environment 2006*, editor B. Frankovic, ISBN 953-6886-09-X (Vol. 1), pp. 235-245

- U. V. Desnica, D. Desnica-Frankovic and M. Rakic, *Potential for PV application in the mountainousand highlands regions of Croatia*, Proceedings of *6th Balkan Power Conference*, Ohrid, FYROM, May 31-June 2, 2006 (ISBN 961-243-040-3).

- *"Estimation of Costs for Implementation of a PV System in an Isolated Region"*, Balkan Power Conference, Ohrid, June 2006

- *"Economic and Environmental Assessment of Solar Systems Installed at an Isolated Location"*, poster presentation, Energy and the Environment, International Congress, Opatija, Croatia, October 25-27, 2006

- Markovska N.: Evaluating GHG Mitigation Options and Technology Needs in the Energy Sector in Macedonia, *International Conference* "*Climate Change in South-Eastern European Countries: Causes, Impacts, Solutions"*, Graz, Austria, March, 2007.

- Markovska N., Todorovski M., Bosevski T., Pop-Jordanov J.: Cost and Environmental Effectiveness of Climate Change Mitigation Measures**,** invited lecture (full paper)**,** *"Sustainable Energy Production and Consumption and Environmental Costing", NATO Advanced Research Workshop,* Naples, Italy*,* July, 2007 (monograph in press)

- Ž. Đurišić, M. Bubnjević, D. Mikičić, N. Rajaković, Wind Atlas of Serbian Region Vojvodina, Proc. of European Wind Energy Conference (EWEC 2007) Milano, Italy, May 2007.
  (Online: www. ewec2007proceedings.info/allpapers2/249_Ewec2007fullpaper.pdf).

- J. Trifunović, Ž. Đurišić, D. Mikičić, A. Kunosić, Surface finishing of wind turbine gears by pulsed plasma processes, Proc. of European Wind Energy Conference (EWEC 2007), Milano, Italy, May 2007.
  (Online: www. ewec2007proceedings.info/allpapers2/250_Ewec2007fullpaper.pdf)

- N. Rajaković, D. Nikolić, Z. Nikolić, Photovoltaic power supply basic components calculation, 6th *International conference for renewable energy sources*, Budva, October, 2007

- N. Rajaković, D. Nikolić, Z. Nikolić, Photovoltaic power supply measurements during winter solstice, 6th *International conference for renewable energy sources*, Budva, October, 2007

- *"Current-voltage Characteristics of the Copper (I) oxide Solar Cells"* Physica Macedonica 55, (2006) p.35-42.

- A.Krkoleva, M.Kayikci J.V.Milanović and V.Borozan, "Characteristic Responses of Distribution Network Cell: The Effect of Cell Structure and Configuration", *CD Rom of the CIRED 2007,* 21-24 May 2007, Vienna, Austria

- V.Georgieva, M.Georgieva, Electrochemical deposited cuprous oxide and zinc oxide films for solar application, YUCOMAT 2007, 10-14 Sept. (abstract) Herzeg Novi, Crna Gora

- S.C.Vegunta, J.V.Milanovic, T.J.Koay and M.T.Aung, "Automated assessment of voltage sag performance at low voltage buses"*, CD Rom of the CIRED 2007,* 21-24 May 2007, Vienna, Austria

- M.Kayikci and J. V. Milanović, "Improvement of Transient Responses of Distribution Network Cell with Renewable Generation", *CD Rom of the CIRED 2007,* 21-24 May 2007, Vienna, Austria

- V.Georgieva, M.Georgieva, Electrochemical deposited cuprous oxide and zinc oxide films for solar application, YUCOMAT 2007, 10-14 Sept. (abstract) Herzeg Novi, Crna Gora

**Publications**

- M.Kayikci and J.V. Milanovic, "Reactive Power Control Strategies For DFIG Based Plants", *submitted to the IEEE Transactions on Energy Conversion,* TEC-00169-2005 *(16/11/05),*(under review)

- Markovska N., Pop-Jordanov J.: Strengths, Weaknesses, Opportunities and Treats of the National Energy Sector in Light of Sustainability, Energy Policy

- Ž. Đurišić, N. Rajaković, D. Mikičić, M. Bubnjević, Wind energy potential map of Vojvodina, Energija, N$^{o}$. 2, March, 2007, ISSN: 0354-8651, pp. 118 – 120.

- Nenčić, N. Rajaković, RES and the perspective of implementation in Serbia, Energija, N$^{o}$. 2, March, 2007

- D. Nikolić, N. Rajaković , Examples of Islandic Solar Energy Applications on Holy Mountain (Holy Monastery of Hilandarion, Greece), Energija, N$^{o}$. 2, Mart, 2007

Moreover, the following **presentations** related to the project will be given in the following events:

- Between 10.-15. June 2006, PMAPS 2006 Conference will take place in Stockholm, Sweden. ULJ will present a paper on Unified Approach to Reliability Assessment in an Isolated RES System. The results are based on reliability research performed for the purpose of RISE project.

- In June 2006, BPC 2006 Conference will take place in Ohrid, FYROM. ULJ will present a paper on Selective Reliability Indices for Assessment in an Isolated RES System. The results are based on reliability research performed for the purpose of RISE project.

- German Radio " Deutsche Welle" and their internet site on the 8.11.2005
- FYROM newspaper " Dnevnik" on the 7.12.2005: www.dnevnik.com.mk
- FYROM newspaper " Vecer" on the 10.12.2005: www.vecer.com.mk
- FYROM newspaper "Manager" on the 6.12.2005: http://80.77.145.77/manager/index.asp
- FYROM Television "MTV1"
- FYROM television " Kanal 5"

## 2.4 Report of impact for on the general public (outside of the Consortium)

### ICEIM-MANU

**Events**

- Lectures on Renewables in national conditions with reference to RISE results – Natasa Markovska, at:
    - Workshop on Promotion of RES in National Conditions, VBPC-RES, EU-FP6 Project 27.04.2007, attendence: wide participation of variety of national energy stakeholders
    - Faculty for Business Economy, 27 January 2007, attendance: 15 postgraduate students
    - South and Eastern European University, Institute for Environment and Health, 2 November 2007, attendance: 25 postgraduate students

### IRB (Rudjer Boskovic Institute)

**Events**

**1. Interviews for TV stations** (U. Desnica)

a) An interview for Croatian TV, Channel 1, given to Tomislav Pupacic, for 'Trenutak spoznaje' (*'A Moment in Science'*), regarding present status of RES generally and in Croatia, emitted on October 18th 2007 (11.05 h)
(Unused parts of this interview will be used in another regular show of HTV1 planned on the similar subject; to be emitted in one of the shows of 'Dobro jutro Hrvatska' ('Good mornig Croatia') emitted each morning on HTV1).

b) An interview for Croatian TV, Channel 1, given to Snjezana Babic, for the program *EKO-Zone*, emitted January 8th, (and later, for its content, awarded with *Velebitski cvijet* award.)

c) An interview given to Kornat Vilovic from the TV station 'Kapital Network' (first business TV station in Croatia). The interview was emitted within the regular program 'Boja novca' 138 ('The Colour of Money') on March 20. 2007, in 20:30 h.

**2) Interviews for media**

a) An interview related to RES opportunities to Tanja Rudez, from one of the largest-circulation Croatian daily newspapers, Jutarnji List, (resulted in almost 2-pages of their large format), printed on Sept. 7th, 2007.

b) An interview about future energies and RES, given to to Sergej Zupancic from the largest daily Croatian newspaper '*Vecernji List*' ('Evening News'); published March 3, 2007

### 3) Lectures/Talks/Presentations

a) Presentations to the RES professionals & policy makers (government officials) at international and Croatian Conferences (from that activity 5 papers/presentations published, or in the process of publication)
b) Dissemination through national organizations like CCC (Croatian Chamber of the Commerce). Participated in the Founding assembly of the RES Association of Croatian Chamber of Economy and Commerce;

c) Influencing laws on stimulations of RES, in particular proposing ammendments in working versions of these laws (on feed-in tarrifs, caps, contract duration...)

d) Presentations to local officials at the county level, to potential users, and to general public, etc in order to inform and educate them on the technical and particularly financial opportunities when using RES

## UB

### Events

**1.** Interview for local Radio station, "International Radio Serbia", on using the wind potential in Serbia – Dušan Mikičić, 31st May 2007, Belgrade, Serbia

**2.** Live Internet video streaming coverage of the Local Workshop presentations within the 7th RISE Contractual Meeting. 11th September 2007, Belgrade, Serbia
About 40 attendees from the Serbian Energy Agency, Serbian Energy Efficiency Agency, Srbijagas and the RISE project.

**3.** Presentation of the possibilities for development of pilot PV system on the City Hall of Municipality Vračar – Ivica Nenčić, 3rd October 2007, Belgrade, Serbia
About 50 attendees from local utilities, newspapers and TV stations, citizens of municipality Vračar. Almost all local newspapers and several TV stations covered this event.

**4.** Presentation "Possibilities of development of small-scale wind turbines in Municipality Kragujevac" – Dušan Mikičić, Branko Radičević, 16th October, 2007, Factory Zastava, Kragujevac, Serbia
About 35 attendees from local municipality and factory Zastava.

**5.** Presentation of the results of exploration on wind resource in Serbia - Round table "Promotion of Renewables in Serbia" – "Power System Conference" – Nikola Rajaković, 30th October 2007, Belgrade, Serbia
About 50 attendees from universities, research organizations, local utilities, Republic Regulatory Agencies (Energy Efficiency Agency, Energy Agency), OSCE, EAR, Wellbury GmbH,…

**6.** Presentation of the possibilities for development of pilot Wind/PV hybrid system for isolated regions in Municipality Mladenovac – Nikola Rajaković, 7th November 2007, Belgrade, Serbia
About 15 attendees from local municipality and local electric utility.

**7.** Presentation "Development of renewables for isolated consumers in Belgrade region", Belgrade City Energy Department - Nikola Rajaković, 8th November 2007, Belgrade, Serbia,
About 15 attendees from City Energy Department.

## UKIM

### Events

The representatives of the sheep-breading company “Nistrovski Korab” which owns the sheepfolds were contacted. They were introduced to the idea of possible RES applications on their sheepfolds and showed particular interest in further information. They showed good cooperation providing important data for the two locations.

## UTU

### Events

- Rounding Table on energy efficiency organized by the Local centre for Energy, Environment, and Economy, on 19. June, 2007. Number of participants: 20 local participants, affiliation: NGO, Academia, Repair shops, retailers of technical equipment, Media coverage of the Event: one interview has been given to the local Radio station considering the energy possibilities of RES in Tuzla Canton

- The RISE DSS software developed through this Project has included in to the lecture process and it is used as the laboratory tool in the Power Market and Energy Management courses, respectively, in the Faculty of Electrical Engineering, University of Tuzla, Number of students: 50

- The results of RISE have presented on the local workshop on RES to Decision Makers, General public, SME, and students. The workshop was held on 23, February, 2007. in the chamber of commerce of Tuzla Canton. Number of participants: 25, affiliation: SME, local government, Academia, Media coverage of the Event was provided

# Part 3: Detailed Final Report
# (Non Confidential)

## 3.1. List of Deliverables

*Workpackage 1: Collection and Analysis of Data on Candidate Study Cases*

Deliverable **D1.1 "Regional map with data on solar potential",** due on the 24th month has been submitted on time

Deliverable **D1.2 "Regional map with data on wind potential"**, due on the 24th month has been submitted on time

Deliverable **D1.3 "Regional map with data on biomass potential"**, due on the 24th month has been submitted on time

Deliverable **D1.4 "Regional map with data on small hydro potential"**, due on the 24th month has been submitted on time

Deliverable **D1.6 "Report on possibilities for usage of the technology for anaerobic WWTP and biogas production",** due on the 24th month has been submitted on time.

Deliverable **D1.7: "Report on target locations in the WB countries together with load identification,** environmental, economic and social aspects of each location", due on the12th month has been submitted on time

Deliverable **D1.8 "List of technical requirements with respect to security, reliability and quality of power supplied that new RES installations should meet under most probable operating scenarios",** due on the 6th month has been submitted on time

*Workpackage 2: Investigation of Low-Cost Innovative RES and Wastewater treatment solutions*

Deliverable **D2.1"Report on the state of the art on low-cost RES technologies"**, due on the 6th month has been submitted on time

Deliverable **D2.2" Report on the outcomes of research on PV technologies"** due on the 30$^{th}$ month has been submitted on time

Deliverable **D2.3" Report on the outcomes of research in Wind technologies"** due on the 30$^{th}$ month has been submitted on time

Deliverable **D2.4" Report from the pilot WWTP with production of biogas"** due on the 30$^{th}$ month has been submitted on time

Deliverable **D2.5" Report on cost-effective technology for usage of biogas"** due on the 30$^{th}$ month has been submitted on time

*Workpackage 3: Development of advanced Decision Support Methodologies for dimensioning of RESin isolated grids*

Deliverable **D3.1"Survey of state-of-the-art of decision support systems for renewable energy sources in isolated regions"** due on the 6th month has been submitted on time

Deliverable **D3.2"Working paper on functionality and final specification of DSS"** due on the 12th month has been submitted on time.

Deliverable **D3.3"Report on DSS methodology and tools"** due on the 24th month has been submitted on time

Deliverable **D3.4"Web-based DSS modules"** due on the 24th month has been submitted on time.

Deliverable **D3.5"Report on DSS tools: User Manual" (Additional Deliverable)**

*Workpackage 4: Application to selected target Sites*

Deliverable **D4.1 "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of Croatia"** due on the 30th month has been submitted on time

Deliverable **D4.2 "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of Serbia"** due on the 30th month has been submitted on time

Deliverable **D4.3 "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of FYROM"** due on the 30th month has been submitted on time

Deliverable **D4.4 "Report with technical description, economic benefits, environmental benefits, life cycle analysis for the study cases of Bosnia Herzegovina"** due on the 30th month has been submitted on time

*Workpackage 5: Design of Operational Tools*

Deliverable**D5.1 "Survey of State of the art tools for operation and control of RES supplied isolated regions"** due on the 6th month has been submitted on time
Deliverable**D5.2 "Theoretical background, flowcharts and preliminary results of forecasting algorithms"** due on the 18th month is delayed. It will be submitted in the first months of the third year.

Deliverable **D5.3 "Theoretical background, flowcharts and preliminary results of energy scheduling algorithms"** due on the 18th month has been submitted on time.

Deliverable **D5.4 "Report Functional Specifications of integrated operational tool"** due on the 30th month has been submitted on time

Deliverable **D5.5 "Design of prototype WWTP"** due on the 30th month has been submitted on time

*Workpackage 6: Projection to future large-scale integration of RES in isolated regions –economic and environmental aspects*

Deliverable **D6.1 "Report with mapping of RES potential and associated demand in wide areas of WB."** due on the 36th month has been submitted on time

Deliverable **D6.2 "Report with a comparative economic analysis among solutions with traditional approach and different mix of technologies. The solutions will be evaluated by cost."** due on the 36th month has been submitted on time

Deliverable **D6.3 "Report with trade off analysis on selected solutions and traditional grid interconnected solutions regarding visual impacts and pollutant emissions. The solutions will be evaluated by environmental impact."** due on the 36th month has been submitted on time

Deliverable **D6.4 "Report on the socio-economic aspects of the RES applications in the WB countries."** due on the 36th month has been submitted on time

Deliverable **D6.5 "Policy Report aiming to a wide-scale integration of RES in isolated regions in WB countries."** due on the 36th month has been submitted on time

*Workpackage 7: Results Dissemination*

Deliverable **D 7.1.1, "RISE 1st Electronic Newsletter"** due on the 6th month has been issued on time

Deliverable **D 7.1.2 "RISE 2nd Electronic Newsletter"** due on the 12th month has been issued on the 14th month

Deliverable **D 7.1.3 "RISE 3rd Electronic Newsletter"** due on the 18th month has been issued on time

Deliverable **D 7.1.4 "RISE 4th Electronic Newsletter"** due on the 24th month has been issued on time

Deliverable **D 7.1.5, "RISE 5th Electronic Newsletter"** due on the 30th month has been issued on time

Deliverable **D 7.1.6 "RISE 6th Electronic Newsletter"** due on the 36th month has been issued on time

**Additional Newsletter:** "**RISE 7th Electronic Newsletter"** has been issued on time.

**Quality Assurance**
A "Quality Assurance Procedure" has been agreed by all partners in order to provide a practical procedure that delimits responsibilities, work procedures and deadlines in order to ensure that deliverables fulfil the objectives of the RISE project, according to the Contract. This is provided as an Annex document.

## 3.2 Comparison of initially planned activities and work actually accomplished

There are no deviations from work program to be reported. All the deliverables have been submitted on time and fulfilling the objectives.

## 3.3. Management and co-ordination aspects

The following official meetings have been held on the following dates:

- 31st January – 1st February 2005, kick-off meeting hosted by the ICCS/NTUA, Athens, Greece
- 25-26 May 2005, hosted by IRB, Zagreb, Croatia
- 28-30 November 2005, hosted by INESC, Porto, Portugal
- 29-30 May 2006, hosted by MEPSO, UKIM and ICEIM-MANU, Ohrid, FYROM
- 30-31 October 2006, hosted by ARMINES, Sophia - Antipolis, France
- 16-17 April 2007, 6th meeting hosted by the ULJ, Ljublgana, Slovenia
- 10-11 September 2007, 7th meeting hosted by UB, Belgrad, Serbia
- 22-23 November 2007, final (8th) meeting hosted by ICCS/NTUA, Athens, Greece

*The meetings in Zagreb, Porto, Ohrid and Sophia-Antipolis included technical meetings followed by the Consortium meeting typically in the last day. This form of oranization without parallel sessions proved particularly productive.*

Next to the above formal meetings, a number of focused technical meetings have taken place. For example, to facilitate the work in WP3, T3.2 and for preparation of the Workplan of WP3, Milestones M3.1, M3.2 and M3.3, and the Deliverable D 3.2, the partners of ULJ met with partners of IES several times.
Four times the meetings took place in Nova Gorica, at IES headquarters:
• 13. May 2005
• 5. August 2005
• 28. September 2005
• 25. November 2005.
This last meeting only came into financial books in December 2005, so was included in the Year 2 financial report (the same goes for Consortium meeting Porto).

The meetings were crucial to steer the work of the partners on WP3 in the right direction, and instrumental in preparing the D 3.2. The other meetings took place in Ljubljana and did not generate any additional costs for ULJ.Furthermore, INESC Porto and ARMINES met on 05 May 2006 to discuss the Workplan and the specification of software for Task 6.1. This meeting was crucial to steer the work of the WP6 partners in the right direction. This meeting did not generate any additional costs for INESC Porto.

## 3.4 Exploitation Plans

*The main deliverable of the RISE project is* to contribute to sustainable development of the region, especially in the making good of the consequences of the war in the environment and health, through the re-establishment of the collaboration among industry and research /academic institutions of the WB countries and such have positive effect on the overall future development of the region.

Within the activities of the project contacts were established with the local authorities of the WB countries in order to obtain information about some sites/villages/households without electricity, while electricity and other companies provided technical information of the locations and showed interest in further collaboration on the project.

The Faculty of Electrical Engineering, Belgrade University is now member of EWEA (European Wind Energy Association).

**PATENT**

A patent was obtained by BIG (Inventor: KUNGULOVSKI Ivan, KUNGULOVSKI Dzoko), Catalogue number: 570, Patent Title: *Wastewater treatment plant for biological treatment of municipal and industrialwastewaters in a modular sequence system (SB Reactor) with the usage of bioactive sludge enrichedwith mixed cultures of microorganisms*. Field: Ecology

The invention refers to a purifying station for biological treatment of wastewaters in a modular container with the application of a bioactive sludge enriched with a mixed culture of microorganisms. A part from this modular container design was borrowed from the anaerobic pool design which has been made within the EC funded RISE project (Contract number **FP6-INCO2-509161).**

The microorganisms are previously isolated, selected, adapted and reproduced in form of mixed cultures from microorganisms (bacteria, yeasts). The hydraulic retention time (HRT) of the wastewater in the bio-pools may last only few hours, which ultimately brings rationalization of the pools' dimension. More exactly, the pools are relatively smaller, which means smaller initial investments. Of course, this is essential for settlements that can offer a smaller land area for construction of the purifying station. The

advantages of this new technology are also the low electric power needed for aeration, and lower sludge production.

The quality of purification is in the frame of the European Directive (91/271/EEC) connected with the treatment of wastewaters and their emission standards.

**AWARDS**

1. This patent was rewarded with a gold medal on the IENA fair for patents and innovations which was held in Nurenberg, Germany from 8-12.11.2005.

2. It was also rewarded with a gold medal from the Ministry of science and education of the Russian Federation on the IENA fair for patents and innovations which was held in Nurenberg, Germany from 8-12.11.2005.

3. This patent was chosen to be the Patent of the Year 2005 in FYROM on 05.12.2005, by the FYROM government and the Department of Industrial Ownership.

## Table 1: RTD – Project Planning and Timetable