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ANALYSIS OF RENEWABLE ENERGY AND ITS IMPACT ON RURAL DEVELOPMENT IN CROATIA

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CONTENT

1 Introduction

Croatia is a country with good natural potentials and possibilities for the use of renewable energy sources (RES). The importance of RES in Croatia was recognized already in 70s and 80s of the last century (when Croatia was a part of former Yugoslavia) when well-developed R&D programs promoting solar, wind, biomass, and geothermal technologies were established and supported with legislative and financial measures.

However, after Croatian independence, RES were not in the focus of the official energy policy and the potential of RES was somewhat neglected.

In recent years, due to political reasons (EU accession process, ratification of Kyoto protocol) the issue of RES became very important. Croatia has harmonized the overall concept of energy sector reforms with the legal and institutional EU requirements, within the limits of specific national solutions. The Energy Act and the Energy Strategy of Croatia stipulate positive attitude towards RES and the use of RES became one of the strategic goals of the national energy policy. The Croatian energy policy today is directed towards increased efficiency, security of supply and diversification, market deregulation, the use of renewables and environmental protection.

The development of Croatian renewable energy resources market is of utmost importance for the Croatian economy because it reduces its dependency on the import of electrical power and fossil fuels and decreases overall emission of greenhouse gases. In the long run, market development will improve the climate for private investments in renewable energy resources in Croatia; increase the use of national equipment and services, resulting consequently in job creation. Therefore, recently there were numerous scientific and popular discussions, symposia and initiatives regarding use of RES.

Moreover, in the last ten years in Croatia numerous initiatives and expression of intention and interest for starting energy production from RES by foreign and domestic investors were recorded, but until now many project implementations have failed due to the lack of financial support .

2 Overview of the use and relevance of renewable energies

Croatia's primary energy production consists of natural gas (average 43% in the period 2002-2007), hydro power (28%), crude oil (21%) and renewable energy sources (8%)[1]. In total, average domestic production in the period 2002 - 2007 constituted 48% of the total energy needs, the remaining 52% being imported.

In 2007 Croatian production of primary energy decreased by 6.4 percent compared to 2006. The production decrease was recorded in most of primary energy forms including production of fuel wood (decrease of 12% compared to previous year). The only energy forms with growing production in 2007 were natural gas production and energy from renewable sources. However, it should be mentioned that the amounts of renewable energy still make a very low part of the total primary energy.

Because of decreased primary energy production and increased total energy consumption, the own supply of energy was 7.8 percent lower in 2007 than the year before and its level was 46.9 percent (source: Energy in Croatia 2007: annual energy report).

In the future, a gradual reduction in the production of fossil fuels and an increase in energy generation from renewable sources are expected.

2.1 Relevance of renewable energies in national energy supply

Croatia has a very big potential in RES, especially regarding biomass, wind and solar energy. Respecting their competitiveness and potential contribution to the national energy balance biomass and solar plants could significantly contribute to heat energy production and wind parks and biomass cogenerations in electricity generation.

However, the systematic use of RES started only in 2004. Until 2004, the only renewable energy source Croatia had were large scale hydro power plants, and several small hydro plants (below 10 MW_e), which did not contribute significantly to the energy generation. Besides that, fuel wood as a traditional way of heating was still widely used.

The share of hydro power (including large and small power plants) in the total energy production between 2002 and 2005 varied between 25% and 34% and in 2005 its share was 31.6%. In the same period, the share of fuel wood decreased slightly from 8.5 per cent to 7.5 per cent. Other renewable energy sources (wind energy, solar energy, geothermal energy and landfill gas) had a share of only 0.5 % in total energy generation in 2005.

The share of renewable energy sources in total energy consumption in 2006 was around 3.8 percent. RES made for 7.57 percent of total primary energy production in 2006 with biomass contributing with 7.08 percent.

In 2007 the share of renewable energy sources in total energy supply and total energy consumption was about 7.4 percent and 3.5 percent respectively. The share of biomass and

[1] The energy produced from renewable sources (biomass, wind, solar and geothermal energy) has been recorded in Croatian statistical data since 2004.

hydro energy decreased, while the share of wind and solar energy increased compared to the previous year.

Table 1 Production and share of renewable energy in total energy production and demand (TJ: Tera Joule)

	2004		2005		2006		2007	
Total energy production	204 400		197 230		208 760		195 440	
Supply by RE	electricity	heat	electricity	heat	electricity	heat	electricity	heat
-biomass	14.40	16 230	39.24	14 767	21.59	14 767	25.27	13 380
-wind	7.06	-	34.20	-	68.26	-	125.67	-
-solar	0.0455	-	0.1805	-	0.1769	-	0.1872	26,1
-hydroenergy*	454.68	-	389.88	-	394.45	-	298.80	-
-geothermal**	-	541.94	-	547.33	-	558.52	-	562.81
Share of RE in total energy production (%)	**8.44**		**8.00**		**7.57**		**7.38**	
-biomass	7.947		7.507		7.084		6.859	
-wind	0.003		0.017		0.033		0.064	
-solar	0.000		0.000		0.000		0.013	
-hydroenergy*	0.222		0.198		0.189		0.153	
-geothermal**	0.265		0.278		0.268		0.288	
Total energy demand	412 040		411 660		410 560		416 780	
Share of RE in total energy demand (%)	**4.19**		**3.83**		**3.85**		**3.46**	
-biomass	3.942		3.597		3.602		3.216	
-wind	0.002		0.008		0.017		0.030	
-solar	0.000		0.000		0.000		0.006	
-hydroenergy*	0.110		0.095		0.096		0.072	
-geothermal**	0.132		0.133		0.136		0.135	

* Hydroenergy includes only energy generation from small power plants

** Heat generation from geothermal sources regards space heating and hot water preparation in spas and recreational centres

Source: Source: Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

2.1.1 Production and share in total electricity supply

The installed electricity generating capacities in the Republic of Croatia include hydro and thermal power plants owned by the HEP Group (Croatian Power Company), a certain number of industrial power plants and a few privately owned power plants (wind power plants, small hydro power plants, biomass plants and a few small installations of PV).

Most of electricity is produced from hydropower, but fossil fuels, such as coal, oil and natural gas are still quite significant in the portfolio. Nuclear electricity from NPP Krško, shared 50-50% with Slovenia contributes 17% of Croatian electricity generation mix.

Total electricity production in Croatia in 2005 was 12,458.9 GWh, out of which about 51.8% was obtained from renewable energy sources with large hydro power plants participating with 50.8 % while 1 percent of total electricity generation came from other renewable sources (small hydro power plants, wind energy, landfill gas, solar energy). Electricity from renewable sources made for 41.8 % of total energy consumption, where electricity from large hydro power plants made for 40.9 %, while electricity from other renewable sources made for 0.83 % of this share.

The total electricity production in 2006 and 2007 remained at the same level, however, the production of hydro power plants dropped significantly in 2007 due to the weather conditions. Therefore, the share of electricity produced from RES (including large hydro power plants) in 2006 amounted to 49.5 percent and in 2007 only 36.2 percent. However, the share of RES excluding large hydro power plants remained unchanged and amounted to 1 percent. Due to the increase in total electricity consumption, the amount of electricity generated from renewable sources slowly dropped and made for 0.75 percent of total electricity consumption in 2007.

Table 2 Production and share of renewable energy in total electricity consumption (GWh)

	2004	2005	2006	2007
Total electricity generation (GWh)	13,321.30	12,458.90	12,429.60	12,245.10
Electricity generation from RES				
- biomass plants	4.00	10.90	6.00	7.02
- small hydropower plants	126.30	108.30	109.57	83.0
- wind power plants	1.69	9.50	18.96	34.91
- solar power plants	0.013	0.054	0.049	0.053
Absolute supply of RE for electricity* (GWh)	132.00	128.75	134.57	124.98
Share of RES in total electricity generation (%)	**0.99**	**1.03**	**1.08**	**1.02**
Total electricity consumption (GWh)*	14,762.60	15,440.90	16,143.00	16,579.40
Share of RES in total electricity consumption (%)	**0.89**	**0.83**	**0.83**	**0.75**

* Without large hydropower plants
**Without transmission and distribution losses
Source: Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

Since 1994 HEP (Croatian Power Company) purchased electricity produced in small power plants (up to 5MW) at prices higher than their own electricity production price in order to encourage first investors in this sector (source: *www.sumari.hr/biomasa/drugidanibiomase/stanic.ppt*).

With the new regulations issued in 2007 the production of electricity from RES became even more profitable. This encouraged many investors (domestic and foreign) to initiate projects of energy exploitation of RS, especially wind energy.

At the moment 9 projects of biomass thermal power stations (with a total power of 36.6 MW), 13 biogas power stations (with a total power of 23.8 MW), one power station on waste sludge and one landfill gas power plant are in the implementation procedure (source: Symposium 'Energy from biomass', Zagreb, April 2007).

However, because of complicated administrative procedures for obtaining necessary documentation (at national and local level starting from acquiring building permits to acquiring the eligible producer's status[2]), a preparation phase of many projects takes a very long time.

One of constrains of production of electricity from renewable sources in Croatia is the fact that the integration of small scale RES plants (less than 1 MW, but usually in the range up to 200 kW) in distribution grid in Croatia is very limited. The technical conditions are still not yet developed and transfer of best experiences in this field is highly needed.

2.1.2 Production and share in national transport

The transport sector represents about 30% of the total final energy consumption in Croatia, with a very high growth rate (more than 5% annually over the past five years). Road transport accounts for 90%, the largest share of energy consumption in this sector. Given the rise in number of cars, longer average distances covered by car and fewer individuals travelling in each of the vehicles, this trend is expected to continue in the future.

The consumption of biofuels in Croatia is not sufficiently developed. Biodiesel production started in 2006 and the share of biodiesel in total diesel consumption in 2006 was only 0.4%. Because of the fact that total biodiesel production decreased in 2007 (due to the lack of feedstock) this share dropped to 0.2% in 2007.

Biodiesel is sold only at petrol stations owned by biodiesel producers and, so far, it cannot be purchased at other petrol stations in Croatia.

Certain major towns in Croatia are investigating the possibility of introducing biodiesel as a replacement fuel for diesel in buses used for public transport. The largest progress in implementation of this measure has been made by the City of Zagreb, where biodiesel is used in public transport since beginning of 2007.

At the moment, there is no production of bio ethanol in Croatia.

[2] "Eligible Producer" is an energy undertaking who produces electricity and heat in a cogeneration plant, or uses waste or renewable energy resources in economically viable manner in compliance with environmental protection. An eligible producer, apart from hydropower plants larger than 10 MW, can acquire the right to the incentive price prescribed by the Tariff System for the Production of Electricity from Renewable Energy Sources and Cogeneration.

Table 3 Production and share of renewable energy in national diesel consumption

		2006	2007
Total diesel demand	000 tonnes	1426.9	1544.1
	TJ*	60785.9	65778.7
Absolute supply of RE for diesel	000 tonnes	7.0	4.334
	TJ*	258.3	159.9246
Share (%)		**0.42%**	**0.24%**

*1 MJ of biodiesel = 0.866197 MJ of diesel (Regulation on Biofuel Quality, Official Gazzette 141/05)

Source: Energy in Croatia 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

2.1.3 Production and share in national heating consumption

All major Croatian continental cities have heat energy supply from centralized heating systems. Heat energy is produced either in co-generation plants for larger city distribution, or in smaller heating units for particular city areas. In the coastal region electricity is the commonly used source for heating. Significant part of the heat energy in Croatia is also generated from fire wood, a traditional source of heating.

Croatian statistics do not record the total energy demand for heating supply. In the publication "Energy in Croatia" (Ministry of Economy, Labour and Entrepreneurship) the Energy Balance of Heat Energy takes account of only heat generation (steam and hot water) from public and industrial heating and cogeneration plants.

According to that data, the total production of heat energy in these plants in 2004 amounted to 33.529 PJ. This production decreased in the following years up to 32.447 PJ in 2007.

In 2004 the production of heat from renewable sources amounted to 16,771.9 TJ of which 16,230 TJ regards biomass plants (refer to biomass-fired industrial facilities and do not contain information on heat production of small heating furnaces and on hot water preparation in households) and 541.94TJ geothermal energy (either for space heating and hot water preparation). Due to the decrease in the production of fuel wood the total heat generation in 2005 decreased 9% compared to the previous year and it remain almost unchanged in 2006.

Total heat production from RES in 2007 was 13,968.9 TJ, or 16% lower than in 2004. For the first time, in 2007 heat production from solar plants was recorded and it amounted to 26.1 TJ.

Table 4 Production of renewable energy for heating (TJ)

	2004	2005	2006	2007
Supply of RE for heating (TJ)	16,771.9	15,314.3	15,325.52	13,968.9
- solar energy	-	-	-	26.1
- biomass*	16,230	14,767	14,767	13,380
- geothermal energy**	541.94	547.33	558.52	562.81

*Heat generation from biomass includes the generation in industrial heating facilities and heat generation from fuel wood for heating and hot water preparation in households

**Heat generation from geothermal sources regards space heating and hot water preparation in spas and recreational centres

Source: Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

2.2 Sources of renewable energies: implications for farms

2.2.1 Biomass for energy production

- **Annual crops**

Harvested area of three main oilseeds crops in Croatia (soya, rapeseed and sunflower) in 2007 was approximately 80 thousand hectares, with soybean dominating in acreage and yield. Oil from all three oilseed crops can be used for biodiesel production, although, besides economic justification, rapeseed oil is also the most suitable from the technical aspect of biodiesel production.

Owing to its favourable climate conditions, Croatia has significant potential for biodiesel production from rapeseed oil. However, the production of oilseed rape has not been properly developed, so that there are difficulties in securing raw materials for biodiesel production.

To understand the whole background of the national oilseed production and agriculture in general, it is important to stress the ongoing trend of decrease in agricultural production and abandonment of rural areas. The total surface under unused agricultural areas remains controversial. It varies from 102.422,97 ha (Agriculture Census, 2003) to as much as 377.370 ha (Statistical Yearbook 2003) depending on the methodology used (UNIDO, 2006).

The production area of rapeseed increased between 2000 and 2005 by more than 50% and it amounted to 20 thousand hectares in 2005. In 2006 the production strongly decreased to 8.4 thousand hectares and in 2007 it again increased to 13 thousand hectares[3]. Unlike other agricultural plants, oil rape is mostly produced on a large agricultural areas owned by legal entities (around 60%). Production on family owned farms has been contracted between the farmers and processors.

[3] None of these changes were the result of biodiesel production.

It is noticeable that a rapeseed yield per ha was quite low (ranging from 1.80 t/ha to 2.38 t/ha) until 2007 when it increased to 3 t/ha. Such low yields are understandable when one takes into consideration that rapeseed is often grown on the least improved soils, with poor water and air properties and with marked depressions in which the surface water tends to stagnate, which leads to a reduction of plant density and gap formation. Obsolete and inappropriate machinery, low level of technology applied, poor pest control and insufficient education of family farmers are other very important reasons for the small areas devoted to rapeseed and to the small average yields, that is, total production.

The Government supports oilseed production in a way that this production is subsidised with the highest amount of subsidies compared to other annual crops. The subsidy for rapeseed, based on production area, amounts to 2,250 HRK[4] /ha which is increased to 2,550 HRK/ha for rapeseed intended for biodiesel production.

Even though, the subsidy for rapeseed is about three quarters higher than those for wheat and maize, farmers are still reluctant to switch from the traditional cultures to new ones, resulting in low experience and consequently low yield in rapeseed production. It is expected that only significantly higher margin could motivate farmers to switch to rapeseed production.

Considering the present situation in Croatia, the quantities of rapeseed oil produced annually are at the moment insufficient for starting a larger industrial production of biodiesel and it is highly questionable whether in the near future an increase of rapeseed oil production could be expected. Recycled edible oil could thus serve as an important additional resource especially in the initial phase of biodiesel production in Croatia.

Table 5 Harvested area, yield and total production of oilseed rape, common wheat and maize grain

	Common wheat			
	2004	**2005**	**2006**	**2007**
Area (1 000 ha)	162.63	146.25	177.14	177.75
Yield (100 Kg/ha)	49.28	41.14	45.84	46.24
Total production[1]	801.42	601.75	812.00	821.89
Prices [2]. EUR/kg	0.15	0.15	0.13	0.19

Source [1]: CENTRAL BUREAU OF STATISTICS. 2008

Source[2]: TISUP. Ministry of Agriculture, Fisheries and Rural Development

	Maize			
	2004	**2005**	**2006**	**2007**
Area (1 000 ha)	306.347	318.973	296	289
Yield (100 Kg/ha)	63	69.18	65.3	49.4
Total production[1]	1931.627	2206.729	1934.517	1424.599
Prices [2]. EUR/kg	0.16	0.10	0.10	0.18

Source [1]: CENTRAL BUREAU OF STATISTICS. 2008

Source[2]: TISUP. Ministry of Agriculture, Fisheries and Rural Development

[4] 1 € is approx. 7,33 HRK (as of May. 30th 2009, according to Croatian National bank)

	Barley			
	2004	2005	2006	2007
Area (1 000 ha)	67.54	50.34	59.16	59.00
Yield (100 Kg/ha)	35.18	32.00	36.40	38.20
Total production[1]	237.60	162.53	215.26	225.27
Prices [2]. EUR/kg	0.14	0.12	0.12	0.18

Source [1]: CENTRAL BUREAU OF STATISTICS. 2008
Source[2]: TISUP. Ministry of Agriculture, Fisheries and Rural Development

	Oilseed rape			
	2004	2005	2006	2007
Area (1 000 ha)	14.28	20.15	8.41	13.07
Yield (100 Kg/ha)	22.00	20.48	23.77	30.10
Total production[1]	31.39	41.28	20.00	39.33
Prices [2]. EUR/kg	0.21	0.18	0.22	0.24

Source [1]: CENTRAL BUREAU OF STATISTICS. 2008
Source[2]: TISUP. Ministry of Agriculture, Fisheries and Rural Development

	Soya			
	2004	2005	2006	2007
Area (1 000 ha)	36.97	48.22	62.81	46.50
Yield (100 Kg/ha)	26.48	24.81	27.70	19.50
Total production[1]	97.92	119.60	174.22	90.64
Prices [2]. EUR/kg	0.24	0.21	0.22	0.29

Source [1]: CENTRAL BUREAU OF STATISTICS. 2008
Source[2]: TISUP. Ministry of Agriculture, Fisheries and Rural Development

There is no clear strategy or accepted plans how to fulfil Croatian goals to cover the total national biodiesel demand of approx. 45.000 t by the year 2010. Two main scenarios are ‘agricultural model‘ and ‘industrial model‘ of development. ‘Agricultural model‘ perceives biodiesel as one of the solutions for development of the rural communities through keeping business incentives and job creation in the rural areas. That is why they have a reasonable standing for an ongoing initiative to build several smaller plants which will have more positive impact on the local rural communities. The ‘industrial model‘ suppose development of one big biodiesel site that would cover national biodiesel demand.

Future production of bioethanol in Croatia will certainly rely on production of wheat and maize as the two most important arable crops in Croatia.

According to official data, the harvested area of wheat and maize in 2007 amounted to 177,750 hectares and 289,000 hectares respectively. The area under wheat increased in the last 5 years by 13% while the harvested area of maize decreased by 5% in the same period. The average yield of wheat and maize between 2003 and 2007 was 4.3 tonnes and 5.8 tonnes per hectare respectively.

Due to the unorganised market for cereals and uncontrolled exports of corn in some years there were severe problems in domestic livestock production.

Therefore, in order to meet the needs for raw materials for future bio ethanol production, there should be an increase of corn and wheat production, which can be achieved by increasing the harvested area or by increasing the average yield per hectare.

In order to estimate the potential of biomass for biofuel production (biodiesel and bioethanol) an analysis with four variants including improved yields, increased cultivated areas and a combination of these measures was made (Green paper draft, 2008).

Table 6 Possible production of biofuels in Croatia from corn, wheat, barley, rapeseed and soya

	Variant 1*	Variant 2**	Variant 3***	Variant 4****
Biodiesel [t]	3 682	9 225	21 901	32 353
Bioethanol [t]	110 518	13 302	249 327	307 878
Total [t]	114 200	22 527	271 228	340 231
Total [PJ]	3.09	0.69	7.47	9.41

* increased yields at the currently used agricultural areas (maize at 8 t/ha, wheat at 5.5 t/ha, barley at 4.5 t/ha, rapeseed at 3.5 t/ha and soya at 2.8 t/ha)
** increased cultivated agricultural areas (by 150 000 ha) with current yields
*** increased cultivated agricultural areas and increased yields at the currently used agricultural areas
**** increased cultivated agricultural areas and increased yields at total used agricultural areas
Source: Green paper draft, 2008

It is necessary to stress that this potential was calculated with the condition of satisfying food demands in Croatia, creating compulsory grain reserves and respecting cultivating timetables in order to avoid negative affects to the soil.

Furthermore, the estimated potential from waste edible oil amounts to 4.4 million litres from which around 3,800 tonnes of biodiesel can be produced annually.

- **Wooden and forestry materials**

Forests and forestland in the Republic of Croatia, covering an area of 2,688,687 ha (47% of land), contains 397,963,000 m^3 of growing stock which increases 10,526,238 m^3 a year.

According to property structure, 75% or 2 018 987 ha of the woods are legally owned by the Republic of Croatia and managed by Hrvatske šume Ltd. Zagreb, and contains 302 500 000 m^3 of wood reserves with the annual total increase of about 8 000 000 m^3. Private woods proprietors own 581 770 ha or 22% of the whole wooded area rich with 78 500 000 m^3 of wood reserves and with the annual total increase of about 2 100 000 m^3. The rest of 3 % of the wooded area or 87 930 ha is owned by legal subjects founded by the Republic of Croatia. There are about 17 000 000 m^3 of wood reserves in these areas, with the annual total increase of about 400 000 m^3.

Under normal conditions, the application of tending and regenerating treatments in the forests according to the principles of sustainable development, or sustainability, provides the

Croatian forestry profession with 6 560 000 m^3 of diverse wood products for processing. Of this quantity, about 40% relates to stacked wood with 7 or more cm in diameter, which is suitable for energy production. Of this amount, a considerable percentage of smaller-diameter trees remain in the forest because of inadequate prices, the processing technology and the underestimated market value.

Energy generation from wooden biomass has a long tradition, especially in rural areas in Croatia. In 1965 this energy made for almost one fourth of total energy consumption. However, today fuel wood contributes to total energy consumption with only 7% mainly due to poor knowledge about the modern use of biomass as an energy source.

In recent years, the interest of investors in biomass plants increased notably. Fossil fuel boiler rooms are increasingly replaced with wood remains boiler rooms, the number of machines installed for the production of briquettes is growing, and significant investments in the pellet production technology and in the cogeneration plants are being planned.

Out of 145 project drafts applied to a public tender opened in 2007 for the award of the state support of development and sustainability of the wood-processing industry, 52 draft projects refer to the implementation of the production of energy sources from wood remains.

The first central heating system with a 1-MW biomass-fired boiler was installed in 1995, and the second forest biomass-fired district heating plant (1-MW) was put into operation in 2005. During 2007 and 2008 Environmental Protection and Energy Efficiency Fund approved funding for additional four centralized system of biomass plants, which are in the process of development.

At the moment, there are 6 pellet producers in Croatia with the production of 142 300 tonnes in 2008 (source: http://www.poslovni.hr/105691.aspx). However, due to the undeveloped domestic market all produced pellets have been exported. There is one company producing pellets furnaces / boilers with the majority of production being exported.

Table 7 Solid Biofuels Production

		2004	2005	2006	2007
Wood pellets	t	2 000 t	2 000 t	6000 t	41 000 t
Wood briquettes	t	1 200 – 1 500 t	8 500 t	19 400 t	27 475 t
Firewood	m^3	1 460 000 m^3	1 390 000 m^3	1 668 000 m^3	1 450 600 m^3

Source: Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

Having in mind the increasing trend of pellet demand in the foreign markets, implementing some incentive measures would enhance further broadening of pellet production and it would bring an additional source of income to their producers.

In order to popularize the use of pellets the Ministry of Regional Development bought 300 furnaces designed for pellet utilisation, and distributed them to schools and libraries.

Thanks to great and still unused potential of natural forests in Croatia, there is still no need for planting rapid growing trees for the purpose of energy generation.

However, according to media (http://www.nacional.hr/clanak/48066/za-biodizel-od-azijske-trstike-25-milijarde-eura) German company Genesis Projekt in collaboration with a group of local entrepreneurs, is planning to raise the plant Miscanthus on 140 thousand hectares for bio fuel production. There is a plan to build seven laboratories and as many plants for biofuels production. Planned start for construction of the first facility is mid-2010. Investment value of the project is two and a half billion euros in the next 20 years.

In the Green paper draft (2008) the potential of wood biomass including possible energy forests is estimated. According to these estimates it is possible to generate 80.62 PJ of energy from solid biomass with additional 12.88 PJ from energy forests that could be cultivated on degraded forest land (it is estimated that there is around 600 – 800 thousand hectares of available land for this purpose).

Table 8 Total estimated potential of wood biomass from forestry, industry and agriculture

No	Sort of biomass	Volume	Density	Mass	Net calorific value	Energy
		m3/ year.	kg/m3	t/year	kWh/kg	PJ
1	Cord wood	1,889,551	730	1,379,372	4.90	24.33
2	Wood residue	700,928	700	490,650	4.90	8.65
3	Abbaino	207,306	550	114,018	4.90	2.01
4	Wood industry residue	1,389,000	730	1,013,970	4.90	17.89
5	Water management, Roads and HEP*	400,000	680	272,000	4.90	4.80
6	Agro residue	2,888,000	450	1,299,600	4.90	22.93
7	Total	7,474,785	-	4,569,610	-	80.62
8	Energy forests	1,000,000	730	730,000	4.90	12.88
9	Total	8,474,785	-	5,299,610	-	93.49

*wood biomass from wood harvesting during maintenance of waterways and power facilities (waterways, protected transmission corridors and electricity distribution lines) as well as protected road corridors

Source: Green paper draft, 2008

- **Wastes of agricultural production, e.g. liquid manure**

The cattle raised in Croatia in year 2003 produced more than 13 866 120 m^3 excrements containing at least 418 467 540 Nm^3 (302 113 544 tons) methane. If this gas was used in cogeneration plants more than 1.300 GWh of electricity and the same amount of heat energy could have been generated – corresponding to 10% of electric energy consumption in the respective year.

The main market barriers for agricultural biogas project are small average size of animal farms, scattered farms, lack of updated data and structural problems of agriculture with low level of enforcement of environmental laws on farm waste management..

Broadly speaking, biomass utilisation in Croatia is well promoted among renewables and many projects are pending for their implementation. However, among different biomass types, biogas was not enjoying special attention. For that reason, the main social barrier for a biogas project would be the low level of knowledge, information and awareness of biogas possibilities both in the sense of profitability and positive externalities for the local community (Kulišić, 2008)

Modern, ecologically orientated waste management has a strong interest in reducing the volume of waste contained in landfills. In year 2005, approximately 1 450 000 tons of communal waste was collected in Croatia. Using the currently existing advanced technologies for mechanical-biological waste treatment (i.e. the one implemented in Lübeck plant) approximately 600 000 tons of fraction having high calorific value, which can be used as fuel in thermal power plants (combustion equivalent of 225 000 tons of fuel oil) could have been separated. By processing the organic matter separated in biogas plants, approximately 21 003 000 Nm^3 of biogas (respectively 10 500 000 Nm^3 of methane) could have been generated (combustion equivalent to 10 500 tons of fuel oil). In addition the volume of the waste to be deposited in the landfills could have been reduced up to 55% (Jugović, 2007).

Current legislation on RES electricity has demonstrated some difficulties in biogas production. Those difficulties are influencing biogas plants development strongly, especially in the part related to spatial planning and obtaining the location permit mandatory for registration at the RES Registry – the first step towards gaining the Eligible Producer status and benefiting from the feed-in tariff.

Although related to agriculture policy, biogas is managed only by Ministry of Economy, Labour and Entrepreneurship. Due to the poor communication between the Ministries, biogas is not mentioned in the strategic document “IPARD Programme 2007 – 2013 Agriculture and Rural Development Plan” prepared by the Ministry of Agriculture, Forestry and Water Management in December 2007 (Kulišić, 2008).

Absence of Biomass Action Plan brings overlapping of biomass project where several projects are developing on the basis of the same biomass feedstock which will result in failure of at least one of the projects (Kulišić, 2008).

In the past year, biogas is frequently mentioned in media with “dazzling” statements on biogas potential, profitability and significance in energy sector coming from both scientific and commercial sector. It is reasonable to expect that either a success or failure of the first biogas plant venture will be covered by media with similar attention which will have significant impact on dynamics of biogas sector development in Croatia.

Biogas production and utilisation will be left at modest contribution (up to 1% of the total gross electricity consumption in Croatia) if feedstock is not extended to energy crops and other sources such as food processing industry, kitchen waste, expired foodstuff, slaughterhouse waste and similar. So far, no research has been done in investigating biogas potentials in Croatia other than agriculture feedstock, namely animal manure.

2.2.2 Other energy sources: wind energy, solar energy, hydro-energy

- **Wind energy**

Wind parks are the most important RES to produce electricity in Croatia (not counting the potential in existing large hydropower plants).

First wind turbines in Croatia were placed into trial operation in late 2004. The total installed capacity of the wind park Ravne I is 5.95 MW, and its annual output is approximately 15 million kWh of electricity. The contractor for the first Croatian wind park was a private investor.

Another operating wind park Trtar-Krtolin (14 wind turbines) has 11.20 MW of total installed capacity and 32.2 million kWh of annual output capability under average wind conditions. Its energy generation started in 2006. The same investor placed an additional wind park into trial operation (11 wind turbines, 9.6 MW, expected energy generation 24 GWh) in June 2009 (source: http://energetika-net.hr/oie/vijesti/6373)

Table 9 Number of wind parks and energy supply

	2005	2006	2007
Total installed capacity (MW)	5.95	17.15	17.15
Electricity generation (GWh)	9.5	18.96	34.91
Number of wind parks	1	2	2

Source: Energy in Croatia 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

There is great interest shown by investors (domestic and foreign) for wind parks which is greatly facilitated by favourable legislation and guaranteed sales prices (feed-in tariffs). There are more than 50 projects of wind parks mostly in the costal area.

However, the investors face a problem of the total wind power than can be absorbed into the Croatian power system which is highly dependant on grid conditions and is currently restricted to 360 MW for al of Croatia. This limit is expected to increase, as grid is extended and projects are implemented. Imposing a limit of 360 MW has led to high insecurity among wind project developers, as some of them were not allowed to build the full capacity planned in their projects.

Furthermore, there is currently no wind energy resources atlas for Croatia and research for individual locations is being conducted by potential investors themselves.

Local authorities have shown interest in development of wind power plants and support such projects with the expectations that such plants should contribute to the regional economic development.

- **Solar energy**

Solar energy has high potential in Croatia, especially in southern areas, and it is currently used for spatial and water heating. Photovoltaic (PV) are still not widely used, and are not expected to grow significantly, since new renewable policy sets the limit of 1 MW of PV installed in the entire Croatia in 2010 to be included in the incentive system[5].

The natural potential of solar energy in continental regions of Croatia, with an average insolation of 3.6 kWh/m2, amounts to around 74,300 TWh/annum (267.500 PJ/annum.), which is over 800 times more than the consumption of primary energy in Croatia in 2000.

Technical potential of solar energy on 1% of the continental part of Croatia is estimated at 830 TWh/annum (3.000 PJ/annum) or close to 10 times of the daily consumption of primary energy in Croatia. With the presumption that 60% of that energy is used for heating and 40 % for electricity generation, we can conclude the following:

_* The technical potential to produce heat from solar collectors and the use of passive solar energy (solar architecture) amounts to 175 TWh/annum. (630 PJ/annum);
_* The technical potential to electricity generation from photovoltaic (PV) systems and solar thermal power plants amounts to around 33 TWh/annum.

The economic potential of solar energy in Croatia is estimated as follows:
_* Heat produced from solar energy amounting to around 50 % of total low temperature heat in 2000 in Croatia, or nearly 12 TWh/annum (43.2 PJ/annum.), the production of heat from solar collectors and passive use of solar energy (solar architecture). That makes up for about 7% of the technical potential of solar energy for heating in Croatia.
_* Electricity generated from solar energy in photovoltaic systems and solar thermal power plants could become economically viable around 2020. With the use of a little less than 1% of the technical potential, the economic potential to produce solar electricity would amount to around 0.3 TWh/annum, which is the equivalent of around 200 MW of electricity-generating capacity (Green paper draft, 2008).

Until 2007 there were no reliable data which would enable a determination of the installed heat capacities of solar collectors, therefore, this data was not included in the energy reports. Installed heat capacity in 2007 was estimated to 45.5 MW, and this estimation was made according to the surface and type of collectors as recommended by the European Solar Thermal Industry Federation (ESTIF), data on installed capacities until 1998 and data on sales

[5] The limit is set to 1MW as PV are more expensive than other RES and, since Croatia is at the begining of the development fo RES market,it has been decided to focus on chaper RES.

and imports of plate and vacuum solar collectors for period of 1998 – 2007. Heat generation derived from estimations given for the installed capacity in 2007 was 26.1 TJ.

Table 10 Number of adopters and energy supply: solar energy

	2004	2005	2006	2007
Total installed capacity (MW)	0,01274	0.04884	0.04996	0.05608
Electricity generation (MWh)	12.63	50.14	49.13	52.65
Number of solar plants	2	3	3	4

Source: Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

Installed electrical power capacity from solar collectors in 2005 was 48.84 kW and it increased to 49.96 kW in 2006. The data for 2007 show 49.96 kW of realised power plants and 954.12 kW of solar power plants have been registered as projects. The total installed power, related to finished facilities connected to the grid, is 23 MW.

Electricity generation from solar energy in 2005, 2006 and 2007 amounted to 50.14 MWh, 49.13 MWh and 52.65 MWh respectively.

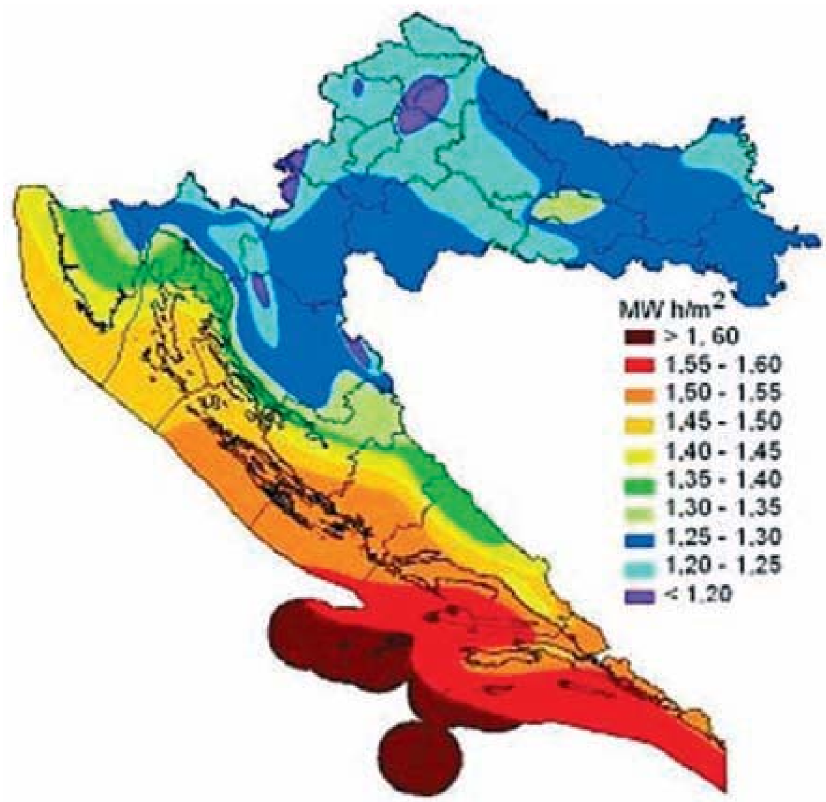

Figure 1 - Average yearly insolation in Croatia
Source: www.energetika-net.hr

Similar to other REs, the interest of investors in solar power plants increased in recent years.

However, the main problems in the development of solar power plants are relatively expensive technology, especially for electricity generation and administrative constrains.

- **Hydro-energy**

Hydro power plants account for approximately 50% of the total installed electricity generation capacity and generation, depending on the hydrologic conditions (for example, shares of produced electricity from hydro power plants in 2006 and in 2008 were 52% and 46% respectively. *Source*: *Croatian electricity system in 2008, basic preliminary data*).

Technically exploitable water potential resources in Croatia are estimated at 12.45 TWh/annum. Of that potential, approximately 6.13 TWh/annum or 49.2% is currently used in hydropower plants. Based on experience of other countries with similar topographic and morphological features, about 10% of the total potential refers to the potential of small water courses (around 1 TWh/annum) (Green paper draft, 2008)..

The HEP Group (Croatian Power Company) has 25 hydro power plants (11 storage plants, 4 small storage plants, 6 run-of-river plants and 4 small run-of-river plants) with the available power of 2071.26 MW. The total production in these plants in 2007 amounted to 4300 GWh.

There are additional four small hydro power plants selling all produced electricity to the grid, and one small plant producing electricity for its own needs and giving only surplus to the grid. The installed capacity of these power plants is 4.084 MW and they sold 10.532 GWh to the network during 2007.

Table 11 Number of installations and supply of hydro energy

	2004	2005	2006	2007
Total installed capacity (MW)	2 078.6	2 075.34	2 075.34	2 075.34
- Installed capacity of small hydro power plants (MW)	32.763	32.764	32.764	32.764
Total energy generation of hydro power plants (PJ)	69.00	62.40	58.18	42.21
- Energy generation of small hydro power plants (PJ)	0.298	0.394	0.389	0.455
Number of larger-scale power plants	17	17	17	17
Number of small hydro power plants (less than 10 MW)	13	13	13	13

Source: - Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship.

- **Geothermal energy**

There is a long tradition of exploiting geothermal energy from natural resources in Croatia for medical purposes and hot baths. Geothermal energy is the foundation of economic success of numerous mineral springs in Croatia. The technology to obtain geothermal energy from deep bores is well developed in Croatia.

Total geothermal energy potential from drilled bores in Croatia is estimated at 203MJ/s (using heat at water temperature up to 500C) or 320MJ/s (at water temperature of 25^{o}C). In case of complete utilization of the basin that potential is 840MJ/s (or 1170MJ/s).

Total installed capacities of geothermal sources in 2007 in 18 locations in use in Croatia amount to 36.66 MW when space heating is concerned, and 113.9 MW when geothermal energy for space heating and hot water preparation in spas and recreational centres is concerned.

Geothermal sources are mostly found in rural areas and the utilisation of this energy is extremely important for their economic development as it will result in the opening of new industrial facilities and new work places.

In Croatia there are several geothermal power projects under development. These projects aren't meant to be used only for electricity generation, but are planned as multi-purpose projects (heating of nearby places, production of flowers, vegetables, fish, opening of tourist spa centre
etc.).

Table 12 Supply of geothermal energy

	2004	2005	2006	2007
Total installed heat capacity (MW)	113.9	113.9	113.9	33.66*
				113.9**
Heat production (TJ)	541.94	547.33	558.52	139.5*
				562.81**

* space heating
** space heating and hot water preparation in spas and recreational centres
Source: Energy in Croatia 2004, 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

2.3 Main effects with respect to agricultural and forestry production

The negotiations with the EU and harmonization of relevant Energy Acts with the EU legislation have brought forth significant changes to the Croatian energy market making it very attractive for investment. However, up till now main investors in energy generation from RES are domestic and foreign companies, while there were no such projects developed on family owned farms.

Power generation from biomass so far had no significant impact on the development of agriculture and forestry in Croatia.

Currently, biodiesel is mainly produced from imported oilseed rape and from waste oil due to insufficient domestic production of oilseed rape. Domestic farmers traditionally favour production of wheat and corn, although the incentive for oilseed rape per hectare is much higher compared to wheat and corn incentives. Thus so far, there are no contractual relationships between farmers and biodiesel producers.

All existing biomass plants are owned by companies / cooperatives, while family farms have not shown significant interest to invest in RE plants (due to high investment costs and insufficient knowledge).

At the moment there is only one association of producers of oilseed rape for biodiesel production, however, the establishment of the association did not significantly affect the oilseed rape production.

Energy generation from forest biomass is mainly conducted through the company projects the Forest Inc., and through industrial cogeneration and heating plants. Since Croatia has sufficient quantities of wooden materials from natural forests, there was no need to plant rapid growing trees for bio energy production.

Biogas production in Croatia initiated in 2009 and there is already a significant interest among investors for such production (mostly larger companies/cooperatives). According to expert estimates, a number of biogas plants will grow strongly in coming years.

2.4 Overview of the installations producing bio energy

2.4.1 Number and capacity development over the last years

Biogas

The first biogas plant operating in Croatia is the small landfill-gas fired thermal power facility at the waste disposal site in Zagreb, with a total installed capacity 2 MW in 2004. "BIO MOTO" Ltd is the company responsible for management and maintenance of the biogas plant.

The second biogas plant that uses waste water treatment sludge as substrate started to operate in August 2008. Total installed capacity is 2x1.5 MW_{el} but the production is still in its starting phase and all energy produced is utilised for energy demand within the wastewater treatment plant (Kulišić, 2009).

Another biogas plant, using a raw material originating from agriculture, started to operate at the end of 2008 (obtained eligible producer status in April 2009) (Kulišić, 2009). Nevertheless, biogas market is emerging in Croatia which makes it rather dynamic sector. According to some expert estimates, it is expected to have further 30 plants in the next 10 years because of increased awareness of advantages of such production. On the other side, these estimates could be questionable due to the unfavourable policy; naimly biogass plant could be built only on a building plot and raw materials are produced on agricultural plots what impose that raw materials should be transported.

Table 13 Number of producers/processors and energy supply: biogas

	2005	2006	2007
Total installed capacity (MW)	2	2	5
Number of producers	1	1	2
Number of producers just for own consumption	-	-	1

Source: Energy in Croatia 2005, 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

Biodiesel

In 2006, a firm Modibit ltd. started to produce biodiesel as the first example of biodiesel production in Croatia. The plant capacity is 20,000 tons of biodiesel per year. The feedstock used is rapeseed (canola) oil from both imports and domestic origins combined to a lesser extent with soybean (import) and waste cooking oil. In 2006, total biodiesel production of 7,000 tons from the trial period was intended for exports.

In June 2007, Vitrex ltd. started producing biodiesel from waste cooking oil which makes it the second biodiesel plant operating in Croatia. Its capacity is 9 000 tons per year of biodiesel which increases the total Croatian bio fuel production capacity up to 29 000 tons per year.

In 2007, 4 334 t of biodiesel was produced in Croatia, out of which 3 583 t were placed in the domestic market. About 1,300 t of biodiesel originated from domestic rapeseed, 320 t originated from collected waste cooking oil and the rest of the feedstock needed for the biodiesed production was imported.

The main problem in biodiesel production in Croatia regards deficiency of feedstock (existing plants import significant part of oil used for biodiesel production).

The UNIDO project (2008) showed that the majority of stakeholders believe that the first step in implementing biodiesel production should be made by the Government but these actions should be supplemented with expert advice/consulting.

Table 14 Number of producers and energy supply: biodiesel

	2006	2007
Total supply (tonnes)	7000	4334
Total installed capacity (tonnes)	20000	29000
Number of producers	1	2

Source: Energy in Croatia 2006, 2007, Ministry of Economy, Labour and Entrepreneurship

Bio-ethanol

Due to the lack of interest and no strategic commitments at the moment, there is no production of bio ethanol in Croatia.

The Ministry of Economy, Labour and Entrepreneurship emphasizes that policy does not favour any particular renewable source, but this is left to the entrepreneurial initiative and other restrictive (eliminatory) factors. "The development and the share of each RES mostly affect price and maturity of technology, availability and price of raw materials and natural and technical potential of certain sources (Source: Privredni vjesnik, http://www.privredni.hr/index.php?Itemid=2&id=122&option=com_content&task=view)

3 National policy and concepts promoting renewable energies

3.1 National policy

In the context of Croatia's EU accession processes Croatia has harmonised the overall concept of energy sector reforms with the legal and institutional EU requirements, however within the limits of the specific national solutions.

The main legal source for the Croatian energy sector is the Energy Act (*Official Gazette* 68/01, 177/04, 76/07, 152/08), which stipulates positive attitude towards renewable energy sources. The legal framework for the field of renewable energy resources, energy efficiency and cogeneration in Croatia is contained also in the Electricity Market Act, the Act on Regulation of Energy Activities, the Act on Environmental Protection and Energy Efficiency Fund as well as accompanying implementation regulations.

The following secondary legislation relevant for renewable energy sources and cogeneration in Croatia were issued, adopted and enforced:

- Regulation on incentive fees for promoting electricity production from renewable energy sources and cogeneration (all electricity buyers; tariff buyers and eligible buyers shall pay an incentive fee to the market operator) http://releel.mingorp.hr/UserDocsImages/2_Incentives_for_RES_CHP_33_07.pdf
- Regulation on a minimum share of electricity produced from renewable energy sources and cogeneration whose production is incentivised (until 31 December 2010, the minimum share of electricity produced from plants using renewable sources whose production is incentivised shall amount to 5.8 % of the total electricity consumption – excluding hydro power plants exceeding 10 MW of capacity) http://releel.mingorp.hr/UserDocsImages/3_Min_share_of_RES_CHP_33_07.pdf
- Tariff system for the production of electricity from renewable energy sources and cogeneration (Until year 2010 the incentive fee will be: for year 2008: 0.0198 kn[6]/kWh + VAT, for year 2009: 0.0271 kn/kWh + VAT, for year 2010: 0.0350 kn/kWh + VAT)
- Ordinance on the use of renewable energy sources and cogeneration
- Ordinance on attaining the status of eligible electricity producer.

In order to implement the Directive 2003/30/EC on the promotion of the use of biofuels the Act on Biofuels for transport has been enacted in May 2009. According to this Act, all secondary regulations and documents (including national and local plans of promotion of bio fuel production and consumption, national action plan, regulations of subsidies etc.) have to be enacted within one year from the entry into force of this Act.

The regulations to encourage the application of renewable resources for production of heat and cooling energy are expected to be passed by the end of the year.

Croatia has set the following strategic goals related to the use of renewable energy sources (Green paper draft, 2008):

[6] 1 € is approx. 7,33 HRK (as of May. 30th 2009, according to Croatian National bank)

- Mandatory target of 20% share of renewable sources in the final energy consumption by 2020 according to the Directive on the promotion of the use of energy from renewable sources published in January 2008 in the framework of the EU objectives defined in the Climate Action and Renewable Energy Package (CAREP) for 2020)
- Mandatory target of 10% share of biofuels by 2020 in the consumption of gasoline and diesel fuel according to the Directive on the Promotion of the use of biofuels and other renewable fuels for transport
- 35% share of electricity generation from renewable sources, including large hydropower plants by 2020, in the overall electricity generation

The most common aspect of RES implementation promotion are the guaranteed purchasing prices for electricity produced from such sources (feed-in tariffs), subventions for the manufacturing of equipment for use in RES, as well as the commitment to purchase the electricity produced from RES. The use of RES in the context of the electricity market is for the time being the most developed in a legal- institutional sense.

In March and July 2007, Croatia has introduced the feed-in tariff system for support of renewable electricity generation. Tariffs are determined by technology, are valid for 12 years and are adjusted every year according to average small goods' price coefficient, as well as dependant of the share of domestic component within the project.

The feed-in tariffs are set according to the energy source it is generated from. Green electricity producers which have signed a contract with the market regulator are eligible for these tariffs.

Croatia has a specific clause in energy policy, which states that renewable electricity will be supported only until the share of 5.8% in total electricity consumption in 2010 (which would be around 1100 GWh) is reached.

Ministry of Agriculture, Forestry and Water Management enacted Law on Amendments of the Law on state support in Agriculture, Fishery and Forestry (OG 85/06) that defines incentives for rapeseed produced for biodiesel production. Law entered into force on January 1, 2007. According to this Law the incentive for rapeseed production delivered for biodiesel processing amounts to 2.550,00 kn/ha. Beneficiaries of incentive should have planted minimally 3ha of rapeseed.

Promotion of bio fuel use has been prescribed in the Energy Act which identifies the usage of renewables as a matter of state interest, defines biofuels, and defines the production of biofuels and road transport of oil, oil derivatives and biofuels as energy activity. Regulation on Biofuels Quality (OG 141/05) identifies national indicative target of 5.75% bio fuel share of total annual consumption of gasoline and diesel fuel which must be realised by 2010.

The Ministry of Economy, Labour and Entrepreneurship, the Ministry of Environmental Protection, Spatial Planning and Construction and the Croatian Energy Regulatory Agency are competent for the implementation of policy and measures in part which is related to the placement of biofuels on domestic market.

As mentioned above, RES policy is well developed at the highest levels while local and regional levels are mostly not able to follow the stated policies at local level. Recently, local authorities are establishing regional developing agencies and regional energy agencies in order to facilitate utilisation of EU programmes.

Regarding project preparation procedure, there is a problem with obtaining eligible producer status and enjoying the feed-in tariff system. The Ministry has foreseen some 6 months to 1 year procedure but it is still early to say if this period was realistic. The main problem occurs in the grid connection and examination of domestic component in the project. Complicated and long procedure for licences issuing is one of the most common barriers to any kind of project, including RES, in Croatia (Kulišić, 2008).

Table 14 Basic principles guiding national policy on renewable energies

Guiding principles	Ranking 0=non relevant 5=highly relevant
Need for a substitution of traditional fossil fuels	5 According to the Croatian legislative and strategic documents the substitution will need to be carried out.
Development of a national concept promoting renewable energies	5 Croatian public is at the moment not aware of the significance of this issue, therefore there is a need of continuous promotion of the renewable energies
Financial support in promoting renewable energies	4 To ensure development of RES utilization in Croatia and fulfilling the obligation towards the Croatian Legislative different forms of financial support have beed defined.
National focus more on promoting of renewable energies based on biomass (biogas, biodiesel, bio ethanol)	3 Even though the priority in national RE production is put on wind power, energy production from biomass also has an important place in national strategic documents.
National focus more on promoting renewable energies based on non-biomass (wind, solar, hydroenergy)	4 Due to the available potential and no need for investment into raw materials (only investments into technology) wind has been set as a priority.
Stimulation/support of the private sector	5 Without Government stimulation, production of certain RES is not feasible; therefore support is envisaged for private investors.
Competitiveness of renewable energies with fossil energy	5
National independence of fossil energy supplies	4 Full independence cannot be achieved but in strategic documents the role of RES should increase in the following years.

Source: Interviews with experts

With its Energy Strategy (Green paper, draft, 2008) Croatia is determined to use RES in keeping with the principles of sustainable development. Following table shows the RES structure in Croatia foreseen in the Strategy to 2020, with a view to 2030.

Table 15 Forecast of the renewable energy sources structure to 2020 (with a view to 2030)

		2010	2020	2030
Biomass	[PJ]	18.14	36.27	68.72
Biofuel	[PJ]	2.50	9.55	14.35
Wind energy	[PJ]	1.02	9.50	15.84
Hydro power – small HPPs	[PJ]	0.40	0.97	1.55
Hydro power – Large HPPs	[PJ]	21.06	23.76	23.76
Geothermal energy	[PJ]	0.15	5.51	8.54
Solar energy	[PJ]	0.51	5.27	13.87
TOTAL	[PJ]	43.78	88.42	146.63
	[t_{oe}]	1 042 000	2 105 000	3 491 000

Source: Green paper, draft, 2008

3.2 National concepts and programmes

In 1997, the Croatian government started five national energy programs dealing with renewable energy sources: BIOEN (biomass and waste), SUNEN (solar energy), ENWIND (wind energy), MAHE (small hydro) and GEOEN (geothermal energy). Those programs include all significant matters connected to a more frequent use of renewable energy resources.

The program for biomass and waste energy use BIOEN has shown that electricity generation from biomass and waste could meet up to 15 percent of the total primary energy consumption until 2020. Biodiesel project, as a part of the BIOEN program, which started in 2000, had a goal of introduction of biodiesel production in the Republic of Croatia. Within this project the following achievements were reached:

- the duty rate for biodiesel was set up at 4%
- the Regulation on Biofuel Quality was adopted, establishing the national target of a 5,75 % biofuel share in the total quantity of fuels in 2010
- defined incentives for rapeseed production intended for biodiesel production of 2,550 kn /ha (300 kn extra compared to the production intended for human/livestock consumption)

The program for solar energy use SUNEN has shown that solar energy utilisation combined with LPG and/or natural gas is a technologically and ecologically acceptable solution for the Croatian coastline. The hybrid combination of solar energy, wind energy and LPG can help solve the problem of energy infrastructure on islands and also start the development of traditional island activities with the engagement of local resources in accordance with the strategic development of Croatian islands.

Wind energy, as an ecologically acceptable and available domestic energy resource is a relatively unused resource which can contribute to covering a part of energy needs in Croatia. For wind energy utilisation by new generation wind turbines, the program for wind energy use, ENWIND, has been started. The program includes the assumptions for an economical wind energy use.

Geothermal energy use program, GEOEN, has shown the need for the creation of conditions which would increase geothermal energy utilisation in existing installations. Another important matter is the need for carrying out an appropriate and global marketing campaign and making private entrepreneurs and local communities interested in geothermal energy utilisation.

The basic goal of the MAHE program is planning the construction of small power plants, removing all barriers and obtaining conditions for a rapid construction of small power plants in Croatia.

Apart from feed-in tariffs, there are also complementary instruments used for the promotion of the utilisation of RES such as direct subsidies (the Ministry of Economy, Labour and Entrepreneurship supports development of the equipment for RE production), and different forms of financing (Environmental Protection and Energy Efficiency Fund, Croatian bank for reconstruction and development, European bank for reconstruction and development, local authorities, etc.).

Throughout the development of the Republic of Croatia, investments strengthening the competitiveness through energy savings and investments into ecologically sustainable market of renewable energy resources become increasingly important. These investments have multiple effects, e.g. the share of imported energy is reduced, independence on the energy market is strengthened and the environmental protection enhanced. For the purpose of financing environmental protection projects, HBOR (Croatian bank for reconstruction and development) extends loans through the Loan programme for the Preparation of Renewable Energy Resources and Loan Programme for the Financing of Projects of Environmental protection, Energy Efficiency and Renewable Energy Resources.

The Government of the Republic of Croatia has received a grant from the Global Environmental Facility Trust Fund (GEF), i.e. from the International Bank for Reconstruction and Development (IBRD) as the Implementing Agency of the GEF, in the total amount of USD 5.5 million for financing the implementation of the Renewable Energy Resources Project. The main aim of the Project is to support the development of economically and ecologically sustainable market of renewable energy resources.

The use of RES at national level has been promoted also through foundation of the HEP – Obnovljivi izvori energije (HEP Renewable Energy Sources) a daughter company of Hrvatska

Elektroprivreda (HEP Group) -national electricity company, in 2006. The purpose of the company is grouping and supporting renewable energy projects.

4 Impact of the promotion of renewable energies

4.1 Impact on the agricultural sector

Global trend of increased use of RES had significant influence on energy sector in Croatia. The impact of utilisation of RES is difficult to quantify, however some positive shifts are observable.

Regarding use of biomass from wooden materials following has been made:

- legal framework in accordance with the EU regulations have been set up
- Šumska biomasa ltd. has been set up in order to manage wooden and forestry biomass
- currently, 6 plants producing wooden pellets, with the total capacity o 140,000 t /year
- 2 cogeneration plants using wooden biomass
- several ongoing projects of energy generation from wooden biomass
- development of domestic biomass market.

However, the impact of use of RES on agriculture in Croatia is much less observable. There are only individual cases of farmers involved in RE production and it mainly regards several producers of rapeseed for biodiesel production and recently opened biogas plant.

However, all stakeholders agree that RE generation should and will have important influence on agriculture. The agricultural sector would benefit from the increased oilseed production for biodiesel through an increased usage of the considerable amounts of currently idle acreage, the introduction of rapeseed as the third crop in crop rotation, a guaranteed additional profit for farmers, and better exploitation of farming machinery which would all be summarized in increased profitability of agricultural production All these will lead to increase in employment rate and income generation opportunities and contribute to rural and agricultural development.

Therefore, the cultivation of energy/non food crops to produce biofuels should be an area of particular interest under Croatian agricultural policy for creating new economic resources and preserving employment in the rural communities.

4.2 Impact on rural development

At the moment, rural development measures adopted in Croatia are not directly linked to the use of RES.

However, national rural development strategy 2008 – 2013 recognises that strengthening the sector of energy production from renewable sources is the opportunity for the development of rural areas. Furthermore, one of the priorities related to improving the quality of life in rural areas and expansion of rural economy set up in this Strategy is investment in renewable energy.

Researches on potential locations for the installation of renewable resources (including wind and solar plants) have shown the greatest potential of rural areas and islands. Therefore, the installation of RES plants in these areas could encourage development of those parts of Croatia and improve quality of life of local population.

The introduction of biodiesel production in Croatia could play a significant role not only from energy point of view, but will also help in regulating the unemployment rate, especially regional unemployment deriving from the structural changes in agriculture.

Production of biodiesel from rapeseed oil is expected to contribute to the multifunctionality of agriculture and create several new job opportunities in rural areas due to the required labour for rapeseed agricultural production, which will also lessen the urge to abandon land and reduce the ongoing migration into cities.

From the farmer's point of view, rapeseed growing for production of biodiesel could provide better income stability.

Some local governments already recognised the importance of RES in the energy supply and they support installations of such plants. However, the number of these communities is rather small, while others do not have any programmes supporting the use of RES.

In the following year it is expected strong growth of biomass use, what will significantly contribute to the economic development, employment, especially in rural areas as well as reduction of air pollutant emissions.

According to expert estimates if additional 100,000 ha (out of 300,000 ha of uncultivated area) would be used for production of annual crops for biodiesel production, some 5,000 persons could be directly employed in this sector and further 2,000 persons could be employed in related activities (industry, civil engineering..). Collateral benefits should also be emphasised, such as money circulation in the local community, the development of the regional economy and similar knock-on benefits.

Effects of the introduction of incentive measures for RES will be visible only in a few years, and according to some expert estimates, the use of RES will have significant influence on rural development only after Croatian EU accession.

Table 16 Impact of renewable energies on rural development

Criteria	Ranking 0=non relevant 5=highly relevant
Role in national rural development programmes	3
Provision of new jobs on farm	0
Provision of new jobs in rural areas (non-farm)	0
New/additional source of farm income	0
New/additional source of income in rural areas	0

Source: Interviews with experts

Even though all experts agree that RES could / should significantly influence rural development in Croatia, current situation shows that the impact of the use of RES did not have a noteworthy effect on development of rural areas. The only national programme with direct support to RES in rural areas is IPARD programme which financially supports investments in the construction and / or reconstruction of heating systems that use organic waste (biomass) from agriculture and forestry.

5 Strengths and weaknesses of renewable energies

Table 17 Summary of SWOT-analysis

Strengths	Weaknesses
- Very good natural potentials and possibilities for the utilisation of RES, especially biomass, wind, solar and geothermal energy - Considerable biomass for energy generation and for biofuel production (wooden and forestry materials and annual crops) - Sizeable abandoned agricultural land as potential for production of annual crops for biofuel production - Long tradition in energy generation from wooden biomass and exploitation of geothermal energy - Considerable interest of (domestic and foreign) investors - Developed and proven technologies -	- Unorganised forestry and agricultural production in respect to energy production - Insufficient knowledge of agricultural producers in production of biofuel crops - Low yield of potential biofuel crops - High dependence on climatic conditions in production of biofuels crops (no irrigation) - Lack of raw materials for biofuel production (import of high quality grains) - Absence of administrative streamlining the projects - Red tape for setting up the plant - Most of the plant components are imported - Very limited integration of small scale wind power plants in distribution grid in Croatia
Opportunities	**Threats**
- Use of RE as a national strategic goal - National programmes promoting utilisation of RES - Favourable legal framework for production of electricity from RES (guaranteed purchasing price) - High incentives for rapeseed production intended for biodiesel production - Harmonized the overall concept of energy sector with the legal and institutional EU requirements - Croatian energy market became very attractive for investment - Availability of the world and EU loans and funds - Positive public attitudes towards	- Small farm size - High investment costs and long investment return - Administrative constrains (at national and local level) - Lack of legal framework for biofuel production and geothermal energy generation - No subsidies for production of heat energy from RES - Low level of cooperation between Ministries (energy, agriculture, environmental protection, physical planning and construction) - Export of grains and wood (possible raw materials for RE) - Insufficient public knowledge of

RES - Increased price instability of conventional sources of energy – greater economic attractiveness of RES - Favourable conditions for installation of biogas plants at newly established farms - New workplaces (agriculture, forestry, industry, projecting and consulting,..)	advantages of RES (including all levels of society and possible stakeholders) - Lack of administrative support at local level regarding spatial planning - Lack of interest for the sale of biodiesel in Croatia

5.1 Strengths and weaknesses

Croatia has a very good natural potentials and possibilities for the use of renewable energy sources, especially biomass, wind and solar energy with a distinctive regional distribution of particular sources.

There is a long tradition of exploiting wooden biomass for heating and geothermal energy for medical purposes and hot baths. Biomass production as well as geothermal sources are mostly found in rural areas and the utilisation of these energy sources is extremely important for their economic development as it would result in the opening of new industrial facilities and new work places.

However, the potential of RES has not been sufficiently utilized. Despite high incentives for crops used in biofuel production, the current production of these crops (especially rapeseed) is not very developed (low yields, farmers not interested in this production, insufficient knowledge of agricultural producers in production of crops used in biofuel production). Further, the potential of small rivers as well as wind potential are still insufficiently explored.

Important constrain of RE expansion are high investment costs due to the necessity to import most of the power plant components.

One of constrains of production of electricity from renewable sources in Croatia is the fact that the integration of small scale RES plants (less them 1 MW, but usually in the range up to 200 kW) in distribution grid in Croatia is very limited. The technical conditions are still not yet developed and transfer of best experiences in this field is highly needed.

5.2 Opportunities and Threats

The use of RES became one of the strategic goals of the national energy policy in the Republic of Croatia what enabled strong development of this sector.

Croatia has harmonized the overall concept of energy sector reforms with the legal and institutional EU requirements. Favourable legislation and guaranteed sales prices (feed-in tariffs) make the Croatian energy market as very attractive for both domestic and foreign investors.

Although in the last ten years in Croatia are recorded numerous initiatives and expression of intention and interest for starting biofuel production by foreign and domestic investors, until now majority of project implementations have failed.

Main constrain, apart from the high investment costs, is the administrative procedure of issuing all necessary documentation. The problem mostly appears due to the weak cooperation of different policy makers involved in the issues of RES.

Even though some local communities recognised the economic and environmental potential of utilisation of RES (some municipalities financially supported development of biomass plants for local heating), many local governments still do not support usage of RES. The main problem regards a lack of administrative support regarding spatial planning, but also lack of financial support to RES projects.

Intensive public debate about RES resulted in the positive attitude towards use of RES. However, the awareness of majority of population of advantages of RES is still weak.

6 Conclusions

Croatia has good natural potentials and possibilities for the use of renewable energy sources. Geographic position of Croatia is its strength and opportunity for sustainable energy sector development: physical advantages of maritime country and country with good sites for construction of power generation facilities (underground gas storages, hydropower plants, wind parks and other renewable energy sources) as well as large areas for production of biomass used in energy generation. Wind parks and biomass cogenerations have great potential in electricity generation while the main renewable sources for heat production could be biomass and solar plants.

However, all this potential is not sufficiently used. The total share of renewable energy sources in primary energy production in Croatia is less than 1% (excluding large hydro power plants and fire wood traditionally used as a way of heating).

Current legislative framework in Croatia has been harmonized with the legal and institutional EU requirements, encouraging energy generation from renewable energy sources. Nevertheless, there are some constrains in use of RES, mainly regarding administrative barriers which support the complex procedure of issuing the approvals, concessions and other necessary certificates to run power plants.

The number of potential investors in RES is constantly increasing; the greatest interest is shown for wind power plants. Solar power plants and biogas facilities are also recently very popular among developers. However, the number of projects is still insufficient in relation to the interest of the investors and citizens. One of the reasons is, probably, the considerable investment that is necessary for the realisation of these projects.

So far, energy generation from renewable sources did not have significant influence on agricultural production or rural development in Croatia. At the moment, rural development measures adopted in Croatia are not directly linked with the use of RES. However, all stakeholders agree that RES could contribute significantly to development of rural areas in Croatia through the economic development and increased employment as well as reduction of air pollutant emissions. According to expert estimates, it is not expected that use of RES will have significant influence on rural development until Croatian EU accession.

Due to the specificity of renewable energy sources and their underdeveloped market status the state must devote considerable effort and strong political will to succeed in promoting new and clean technologies.

- It is be essential to strengthen the cooperation between all relevant policies involved in RE sector (energy, agriculture, environment protection, spatial planning and construction) in order to fully exploit natural potential in energy generation from RES.
- The administrative procedure for obtaining all necessary documents necessary for setting up a RE plant should be simplyfied
- Regional energy agencies should be established in order to help local communities and / or single investors to obtain funds from national and international sources.

- Further incentives such as various types of support for manufacturers, encouraging scientific and technological research, direct support for RES programs and projects from the state budget, as well as the establishment of international cooperation in this area should be introduced
- A strong and widespread public awareness raising campaign that promotes renewable technologies and all of their benefits should be organised.

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Annex 3 List of interviewed experts

1. Representative of the *Croatian chamber of commerce*
2. Representative of the *North-west Croatia Energy Agency* (established under the framework of the Intelligent Energy Europe programme)
3. Representative of the *Energy Institute Hrvoje Požar* (its founder is the Government of the Republic of Croatia)
4. Representatives of the Faculty of Agriculture University of Zagreb (2 persons)
5. Representative of the Ministry of Regional Development, Forestry and Water Management
6. Representative of the Minsitry of Economy, Labour and Entrepreneurship
7. Biodisel producers (2 persons)