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Assessment of Renewable Energy Sources Potential in the Cross- Border Region Bulgaria – FYROM by Components

Report on Activity 2

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Report on Activity 2

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Amendments in documentation						
№	DATE	Prepared by	Description of amendment	Reason of amendment	Checked by	Endorsed by
1.	07.05.2014		Substantial correction of a text regarding biomass for Zrnovci municipality, other minor remarks.	By request of the Contracting Authority		
2.						
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1 PREAMBLE

The present report was elaborated based on Contract No. **№2007CB16IPO007-2011-2-89-2** signed between the CONTRACTING AUTHORITY **Zrnovci Municipality**, with seat and registered address: FYROM, b.b. Ilindenska Str., registration number 6010407, represented by the Mayor Mr. Blaze STANKOV, as one party, and INTELADVISERS LTD., with a seat and registered address in the city of Sofia, 229, Botevgradsko chaussee boulevard, floor 3, UIN 200012741, listed in the Registry Agency represented by its Managing Director Theodora Ivanova Pavlova as the CONTRACTOR, as the other party.

The Report on Activity 2 indicates the areas for production of energy from Renewable Energy Sources (RES) in the region of Zrnovci municipality (FYROM) and Belitsa (Bulgaria).

1.1 Description of the subject of the research

Subject of this research is drawing up of a list of areas suitable for production of energy from RES. Based on the checks done of the suitable areas in Zrnovci and Belitsa municipalities and based on the information gathered in the process, several areas have been identified as suitable for production of energy from RES. The following types of RES have been reviewed in the Report: hydro energy, biomass, solar and wind energy. The report was developed in two main parts: the first one relating to Belitsa Municipality and the second one to Zrnovci Municipality, where suitable areas have been selected and assessment of the forecasted theoretical and technical potential for energy production has been made separately for each RES and for each municipality. Research and analysis of RES potential was made for both districts.

1.2 Basic definitions

1.2.1 Types of RES

Renewable Energy Sources encompass solar, wind, water, geothermal energy, as well as energy obtained from plant and animal biomass. Production of energy from RES is supported by Bulgarian and EU legislation. When a project based on using RES is implemented, purchasing of energy is guaranteed at preferential rates according to the regulations and decrees adopted. The different types of RES require specialized preparation and resources.

Energy from water sources

Hydro Power Plants (HPP) are a traditionally well-developed renewable source of energy. HPP produce energy through gravity of falling or running water. This is the most widespread energy form of RES across the world. Price of energy from RES is relatively low which makes it a competitive source of renewable energy. Additionally, HPP are a flexible source of energy being able to get charged or discharged very fast in order to respond to the ever changing needs for electricity. The main ecological issue with them is the damming of rivers where the obstruction of the river flow affects negatively the ecosystems along the river basin, while the construction of dams and reservoirs is often accompanied by displacement of people and livestock. Once constructed, HPP does not directly produce waste and has lower carbon footprint compared to the energy obtained from solid and liquid fuels.

Biomass

The term “biomass” is a generic term used in relation to organic matters of plant or animal origin that may be recycled, processed and used for production of energy. Most often it is being associated with plants or plant-based products called lignocellulose biomass. These are

predominantly waste products of plant origin from wood processing, agriculture, food processing, household waste, the industry and others. As an energy source biomass can be used directly by burning to produce heat or indirectly after having been transformed into different forms of bio fuels. Transformation of biomass into biofuels is done via following methods: thermal, chemical and biochemical.

The decreasing reserves of primary energy sources and the ecological issues arising from their use are just some of the reasons that led to the search for alternative sources of energy and to the development of new technologies for their utilization. Being a part of the Renewable Energy Sources, biomass is among the energy vectors that, unlike a certain part of the other renewable, are well-known and widely used.

Among the main advantages of biomass compared to other Renewable Energy Sources is its capacity to directly turn into liquid fuels like biodiesel and ethanol, as well as its suitability for use in the production of biogas, especially in agricultural areas with large amounts of livestock.

Main sources of bio energy are wood and wood chips; beside the waste from wood processing, fast growing hardwood species are also used for the production of biomass. Normally these are specially selected wood varieties like hybrid ivy and poplar, maple, ash tree, walnut and plane trees which are good for use within five to eight years after planting. Waste from forestry includes also biomass which has not been collected or removed from clearings, as well as materials obtained by forest management activities like thinning or removal of dying trees. Solid and liquid wastes from agriculture are also sources of biomass. Out of the solid agriculture wastes, in the energy production mostly hay, corn stems, rice stems and others are used, with maize feed holding serious percentage. Liquid wastes from agriculture being mainly waste products from animal and poultry farms are also used in the production of biogas. Beside agriculture crops biomass includes also certain water cultures. These are predominantly some varieties of algae. Biomass includes certain solid industrial wastes like oils and minerals of vegetal and animal origin, and some household waste containing a substantial quantity of organic matters obtained by plants represent a source of renewable energy.

Several main technologies are used for the utilization of biomass. Some of them are direct burning, parallel burning, gasification, pyrolysis and anaerobic assimilation. Parallel burning, gasification and anaerobic assimilation are technologies still having relatively limited application. They are suitable for use mainly in industrial environment. In parallel burning, the biomass is used as an additional resource of energy in highly effective coal-fired steam boilers. Gasification is related to the production of biogas used as a fuel in energy plants with combined production cycles. Anaerobic assimilation is a process in which methane and other secondary products are obtained. In this process organic matters are disintegrated by bacteria in oxygen-free medium. Undoubtedly, direct burning in furnaces and heaters is the easiest way of biomass utilization. The main disadvantage is its lower effectiveness due to temperature losses through their bodies or through exhaust gases.

Biogas is a fuel gas obtained through organized fermentation of biological products in anaerobic medium. Its basic composition is: 55%÷75% methane and 25%÷45% CO₂. Calorific value of biogas is from 4,5 to 7,5 kWh/m³. One kilogram of methane equals 1,18 kilo of heavy oil, i.e. 1 m³ of methane = 1 l of heavy oil. Out of 1 kilogram of biomass (as a dry substance) 200 l to 1.200 l of bio gas are obtained depending on the biomass composition and the conditions of fermentation.

Starting raw materials for the production of biogas are wastes produced by animal farms – grass, straw, leaves, pine needles, manure, feces, litter (mixture of feces and straw), wash waters, food and household waste. These materials contain organic and non-organic substances; thus, they are a suitable medium for the growth of various microorganisms. These materials represent a serious problem as they pile up in large quantities and pollute the environment. During their natural fermentation methane is being released which is a greenhouse gas and makes up 7% to 10% of the global methane pollution.

Main source for the production of bio diesel is rapeseed. There is a high demand for this product on European markets which makes it an inseparable part of the contemporary grain production. It flowers from 15th of April till 10th of May and is a good source of anther for bees.

Seeds of this plant contain from 40% to 52% slow-drying oil, up to 20% proteins and over 17% carbohydrates. Nutritional qualities of the rapeseed oil are defined by oil and acid composition and the content of A, E, K and D vitamins, phosphatides and tocopherols. Around 85% of rapeseed oil composition is essential fatty acids: 20% linoleic and 65% oleic acid. This makes it the most important among the plants rich in oils and proteins and it occupies the third place in the global production of vegetable oils and biofuel (diesel). Its waste products are oil cakes and groat. They contain around 33% of proteins and represent valuable forage for livestock. Groat from rapeseed oil is very close to the one from soy in terms of feed quality.

The rapeseeds grow slowly already at 1÷2 °C, while in spring they start to vegetate again at 3÷4 °C. Rapeseed is a plant of the long day. It develops greatly in mass and needs a lot of water, especially during buttonisation and flowering, as well as during the growth phase of pods. Seeds germinate upon having absorbed 80÷90% water of their mass. It is tolerate to various types of soils – black, alluvial, grey, cinnamon and brown forest soil. Most of the modern hybrids could be grown even on weaker soils in pre-mountainous areas where other cultures yield unsatisfactory results. Rapeseed requires neutral reaction of soil, but it develops well also with slightly acidic and slightly alkaline reaction of the soil at Ph 6÷7,5. Rapeseed growing technology is to be followed strictly.

Recommendable sowing density is 50÷80 seeds per m² so a yield of minimum 20÷30 plants per m² is secured.

Sowing standard depends on the relevant technology of rapeseed growing and varies from 0,4 to 0,9 kg/decare for the different varieties.

Calorific value of biodiesel is almost the same as of petrol diesel, 10,5 kWh/l and 11,6 kWh/l respectively. Rapeseed yield is approximately 1 170 kg/ha which results in production of 421 kg/ha of biodiesel.

The Paulownia grows at places up to 2 000 m altitude. An altitude of 750 – 800 m is recommendable for the plant cultivation with investment goal.

Growth of trees starts when soil temperature reaches 15 °C÷16 °C. Optimal temperature for growing of paulownia is in the range 24 °C÷33 °C.

Paulownia is highly adaptive to various soils and grows on a wide range of soils but it develops best in deep and well-drained soils.

Comparing its annual yield to those of poplar, willow or miscanthus it appears to be the most effective culture in our geographical area.

The main advantage of paulownia as energy yielding culture is its fast growth in the first 2 years of its life as well as the capacity of its root system to ensure forming of new plants on the spot of the cut stem. Seeds are sown in spring and in the end of the first vegetative period paulownia is cut to the ground level so formation of multitude of new stems during the following year is induced.

Growth during the following year is fast with the plant reaching 3-4 m height in the end of the year and 6-7 m in the second year when it is cut for processing of the biomass obtained in this way. Such a plantation has a life cycle of 20-25 years and is supposed to give 10-12 yields after which the ground can be used again for other purposes.

For the creation of forestry plantations, the following sowing density is recommended: 4x4, 4x5 or 5x5 m with 620÷500 trees/ha. Higher sowing density leads to slowing down of plants growth after the first 3-4 years. Lower sowing density produces much faster initial growth which results in lower quality of the wood material.

For an effective production of biomass trees are planted more densely than it is required in the production of wood material. Recommendable density of planting for production of biomass is between 350÷1000 trees/decare depending on the biomass harvesting technique, its follow-up use and the planting density.

Bioethanol is alcohol produced through fermentation of carbohydrates from sugar plants and cultures containing starch like sugar cane, corn, soya, sorghum, wheat etc. Beside that, for the

production of bioethanol, cellulose biomass from non-alimentary products like wood, straw and others can be used as well. Bioethanol is directly used as a fuel for various vehicles being usually mixed with gasoline for improving its octane number thus decreasing its harmful emissions. Besides, its use does not require any changes or replacements of existing installations of inner combustion engines which does not lead to additional costs. Just like biodiesel, bioethanol is ecologically renewable fuel which EU has established as a compulsory ingredient of petrol fuels in recent years.

Solar energy

Energy from sunlight is used in two ways: through transforming it into electricity or through transforming it into thermal energy for households and industry. Electricity from the sun is obtained through transformation of sunlight either directly through photovoltaic pannels or indirectly through concentrating and focusing of light through enormous quantity of tracking mirrors/lenses. Photovoltaics transform light into power through the so called photovoltaic effect. On the other hand, thermal energy is produced in special flat collectors with selective covering or vacuum pipe collectors which capture and retain the heat from ultraviolet and infrared rays and render it to a thermal carrier, usually antifreeze.

Photovoltaics are important and relatively cheap source of power in areas where either the site is inconvenient for connecting to the power network or it is unreasonably expensive, or if there is no connection point at all. As prices of photovoltaic panels are constantly dropping, and also due to the fact that they do not release any emissions, the interest towards this type of RES is increasing.

The limited working hours during the day, their dependence of the weather conditions, as well as the seasonal nature of the yield may be pointed as some of the main disadvantages. Their life as a resource is also short, but with the progress of technologies this problem will weaken or disappear. Another disadvantage in terms of their principle of work is that power produced by photovoltaics is highly non-inertial which practically means that, for instance, switching from maximum to minimum power (in cloudy conditions) happens momentarily, without any delay. In the course of work these impulses lead to inconsistencies in the loads and to misbalances in the power system which is an unwanted effect.

Production of energy by photovoltaic power stations is directly influenced by the geographical position of the site, the daily dose of radiation reaching it and the index of transparency.

Solar energy is the energy that reaches a unit of surface for a unit of time. Measure unit is kWh/m² per day.

Index of transparency of air reflects the solar radiation reaching the Earth surface from the atmosphere which has a value of between 0 and 1.

High index of transparency means that the air has a high level of cleanliness and there are no obstacles for the solar radiation.

Geographical latitude of the site defines the amount of solar radiation and impacts the measuring of strings of the photovoltaic system.

Wind energy

Wind power plants are quickly getting to the lead position in the group of renewable energy sources. In Bulgaria there are several geographical areas that are suitable for the construction of mainly medium-sized wind turbines. Research and design of such equipment is to be done very carefully and thoroughly due to the specifics of the wind energy.

Wind turbines turn the kinetic energy of the wind into electric power. It happens through transformation of the linear movement of wind into torque of the vane shaft which in turn passes this torque onto a reductor and a generator.

The energy obtained in this way is attractive for several reasons: there is plenty of wind, it is free and practically inexhaustible, does not lead to pollution and climatic anomalies.

Researches done with the aim of determining the power potential of wind energy show that there are objective possibilities for its development.

Typically, this kind of wind power plants are constructed in the so called "wind parks" which are situated in previously assessed sites with a high amount of wind.

Again, the following might be pointed out as disadvantages: unbalanced loading; non-possibility of reliable long-run forecasting of winds and the production of energy respectively; difficult connection to the network due to the common remoteness of parks from the network; low frequency vibrations and noises; danger for bats and birds flying and nesting in the area.

Geothermal Energy

Geothermal energy is a thermal energy which is generated and stored in the Earth's crust. This energy originates from the initial forming of our planet (20%) and from the radioactive decomposition of the minerals contained in it (80%). The geothermal gradient, which represents the difference in the temperatures of the core and the surface of the planet, maintains a constant transportation of thermal energy from the inner part to the surface of the planet.

As a completely clean and practically free source of energy it is the best option of providing heating and hot water to a number of settlements, touristic centers and enterprises.

Geothermal energy is profitable, reliable, sustainable and ecological.

The high initial investment, as well as the peculiar disposition of the source which usually is situated on the boundary between tectonic plates, are the main disadvantages.

1.2.2. Theoretical and technical potential of RES

The index "Potential of Renewable Energy Resources" is viewed in two aspects:

- **Theoretical potential** is the resource which is established on an on-going basis from data from various scientific researches and measurements. In terms of biomass for instance it is the entire quantity of standing lumber, while for water sources it is the entire water resource available. Theoretical potential is the base for the assessment of the technical potential.
- **Technical potential** is defined as a part of the theoretical potential whose use is limited by technical and non-technical conditions obstructing the use of the complete quantity of the renewable energy source. An example of non-technical condition limiting the utilization of the biomass resource is the protected territories where economic activities are banned.

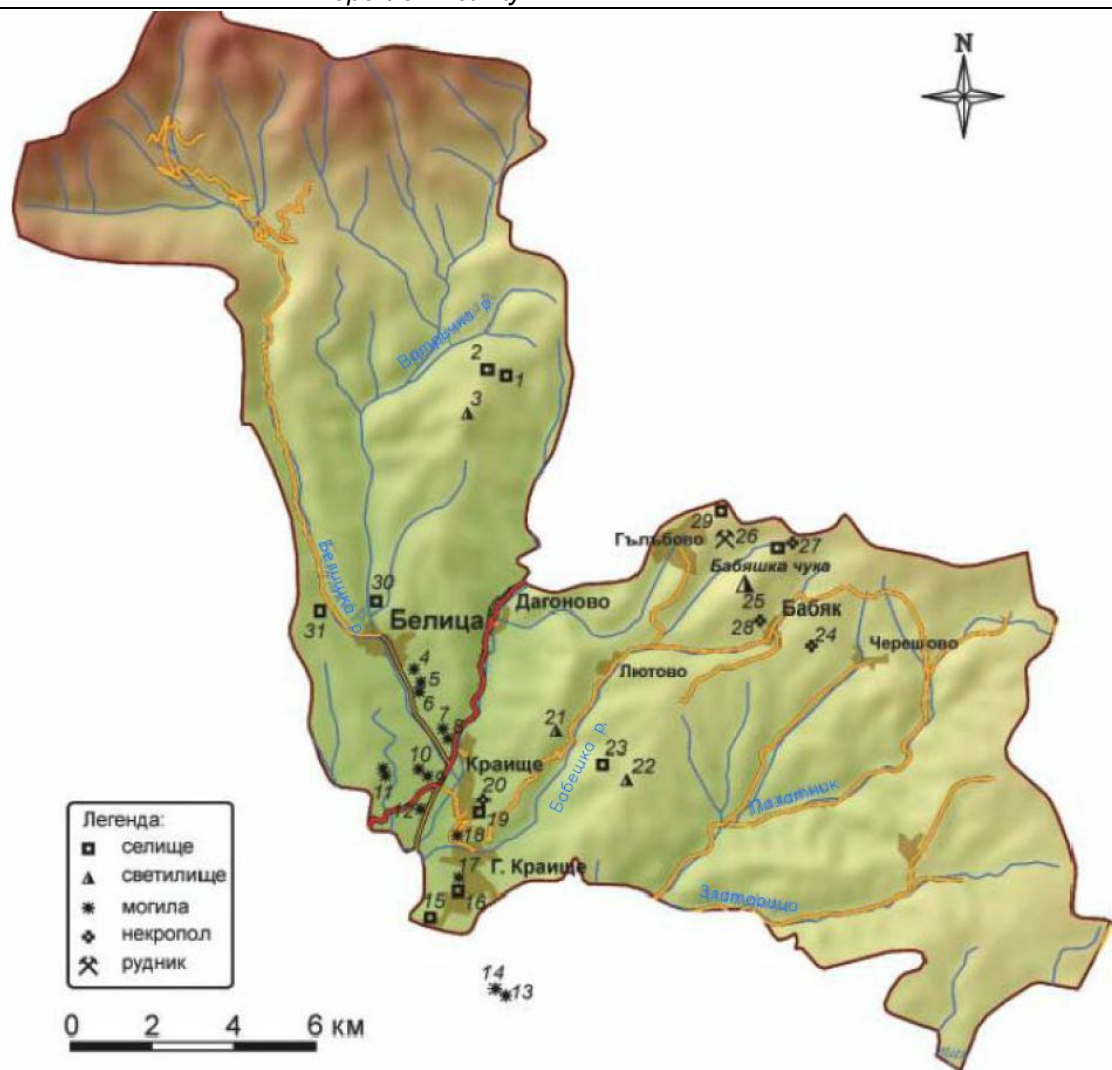
2 . BELITSA MUNICIPALITY

2.1 SUMMARY

Belitsa Municipality is one of the smallest municipalities in Southwestern Bulgaria with an area of 382 km² and a population of 9 927 inhabitants and is one of the municipalities of Blagoevgrad region. The town of Belitsa is the main administrative center of the municipality with 3 362 inhabitants, situated on the southern slopes of the Rila Mountain. The municipality borders the municipalities of Bansko , Razlog, Yakorouda, as well as Velingrad municipality in the District of Pazardjik; Rila Municipality in Kyustendil district and Samokov Municipality in Sofia district. It covers twelve settlements: the town of Belitsa and eleven villages: Kraishte, Gorno Kraishte, Dagonovo, Babyak, Gulubovo, Palatik, Chereshevo, Kuzyovo, Ortsevo, Lyutovo and Zlatarica.



Boundaries of Belitsa municipality



Map of Belitsa Municipality

The settlement network is poorly developed due to the limitations of the terrain, with no significant administrative and economic center. Eight of the mayoralties (Babyak, Gulubovo, Palatik, Chereshevo, Kuzyovo, Ortsevo, Lyutovo and Zlatarica) are scattered in the higher part of the Rhodope mountains.

Total area of the municipality is 293 536 decars.

2.1.1 Natural Resources

- **Relief**

The relief is mostly mountainous and hilly. Its average decline is 9.1%. The area covers parts of Rila and Rhodope mountains and the valley of the river Mesta. East of the Belichka river valley stretch certain parts of the eastern section of Rila Mountain. There are wide meadows in Semkovo (1600 - 1750m above sea level) on the southern slope of Rila Mountain and mountain slopes steeply dropping to Razlog valley. The municipal center – town of Belitsa is 880 m above sea level in the southern part of Rila Mountain and is connected by a 4 km deviation of the main road Razlog - Velingrad.

- **Climate**

The climate in the municipality is transitional-continental with Mediterranean influence, while in the higher parts of the mountains it is mountainous. The Mestenska Valley has a transitional-Mediterranean climate, but less pronounced than that in the Struma River valley due to its higher altitude. In the valley of Mesta River northwest winds prevail. The Rila massif rises on the border between the moderate-continental and transitional-Mediterranean climate. The mountainous terrain, large vertical segmentation and radial orientation of mountain ridges determine the layered weather with pronounced local variations. The maximum precipitation is in June, minimum - in February. Winters are cold with an average temperature in January of -2° C. Snow cover lasts about 150 days a year, and with the increase in altitude the number of days with snow cover also increases. Summers are short and cool with an average temperature in July of 18° C.

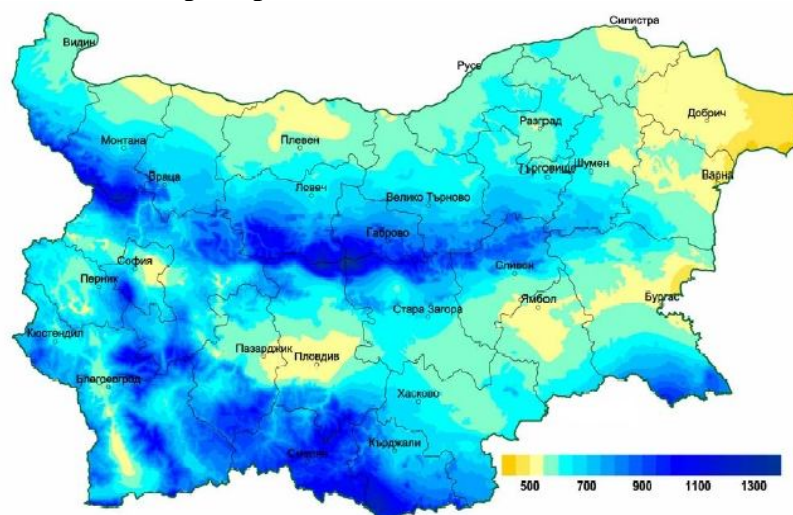
Average monthly air temperature (°C)

Belitsa Meteorological Station	January	February	March	April	May	June	July	August	September	October	November	December	Average Annual
	-1,7	0,3	3,9	9,0	13,6	16,7	18,6	18,9	15,1	10,4	6,2	0,8	9,3

Relative air humidity (%)

Belitsa Meteorological Station	January	February	March	April	May	June	July	August	September	October	November	December	Average Annual
	84	82	74	67	68	68	65	63	65	71	88	85	73

Annual amount of precipitation



Spatial distribution of annual precipitation in Bulgaria (in mm)

In the table below monthly and annual amount of precipitation is shown (55-year period average) for the two neighboring rain measuring stations in Razlog and Yakoruda

Monthly and annual amount of precipitation (in mm)

Rain measuring station	January	February	March	April	May	June	July	August	September	October	November	December	Average Annual
Razlog	66	56	53	61	59	57	48	29	34	60	71	72	66
Yakoruda	54	48	45	48	75	70	57	43	39	53	66	62	66

• **Soils**

Highland zones of Rila and Rhodope mountains are occupied by brown forest and mountain-forest dark soils. Lower parts of the valley of Mesta river are occupied by alluvial and alluvial-meadow soils.

Soil and climatic conditions and the strong vertical segmentation of the landscape have led to the development of strong and very strong degrees of erosion, especially in deforested areas. A major problem in the region is the massive logging, leading to increased erosion. Major part of the agricultural land located in the mountainous area is steeper than 6 degrees; it is not cultivated and grass grows on it naturally, which partly limits the erosion in a natural way.

–**Brown forest soils** - (Photo 1) sandy-clay. These are the most widespread soils in mountainous areas above 600 m altitude. They are humus-rich with a content of up to 12%, but the humus substance is not of a very good quality - the process of humification has not been completed. The reaction is slightly acidic - pH 5,5 ÷ 6. They are medium-stocked with easily absorbed nitrogen and phosphorus. Forest vegetation usually grows on them and they are rarely used for agriculture (mostly potatoes). In the higher parts of the mountains brown forest soils turn into dark colored forest and mountain-meadow soils. On the surface, there is usually 5 cm litter of dead organic debris, then 10 to 60 cm humus-accumulative horizon. They are fragmented and contain sharp stones across the profile.

- **Alluvial and alluvial-meadow soils** - (Photo 2a and photo 2b) distributed on I and II terraces above the rivers in the country. They are rich in stone materials and humus substances, are highly water-permeable and suitable for growing vegetables. Beside fertilization, the main activities to increase their fertility are aimed at preventing them from flooding by rivers, as well as from swamping and salinization.



Photo 1



Photo 2a



Photo 2b

• **Water resources**

The water resources of the municipality are formed by the Rila mountain rivers Mesta (coming out of the territory of the neighboring municipality Yakorouda), Belishka, Votrachka and the rivers coming from the West Rhodope mountains: Babeshka, Zlatarica, Palatik and their tributaries. Abundant precipitation, prolonged snow cover and relatively well-developed forest and grass vegetation determine the affluence of Rila mountain rivers in the municipality.

In the region of Belitsa municipality there are two springs, and on the territory of the municipalities in Rila National Park there are four mountain lakes.

Water Supply Systems

- **Potable water supply of the town of Belitsa and the tourist sites**

The water intake for potable water supply of Belitsa is on Vapata River with a maximum authorized amount of water - 0,35 l/s. The water supply system is made of asbestos-cement pipes which are not suitable for the construction of hydropower plants.

- **Potable water supply of Belitsa Park for readaptation of dancing bears**

The water intake for potable water supply of Belitsa Park for readaptation of dancing bears is Polenishka River with a maximum authorized amount of water - 0,2 l / s.

- **Flora**

Physical and geographical conditions specific to the area determine the availability of diverse natural forest vegetation. The coniferous species dominate the Rila Mountain: white and black pine, spruce, white and black fir. In the lower parts of the mountain oak is the most widespread of the deciduous species, with deciduous vegetation entering Rila river valleys deep in the mountain. Trees over 60 years of age dominate, as well as medium-aged up to 60 years.

- **Fauna**

The territory of Belitsa municipality includes Rila National Park which is a second-category protected natural site according to the classification of the International Union for Conservation of Nature. Situated on a territory covering 4 districts and 11 municipalities, the Belitsa section is of great importance for the conservation of biodiversity of large mammals. Species such as chamois, deer, wild boar and wolf can be found there. The chamois appears not only in the Red Book of Bulgaria as endangered species; it is also listed in the global ranking of the world semi-endangered species. The Dry Lake, which is one of the few habitats of glacial relict alpine newt, is also situated in this area. Other glacial relicts in the area are viviparous lizard and viper.

- **Protected sites**

The region has a large number of protected natural areas. The northern part of the municipality is located within the National Park of Rila, a 2nd category protected natural site under the classification of the International Union for Conservation of Nature.

- **Cultural and historical heritage**

6 km from Belitsa there is a Neolithic settlement dated to the early Neolithic Age with painted ceramics.

Near the town of Belitsa, 2 km from the Park for readaptation of dancing bears in the "Temnitsko" area is situated a Thracian settlement representing a Necropolis from IV century B.C.

3 km from Belitsa is the ancient site “Belichka Chuka”, representing a tomb from IV – V century BC.

7 km north of Belitsa in the area “Krastava mogila” a Thracian rock settlement is situated which has the status of immobile archaeological cultural heritage.

2.2 ENERGY FROM WATER RESOURCES

2.2.1 Water resources for HPP (hydro power plants)

Major rivers for production of electricity passing through the territory of the Belitsa Municipality are the Belishka, Votrachka, Stankova and Babeshka rivers.

In this research data is used from the climatic indices of Bulgaria about temperature and relative air humidity, monthly and annual amounts of precipitation and maximum precipitation which play an important role in the forming of river flux.

2.2.2 Hydroenergetics

In Annex 1 there is a table containing the HPPs constructed in Belitsa municipality.

2.2.3 Description of hydrological regime of rivers

Basic hydrological parameters have been determined based on observations in the period 1961 ÷ 1998.

➤ *Belishka River*

- Orohydrographical characteristics

Belishka river draws its waters from Vapski Lakes, Skalishki Lakes, the south-east slopes of Kanarata Peak (2691 m), Pastri Slap Peak (2683 m) and Goliama Pastrica peak (2606 m).

In the upper stream the watershed of the river is largely covered with predominantly coniferous trees but there are also deciduous trees.

Up to Hydrometeorological Station (HMS) 460 – Belishka River, 5 km above Belitsa town the watershed covers an area of 64,7 km²

- Basic hydrological characteristics

Table 1 Basic hydrological parameters of Belishka river

F (km ²)	M ₀ (l/s.km ²)	Water quantity and volume	Provision %						
			Average	95	90	75	5	1	0.1
64.7	19.32	Q ₀ (m ³ /s)	1.25	0.69	0.79	1.05	91	138	211
		W ₀ (МЛН. m ³)	38.38	21.63	24.98	33.10	-	-	-

➤ *Votrachka River with right tributary Stankova River*

In the watershed of Stankova river there is no hydrometeorological station (HMS) set up. For the determination of water draining characteristics data have been used from the analogue station HMS №210 on Votrachka river above Belitsa town, and additionally from the HMS №211 on Biala river. The source feeding of the watersheds of Belishka and Votrachka rivers comes from deep fissures and the influence of heavy rain alluviums in the foot of high peaks is significant over the average multi-year water flux.

Due to the specific high mountain conditions, topographical, orohydrographical, soil-geological and climatic peculiarities of the watersheds, the superficial water flux is influenced by the climatic peculiarities and the precipitation.

Table 2 Basic hydrological parameters of Stankova river

F (km ²)	M _o (l/s.km ²)	Water quantity and volume	Provision %						
			Average	95	90	75	5	1	0.1
10.10	36.5	Q _o (m ³ /s)	0.369	-	-	-	-	57.80	-
		W _o (МЛН. м ³)	11.64	-	-	-	-	-	-

Table 3 Basic hydrological parameters of Votrachka river

F (km ²)	M _o (l/s.km ²)	Water quantity and volume	Provision %						
			Average	95	90	75	5	1	0.1
33.48	21.59	Q _o (m ³ /s)	0.716	0.309	0.456	0.607	-	-	-
		W _o (МЛН. м ³)	22.80	11.32	14.38	19.42	-	-	-

➤ **Babeshka River**

Table 4 Basic hydrological parameters of Babesha river - delta

F (km ²)	M _o (l/s.km ²)	Water quantity and volume	Provision %						
			Average	95	90	75	5	1	0.1
31.20	12.14	Q _o (m ³ /s)	0.378	0.256	0.286	0.324	-	-	-
		W _o (МЛН. м ³)	11.92	8.073	9.019	10.22	-	-	-

2.2.4 Potential area for construction of HPP

Based on the available technical information and the examinations done on the spot, an area for construction of HPP on Babeshka river above Gorno Kraishte village in Belitsa municipality has been selected. This area has been proposed for possible construction of a small HPP and basic parameters of the future plant have been established. By the moment of elaboration of this report there were no other investment intentions and it is free for future development.

The waters of Babeshka River will be used for production of energy.

Based on the inspections done of Babeshka river the place of water catchment and HPP building have been chosen to be in the area above Gorno Kraishte village.

Babeshka River HPP is planned to be of a derivation type with a water catchment, pressure pipeline and a building for the HPP.

The water catchment will be a bottom grid of Tyrolean type. The catchment will be placed on a part of the river close to the road. The bottom level of the river is at an altitude of circa 940 m.

The water level above the catchment basin is at around 948 m. The catchment basin will include bottom grids placed across the river, tidal outlets for alluvia, fish passage and sludge basin with water intake chambers for a pressure pipeline.

The pressure pipeline will be about 2,4 km long. It will be dug in 1 m underground. Its route will run along the shallower bank of the river. The pipe diameter will be 0,6 m. Pipes will be made of fiberglass. The platform of the HPP building will be situated in the end of the narrow valley immediately in its extension. The HPP site is 1,5 km above the village of Gorno Kraishte. Next to it there is a country road along the river.

2.2.5 Determination of the theoretical and technical potential

Table 5 below shows the estimation of the theoretical and technical potential of the relevant site in Belitsa municipality.

Table 5 Theoretical and technical potential of the site in consideration

Water amount	Pressure	Power	Theoretical potential	Technical potential
[l/s]	[m]	kW	MWh/year	MWh/year
500	110	440	3 854	2 024

2.2.6 Parameters of the small HPP and potential annual average energy production

- Water amount: 0.500 m³/s
- Pressure: 110 m
- Turbine type: Pelton
- Power: 440 kW
- Average annual energy production: 2 024 MWh

In Annex 2 (Drawings 1 and 2) the position of the selected zone of production is indicated.

2.3 ENERGY FROM BIOMASS

2.3.1 Evaluation of the surveyed area

Fields occupy most of the arable land in the Municipality Belitsa: 19 131 decars or 55.9% of the municipal territory. The amount of permanent crops is 3 241 decars (9.5% of arable land). The amount of natural meadows is considerable: 11 787 decars (34.5%).

The total area of cultivated land (arable land, with fields and pastures) is 62 146 decars, or 21.1% of the municipal territory.

The main crops for the municipality are potatoes. Other crops grown are: beans, corn for grain and tobacco.

Livestock production is carried out only in the private sector and is characterized by the large number of small farms raising animals. Around 1690 heads of cattle, 6400 sheep, 445 goats and 314 horses are bred in the municipality.

In the municipality there are wood processing factories for production of lumber. Sawdust, splinters and barks are waste by-products from this production. Quantities of these residues are not known, but it is possible for their processing to be organized into pellets or briquettes for distribution to residents; thus, the quantity of timber used as firewood and illegal logging will be reduced.

On the territory of the town of Belitsa there is a working installation for production of pellets. This installation is owned by one of the factories and its capacity is unknown. It is probably used for recycling of waste from its own production.

Organized waste collection is done twice a week for Belitsa and once for the villages served in an organized manner. Amount of waste generated in the municipality is about 5152 tons from households and 11,700 tons from construction works.

Biogas production

For the production of biogas in the municipality a bioreactor needs to be constructed on a previously inspected and approved place near sources of organic waste. A major issue is that regular collection and consistency in the and production of manure from individual farms in Belitsa Municipality needs to be ensured. Removal should be done regularly and in organized way.

- Out of one ton of manure from cattle between 200 ÷ 350 m³ of biogas are obtained with a methane content of 60%;
- Out of one ton of plants between 300 ÷ 630 m³ of biogas are obtained with a methane content up to 70%.

Biodiesel production

The amount of natural meadows is 11,787 decares. At this stage there are no known abandoned and uncultivated agricultural areas due to a lack of interest or owners. These lands are suitable for sowing of oilseed cultures such as rapeseed or corn.

After removal of seeds, the waste biomass may be used as silage to animals or for the production of biogas in bioreactors.

2.3.2 Determination of the theoretical and technical potential

Rapeseed for production of bio diesel:

If 25% of the arable land of the municipality Belitsa i.e. 5000 decars (500 ha) are allocated for the production of rapeseed, this would make 210 500 kg of biodiesel or 2,525,250 kWh a year.

Theoretical potential is 10 101 MWh per year, while technical potential is 2 525,25 MWh per year.

Straw for direct combustion for heating:

The technological potential of the straw used for animal bedding is about 23 MWh / year, and the theoretical potential is about 60 MWh / year.

Manure for biogas production and utilization by cogeneration:

It is possible to collect the manure of the animals listed in item 2.3.1. to produce biogas in the amount of 190 m³ / h or about 1200 kW. Energy value of biogas produced from manure is estimated at around 480 000 m³ of biogas per year, or at energy of 3 024 000 kWh per year. This would ensure the operation of a boiler or a cogenerator with a power of 370 kW at annual load of around 8000 hours.

Theoretical potential is 10 485 MWh/year, while technical potential is 3 024 MWh/year.

The lower operational calorific value of the biogas depends on the content of methane (50% ÷ 70%) and is in the range of 8 ÷ 6 kWh/m³.

If the residues of agricultural crops after harvesting are measured, additional quantity of produced biogas can be determined, keeping in mind the yield of biogas from a tonne of organic dry matter which is:

- Fresh alfalfa: 350 m³
- Grass: 550 m³
- Straw: 340 m³
- Tree leaves: 250 m³
- Corn stalks: 420 m³

-
- Dairy waste: 630 m³
 - Sewage water: 600 m³

2.3.2 Possible zones of construction of installations for utilization of biomass

The most probable biogas installation is the one located in Belitsa, provided that it will be using manure only from Belitsa and the closest villages: Kraishte, Gorno Kraishte and Dagonovo. They are at an average distance of 3 km from the road junction to Belitsa and are at the same altitude. In the other villages biogas could be produced in each settlement separately in small quantities from 1.5 to 3,5 m³ per hour. These installations may have an effect only in environmental aspect.

2.4 SOLAR ENERGY

2.4.1 Potential areas of construction of photovoltaic installation

The suggested sites of construction of photovoltaic panels are relatively flat without declinations and large inclinations. They are selected to be close to asphalt or dirt road, with access for heavy machinery and equipment.

➤ Area 1

Area 1 is provisionally named Belitsa1, to facilitate its recognition of the photos and in the calculations.

❖ Geographic coordinates

The exact coordinates of the site are shown below, as well as satellite images and photos.

N 41 ° 55'45, 82 "

E 23 ° 34'42, 55 "

Altitude 808 m.

The site is about 3 km from the center of Belitsa; 1 km from the main road of the municipality II-84 Razlog-Velingrad; 84 km from Sofia; 329 km from the port of Burgas.

The place is dominated by low vegetation, as evidenced by the attached photos.





The site is selected so that it is accessible for installation and operation near asphalt or passable roads to facilitate work of machines. No risk of damming, swamping or fogging.

There is no danger of shading as the horizon is clear both to the east and to the west .

Soil is firm, can bear concrete foundations on the surface or in non-freezing depth. In the preliminary examination no signs of shallow underground rocks were found which provides an opportunity for installation of constructions onto pile-driven steel poles or screws.

The exact conditions of the installation will be clear after a detailed geological survey of the soil is taken.

➤ **Area 2**

Area 2 is provisionally named Kraishte (because of its proximity to Kraishte village) to facilitate its recognition on the photos and in calculations.

❖ **Geographic coordinates**

The exact coordinates of the field are shown below, as well as satellite images and photos.

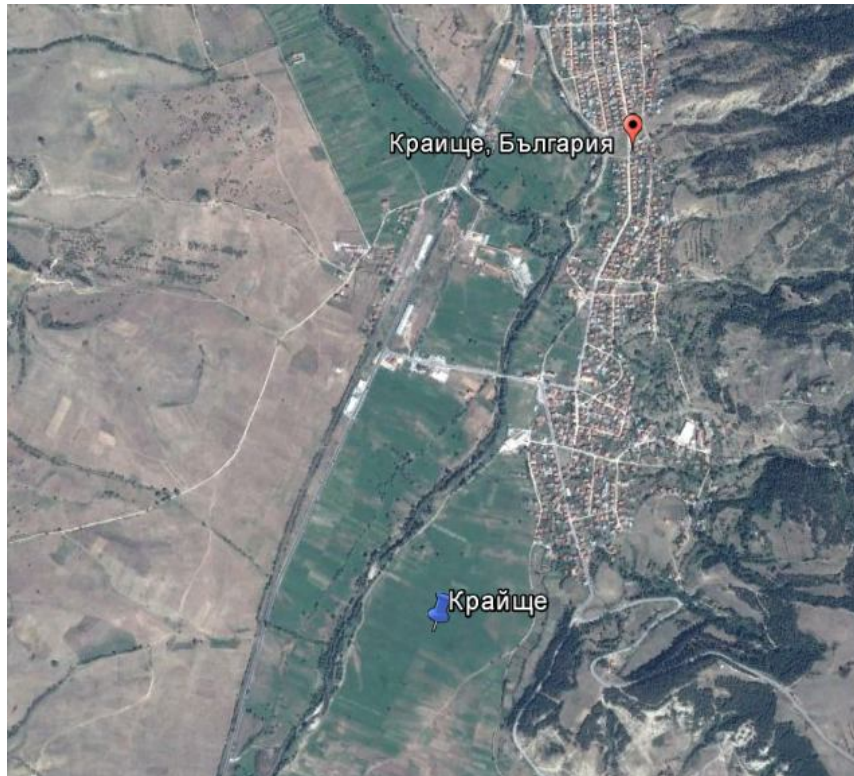
N 41 ° 54'28 .16 "

E 23 ° 34'50 .90 "

Altitude is 755 ÷ 765 m. Area is ventilated which will ensure better cooling of modules at higher ambient temperatures during summer months.

The site is about 2 km from the center of Kraishte village, 100 km from Sofia; it is next to the main road of the municipality II -84 Razlog - Velingrad; 326 km from the port of Burgas (all distances measured in straight line).

The place is dominated by low vegetation, as evidenced by the attached photos.





The location was selected so that it is accessible for installation and operation, near asphalt road, to facilitate the work of machines. Large leveling or removal of soil is not required. It is located near Mesta River, which could be a prerequisite for the formation of fog, thus reducing its electricity production.

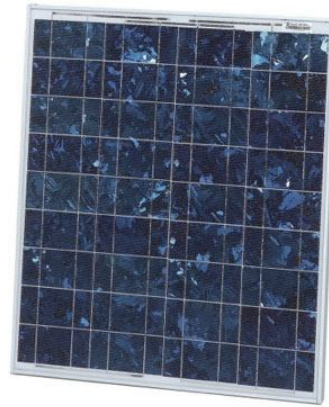
There is no danger of shading, as the horizon is clear both to the east and to the west.

In the preliminary examination no signs of shallow underground rocks were found, which makes installation of constructions on pile-driven steel poles or screws possible.

The exact conditions of the installation will be clear after a detailed geological survey of the soil.

2.4.2 Parameters of photovoltaic installation

- Types of photovoltaic modules



Crystal, mono and poly

Amorphous
(thin-ply)

➤ Crystal silicon photovoltaic modules

Advantages: possibility of installing more capacity in the relevant field.

Disadvantage: Substantially greater heat losses.

➤ Amorphous silicon photovoltaic modules

Advantages of this technology are better performance in diffuse light (in cloudy conditions), as well as lower temperature quotient, providing 10% more efficient operation at environment temperatures of around 35 °C.

Major disadvantage: significantly smaller installed capacity.

Based on the results obtained and the recommended technology for this field, the economic forecasts envisage the following average annual production:

Technology	<i>PVGIS-CMSAF</i>
Crystal	1720 kWh/kWp
Losses registered in the system for 1 kW:	
- Temperature losses:	8,6%
- Losses from reflections:	2,8%
- Losses in cables, invertors, transformers etc.:	10%
Thin-ply	1720 kWh/kWp
Losses registered in the system for 1 kW:	
- Temperature losses:	1,0%
- Losses from reflections??:	2,8%
- Losses in cables, invertors, transformers etc.:	10%

2.4.3 Determination of theoretical and technical potential

The theoretical potential is 1,55 MWh/m² annually, while the technical potential is 1,72 MWh/year.

2.5 WIND ENERGY

2.5.1 Potential areas for construction of wind generators

Before a wind system is installed, the existence of sufficient potential for its operation should be verified. Necessary information can be obtained through statistical reports from the National Institute for Meteorology and Hydrology, or own measurements of the indicators in the selected site could be done.

Locations selected for the installation of wind turbines have been selected according to the theoretical rationale of Bulgarian Academy of Science (return on investment at over 1,000 m above sea level and a certain wind speed), as well as based on their accessibility for transportation and installation of machinery.

➤ Area 1

(provisionally named WindGenerator1)

❖ Geographic coordinates

The exact coordinates of the area are shown below, as well as satellite images and photos.

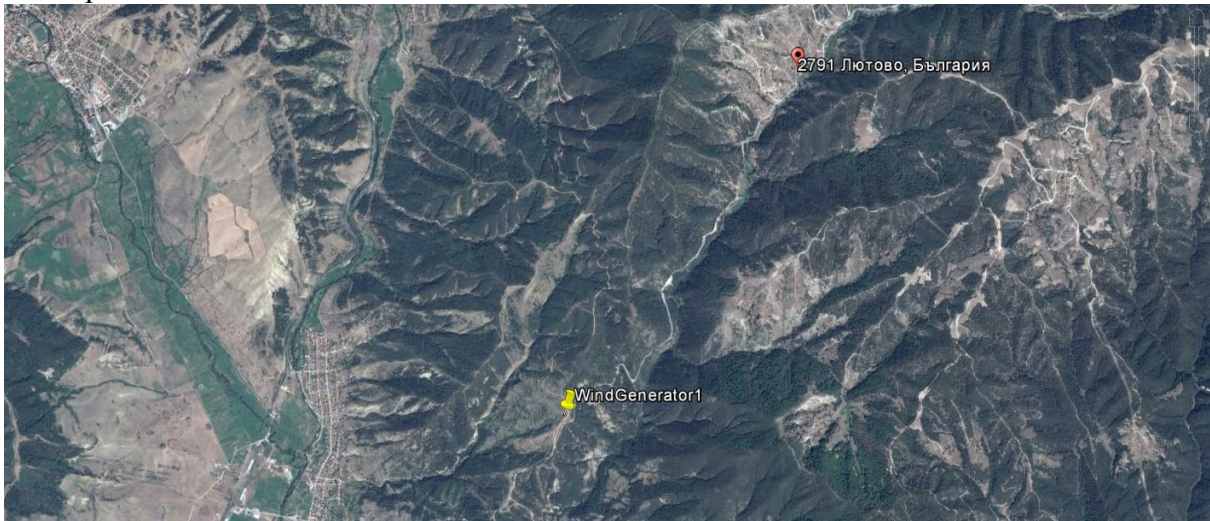
N 41 ° 55'19 .88 "

E 23 ° 36'37 .19 "

Altitude 1040 m.

The distance from the site to the administrative center of Belitsa municipality is about 20 km, near the road Dolno Kraishte - Lyutovo; 4 km from the village of Lyutovo.

Coniferous trees up to 10 m high predominate on the site, which is evidenced on the attached photos.





The selected location is accessible for installation and operation, near asphalt and relatively passable road, to facilitate work of machines.

Soil is firm, can bear concrete foundations on the surface or in non-freezing depth.
The exact conditions of the installation will be clear after a detailed geological survey of the soil.

➤ **Area 2**

(provisionally named WindGenerator2)

❖ Geographic coordinates

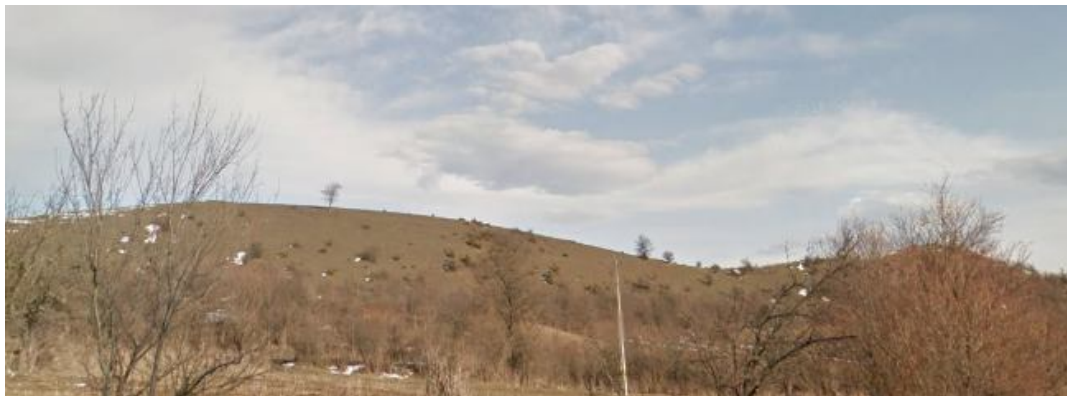
The exact coordinates of the site are shown below, as well as satellite images and photos.

N 41 ° 56'24 .95 "

E 23 ° 34'29 .71 "

Altitude 850 m.

The distance from the site to the administrative center of the municipality Belitsa is about 1 km.



Coniferous trees up to 10 m high predominate on the site, which is evidenced on the attached photos.

2.5.2 Theoretical data of wind potential

As the places are within close distance the preliminary report summarizes data for both sites.

Municipality of Belitsa is within an area of small wind energy potential. The characteristics of this area are:

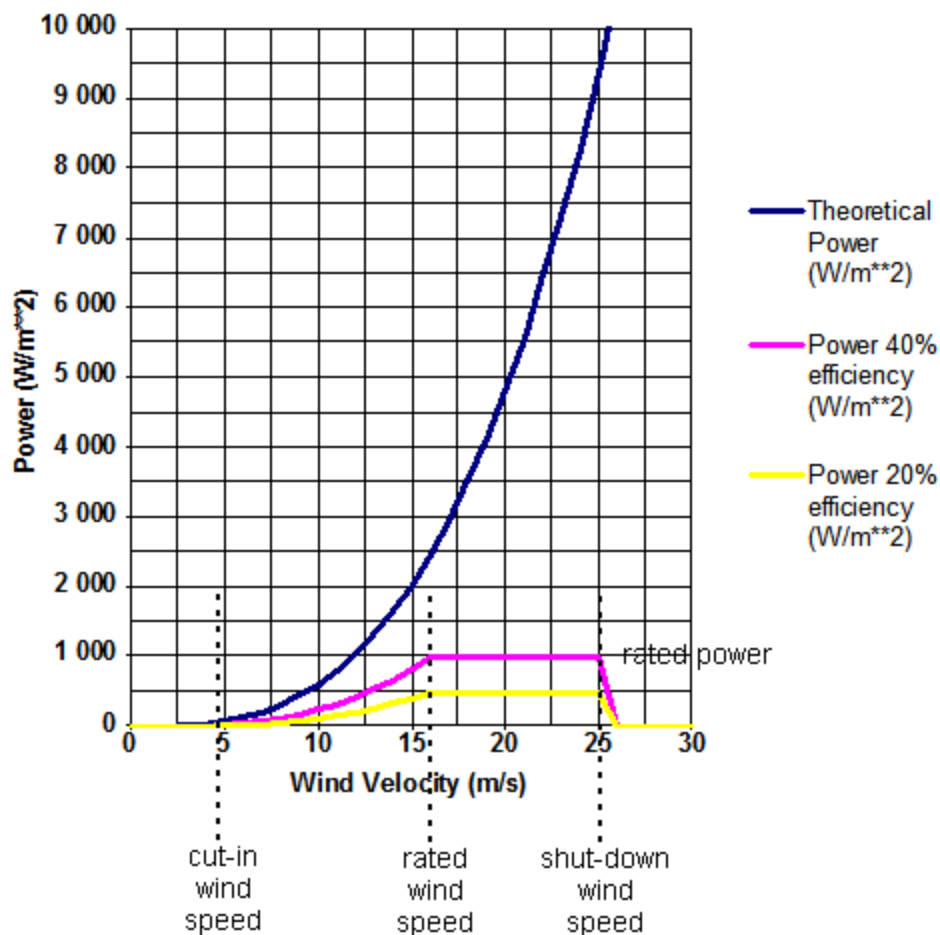
Average wind speed - $6 \div 7$ m / s;

Energy potential - 100 W/m² (Less than 1450 kWh/m² per year);

Average duration of the speed range $\sum \tau_{5-25}$ m/s in this area is about 1000 h, which represents about 12% of the number of hours over the year.

Table 6 Average wind speed in m/s by bearings for the Belitsa station (936 ÷ 1000 m altitude)

<i>Direction/month</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>
<i>N</i>	3.8	3.3	3.6	2.7	4.3	4.3	3.3	6.8	4.3	2.6	4.0	5.0
<i>NE</i>	3.3	3.0	3.2	2.6	3.4	2.9	2.5	3.8	3.2	1.9	4.5	4.8
<i>E</i>	8.5	3.6	3.1	4.5	3.2	3.1	3.1	4.3	4.4	5.1	7.5	5.8
<i>SE</i>	4.0	7.0	3.6	3.4	3.0	2.6	2.6	4.0	3.2	4.3	3.0	9.0
<i>S</i>	3.0	1.5	8.3	2.3	2.8	2.2	3.7	5.0	3.0	2.7	2.5	3.0
<i>SW</i>	3.7	5.3	6.3	6.7	2.9	4.7	6.1	4.0	9.0	3.9	5.3	5.5
<i>W</i>	5.7	6.0	6.3	6.0	6.6	6.1	6.5	6.2	6.1	6.1	8.2	7.0
<i>NW</i>	8.8	6.1	5.0	6.4	5.3	5.8	4.8	4.7	5.2	4.8	7.5	5.6



Most turbines are designed to switch off at speeds above 25-30 m/s to avoid damage. More powerful turbines switch on at wind speeds above 5 m/s.

The spatial distribution of wind energy is based on lines and surfaces of same values of the power stream density expressed in classes. In Table 7 seven wind classes are identified according to the density of wind energy flow, with their distinctive parameters defined for two different heights: 10 m above the ground (at which wind measurements are done in all meteorological stations across the world) and 50 m.

Table 7 Wind classes

Wind class	h = 10 m		h = 50 m	
	Density of power stream, W/m ²	Wind speed, m/s	Density of power stream, W/m ²	Wind speed, m/s
1	0...100	0...4,4	< 200	< 5,6
2	100...150	4,4...5,1	200...300	5,6...6,4
3	150...200	5,1...5,6	300...400	6,4...7,0
4	200...250	5,6...6,0	400...500	7,0...7,5
5	250...300	6,0...6,4	500...600	7,5...8,0
6	300...400	6,4...7,0	600...800	8,0...8,8
7	> 400	> 7,0	> 800	> 8,8

Analysis of data in the table shows that at height equal to 50 m, wind stream density is twice as high than at a height of 10 m. At the higher altitude wind speed increases by about 25% for each wind class. There are interesting variations in the wind parameters at other heights: 30 m and 80 m. It has been proven that the density of energy stream at a height of 80 m is slightly greater than at 50 m: by 10 ÷ 20%, while speed is also higher, but only 1 ÷ 6%. Values of these parameters at 30 m rank between those relating to 10 m and 50 m.

In choosing turbines, beside the wind speed, the diameter of the rotor is also taken into consideration.

Turbines of the Enercon and Vestas companies are given as an example:

It is assumed that for the purposes of the calculation made, the speed is 5m/s, while the height of the tower for the gondola is minimum 70÷75 m.

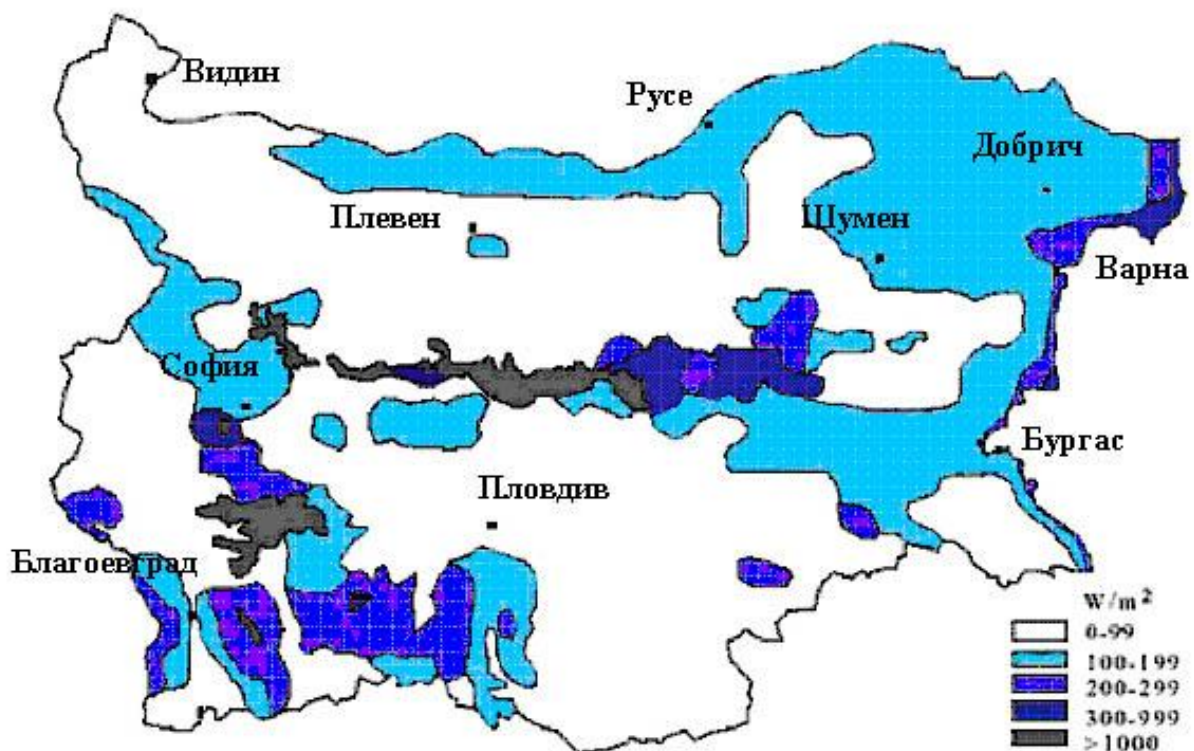
Company	Machine model	Diameter of the rotor, m	Power, kW
Vestas	V90-1,8/ 2,0 MW	90	95,42
	V110- 2,0 MW	110	142,55
Enercon	E-82 E2 / 2,000 kW	82	79,21
	E-70 / 2,300 kW	71	59,38

At lower wind speed lower power wind generators will be more economical.

2.5.3 Determination of the theoretical and technical potential

Theoretical and technical potential cannot be determined without additional measurements being taken on the spot for at least one year.

As a starting point, however, values of energy stream shown in the following map can be taken:



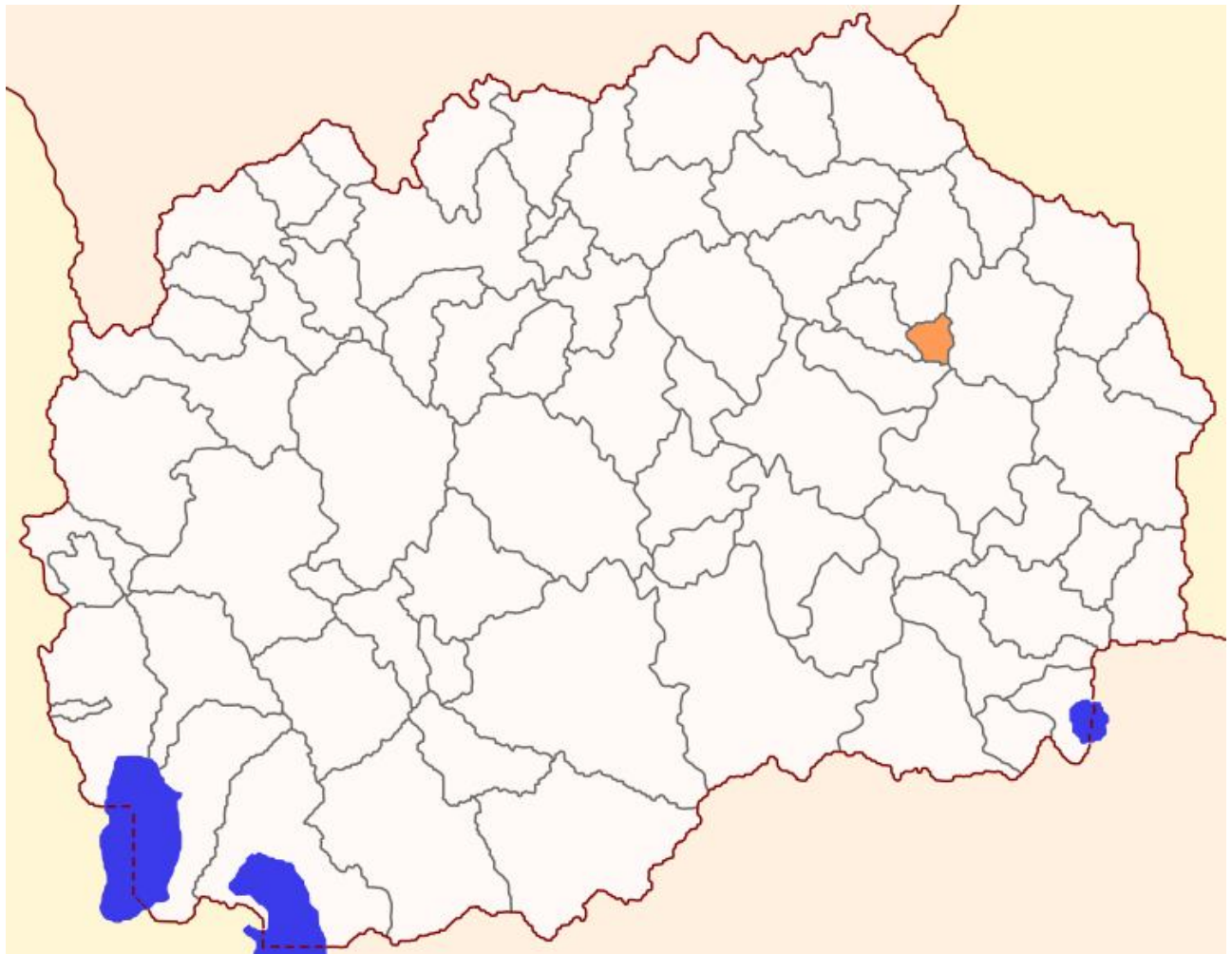
Scheme map of the wind energy density at a height of 10 m above the ground. It is measured in W/ m² from the ground.

3 ZRNOVCI MUNICIPALITY

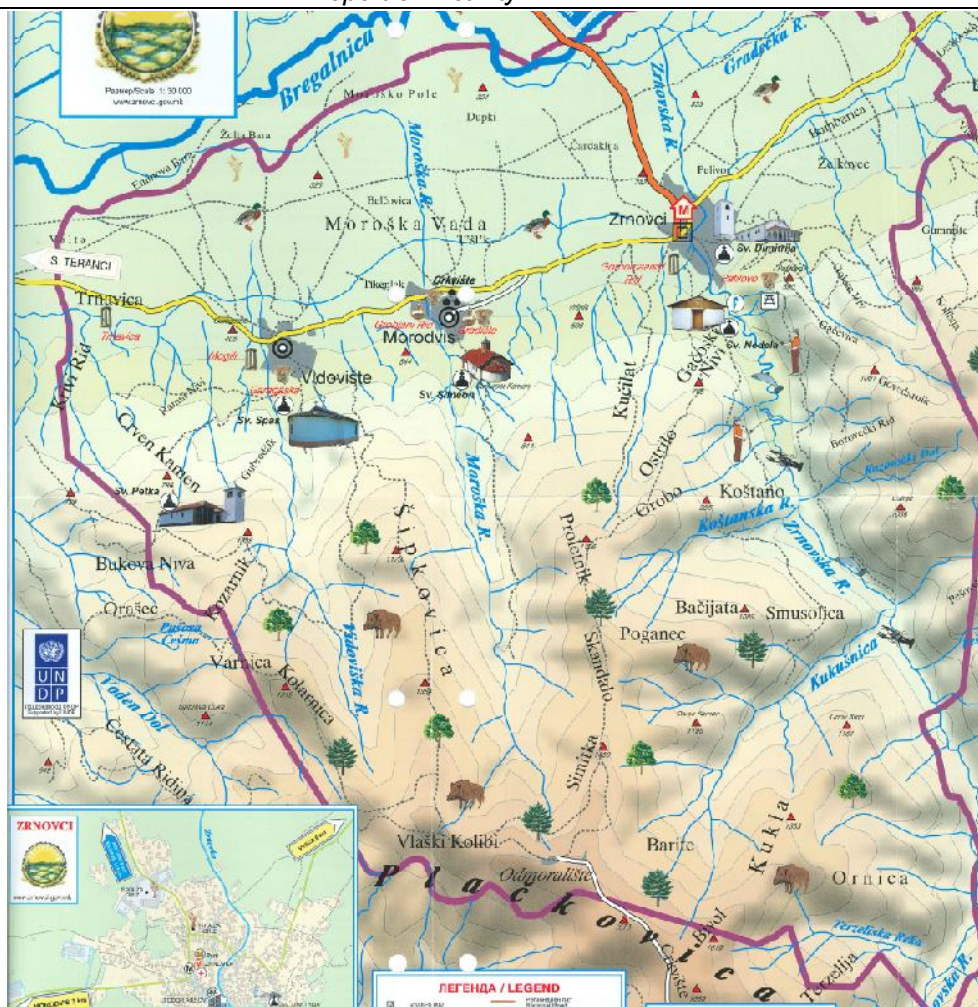
3.1 General description

Zrnovci municipality is one of the smaller municipalities in the eastern part of the Former Yugoslav Republic of Macedonia with a territory of 55,82 km² and a population of 3 112 inhabitants according to the state statistics data as of 2012. It is situated along the cross-border highway connecting Skopje-Veles-Shtip-Kochani-Delchevo with the Republic of Bulgaria. Zrnovci village is the administrative center of the municipality. Being mainly agricultural area, Zrnovci is one of the least environmentally polluted. It is located in the skirts of Plachkovica Mountain, i.e. in the zone of the Serbian-Macedonian massif or the “old” Rhodope mountain.

It is 8 km away from the closest railway in the town of Kochani, 134 km from the capital Skopje, 118 km from the international airport Alexander the Great (near Skopje) and 60 km from the border crossing point Delchevo-Bulgaria.



Location of the municipality in FYROMacedonia



Borders of Zrnovci Municipality

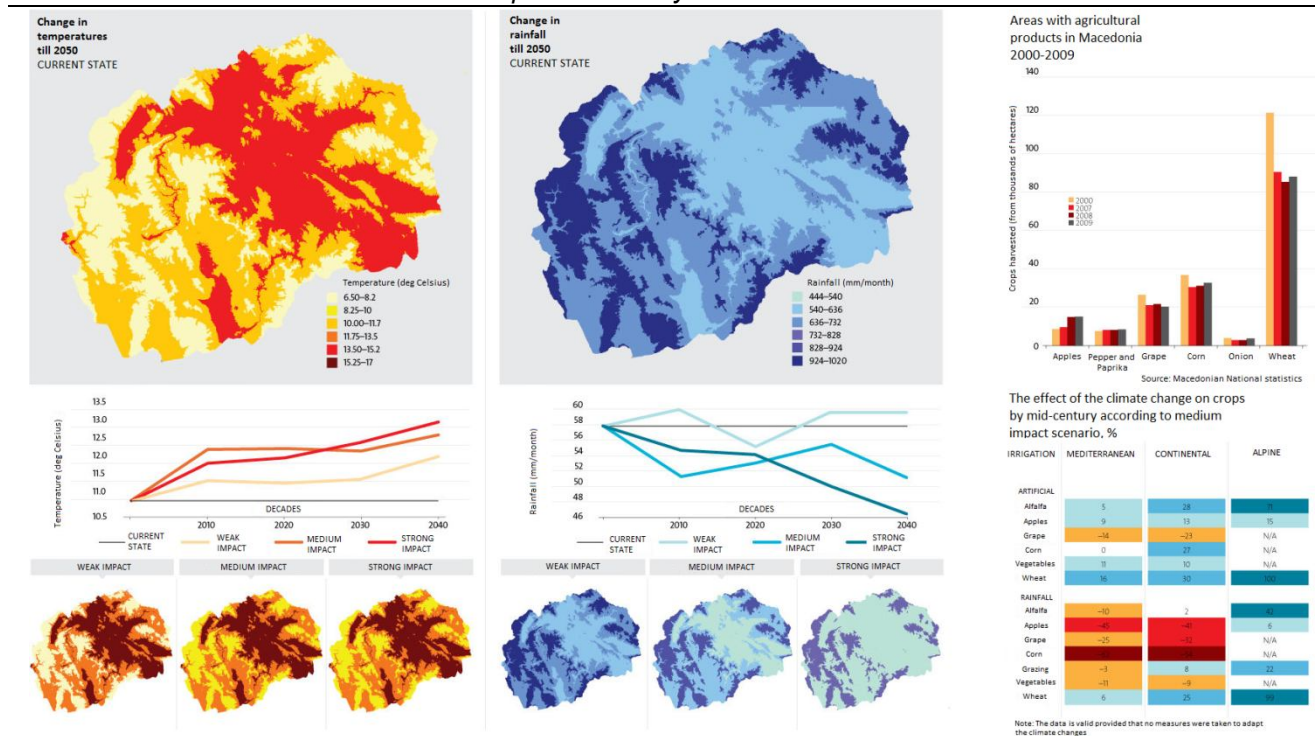
The largest village Zrnovtsi, which is the center of the municipality is located in the eastern part of Macedonia at an altitude of 345 m, in the Kochani valley, just at the foot of Plachkovitsa mountain on an area of 2 848 decares. Zrnovtsi is protected from the strong northern winds by the Ossogovska mountain, and from the strong air intrusions from south by the Plachkovitsa mountain. Out of the whole territory of Zrnovtsi 57% is forests and 32% is agricultural land. The majority of the arable land are rice fields.

3.1.1 Natural resources

- **Relief**

The area is mostly mountainous. Through Zrnovtsi passes Zrnovska River, which is one of the largest tributaries of the Bregalnitsa river. A hydroelectric plant was built here, which changed the river and the environmental conditions in it to some extent. The river and its basin are particularly important for the town as they are rich in flora and fauna. Other natural objects are Buovitsa and Poganechka springs which have very cold and clear mountain water, Divata Topola in Vidovishte, the natural lake Sulyov Puddle. There is presence of endemic trout and endemic crabs in the upper stream of Zrnovska river.

- **Temperature and fall values**



• **Climate**

The climate is moderate continental with mountainous and Mediterranean climatic influence. It is characterized by warm, dry summers and autumns and relatively cold winters with heavy snowfall.

Climate parameters in the municipality of Zrnovtsi are: average annual temperature 13° C; average relative air humidity 71%; average annual precipitation 547.9 mm.

• **Soils**

Brown forest soils predominate, while in the river valleys soils are alluvial-meadow.

- **Brown forest soils** - (Photo 1) sandy clay soils. They are the most widespread soils in mountainous areas above 600 m altitude. They are rich in humus – up to 12% content, but the humus substance is not a very good quality – the process of humification was not completed. Reaction is slightly acidic - pH 5,5 ÷ 6 . They have average content of absorbable nitrogen and absorbable phosphorus. They are usually covered with forest vegetation as they are rarely used for agriculture (mostly for potatoes). In the higher parts of the mountains brown forest soils turn into dark colored forest and mountain-meadow soils. On the surface, there is usually 5 cm litter of dead organic debris, followed by a layer of 10 to 60 cm of humus-accumulative horizon. They are fragmented – contain sharp stones across the profile.
- **Alluvial and alluvial-meadow soils** - (Photos 2a and 2b) are spread on terraces I and II above the terraces of rivers in the country. They are rich in stone and humus substances, are highly water-permeable and suitable for growing vegetables. The main activities for increasing of their fertility, besides fertilizing, are aimed at protecting them from flooding by the rivers, as well as swamping and salination.



Picture 1



Picture 2a



Picture 2b

- **Cultural and historical heritage**

Morodvis village is well-known for its archeological landmark Crkvishte which is situated in the center of the village. It represents the medieval city Morobizdon which was the cultural, economic and political center of Eastern Macedonia for a millennium. Moroshka River runs through the village and the village is surrounded by sycamore trees.

- **Water resources**

Water supply system of Zrnovci municipality

A water supply system was built to supply settlements in Zrnovtsi municipality that consists of a pressure pipeline connected to a penstock drawing water from a water tower, water treatment plant, mechanical filters located on the right-hand slope, as well as a feeding pipeline to a tank (P1) supplying the village and connected to tanks P2 and P3 supplying the other settlements in the municipality. Water supply system is designed with capacity of 21 l/s.

3.2 ENERGY FROM WATER RESOURCES

3.2.1 Water resources for Hydro Power Plants (HPP)

Several rivers run through the municipality, with the largest being Zrnovska river running through the village of Zrnovtsi. The watershed of the river is 38 km², and its length is 24 km. There is a hydro power plant built on the river. Other major rivers on the territory of the municipality are Moroshka river passing through the village Morodvis with 7 km² watershed and length of 6 km and Vidovishka river passing through the village Vidovishte with 5 km² watershed and length of 6 km.

3.2.2 Hydroenergetics

“Zrnovtsi” HPP was built in 1950 and reconstructed in 2009 and is still in operation. The plant is of derivation type. It was built just above the village of Zrnovtsi.

Basic parameters of Zrnovtsi HPP

- Pressure: 220 m
- Water quantity for turbine: 1 m³/s
- Power: 2x630 kW

- Annual electricity production: 5 500 000 kWh

Current projects

Currently, two new HPPs are under construction in the upper part of the mountains just above the catchment of Zrnovtsi HPP.

3.2.3 Potential area for construction of HPP

Zrnovtsi 2 mini hydro electric plant is being designed to cover electricity consumed by street lighting, the school and municipal buildings.

It will be built on the existing pipeline that draws water from the water tower and brings it to the treatment plant (TP). The pipeline has a diameter of 225 mm. Annex 2 (Drawings 3, 4 and 5) shows the location of existing and future facilities.

The main parameters of the new plant are:

- Pressure: 80 m
- Maximum amount of water - 21 l/s
- Maximum power - 13,4 kW
- Average annual power production - 80 000 kWh
- Maximum annual electricity production - 116 640 kWh

The new plant Zrnovtsi 2 will be located immediately by the Treatment, south of it. The existing site is relatively flat and is located 20 m from the building of the TP. Elevation $\pm 0^{00}$ of the turbine is 2 ÷ 3 m above the TP itself.

3.2.4 Determination of theoretical and technical potential

Table 8 below presents the evaluation of the theoretical and technical potential of the area in the Municipality Zrnovtsi.

Table 8 Theoretical and technical potential of the existing pipeline

Water quantity	Pressure	Power	Theoretical potential	Technical potential
[l/s]	[m]	kW	MWh/year	MWh/year
21	80	13,4	116,64	80

3.3 ENERGY FROM BIOMASS

3.3.1 Assessment of the researched area

The total area of the municipality is 51 764 ha, split as follows: 28 483 ha is Zrnovtsi village, 14 522 ha is Morodvis village; 8759 ha is Vidovishte village.

Forests cover 3034 ha.

Total arable land is 1 692 ha. Main crops are:

- Maize - sown area of 300 ha, yield 7000 kg/ha;

- Wheat - 90 ha sown area, yield 2000 kg/ha;
- Rice - 90 ha sown area, yield 5000 kg/ha.

Horticultural crops are grown of which mainly peppers, leek and pink tomatoes. Fruit-growing and viticulture are underdeveloped with production meant for own consumption of the population. Plums, peaches, cherries and pears are grown.

Animal breeding is less developed, split by villages as follows:

1. Modrovis village:

- Cows – 700 heads;
- Sheep – 400 heads;
- Horses – 20 heads ;
- Pigs – 150 heads;
- Goats – 20 heads.

2. Vidovishte village:

- Cows – 180 heads;
- Sheep – 1050 heads;
- Horses – 10 heads;
- Pigs – 200 heads;
- Goats – 300 heads.

3. Zrnovtsi village:

- Cows – 700 heads;
- Sheep – 30 heads;
- Horses – 40 heads;
- Pigs – 750 heads;
- Goats – 600 heads.

There are one large and two smaller companies for wood processing in the municipality, with a capacity of up to 150 m³ of beams and planks.

According to Zrnovtsi Municipality data biomass is collected annually from waste products from agriculture, animal breeding and wood processing, split in quantities as follows:

- Sawdust after treatment of wood - about 1800 kg;
- Pieces of wood - about 450 kg;
- Straw - 1000 kg/ha, in total 390 000 kg;
- Corn stalks - 1500 kg/ha, a total of 300 000 kg;
- Stem and foliage after harvesting of tomatoes and other vegetables - 6800 kg total;
- Waste of vines - 2500 kg;

Out of wood and vines waste material pellets can be produced whose energy value does not exceed 20 000 kWh per year. Production of pellets or briquettes will have primarily environmental effect in view of utilization of this waste.

Production of biogas

For the production of biogas in the municipality a bioreactor needs to be built on a previously researched and approved site, near sources of organic waste. A major problem is that

consistency in the collection and production of manure from individual farms in Zrnovci municipality needs to be ensured. Disposal should be done regularly and in an organized manner.

- out of one ton of manure from cattle between 200 ÷ 350 m³ of biogas are obtained with a methane content of 60%;
- out of one ton of plants 300 ÷ 630 m³ of biogas are obtained with a methane content up to 70%;

3.3.2 Determination of theoretical and technical potential

Rapeseed and paulownia for production of biodiesel:

For the production of industrial biomass like rapeseed, paulownia and others, the municipality has at its disposal an area of 65 ha.

For sowing of rapeseed in Zrnovci municipality an area of 15 ha has been allocated. It should produce circa 6 315 kg of oil, i.e. 66 310 kWh/g energy.

For sowing of paulownia 50 ha has been allocated.

Quantity of expected yield may vary per hectare and it depends on several factors. The first factor is the choice of plant variety, location, weather conditions, supplementary irrigation and all other factors normally affecting traditional crops. Expected yields of paulownia can vary in the range 30-40 dt / ha/year or up to 80 dt / ha with two-year rotation cycle.

Measured in energy units, dry weight paulownia has an energy content of about 18 MJ per kilo or 42% of the energy contained in an equivalent volume of light fuel. This sets the yield from ha per year as an equivalent to 12,000 ÷ 17,000 liters of fuel from ha. The financial effect can easily be calculated.

The 50 ha of land set for growing of paulownia will yield 850,000 liters of fuel per year, or energy amounting to 8.925 million kWh per year.

The theoretical potential is 89 000 MWh/year, while the technical potential is 8925 MWh / year.

Sludge from wastewater treatment plant for the production of biogas:

Upon visiting the municipality of Zrnovtsi it became clear that there is an ongoing project for treatment plant for wastewater in the municipality. In executing this project, out of the sludge from the treatment plant approx. 390 000 m³ of biogas could be produced, which is about 2.535 million kWh per year.

This determines the power of a boiler or a cogenerator at 300 kW with annual work load of about 8000 hours.

The theoretical potential is 25 000 MWh / year, while technical potential is 2535 MWh/year

Straw and manure for biogas production:

The total possible production of biogas from manure on the farms of the municipality is about 190 m³/h or 1,200 kW. Straw has an energy value of about 23 000 kWh per year. Since it is used for animal bedding it should be used in conjunction with manure for biogas production. Energy value of the produced biogas is estimated at around 2,847,000 kWh per year. This would ensure the operation of a boiler or a cogenerator with a power of 350 kW for 8000 hours work load on annual basis. The risk lies in the organization of delivering manure to the biogas production plant.

Stalks of corn are used for silage. If there are any silage leftovers they can be used for biogas production. The effect would only be environmental.

Stems and foliage of tomatoes and other vegetables could contribute to the production of biogas by about 600 m³ per year, which would also be only an environmental effect.

Technological potential is about 2847 MWh per year, and theoretical is about 30 000 MWh per year.

The lower part of the range of calorific value of biogas depends on the content of methane (50% ÷ 70%) and is in the range of 6 ÷ 8 kWh/m³.

If residues of crops are measured after the harvest an additional quantity of the produced biogas can be determined, whereas the extraction of biogas from tonne of organic dry matter is:

• Fresh alfalfa	350 m ³
• Grass	550 m ³
• Straw	340 m ³
• Tree leaves	250 m ³
• Corn stalks	420 m ³
• Dairy waste	630 m ³
• Sewage waters	600 m ³

3.3.3 Potential areas for construction of installations for biomass utilization

In defining the areas for construction of plants for biomass utilization distances between the potential equipment and the biomass source were taken into account in view of minimizing transportation costs and procedures for connection. For the possible sources for utilization of biomass, in particular biogas, cogeneration installation is suggested. Essentially these are internal combustion engines powered by biogas where heat and electricity are obtained as a final product. The advantages of these systems are high efficiency of utilization of primary energy and their capacity to produce electricity that could be sold at preferential prices under the current EU legislation. Due to these peculiarities, cogeneration with inner combustion engines is also commonly used in landfills, wastewater treatment plants and farms.

We suggest following potential areas for:

- Cogenerator fuelled by biogas produced from manure collected in the three villages in the municipality. It is necessary to construct the necessary connection to the electric network, as well as connection to the heating network of municipal buildings. It might be necessary to have heating network constructed in order to provide heat and hot water for the households by the cogeneration installation. Electricity could be sold or used to cover the own needs of the municipal buildings. Depending on the intended designation of the heat and energy produced, the specific location can either be in immediate proximity to farms or close to consumers, provided that in the latter case collection and disposal of manure is organized.
- Cogenerator fuelled by biogas produced from sewage sludge collected in the WWTP after its construction is finished. The construction site of this cogeneration installation will be next to the future treatment plant. Relevant facilities for biogas production need to be constructed. The point of connection of the cogenerator to the electricity distribution network will determine the possible additional investment in electrical cables and construction of the necessary heating pipeline.
- Installations for the production of biodiesel from rapeseed and paulownia. There are no specific requirements in terms of location of the plant for biodiesel. Location of such a plant can be chosen based on the specific conditions in the municipality (ownership of land, proximity to infrastructure, etc.), as well as the access to raw materials.

3.4 SOLAR ENERGY

3.4.1 Potential area for construction of photovoltaic installation

The considered sites are located in flat areas, as mountainous terrains would encumber the project and make it more expensive.

➤ Area 1

Area 1 is provisionally named Zrnovci 1, in the area of Zrnovci village.

❖ Geographic coordinates

The exact geographic coordinates of the area are shown below, as well as satellite images and photos.

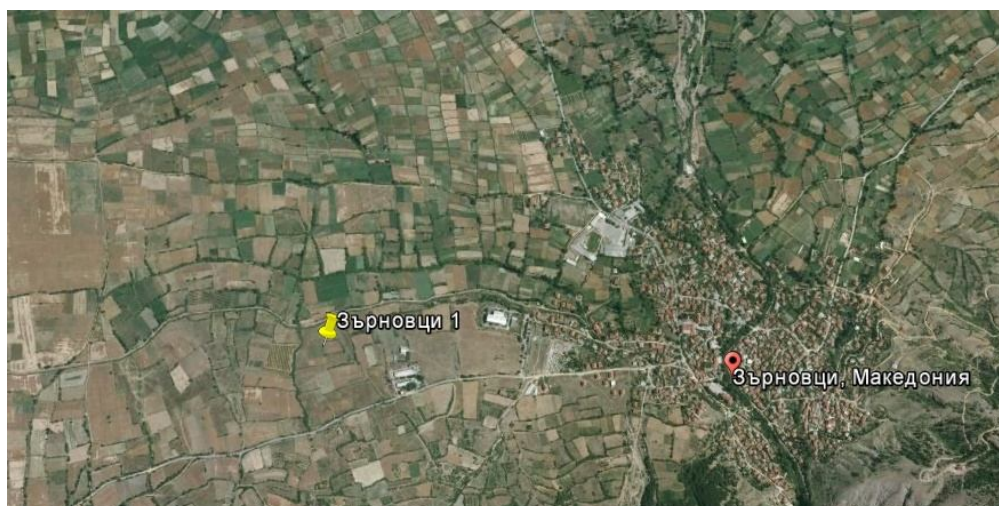
N 41 ° 51'17 .11 "

E 22 ° 25'49 .64 "

Altitude - 370-375 m.

The distance from the area to the center of Zrnovtsi village is about 2 km, immediately on the main road connecting the village with other settlements in the municipality; from the capital Skopje distance is 125 km.

The place is dominated by low vegetation, as evidenced by the photos below.



The location was selected so that it is accessible for installation and operation, near asphalt or passable road, with the ability to facilitate the work of machines. No danger of damming, swamping and fogging.

There is no danger of shading either, as the horizon is clear both to the east and the west.

Soil is firm, can bear concrete foundations on the surface or in non-freezing depth. In the preliminary survey no signs of shallow underground rocks were found, which makes installation of constructions on pile-driven steel poles or screws possible.

The exact conditions of the installation will be clear after a detailed geological survey of the soil.

➤ **Area 2**

Area 2 is provisionally named Vidovishte (because of its proximity to Vidovishte village), for easier identification on the pictures and in the calculations done.

❖ **Geographic coordinates**

The exact coordinates of the field are shown below, as well as satellite images and photos.

N 41 ° 51'5 .11 "

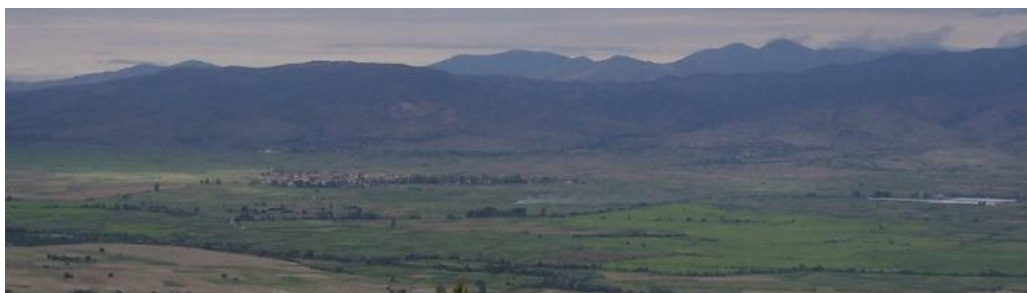
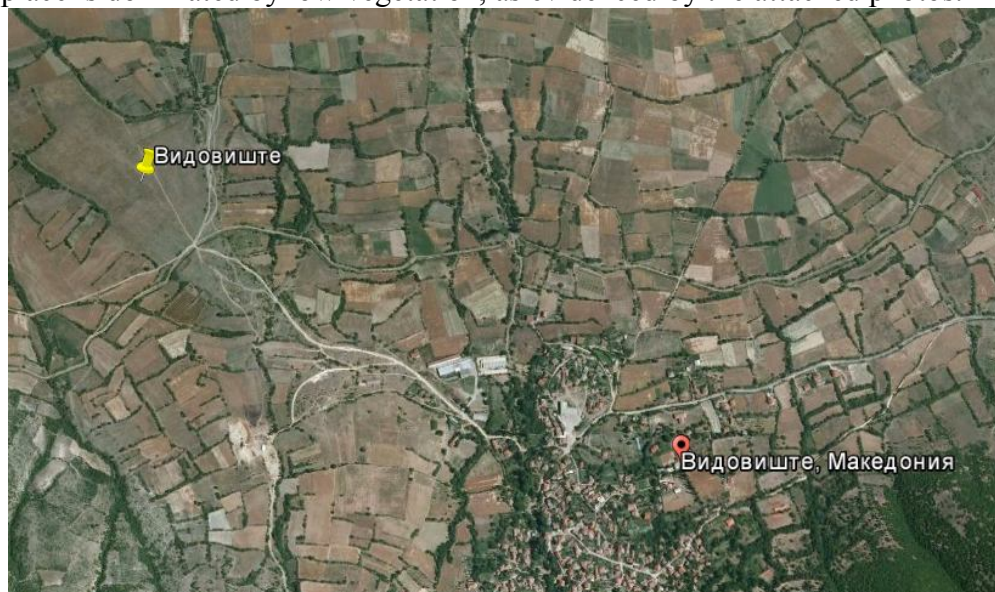
E 22 ° 23'15 .36 "

Altitude - 330 m.

Ventilated area, which will provide better cooling of the modules at higher temperatures of the environment during the summer months.

The distance from the area to the center of Vidovishte village is about 2 km, distance from capital Skopje is 100 km, it is near the asphalt road connecting the settlements in the municipality.

The place is dominated by low vegetation, as evidenced by the attached photos.



The location was selected to be easily accessible for installation and operation, close to asphalt road to facilitate the work of machines. Large leveling or removal of earth are not required. It is located close to Bregalnitsa river which could be a prerequisite for the formation of fog, thus power productivity might be reduced.

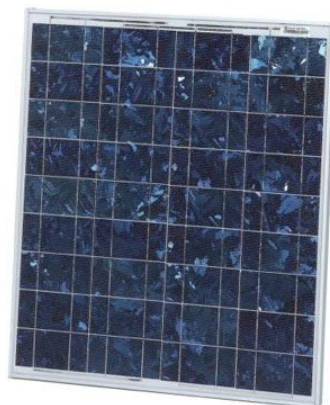
There is no danger of shading because the horizon is relatively clear to the east and west.

In the preliminary survey no signs of shallow underground rocks were found, which makes installation of constructions on pile-driven steel poles or screws possible.

The exact conditions of the installation will be clear after a detailed geological examination of the soil is done.

3.4.2 Parameters of photovoltaic installation

- Types of photovoltaic modules



Crystal, mono and poly

Amorphous (thin-ply)

- Crystal silicon photovoltaic modules

Advantages: possibility of installing more capacity in the relevant field.

Disadvantage: Substantially greater heat losses.

- Amorphous silicon photovoltaic modules

Advantages of this technology are better performance in diffuse light (in cloudy conditions), as well as lower temperature quotient, providing 10% more efficient operation at environment temperatures of around 35 °C.

Major disadvantage: significantly smaller installed capacity.

Based on the results obtained and the recommended technology for this field, the economic forecasts envisage the following average annual production:

Technology	<i>PVGIS-CMSAF</i>
Crystal	1720 kWh/kWp
Losses registered in the system for 1 kW:	
- Temperature losses:	8,6%
- Losses from reflections:	2,8%
- Losses in cables, invertors, transformers etc.:	10%
Thin-ply	1720 kWh/kWp

Losses registered in the system for 1 kW:	
- Temperature losses:	1,0%
- Losses from reflections??:	2,8%
- Losses in cables, invertors, transformers etc.:	10%

3.5 WIND ENERGY

3.5.1 Potential areas for construction of Wind Generators

Before a wind system is installed, the existence of sufficient potential for its operation should be verified. Necessary information could be taken from statistical reports from the Macedonian Institute for Meteorology and Hydrology, or own measurements of the indicators in the selected site could be done.

Locations selected for the installation of wind turbines have been picked according to the theoretical rationale of Bulgarian Academy of Science (return on investment at over 1 000 m above sea level and a certain wind speed), as well as based on their accessibility for transportation and installation of machinery.

➤ Area 1

(provisionally named as WindGenerator1)

❖ Geographic coordinates

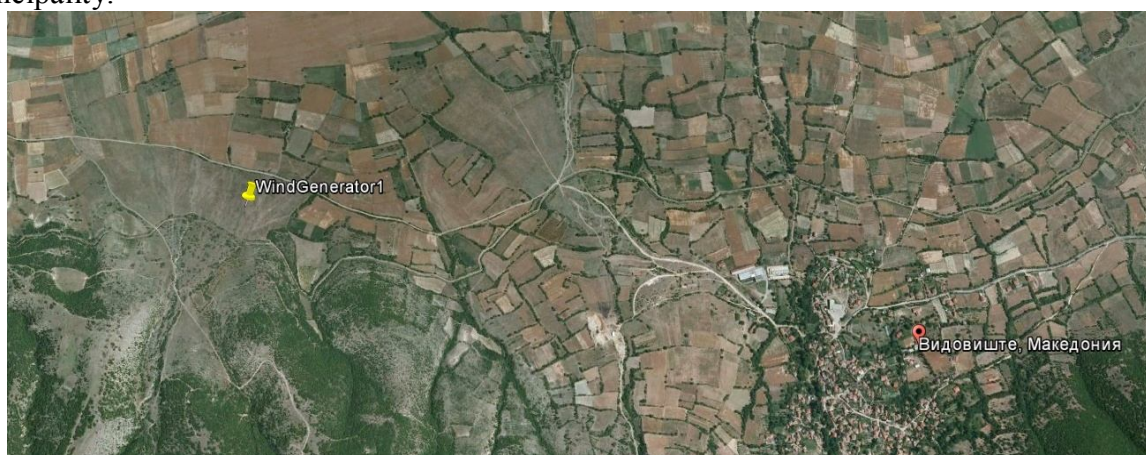
The exact coordinates of the field are shown below, as well as satellite images and photos.

N 41°50'58.52"

E 22°22'42.10"

Altitude: 352 m.

Distance from the area to the center of Vidovishte village is about 2 km, distance from the capital Skopje is 100 km, it is situated close to an asphalt road connecting the settlements in the municipality.



The selected location is easily accessible for installations and operation. It is close to a relatively passable asphalt road which facilitates the work of heavy machines.

The soil is firm and able to bear concrete foundations on the surface or in non-freezing depth.

Exact conditions of installation will be clear after a detailed geological survey of the soil.

➤ Area 2

(provisionally named WindGenerator2)

❖ Geographic coordinates

The exact coordinates of the Area are shown below, as well as satellite images and photos.

N 41°50'25.58"

E 22°23'20.45"

Altitude: 550 m.

Distance from the area to the center of Vidovishte village is about 2 km, to the capital Skopje – 100 km, it is close to an asphalt road connecting the settlements in the municipality.



The selected location is easily accessible for installations and operation. It is close to a relatively passable asphalt road which facilitates the work of heavy machines.

The soil is firm and able to bear concrete foundations on the surface or in non-freezing depth.

Exact conditions of installation will be clear after a detailed geological survey of the soil.

3.5.2 Parameters of wind generators

In choosing turbines, beside the wind speed, the diameter of the rotor is also taken into consideration.

Turbines of the Enercon and Vestas companies are given as an example:

It is assumed that for the purposes of the calculation made, the speed is 5m/s, while the height of the tower for the gondola is minimum 70÷75 m.

Company	Machine model	Diameter of the rotor, m	Power, kW
Vestas	V90-1,8/ 2,0 MW	90	95,42
	V110- 2,0 MW	110	142,55
Enercon	E-82 E2 / 2,000 kW	82	79,21
	E-70 / 2,300 kW	71	59,38

At lower wind speed lower power wind generators will be more economical.

3.5.3 Determination of the theoretical and technical potential

Theoretical and technical potential cannot be determined without additional measurements on the spot taken for at least a year.

At this stage there is not sufficient information hence specific data cannot be provided.

4 REGULATORY BASELINE AND REFERENCES

- [Law on Energy from Renewable Sources](#)
- [Rules on Applying the Law on Promotion of Investments](#)
- [Law on Energetics](#)
- [Law on Energy Efficiency](#)
- [Decree № ПД-16-558 от 08.05.2012 on collection and provision of information through the National Information System about the potential, production and consumption of energy from renewable sources in Republic of Bulgaria](#)
- [Directive on promotion of use of energy from renewable sources aimed at modification and following revocation of Directives 2001/77/EU and 2003/30/EU](#)
- [Photovoltaic Geographical Information System \(PVGIS\) – \[www.re.jrc.ec.europa.eu/pvgis/\]\(http://www.re.jrc.ec.europa.eu/pvgis/\) - updated version PVGIS-CMSAF \(data on the period from 2006 to 2010 is included\)](#)
- [METEONORM – Global data basis on solar radiation](#)
- www.meteonorm.com
- [NASA – Data basis on meteorology and solar energy – \[www.eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi\]\(http://www.eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi\)](#)
- [PVSyst V5.20 – Computer program for research/study, measuring, simulations and analysis of data of entire photovoltaic systems.](#)
- [Directive 2009/38/EC on promotion of use of energy from renewable sources aimed at modification and following revocation of Directives 2001/77/EU and 2003/30/EU.](#)
- [Green Paper. European strategy for provision and supply of energy \(COM \(2000\)769\).](#)
- [Biomass action plan \(COM\(2005\) 628\).](#)
- [European strategy on bio fuels \(COM\(2006\) 34\).](#)
- [Energy from renewable sources - guidelines, Renewable energies in 21st century : creation of sustainable future COM\(2006\) 848\).](#)
- [Law on Energetics \("State Gazette of Republic of Macedonia" issue 63/2006, 36/2007, 106/2008\).](#)
- [Rules on modes and procedures of establishing and approval of preferential rates of purchasing and sale of electrical power produced by energy production facilities using biogas from biomass as a fuel \("Службен весник на Република Македонија" бр. 142/2007\).](#)
- [Rules on the Renewable Sources of Energy for Production of Electricity \("State Gazette of Republic of Macedonia" issue 127/2008\)](#)
- [Rules on issuance of warranties on the origin of electrical power produced from renewable energy sources \("State Gazette of Republic of Macedonia" issue 127/2008\)](#)
- [Rules on acquisition of status of preferential producer of electrical power from renewable energy sources \("State Gazette of Republic of Macedonia" issue 29/2009\).](#)
- [Agreement on Energy community.](#)
- [Framework Convention of the United Nations on climatic changes from 1997.](#)
- [Kyoto Protocol of 2004.](#)
- [Strategy for development of energetics in Republic of Macedonia in the period 2008-2020, with perspective till 2030, Ministry of Economy of Republic of Macedonia.](#)
- [Base study on renewable sources in Republic of Macedonia, MAHY, 2010.](#)
- [Strategy for energy efficiency of Republic of Macedonia till 2020, Ministry of Economy of Republic of Macedonia](#)
- [Strategy for development in the period 2009-2013 of the East Planning Region](#)