

## RENEWABLE ENERGY SOLUTION IN ROMANIA

### INTRODUCTION

The modern lifestyle depends tremendously on the use and existence of fossil fuels. With levels of these fuels constantly decreasing, we should act now to become less dependant on fossil fuels and more dependent on renewable energy sources.

The decreasing levels of fossil fuels isn't the only reason why we should begin to use renewable energy. Pollution is becoming a huge problem in many countries around the world, especially the developing world. With carbon emissions at an all time high, air quality can be very low in some areas, this can lead to respiratory diseases and cancer.

The main reason to switch to cleaner energy production methods is the global warming aspect. The more carbon dioxide we pump into the atmosphere, the greater the effect becomes. We can't just stop using fossil fuels thinking that global warming will go away, but we can slow down and dilute the effects of global warming through the wide spread use of renewable energy resources.

There are many natural energy sources out there, but you have to decide which method is best for you, as all of these sources depend on your current environment.

The installation of a solar panel or a wind turbine to boost every homes power supply would be an amazing step forward. Some governments are in the process of supplying solar panels to hundreds of households to test this method of energy saving.

A technology set to be very important in the future is geothermal energy. With geothermal energy, you are able to extract heat from within the earth and transform it either into a hot water system, or if there is plenty of this energy, a geothermal power plant. Huge amounts of money have been flowed into research of this method, especially in recent years, in order to make the current technology more effective. So, there we have the reasons why we should turn to

renewable energy resources which are more than likely to play a very vital and important role in our future society.

The reason is that both these forms of producing energy have damaging effects on environment. Fossil fuels ingest harmful gases in the environment and the splitting of atoms (nuclear energy), produces radioactive waste.

Keeping in mind the vast damage non-renewable energies have caused to our earth, the option we are left with is using alternative energy sources.

### ***Alternative Forms of Energy / Sun***

Solar energy is all about using natural sunlight. Widely and freely available to almost all of humankind, the light from the Sun is a natural alternative.

Solar energy is ultimately the source for many renewable and non-renewable energy sources. Energy from the sun is captured through a solar panel. A solar panel is typically made up of silicon. And silicon is the substance which absorbs sunlight and then changes it into electrical energy. And the energy you get costs nothing and is renewable.

Solar energy is renewable for sure, but isn't constant. It can only be reaped during daytime. The other concern is only fifty percent of energy received by a solar panel can be converted into electricity.

### ***Alternative Forms of Energy / Wind***

A typical windmill is a huge fan-like standing structure. Wind is of use to us because of its kinetic energy. The wind blows and the blades of the mill spin, which in turn power a generator. These energy harvesters work easily and they can be set up anywhere. Needless to say, the source of energy is clean and renewable. Wind is all that is needed to reap the benefits. A windmill emits nothing harmful, which means no greenhouse gas contribution to the atmosphere.

The pace at which wind energy is being reaped is comparatively slow. The reason is that the investment cost is high. An average wind farm of at least seven 1.8 MW turbines would cost something around US \$12.6 million. However wind energy has various long-term benefits to offer. It's best to have wind farms at countryside locations like farms and ranches. This will also give boost to rural economies.

### ***Alternative Forms of Energy / Water***

Water has been generating energy for years. Hydroelectricity is generated by

damming rivers and using the potential energy of the stored water. The best part about water energy is that it is quite affordable. Though dams look huge, their maintenance costs are actually very low. Appearances can be deceiving.

### ***Alternative Forms of Energy / Hydrogen***

As many of you may know, hydrogen comes from water (which is two-thirds hydrogen and one-third oxygen). Electric current is passed through water to separate hydrogen from oxygen. The resulting gas, Hydrogen, is then stored in pressurized tanks.

Hydrogen Alternative Energy has shown promising results recently. And it has been particularly successful in the car industry. In these cars, the fuel cell system is used which converts hydrogen into electricity. Hydrogen as fuel is eco-friendly and much more safe than gasoline.

### ***Alternative Energy Source / Geo-thermal***

'Geo' means earth and 'thermal' means heat. Geo-thermal means energy from the earth...from under the ground. So geo-thermal energy is the energy reaped from the internal heat of the earth. Heat is used to generate steam which in turn is used to run turbine.

The temperature of the earth's core is about 4000 degree Celsius at the center. It is believed that if we drill just three miles down the crust, we can reach the temperature of around 100 degree Celsius. This temperature, as you may know, is hot enough to boil water. Geo-thermal energy can be garnered from landforms like volcano and volcanic structure which vent out earth's heat.

### ***Alternative Energy Source / Bio-fuel***

Bio-fuel refers to fuels made from plants or animals. Like ethanol from plants, or methane from animal excrement. Ethanol is, in combination with gasoline, being widely used in automobile industry. The process used for obtaining bio-fuel is usually combustion. Like any other alternative energy source, bio-fuel is completely renewable.

The energy crisis that the world faces today is real. And there is no other way to lessen the affects of our suffering planet, than to adapt ourselves to the alternative energy sources. The solution starts with raising awareness about these sources which are limitless and environmentally friendly.

### ***History of Alternative Energy / Alternative to what?***

The history of the alternative energy sources dates back to ancient times. In fact, any new fuel, discovered by humans, became alternative to the old ones at some period of time. For example, in the Middle Ages coal became an alternative to wood, which people commonly used earlier to heat their houses and cook food. Later, at the early 19th century petroleum became an alternative option to whale oil, which was widely used for lighting lamps and resulted in serious destruction of whales in the oceans. The dawn of the 20th century was marked with the appearance of ethanol as the alternative to gasoline.

However, nowadays we put a new meaning into the term “alternative energy”. Today alternative energy is that derived from the sources, which do not deplete or exhaust natural resources and do not harm the environment. Modern understanding of the alternative sources of energy appeared about 1970th, when the most developed countries first felt the shortage of gas.

### ***History of Alternative Energy / Why do we need an alternative?***

The major problem with traditional fuels (which is also a major motivation for the development of the alternative sources) is that the natural resources of fossil fuels, such as oil, gas and coal, are rapidly diminishing. That results in the constant growth of prices for major fuels and high dependency of world economies on imported energy sources.

Another aspect, traditional fossil fuels are widely blamed for, is their devastating effect on the environment of the planet. Humanity has already faced serious consequences of thoughtless use of non-renewable natural resources: global warming and ozone depletion, caused by the vast emissions of greenhouse gases during burning fossil fuels, as well as air pollution and soil erosions, are only several examples of irreversible changes in the environment.

Happily, people have already realized their mistakes, and new eco-friendly sources of energy are developed and implemented widely around the world these days. Modern alternative energy sources, such as wind or sun, are renewable, which means they will never be used up. Besides, alternative energy in its modern meaning is clean and eco-friendly, which is safe not only for humans, but for environment with its flora and fauna as well.

### ***History of Alternative Energy / What are the major types of alternative energy?***

Currently, alternative energy is mostly referred to the following:

1. Solar energy (generating of electricity from sun)

2. Wind energy (generating of electricity from wind)
3. Geothermal energy (using hot water or steam from the Earth's interior for heating buildings or electricity generation)
4. Biofuel and Ethanol (plant-derived substitutes of gasoline for powering vehicles)
5. Hydrogen (used as clean fuel for airplanes, spaceships, and vehicles)

Hydrogen alternative energy and nuclear energy are also frequently mentioned as the alternative sources of energy; however, they are surrounded by growing disputes on their safety for the environment, so it is still unclear how long those energy sources will remain marked as alternative and environment friendly energy sources.

### ***History of Alternative Energy / A Timeline***

Finally, to better illustrate the development of modern alternative sources of energy a short timeline with the major milestones is offered below.

1861 – Auguste Mouchout invented the first active steam engine, powered by the sun.

1839 – William Grove invented the first hydrogen fuel cell.

1888 – Charles Brush built the first windmill to generate electricity.

1892 – The world's first heating system was built in Idaho, where geothermal energy was used to heat the buildings.

1904 - Larderello Fields (Italy) built the first plant to convert geothermal heat into energy.

1908 – Henry Ford built the first mass-produced vehicle, called Ford T Model, running on ethanol. These vehicles remained in production until 1927.

1936 – The world's largest Hoover Dam was built on Colorado River.

1953 – The first solar cell, capable of generating electricity, was made at Bell Laboratories.

1958 – The first solar powered satellite was launched in the USA.

1981-1990 – Over 17000 wind machines were built in California.

2006 – The largest offshore wind turbine, called Repower, capable of generating 5 megawatt of electricity, was first installed in the North Sea.

2006 – Geothermal power plant was built in Alaska, which can generate electricity from geothermal water with the record low temperature of 57°C.

2007 – Ford Fusion Hydrogen 999, powered by hydrogen, reached record speed of over 207 mph.

2009 – The two-seat sun-powered airplane SkySpark reached the record speed of 250 km/h.

### ***Disadvantages of Alternative Energy***

The question that will come to your mind after reading the title of this page is,

'Are there any?' Alternative forms of energy seem to be the perfect solution – the concept is environmental friendly, it's endless, and above all, it's free. So what's the drawback? In fact, many people wouldn't even consider anything except an electric car as their main mode of transportation. However there are various pros and cons that should be kept in mind before taking the alternative energy leap.

### ***Disadvantages of Alternative Energy / No Constant Supply***

The very first disadvantage that holds true for most of the alternative energies is that their supply is dependent on nature and thus are not constant.



For example, solar energy can be generated only at the areas that receive ample sunlight. For other areas that receive below moderate to little sunlight, solar energy would not be of much use.

*-The cloudy Australia sky depicted to the left would not bode well for solar energy applications.-*

Even for the areas with bright sunlight, solar energy can only be generated at daytime and not at nighttime. The same is the case with wind energy. Generating electricity through wind farms is possible only at the countryside or other such areas where windmills can receive wind supply without any obstruction.

With hydroelectricity (or water energy), the situation fares better, because once electricity is generated at the dams the electricity can be drawn with wires and can be transported across miles.

### ***Implementing***

### ***Issues***

This is one of the main reasons alternative energy isn't popular:

Many organizations decide to use alternative energy sources. However, they back out as soon as they find out that it'll incur huge costs.

Alternative energy is especially difficult put into effect in an infrastructure that is already set up. Most of the forms of alternative energies require a certain type of system. This system is very different from the one that they use currently.

Therefore, a major infrastructure/system overhaul is essential before incorporating alternative energy.

### ***Expensive to Use***

Considering the monetary factors, fossil fuels are less costly to use than alternative energy. Fossil fuels are readily available, can be stored at any location or transported using the regular means. However, in the case of alternative energy various changes and thus huge investment is required to reap benefits.

### ***Disadvantages of Alternative Energy / Solar Energy***

Energy can be trapped only during daytime and only at places receiving desired amount of sunlight.

Efficiency of solar panels is generally low, around 10-15%. Therefore, for a good power supply, large surface area is required. For a household supply of let's say 100KWHs, solar panels on at least 400 square meters of land are needed.

Solar power is costly to use in daily life. Cost can be anywhere around 20-25 cents per KWH.

### ***Disadvantages of Alternative Energy / Wind Energy***

Wind energy is a clean fuel. However, it does cause significant amount of noise pollution.

Initial investment is quite high and efficiency is low, around 30%. And many feel that wind towers ruin the scenery of the adjoining place.

### ***Disadvantages of Alternative Energy / BioFuel & BioMass***

Areas which gather biofuels can sustain soil erosion.

Biofuel is an excellent solvent so it generally dissolves the deposits in the filters. Because of this, the engine may need to be replaced more often.

Biomass is a good alternative to using fossil fuels. However, it ends up doing the same thing as fuel. Combustion of biomass produces carbon dioxide and similar greenhouse gases.

Another disadvantage of biomass is that it's generally produced from corn, wheat, barley, and similar crops all of which are seasonal. Thus biomass can

only be produced only in certain seasons.

### ***Disadvantages of Alternative Energy / Hydropower***

Hydropower (water energy) often damages the surrounding environment. Its impact on fish is well known. Many call hydropower stations as an imposition on ecosystem.

Levels of oxygen dissolved in the water also decreases due to damming.

It would be incorrect to say that disadvantages of alternative energy don't exist. However, it would also be wrong to imply that fossil fuel is better than alternative energy. With people growing more concerned for the environment, alternative energy is gaining popularity. And as we incorporate the advantages more in our daily life, the disadvantages of alternative energy will slowly fade away.

## **ROMANIAN HIDRO POTENTIAL**

Romania has an area of 238 391 km<sup>2</sup> and has a population of 23.2 million.

### **Water resources**

The total mean annual precipitation volume is 151.8 km<sup>3</sup>. Runoff comprises 37.8 km<sup>3</sup> of surface and 5.6 km<sup>3</sup> of underground water.

The Ministry of Water, Forestry and the Environment is in charge of water resources, operation through the Romanian Water Authority. No changes are envisaged in the short term in this sector.

There are 144 large dams in operation, of which 78 are for hydropower, 40 are multipurpose, with hydro as one of the their functions, and 26 have other users. A further 36 large dams are under construction (25 for hydro, 7 multipurpose including hydro, and 4 with other functions). There are 204 dams of all sizes in operation, and 38 under construction. the total water storage volume of all the dams in operation is 206 km<sup>3</sup>, of which 117 km<sup>3</sup> is at the large dams.

The largest dams under construction include: Gura Apelor (168 m high, rockfil); Poiana Marului (125 m high, rochfill); and, Rastolita (105 m high, rockfill).

Per capita water consumption is 433-m<sup>3</sup>/year total, and 87.8 m<sup>3</sup>/year for domestic consumption.

There is a legal framework for environment impact assessment and management. The Law on Environment, issued after 1990, specifies the obligations of all water users, including hydro plant owners.

## **Energy and power sectors**

The main sources of primary energy in 1996 were: natural gas (35 per cent); oil (25 per cent); coal (30 per cent); hydro (9 per cent); and, other (1 per cent).

The main sources of electricity production in 1996 were: coal (34.6 per cent); fuel oil (10.5 per cent); natural gas (26.4 per cent); hydro (26.2 per cent); and, nuclear (2.3 per cent). The total electricity consumption was 62 158 GW, representing 2726 kWh/year per capita consumption. During 1996, 809 GWh was imported through short-term exchanges with neighboring countries.

Energy consumption is expected to increase by 2500 to 3000 GWh/year annually during the next decade, while electricity demand will increase by 800 to 1000 GWh/year annually.

The Ministry of Industry is in charge of energy, while RENEL (the National Electricity Authority) is the national power authority. It has various regional subsidiaries for production and distribution.

Deregulation of the energy/energy sector is beginning during 1998, with the objective of co-ordination the power system and energy transportation. RENEL will be transformed into a National voltage power grid, and the system operator (the existing National Power Dispatcher). The energy producer and distribution centers (RENEL subsidiaries at present) will become independent energy producers, that is independent commercial companies. Some of these will be totally or partially privately owned, possibly with foreign participation.

An Energy Law will be issued to specify the conditions for implementation of the new energy market. This will include: implementation of a new electricity tariff system; and, a framework for the contractual relationships between energy partners (generating companies, the network operator, distribution companies and consumers).

The deregulated market will involve separated generation, transmission and distribution, and probably power purchase agreement.

RENEL currently owns 97 per cent of powerplant capacity (with the remaining 3 per cent having private or other public owners) and 98 per cent of hydro plant capacity.

In the future, additional environmental and safety requirements for hydro projects can be expected.

## **Hydropower development**

The gross theoretical and technically feasible hydropower potential is 70 000 GWh/year, evaluated in 1986. The technically feasible hydro potential is 36 000 GWh/year, corresponding to 11 500 MW of capacity. The economic transition to a market economy means that it is difficult to assess the economically feasible potential, but it is approximately 28 000 to 32 000 GWh/year( 9100 to 10 300 MW). So far, about 42 per cent of the technically feasible hydro potential has been developed.

The installed capacity of all powerplants in operation is 18 653 MW, which is less than in previous years as a result of some old thermal units being disconnected. The installed capacity of hydro plants is 5912 MW, which generate 16 700 GWh/year on average (25 per cent of production). In 1996, hydro plants generated 15 684 GWh.

A further 992 MW of hydro capacity is under construction, and 921 MW is planned. The projects under construction include some which were temporarily abandoned after 1990 in review of the difficult economic situation. It is hoped that the involvement of foreign investors or multipurpose water users may provide an opportunity to complete some of these schemes. The mean cost per kWh for the hydro plants under construction is US\$6 to 14/kWh (overall lifetime costs). More accurate evaluations are still being carried out by domestic or foreign consulting companies.

The planned projects were designed before 1990, but insufficient funds are available to begin construction. they include development of the Tisa river through a joint Romanian Ukainian projects( 30 MW, 200 GWh/year).

There is significant uprating potential at existing hydro plants: 370 MW through rehabilitation of about 30 hydro units which have low reliability or generating limitations as a result of deficiencies. At present this capacity is considered permanently unavailable, although it is included in the 5912 MW hydro capacity given above. There is an additional potential of 206 MW through the uprating of 14 hydro units, including the Iron Gates plant.

A 1000 MW pumped-storage plant is planned, Tarnita Lapustesti, which will have four 250 MW units. Romania's first nuclear power unit (700 MW) requires a large base load, and a pumped-storage plant was planned to operation in conjunction with it before 1990. However, the start of construction was delayed, again because of lack of funds. Construction of the plant is now planned with the help of an international loan, and Government guarantees.

## **Small hydro**

There are 256 small, mini or micro hydro plants in operation( up to 10 MW), with a total capacity of 332 MW. A further 28 are under construction(70 MW), and 46 are planned (223 MW).

There is likely to be an increase in interest in small hydro when public/private ownership becomes more important.

## **Future outlook**

The national strategy concerning the electricity energy sectors is mainly related to the transition now under way to a market-oriented economy and the new relationship to be established between power producers and consumers. The main objectives are a reorganization of RENEL from a state-owned organization towards public and private ownership, and implementation of the energy market based on a modern Energy Law.

The main priorities for future hydropower development remain:

Completion of civil works and commissioning of unfinished projects which are considered efficient after economic and financial analysis:

Retrofitting and upgrading works, to bring the power units operational parameters in line with European UCPTE standards;

Increasing the efficiency of plant operation by computerized means, based on least-cost criteria;

Implementation of modern diagnostic and predictive maintenance methods; and,

Modernization of powerplant control using computer technology.

The biggest and the most important hydroelectric power station is Iron Gate I.

The **Iron Gate I Hydroelectric Power Station** (Romanian: *Porțile de Fier I*) is the largest dam on the Danube river and one of the largest hydro power plants in Europe. It is located on the Iron Gate gorge, between Romania and Serbia.

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The project started in 1964 as a joint-venture between the governments of Romania and Serbia for the construction of a major dam on the Danube River which would serve both countries. At the time of completion in 1972, it was one of the largest hydroelectric power stations in the world with twelve units generating 2,052 MW, divided equally between the two countries at 1,026 MW each.<sup>[1]</sup>

The Romanian part of the dam was modernized and the nominal capacity of the six units was increased from 175 MW to 194.4 MW, thus giving an installed capacity of 1,166 MW<sup>[2]</sup> and increasing the entire power generation capacity of the dam to 2,192 MW. On the Serbian part of the dam, modernization started in July 2008 and is still in progress;<sup>[3]</sup> so far Unit 6 has been modernized, and revitalization of the remaining five is in the preparation phase.<sup>[4]</sup> The units are being upgraded with the help of Russian company ОАО "Рязанский станкостроительный завод" (Ryazan Machine Tool Plant), as well as their subcontractors with the participation of eleven domestic companies. The Romanian side of the power station produces approximately 5.4 TWh annually, while the Serbian side of the power station produces 5.65 TWh.<sup>[1]</sup>

The discrepancy in power output between the two halves is due to the generating equipment. While Romania's equipment is newer and thus more efficient (thereby generating more power), it is proving more unreliable; resulting in increased downtime for maintenance/repairs, and consequently lower annual power output overall.

In addition to the upgrades, the Serbian side is planning on building a new, smaller power station, called Iron Gate III .

## SOLAR ENERGY

**Solar power in Romania** had in 2007 an installed capacity of 0.81 MWp. Romania is located in an area with a good solar potential of 210 sunny days per year and with an annual solar energy flux between 1,000 kWh/ m<sup>2</sup>/year and 1,300 kWh/ m<sup>2</sup>/year. From this total amount around 600 to 800 kWh/ m<sup>2</sup>/year is technical feasible. The most important solar regions of Romania are the Black Sea coast, Dobrogea and Oltenia with an average of 1,600 kWh/ m<sup>2</sup>/year.

Romania was a major player in the solar power industry, installing in the 1970's and 80's around 800,000 square metres (8,600,000 sq ft) of low quality solar collectors that placed the country third worldwide in the total surface of PV cells. One of the most important solar project was the installing of a 30 kW solar panel on the roof of the Politehnica University of Bucharest that is capable of producing 60 MWh of electricity per year.

Rominterm, a Romanian company, will install until 2010 a total of 600 solar panels in Mangalia, Constanța County that will make the city self sufficient in terms of heated water during the summer months and provide around 70% of heated water in the winter months and another 1,150 solar panels used for the generation of electricity spread over an area of 1,400 square metres (15,000 sq ft). Another Romanian city, Alba Iulia, installed a total of 1,700 PV cells on several public buildings that produce 257 kWh of electricity per year. Other cities include Giurgiu with 174 solar panels and 391.5 kW installed capacity and Saturn, Romania with 50 panels and 112 kW installed capacity.

The Covaci Solar Park will be Romania's largest solar power plant at completion having a total of 480,000 solar panels with a combined capacity of 35 megawatts and will be located in Timiș County.<sup>[9]</sup> Another important site is the Gura Ialomiței Solar Park in Ialomița County which will have a capacity of 10 megawatts.

The following figures display the solar insolation values for Romania. Romania has moderate solar potential throughout the whole of the country. Its best solar resource is located in the southern portion of the country.

## ***Geothermal***

Romania has the third highest geothermal potential of European nations, with major potential locations on the Western Plain, South Plains in the region of Bucharest, and in the Carpathian regions. The exploration and research for geothermal resources began in Romania in 1962. Over 200 wells have been drilled, proving the existence of low enthalpy geothermal resources with temperature between 40-120 °C. The heat flux contour map for Romania is shown below.

### **Heat Flux of Romania (Source: Energie-Atlas GmbH, 2005)**

At present Romania has a total geothermal installed capacity of about 145.1 MWt producing 2,841 TJ/year. This energy is produced from about 96 direct-use wells with

hot water in the temperature range of 55-115 °C. Of the 96 direct-use wells, 37 are used exclusively for health and recreational purposes. There have been no reports of geothermal pump usage in the area. The exploited and unexploited geothermal resource can be seen in the map below.

### **Geothermal Resource Map**

Romania's highest enthalpy geothermal resource of 3,000 °C was identified at Tusnad-Bai. Five sites have a temperature over 100 °C.

The main technical potential areas include:

- Western Plain with 4,300 TJ/year potential energy production.
- Southern Carpathians (at the contact with the Getical Subcarpathians) with 270 TJ/year potential energy production.
- South Plains with 720 TJ/year potential energy production.

## ***Biomass***

Romania has great biomass potential, which is estimated at 88,000 GWh per year. In 2004, about 43 percent of the biomass potential in the country was exploited. The entirety of that biomass potential went to the production of heat. Heat generated from wood biomass was approximately 54 percent, and heat generated by agricultural biomass was about 46 percent.

Direct burning in the kilns, stoves for space heating, cooking and hot water preparation is about 95 percent of the biomass use. These furnaces have a nominal capacity between 0.8 kW to 4 kW and are hand stocked and with an average efficiency between 15 to 50 percent. The rest of the biomass is used in thermal plants to generate industrial steam and hot water in sawmills and in other industries equals about 5 percent of biomass usage. In sawmills, the average installed capacity is 3.3 MW and in other in other industries 4.7 MW.

In Romania over 550 industrial hot water and steam boilers run on fuel wood. In 2004 the total installed capacity for cogeneration units reached 4,100 MW.

Firewood and agricultural waste account for about 80 percent of the total waste. About 66 percent of the firewood and wood waste is located in the Carpathians and Sub-Carpathians, and about 58 percent of agricultural waste is located in the South Plain, West Plain, and Moldavia. Approximately 63,700 square km of Romania is covered by forests, which is approximately 27 percent of the total land. The exploitable potential of the Romanian forests is estimated at 20,000 cubic meters (Intelligent Europe, 2005).

Large amounts of small-sized wood is obtained in wood industry, but utilization of this wood for energy purposes is insufficient due to difficulties related to gathering, processing and transportation. Studies show that these wood wastes are economically viable resources.

<b>Biomass resource type</b>	<b>Total production</b>	<b>Production density</b>
87,460,377 Total land area covered by	(avg. 2006–2007, km <sup>2</sup> )	(avg. 2006–2007, %)
Permanent Crops Arable Land	4,645	2
Permanent Meadows and Pastures	45,820	19
Forest Area	63,712	27
Other Land	28,298	12
Inland Water	8,455	4
23,856,036 (23) 10,357 (20) Primary crop production	(avg. 2006–2007, tonne)	(tonne / 100 km <sup>2</sup> )
Top 10 primary crops Total primary crops (rank among COO)		
Maize	6,335,616	2,751
Wheat	4,196,212	1,822
Potatoes	3,757,171	131
Cabbages and other brassicas	1,116,338	485
Sunflower seed	1,023,861	444
Sugar beet	925,388	402
Grapes	866,845	376
Tomatoes	695,206	302
Barley	638,309	277
Watermelons	613,878	267
2,898,000 1,258 Animal units, number	(avg. 2006–2007, number)	(number / 100 km <sup>2</sup> )
Poultry Cattle	95,271,500	41,361
Pigs	6,718,500	2,917
Equivalent animal units	6,538,115	2,838
14,655,500 6,363 Annual roundwood production	(2006–2007, m <sup>3</sup> )	(m <sup>3</sup> / 100 km <sup>2</sup> )
Fuel Total	4,142,500	1,798
Industrial	10,513,000	4,564
Wood-based panels	1,319,500	573
Paper and paperboard	(2006–2007, tonne)	(tonne / 100 km <sup>2</sup> )
Recovered paper	495,000	215
	276,500	120

Source: Food and Agriculture Organization of the United Nations

#### Romania Biomass Resource Data

## **WIND**

Romania's wind resources are well-documented, and there are a broad range of existing applications from small autonomous units for rural areas to large off-shore potential. Installed wind capacity for the country is approximately 2.5 MW (UDI, 2009). However, Romania currently has approximately 636 MW of wind capacity under construction. A majority of the capacity under construction is from the Fantanele and Cogealec wind park, with 600 MW. The wind park is located in the southeastern region of Dobrogea, 17 km from the Black Sea. This park will account for approximately 30 percent of Romania's renewable energy (Realitatea, 2009).

### **Romania Wind Resource Map (Source: 3Tier)**

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