Project: BiG>East

(EIE/07/214)

Assessment Studies for Specific Biogas Sites in the target region of Croatia

Deliverable D 6.3

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Document Structure

Summary

Due to lack of spatial data on biogas feedstock availability, the main criteria for selecting the sites was having the soft requirements fulfilled (political support, commitment) at those regions where average biogas substrate availability per square meter was among the first five among all Croatian counties (biogas site 1: Business Zone Velika Ciglena, biogas site 2: Međimurska County). Biogas site 3: Vrana d.o.o. is selected due to its marketing impact on biogas market development in Croatia.

Biogas sites 1 and 2 have estimated 400 kW potential while biogas site 3 has 300 kW potential, being on the safe side, although there is possibility to increase that potential. All biogas sites have mixed feedstock from cow manure, chicken litter and crops biomass. Most feasible biogas utilisation is production of electricity and heat in cogeneration plant. In all sites one could assume that electricity will be sold to the grid at the feed-in tariff of 1,20 HRK/kWh multiplied by correction factor of 93%. One reason for having 93% of feed-in tariff is related to none existence of domestic biogas equipment and to be on conservative side of calculations. All heat will be utilised either in the location or sold to the fixed clients.

Very logical structure of BiG>East methodology could be only partially applied on site selection in Croatia. Large farms are owned by companies that are registered in regions' capitals which made close to impossible to locate exact locations of livestock production. Only in November 2008; Energy Institute gained access to Cattle Farm Register. Data on pigs and poultry are retrieved either from direct communication or through Croatian Livestock database which covers less than 15% of total pig production.

For that reason, calculation of biogas feedstock was based on Agriculture Census 2003 that had partially spatial data. Biogas potential from livestock production for each county was transposed to total area of a county in order to deliver feedstock potential per radius of 1 km. The rationale lies between close relations of feedstock availability in substantial quantities at very small area and biogas project feasibility. This feedstock potential is called "biogas potential indicator[1]" which assumes that if potential per kilometre radius or square kilometre is significant, one could assume that there is at least one biogas site available at the investigated area.

Last but not the least, soft requirements for the project development are well met in the Croatian Show Cases.

[1] For more please see: Kulisic, B. and Par, V.: Agricultural Potentials for Biogas Production in Croatia. Agriculturae Conspectus Scientificus 2009; 74 (1), pending for press

Results within Step 1: Selection of the Region

Description of the selected regions for potential Biogas Sites

All potential biogas sites are situated in different geographical regions and are dealing with different types of biomass that could be suitable for biogas production. Nevertheless, all selected sites for potential biogas development have met, directly or indirectly, two important socio-economic preconditions for successful implementation of biogas project. That is, from one side, strong willingness to enter biogas sector and/or utilise renewable energy (heat) in their business as usual and, on the other side, support from the local authorities.
The figure below provides spatial identification of selected sites in Croatia.

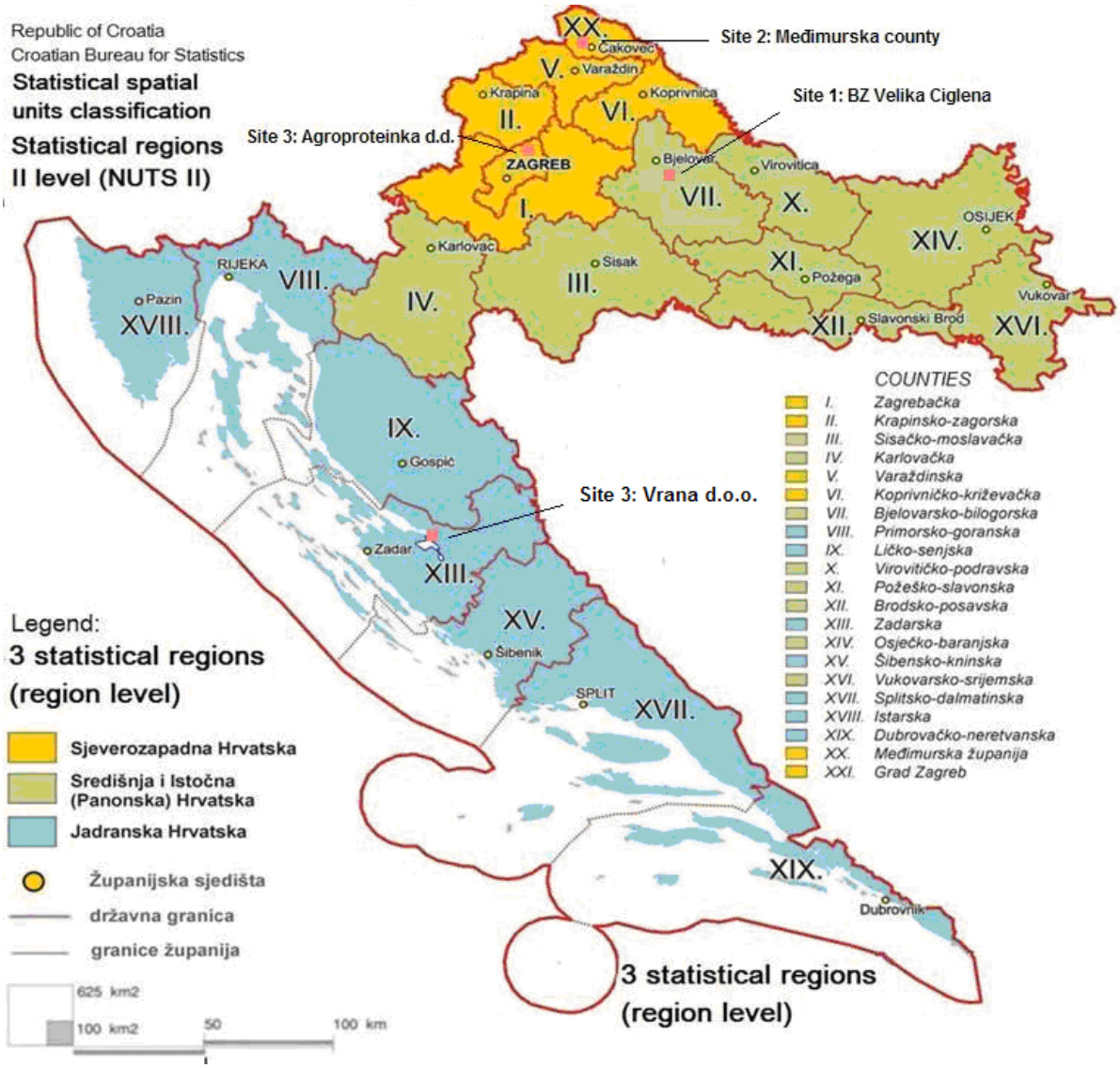

Figure 1 Selected sites for biogas promotion in Croatia

Source: Croatian Bureau of Statistics, 2008

Biogas Site 1: Business Zone Velika Ciglena

VII. County is called also Bjelovarsko-bilogorska and it is situated at the inner edge of Pannonian basin, also known as Croatian bread basket area. On the North and North-East, the County ends with mild hills of Bilogora while on the East it is edged by Papuk (Papuk, 953 m) and Ravna gora. Nevertheless, most of its area has 120 to 150 m altitude.

Figure 2 Orientation of possible biogas site (red dot) in the vicinity of Bjelovar

The County is abundant in fresh water with rivers Česma and Ilova and their tributaries. Česma springs from several wells on southern Bilogora hills. After 123 km, it joins river Lonja. Due to its small slope, Česma is has tendency to of flooding the area. For that reason, flow of Česma's and its tributaries are arranged against floods. At the South-East part of Bilogora, springs river Ilova. Its flooding characteristics are converted into two freshwater fish ponds next to Končanica (towards Eastern border of the county) and Garešnica on the South. Along 85 km of Ilova flow, there is fertile soil and meadows suitable for pasture of dairy cows. In general, this County is known for its possibilities for sport fishing at ponds, rivers (Česma, Ilova, Toplica, Bijela, Velika…) and their numerous arms. Figure below indicates that little ground is left available for manure spreading due to implementation of Nitrate Directive to Croatian legislation in 2008. This fact could positively influence on biogas plant capacity via corresponding increase in feedstock availability.

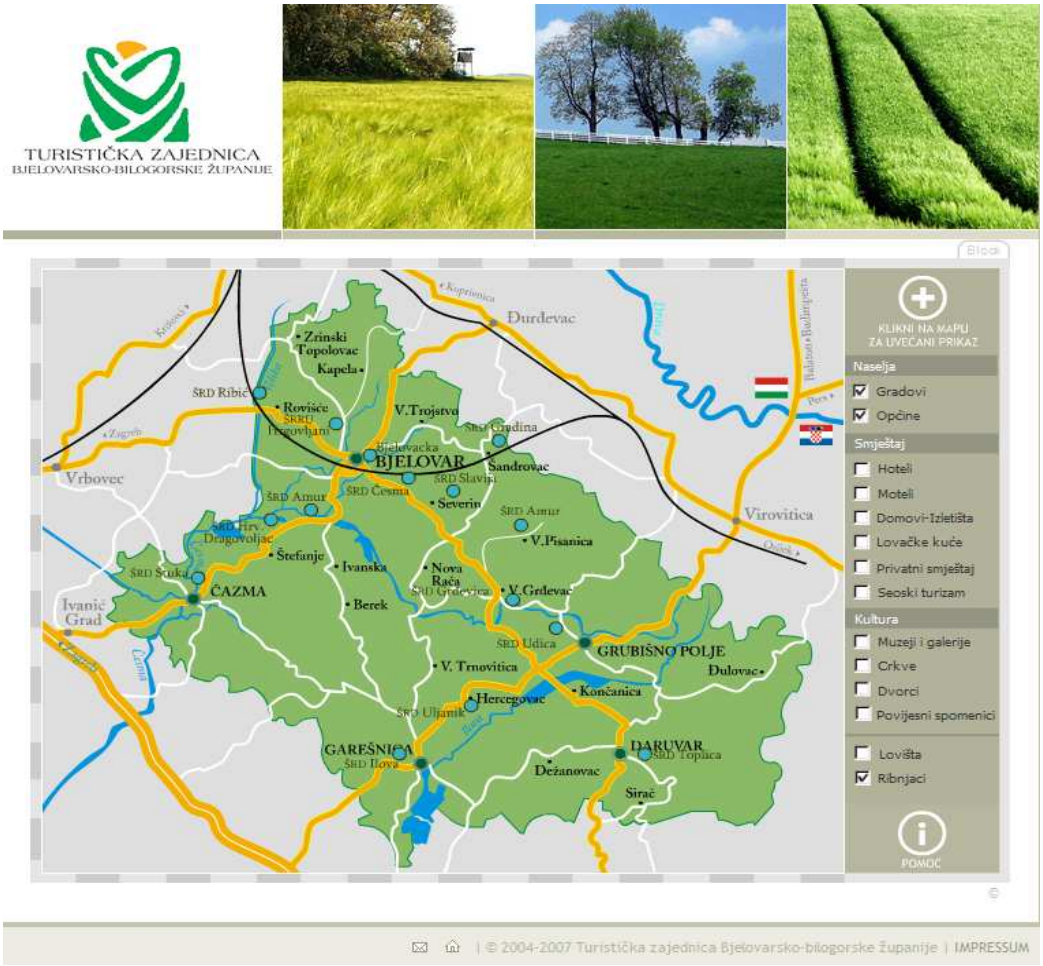

Figure 3 Information on rivers and fishing ponds of Bjelovarsko- bilogorska county

Source: Tourism Board of Bjelovarsko – bilogorska County, retrieved on January 2009

Climate is moderate continental, with moderate cold winters, hot summers and favourable annual precipitation. It has population of 133 084 inhabitants out of which one third is living in Bjelovar.

Basic facts of Bjelovarsko-bilogorska County:

- Area: 2 640 km^2
- Agriculture area:
  - Crop fields and gardens: 76 369 ha (80% cereals, 6% industrial crops; 3% vegetables; 11 % forage crops)
  - Orchards: 3 663 ha
  - Vineyards: 1 442 ha
  - Meadows: 36 971 ha
  - Pastures: 4 035 ha
- Population: 133 084 (1/3 living in Bjelovar)
- Population density: 51 inhabitant/km^2
- Unemployment rate: 26,1 %
- GDP/per capita: 4 781 €
- Average net salary: 479 €/month
- Average gross salary: 661 €/month
- Main industry is agriculture related: livestock, crop growing, eggs, snacks, meat, dairy, vine…

Bjelovarsko-bilogorska county is traditionally related to cattle breeding and dairy industry. Preliminary research of biogas feedstock potential has suggested that Bjelovarsko – bilogorska country is among top five counties on biogas potential per kilometre in diameter. Namely, the estimated potential from all livestock breeding has suggested potential between 0,477 and 1,633 TJ/r=km^2. According to the Agricultural Census 2003, the County had 72 413 heads of cattle, 171 117 heads of pigs and about a million beaks of poultry (Table 1). Sheep and goats are excluded mostly for open farming principle and, thus, unavailability of substrate.

Table 1 Number of livestock in Bjelovarsko- bilogorska County

Cattle			Pigs			Poultry		
Family farm	Business entity	Total	Family farm	Business entity	Total	Family farm	Business entity	Total
62 550	9 863	72 413	167 774	3 343	171 117	945 649	212 587	1 158 236

Source: Agricultural Census 2003

Croatian livestock centre has only about 15% of sows under production control, out of which 88% are sows at big farms that have commercial production of meat. For those farms there are exact locations and corresponding number of pigs, piglets, sows, gilts, boars, mated sows… There are three recorded pig farms for Bjelovarsko- bilogorska County: Svinjogojska farma Rovišće, HSC Služba Njelovar and HSC Služba Daruvar. Details are provided in the table below:

Table 2 Production control of sows at large farms (2007)

Organisation	Breeding boars	Young breeding boars	Sows	Gilts	Pigs and piglets before fattening period
Svinjogojska farma Rovišće	10	6	958	337	3918
HSC Služba Bjelovar	60	94	399	354	903
HSC Služba Daruvar			25	21	43
Total	**70**	**100**	**1382**	**712**	**4864**

Source: Croatian Livestock Centre, 2008

Contrasting the numbers from table 2 (2007) to those in the table 1 (2003), one could conclude that all business entities of the County are recorded by Livestock Centre.

The largest business entity in poultry subsector is Gala d.o.o., company concentrated on egg and laying poultry production. In 2008, the company started reconstruction of 6 poultry houses of 33 600 hens capacity each or total of 201 600 laying hens in one production cycle. In addition, there is also laying poultry production facilities of 4 buildings of 36 000 beaks capacity. The company is located at the outskirts of Bjelovar.

Continuing on the agriculture production, Bjelovarsko-bilogorska County has important food processing industry such as meat and dairy industry, production and processing of freshwater fish, biscuits and wafers industry, snack and beer production as well as grain milling and feed production.

Poslovna zona Velika Ciglena (in English: Business Zone Velika Ciglena) represents the potential biogas site in this region. Local development agency, Poslovni park Bjelovar d.o.o,

owned by Bjelovar city, plans to build small and middle entrepreneurship Zone Velika Ciglena. The Zone's 128 ha is intended for the production of vegetables and flowers in greenhouses, construction of the processing and storage objects (curing, freezing), recreational activities (bathing) and energy plant. Originally, the development of the Zone has been linked with the utilisation of high temperature geothermal field located *in situ*. The interest for the investment in the project already had shown important local and global producers of the electricity from geothermal waters and local and foreign flower and vegetable producers. However, the dynamics of establishing a geothermal power plant are demonstrated to be slower than the development of the Zone's facilities and energy demand itself. The result of was to separate development of the utilisation of geothermal energy from the actual development of the Zone and to look for other possibilities of green energy supply. The rationale for investigating production of electricity and heat from biogas plant lies in the fact that the foreseen business activities have already predicted to have high heating demand in their business processes (due to cascading utilisation of waste heat from geothermal power plant) and the fact that Bjelovarsko-bilogorska county is traditionally known for its livestock (baby beef and dairy cows) production.

Biogas Site 2: Međimurska County

Međimurska County covers 729 km^2 which makes it the smallest country in Croatia. It is situated at the most North part of Croatia, between two rivers: Mura on the Northern side, which makes national border with Hungary, and Drava that makes regional border with neighbouring county of Varaždin. Međimurska County borders also with Slovenia on the West. The administrative centre of the County is Čakovec. The County is well known for its entrepreneurial spirit and developed economy which reflects in big competition in space and high density of population.

Figure 4 Orientation of possible biogas plant site within Međimurska County

Forests of the County are considered rather sensible ecosystems as they represent lowland flooding forests that follow the currents of two rivers. Forests cover 135 km^2 while 541 km^2 are classified as agricultural land. Further classification of agricultural land is given in the Figure below.

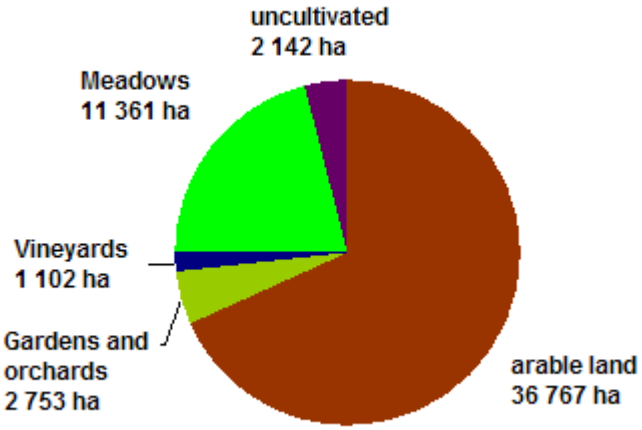

Figure 5 Classification and corresponding area of agricultural land in Međimurska County

Source: Spatial Plan Međimurska županija, 2001

Spatial distribution of biomass availability from livestock is provided in the Figure 6.

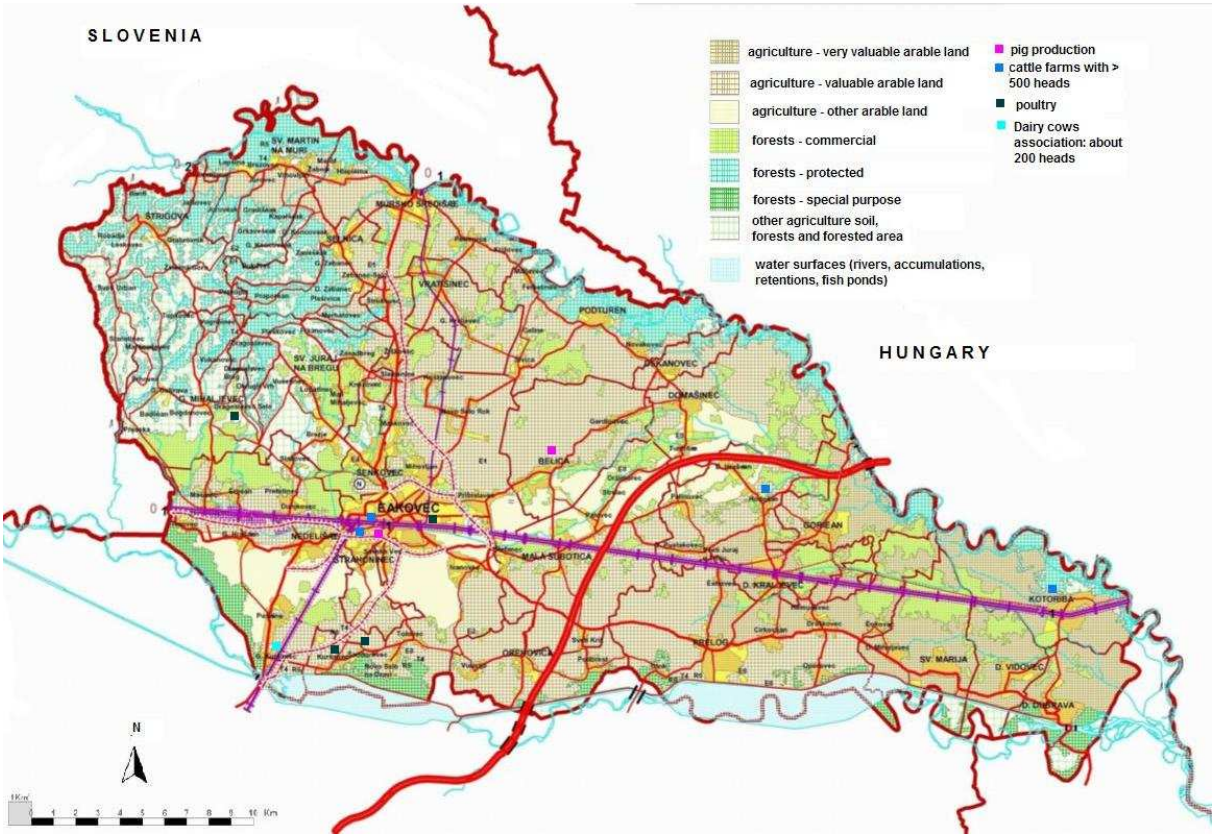

Figure 6 Possible sources of biomass from livestock in Međimurska County

Source: Spatial Plans of Međimurska County, Ministry of Environmental Protection, Spatial Planning and Construction, http://www.mzopu.hr/doc/Prostorni_planovi/21PPZ_WEB.htm, visited December 2008

Both Međimurska County and its neighbouring Varaždinska County are well known for its chicken (broiler) production and meat processing industries. Authorities of Međimurska County are very eager to address the problem of handling the chicken litter that has started to be disposed randomly without control. In addition to that, the authorities are well informed on the Nitrate Directive that represents true hurdle for poultry production in the area.

The largest chicken producer is Perutnina Ptuj - PIPO Čakovec ltd, a company that has considered erecting biogas plant of 1 MW in 2006 as a part of its waste management plan. This plan is still pending. Apart of PIPO, numerous small producers are interested in giving away chicken litter from their farms especially those of Dragoslavec Selo (34 000 chickens).

Međimurska county has concentrated pig production at Agromeđimurje d.d. (Belica) with 300 boars, 1 600 sows and 4 242 piglets and storage tank for pig slurry of 4 200 m^3. The same company has baby beef production in Hodošan (800 heads of cattle) and Kotoriba (2 400 heads of cattle). Agromeđimurje d.d. is agribusiness that manages 2 800 ha of agricultural land and produces 3 000 t of meat, 6 000 t of wheat, 10 000 t of maize, 1 000 t of barely, 1 600 t of rapeseed, 1 000 t of onions, 7 000 t of apples and 1 000 l of vine, annually.

Table 3 Production control of sows at large farms (2007) in Međimurska County

Organisation	Breeding boars	Young breeding boars	Sows	Gilts	Pigs and piglets before fattening period
Farma Agromeđimurje d.d. Čakovec	48	251	1 354	374	4 242
HSC Služba Čakovec	27	29	280	464	4 360
Total	**75**	**280**	**1 634**	**838**	**8 602**

Source: Croatian Livestock Centre, 2008

Another biomass source to consider is large cattle farms situated in the outskirts of Čakovec (2 farms of total 1 995 heads of cattle), association of dairy cows in Kuršanec (180 dairy cows).

Preliminary research of biogas feedstock potential has suggested that Međimurska County is among top five counties on biogas potential per kilometre in diameter. Namely, the estimated potential from all livestock breeding has suggested potential between 0,761 and 2,311 TJ/r=km^2. According to the Agricultural Census 2003, the County had 17 084 heads of cattle, 99 052 heads of pigs and about 1,5 million beaks of poultry (Table 4). Sheep and goats are excluded mostly for open farming principle and, thus, unavailability of substrate.

Table 4 Number of livestock in Međimurska County

Cattle			Pigs			Poultry		
Family farm	Business entity	Total	Family farm	Business entity	Total	Family farm	Business entity	Total
13 001	4 083	17 084	82 663	16 389	99 052	1 039 754	377 115	1 416 869

Source: Agricultural Census 2003

Basic facts of the Međimurska county:

- Area: 729 km^2
- Agriculture area: 541 km^2
- Population: 118 426 (14% living in Čakovec)
- Population density: 163 inhabitant/km^2
- Unemployment rate: 14%
- GDP/per capita: 5 323 €
- Average net salary: 500 €/month
- Average gross salary: 692 €/month
- Industry that could be source of biogas feedstock: livestock, crop growing, poultry meat processing industry, dairy, vine…

This biogas site is selected first for its biogas potential and secondly, it appears that both authorities and livestock producers are very much interested in solving the problem of livestock manure in a biogas plant.

Biogas Site 3: Vrana d.o.o.

Zadarska County, as other Croatian counties situated along the Adriatic coast, shows little biogas potential in total (0,024-0,072 TJ/r=1km) but almost all of its livestock potential is concentrated in two places: Ninske Stolice (cattle farm with 677 heads, upper circle at the map in
Figure 7) and next to Biograd n/M (cattle farm with 453 heads, lower circle at the map in Figure 7). Nevertheless, having a biogas plant in this County could serve as promotion of that renewable energy source at Mediterranean area.

Figure 7 Orientation of possible biogas plant site within Zadarska County

Zadarska County covers in total 7 487 km^2, out of which 3 643 km^2 is mainland, 3 845 km^2 sea and 587 km^2 of islands. According to the 2001 Census, it has 162 045 inhabitants with average population density of 45 inhabitants per square kilometre. Nevertheless, about 40% of population lives in County's capital Zadar while significantly higher density is recorded along the coastline and very few inhabitants in the inner mountainous part of the County called Lika. The County borders with its Northern-east part with Bosnia and Herzegovina.

There are several parts of the County that are under some level of nature protection: National Parks - Paklenica and Kornati archipelago and Nature Parks – Velebit, Telaščica and Vransko Lake. Orientation locations of nature protected areas in respect to the potential biogas plant are shown in
Figure 8 below.

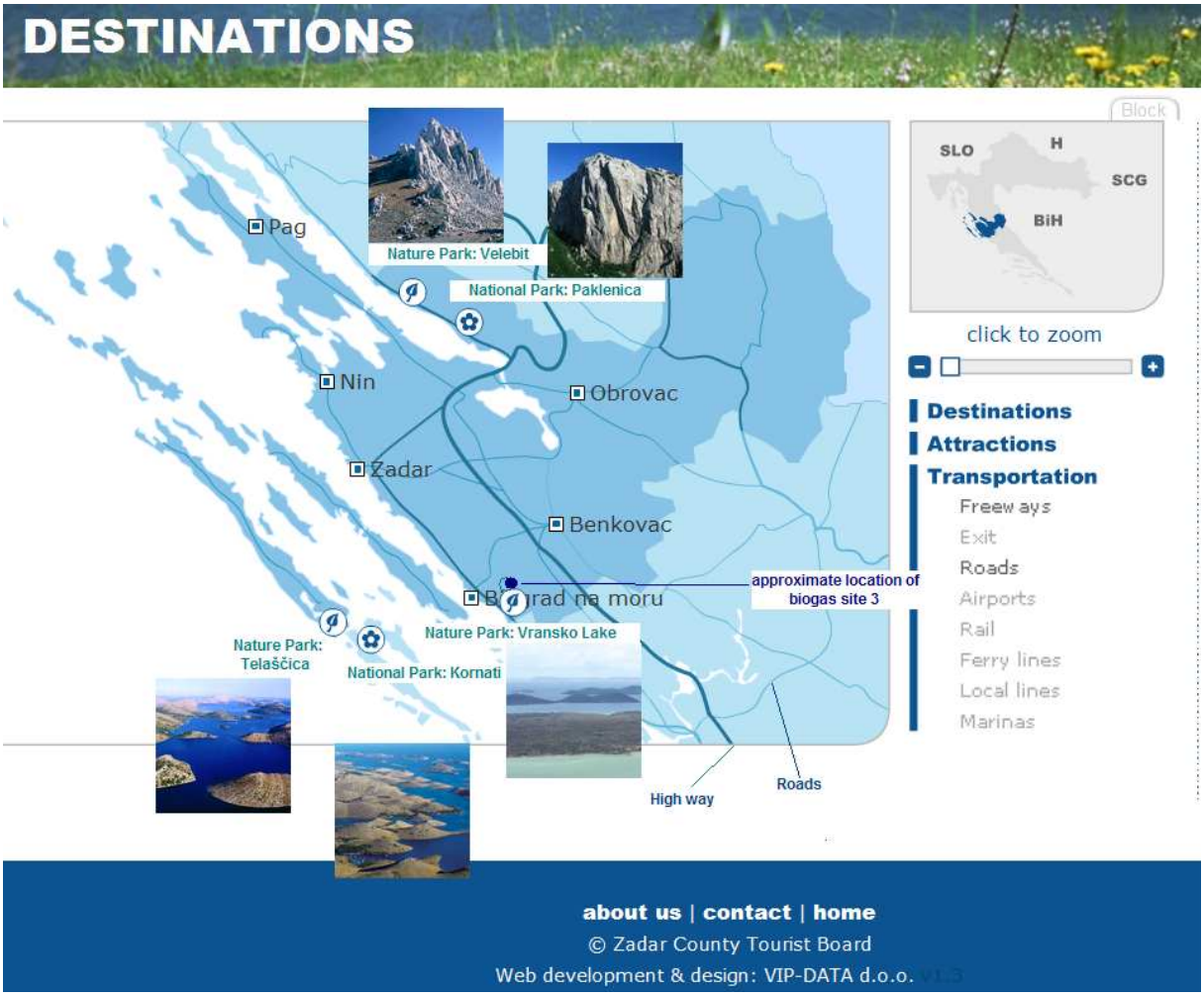

Figure 8 Orientation locations of nature protected areas in respect to the potential biogas plant in Zadarska County

Source: Zadar County Tourist Board, available at http://www.zadar.hr visited on January 2009

Town of Biograd and Nature Park Vransko Lake is in direct vicinity of the potential biogas location. Town of Biograd has population of 5 259 inhabitants and represents typical tourist destination of maritime tourism in Croatia. It is a centre of tourist riviera that includes settlements Sv. Petar na Moru, Turanj, Sv. Filip i Jakov, Biograd, Pakoštane and Drage together with settlements on the island of Pašman. Correspondingly, Biograd has a ferry port and two marinas: Marina Kornati with 450 berths and 60 dry berths and Marina Šangulin with 200

berts and charter cruise offers. In Biograd itself, there are 11 hotels with corresponding number of beds according to each category:

4 stars: 2 hotels with 567 beds in total
3 stars: 7 hotels with 918 beds in total
2 stars: 1 hotel with 72 beds in total
1 star: 1 hotel with 82 beds in total

Figure 9 Biograd na Moru

Source: Tourist Office Biograd na Moru, available at http://www.tzg-biograd.hr/, visited on January 2009

Nature Park Vransko Lake covers 57 km^2 out of which water makes 30 km^2: It represents important ornithological reserve, included to the list of Important Bird Areas in Europe. It is important winter resort for some migratory bird which is included in the Bonn Convention on Migratory Species of Wild Animals.

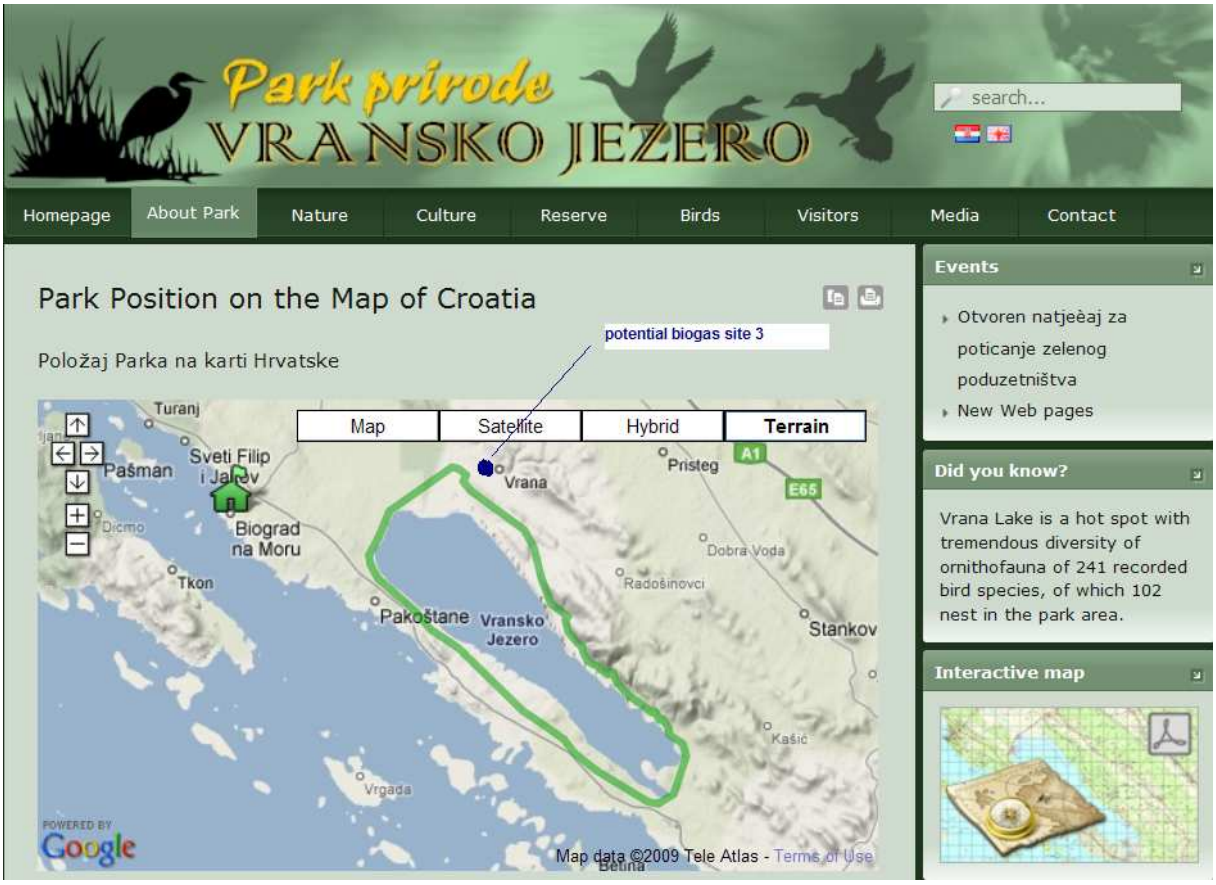

Figure 10 Potential biogas site 3 in respect to the Nature Park Vransko Lake

Source: Official web site of Park prirode Vransko jezero, http://vransko-jezero.hr , visited January 2009

Biomass supply

Biogas Site 1: Business Zone Velika Ciglena

BZ Velika Ciglena (Poslovna zona Velika Ciglena) is situated about 10 km from Bjelovar, the region's capital. Zone is still considering options of utilising on gas, electricity, water, sewage or telecommunication facilities depending on the results of biogas and geothermal energy utilisation possibilities. Zone has all of the aforementioned infrastructure options available in the vicinity. Apart of that, Zone has good road access. The final outcome of energy supply of the Zone is targeted to be combination of geothermal and biogas with natural gas as option for back up system. Despite abundant fresh water reserves as previously described, selected location for the Zone, and future biogas plant, is not within flooding area.

Biogas feedstock could be delivered via several separate channels:

1) Cattle breeders in the vicinity of the Zone
2) Energy crops grown at the agricultural land of the Zone itself
3) Gala d.o.o. egg and laying chicken producing company
4) Organic residues of the Zone's business activities.
5) Waste from biscuits and waffle factory.

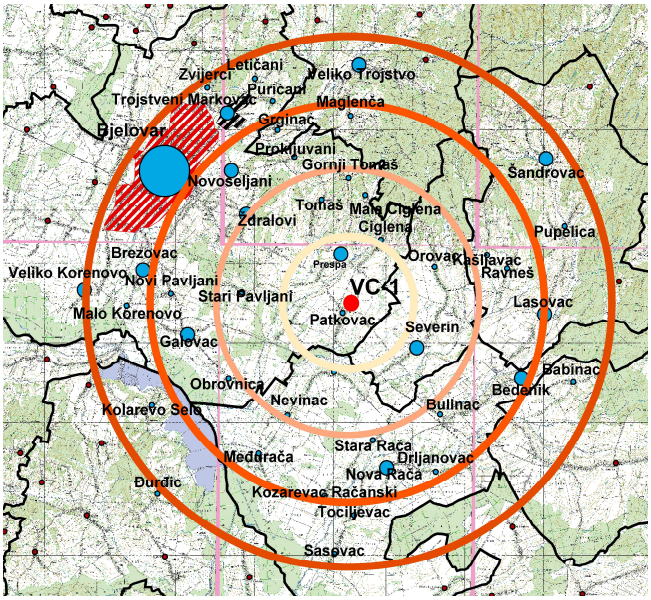

Figure 11 BZ Velika Ciglena and distance diameters of 2 500 m, 5 000 m, 7 500 m and 10 000 m

Availability of cow manure according to heads of cattle, farms and distance from the Zone is provided in the following tables.

Table 5 Cow manure availability within 1-2 kilometre radius from the business zones

Place (Direction):	Patkovac (S)		Prespa (N)		Kokinac (W)	
Farm size (# heads of animals)e	# of cattle	# of farms	# of cattle	# of farms	# of cattle	# of farms
<10	80	18	213	44	85	22
10 - 19	97	8	184	13	105	8
20 - 29	88	4	86	4	92	4
30 - 39	0	0	103	3	68	2
40 - 49	0	0	0	0	133	3
50 - 100	59	1	52	1	354	5
>100	0	0	0	0	418	1
Total	**324**	**31**	**638**	**65**	**1255**	**45**

One could seriously count on farms with more than 50 heads of cattle which narrows down the feedstock delivery from 7 farms with up to 100 heads of cattle and 1 large farm with 418 heads. Figure 12 provides indication of those locations according to their position towards the Zone.

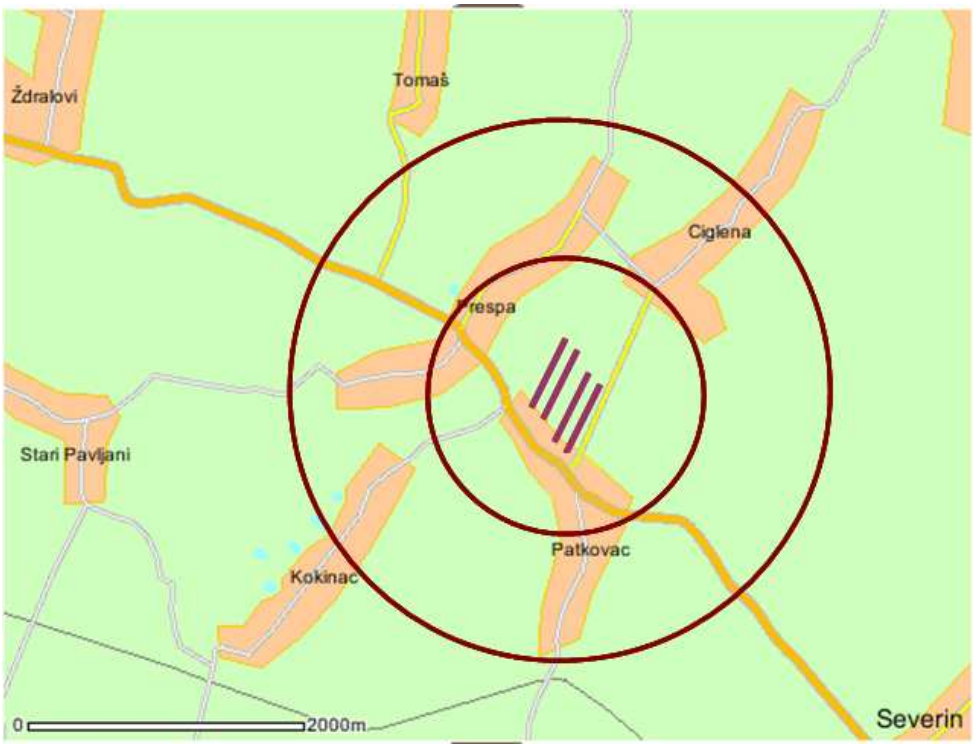

Figure 12 Closer view of the location

It is also worth investigating if there are other larger farms in the vicinity. Table 6 indicates additional manure supply that is further than 2 km but could be useful information.

Table 6 Farms with more than 50 heads of cattle within 7,5 km radius and total number of farms and cattle

Place	Distance	Direction	# of farms		# of heads		Total # of farms	Total # of heads
			50-100 heads	> 100 heads	50-100 heads	> 100 heads		
Ciglena	<3 km	N	1	1	87	135	52	711
Severin	<4 km	SE	3	0	171	0	62	810
Orovac	<4 km	NE	1	4	52	680	62	1161
Nevinac	<5 km	S	2	0	107	0	32	599
Lasovac	<7,5 km	E	0	1	0	371	95	1826

Source: Farm register, data from December 2008

One could indentify 4 large farms with more than 100 heads of cattle in North-East direction (Orovac) and neighbouring villages (Severin and Nevinac). However, Ciglena seems closer with 2 farms, one of 87 and another 135 heads of cattle.

According to the Croatian Waste Management Strategy, average annual production of manure per cow has been estimated at 13,96 t/yr. Attributing that value to the number of cattle on farms with more than 50 heads within the 1-2 km radius, one can deliver 12 330 t/year of cow manure. If adding biomass from further distance, the cumulative cow manure potential is as shown in Table 7.

Table 7 Cow manure availability (tons per year) and corresponding biogas yield

Place	Distance	Direction	Cow manure availability		Biogas yield	
			t/yr	Cumulative t/yr	m^3/year	Cumulative m^3/year
Within 1-2 km radius		**-**	**12 330**	**12 330**	**431 550**	**431 550**
Ciglena	< 3km	N	3 100	15 430	108 500	540 050
Severin	<4 km	SE	2 388	17 818	83 580	623 630
Orovac	< 4 km	NE	10 222	28 040	357 770	981 400
Nevinac	<5 km	S	1 494	29 534	52 290	1 033 690
Lasovac	<7,5 km	E	5 181	34 714	181 335	1 215 025
Total			**34 714**		**1 215 025**	

Zone has 128 ha of land that is suitable for agriculture production. It is true that about one half of the Zone will be dedicated to grow vegetables of business entities located in the Zone, but at this stage of planning is worth investigating possibilities of growing maize silage at half of the available area or 63 ha. Bjelovarsko – bilogorska county is in the top five counties according to maize production (282 442 t in 2006, the average yield 7.36 t/ha). Average silage yield amounts about 45 t/ha which means 2 835 t of maize silage available from the site itself. That corresponds to 567 000 m^3/year of biogas yield with 52% methane content.

Ownership of agricultural land allows investigating some other, maybe more suitable crops for biogas production. It is worth investigating the options together with the corresponding yields of some typical crops of the region for 2006:

- Wheat: 30 440 t; 4.28 t/ha
- Potatoes: 15 005 t; 16.69 t/ha
- Soya beans: 8 135 t; 3.62 t/ha
- Sunflowers: 690 t; 1.5 t/ha
- Alfa alfa: 4 697 t
- Clover: 26 088 t

Egg and laying chicken company is about 10 km far from the site but needs to deal with the chicken manure since it is located at the outskirts of city of Bjelovar. According to the Environmental Impact Assessment study (elaborated in order to gain the permission for reconstruction of chicken houses), company produces 9 566 t/year manure of egg laying hens and 882 t/yr of laying chickens. This corresponds to biogas yield of 1 175 400 m^3/year. The company is obliged to make manure storage appropriate for 6 months storage. The storage facility is actually an empty chicken house of 15x84.4 meters.

Organic residues of the Zone's business activities of greenhouses will be positive but of little influence on biogas yield. Waste from biscuits and waffle factory is also in the outskirts of city of Bjelovar which is important to keep in mind.

For starters, there is following composition of biogas substrate available for the biogas site 1: Poslovna zona Velika Ciglena.

Table 8 Available feedstock with corresponding methane yields of the biogas site 1: BZ Velika Ciglena

Feedstock	Place of origin	Seasonality	Availability t/yr	Biogas yield m^3/yr	Methane content %	Methane yield m^3/yr
Cow manure	Farms with >50 heads of cattle in radius up to 2 km	No	12 330	431 550	60	258 930
Maize silage	Grown at the Zone	Yes	2 835	567 000	52	294 840
Laying hen and chicken litter	Gala d.o.o., company some 10 km away	No	10 488	1 175 400	60	705 240
Total				**2 173 956**		**1 259 010**

Biogas Site 2: Međimurska County

The main issue in selecting this site is that the County itself has expressed its interest in supporting of biogas market development but there are not organised or straightforward answer where exactly to place that biogas site. According to the individual interest of biogas feedstock stakeholders (Agromeđimurje d.o.o., chicken breeders of Dragoslavec Selo and dairy cow association in Kuršanec) and the fact that there are two large cattle farms just next to the city of Čakovec and 3 chicken farms next to Kuršanec of 50 000 beaks, it is suggested that biogas location should be somewhere in the area marked by dark red square in
Figure 13. One could also conclude from Figure 6 and
Figure 13 that, given the fresh water flows and flooding areas and forests area, provide little possibility for locating biogas plant.

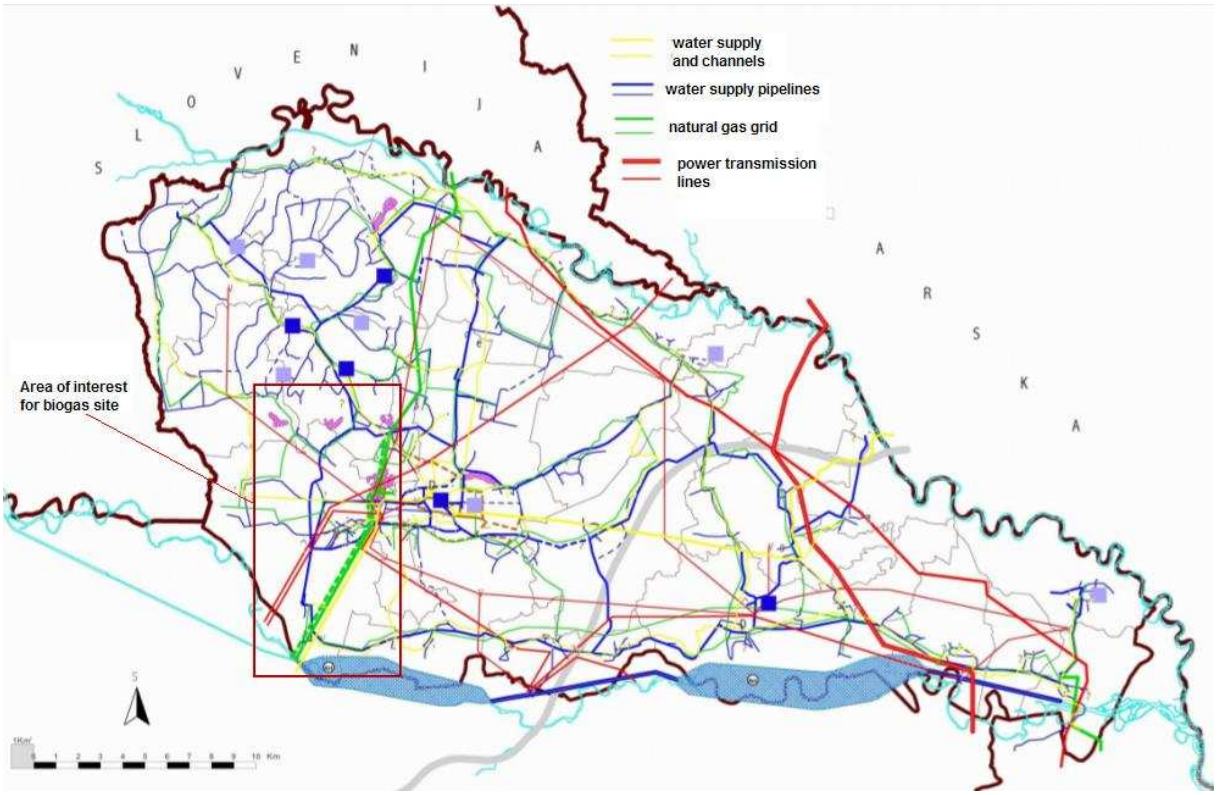

Figure 13 Narrowing down biogas plant location in Međimurska County

Source: Spatial Plans of Međimurska County, Ministry of Environmental Protection, Spatial Planning and Construction, http://www.mzopu.hr/doc/Prostorni_planovi/21PPZ_WEB.htm, visited December 2008

Closer look provides area of 10x8 km with the feedstock available as described in Table 9. Unfortunately, feedstock from a strong interested party Agromeđimurje d.o.o. was too distant from other stakeholders with pig farm in Belica, cattle farms in Hodošan and Kotoriba that are located approximately 10, 20 and 30 km air distance from the selected site, respectively. One should be aware that chicken litter could be easily supplied to the amount of 1/3 of total bio-gas plant feedstock without crossing borders of the selected area. Another issue to be taken care of is maximum share of chicken litter in the "normal" substrate composition is 2/3.

Table 9 Biogas feedstock availability in selected area of Međimurska County

Feedstock	Place of origin	Approximate distance (km)	Availability t/yr	Biogas yield m^3/yr	Methane content %	Methane yield m^3/yr
Cow manure	2 farms with 1 995 heads of cattle on East Group of dairy farms on South	4	35 910	1 256 850	60	754 110
Pig farm	HSC Služba Čakovec	4	4 410	165 375	60	99 225
Chicken litter	Breeders from Kuršanec neighbourhood	7	2 122	238 725	60	143 235
	Breeders from Dragoslavec Selo (North-West)		1442	162 225		97 335
Total				**1 823 175**		**1 093 905**

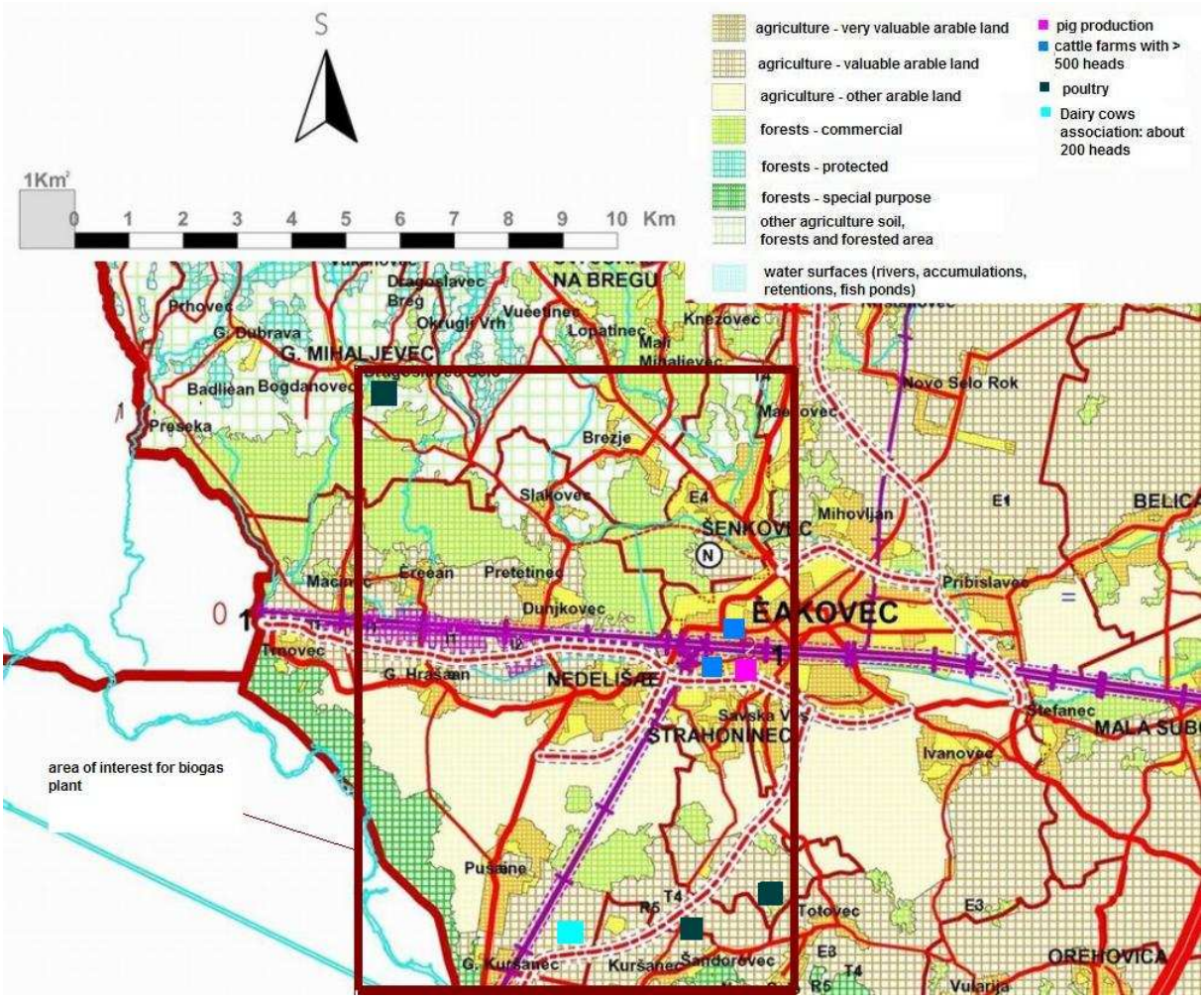

Figure 14 Selected area in Međimurska County for biogas site 2

Source: Spatial Plans of Međimurska County, Ministry of Environmental Protection, Spatial Planning and Construction, http://www.mzopu.hr/doc/Prostorni_planovi/21PPZ_WEB.htm, visited December 2008

Biogas Site 3: Vrana d.o.o.

Most of biomass for biogas plant Vrana d.o.o. would originate from its own production and, possibly, with feedstock supplied from hotels in Biograd na Moru which is shown in Table 9. Note that olive cake is available too but it is not calculated in the potential Total feedstock potential from the site. Potential for waste cooking oil and kitchen waste is based on number of beds in hotels and 33% of occupancy over the year (summer season). It has been assumed that 1 litre of waste cooking oil per day of occupancy rate and 215 g/waste per meal. Values with asterisk are referring to the total potential feedstock availability and numbers without asterisk are expert estimation of possible realisation of that feedstock (80% for cooking oil and 1.5 meal in hotels). Hotels (and restaurants) might serve as additional substrate supply source for organic kitchen waste and waste cooking oil. Collection of waste cooking oil is regulated by law and implemented. Environmental Protection and Energy Efficiency Fund awards with 0.40 HRK/litre for collected cooking waste.

Table 10 Feedstock availability of biogas site 3 at Vransko Lake

Feedstock	Place of origin	Availability t/yr	Biogas yield m^3/yr	Methane content %	Methane yield m^3/yr
Cow manure	At the site	6 000	210 000	60	126 000
Chicken litter	At the site	3500	393750	60	236 250
Olive cake	At the site	2500	?	?	?
Maize silage	At the site	2 000	400 000	52	208 000
Grass silage	At the site	2 000	350 000	52	182 000
Total feedstock from the site			**1 353 750**		**752 250**
Waste cooking oil	Biograd na Moru Hotels	139	55 593	60	33 356
		174	69 491*		41 695*
Organic kitchen waste		64	12 924	60	7 755
		127	25 849*		15 509*
Total Feedstock from Biograd na Moru hotels			**68 517**		**41 111**
			95 340*		**57 204***
Total feedstock potential biogas site 3			**1 422 267**		**793 361**
			1 449 090*		**809 454***

* theoretical potential

Figure 15 Orientation of biogas site (on the left) in the respect of Biograd na Moru (right) and Nature Park Vransko Lake (left bottom)

Source: Google Earth, retrieved January 2009

Biogas Digestate Utilisation

Biogas Site 1: Business Zone Velika Ciglena

Figure 16 Typical landscape of the biogas site 1

Source: Google Earth, retrieved December 2008

Since the selected possible biogas site represents "open possibility", one should calculate what is worth more to do with the discharge. The possibilities could vary from having a separate "digestate to fertiliser" facility that will enhance digestate to the commercial quality, utilisation of digestate in greenhouses and agricultural area of the Zone itself (app. 63 ha of land and app 20 ha of greenhouses) or to give it for free to the neighbouring farmers. The latest seems to be the least choice opportunity due to numerous households with one to ten heads of cattle which is sufficient to fertilise corresponding farm area.

Biogas Site 2: Međimurska County

It is fair to expect that discharge of digestate will be difficult for three main reasons: not all manure will be supplied in biogas plant, local production of compost and high sensitivity area (water above and under the ground). There is already excess supply of compost in the area. Namely, city utilities company has made waste water treatment in combination of producing

compost from the sludge. Usual sales price of water treatment sludge compost is 61 HRK/kg, while in 2008 it dropped to 50 HRK/kg.

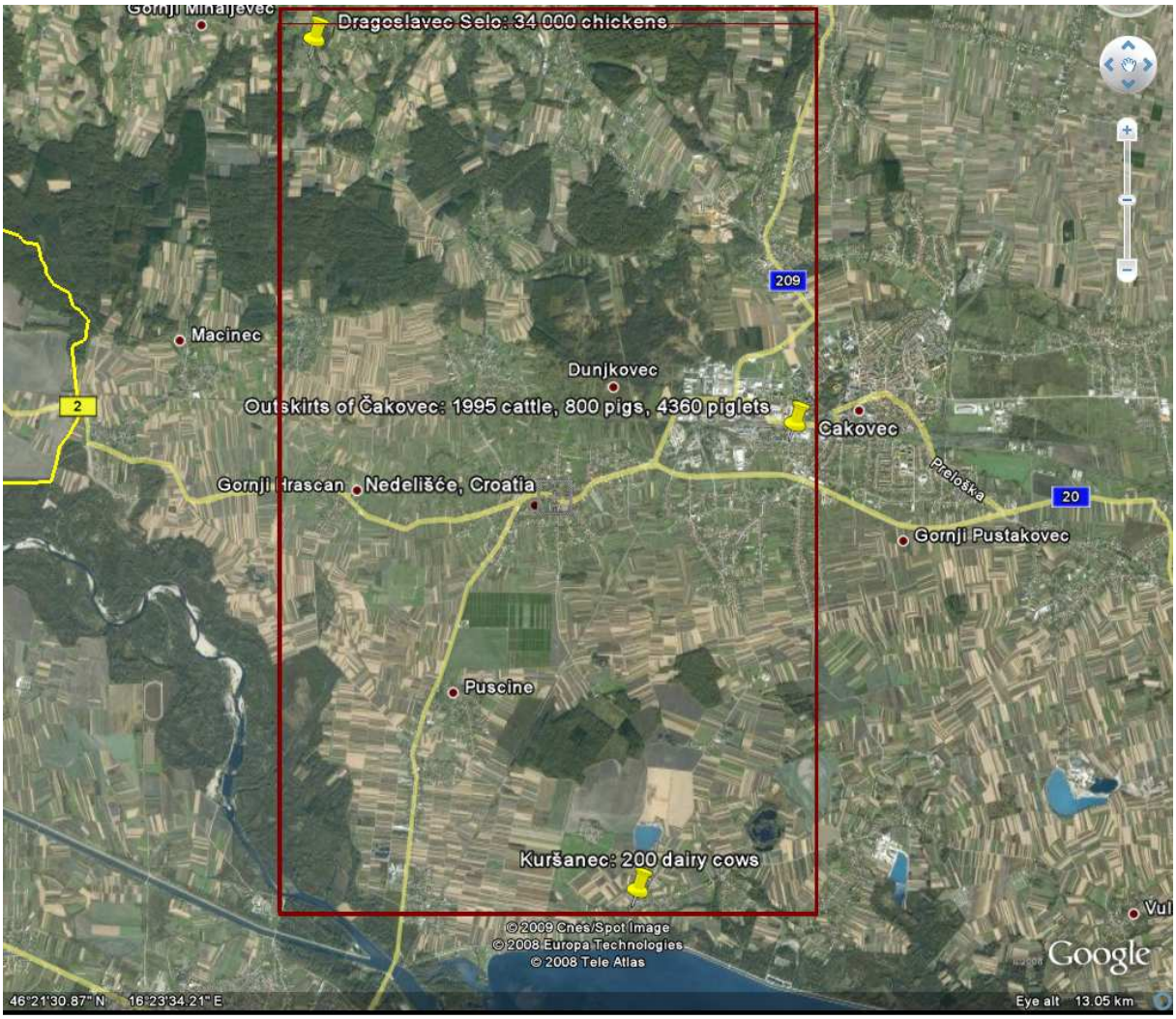

Figure 17 Usual landscape of the selected area for biogas site in Međimurska County

Source: Google Earth, retrieved January 2009

Biogas Site 3: Vrana d.o.o.

There is possibility to utilise the digestate as fertiliser at own farmland (about 1 000 ha vegetables growing, 6 ha of greenhouses, 90 ha of vineyards) as well as to distribute it as a fertiliser to numerous cooperants (small scale vegetable, fruits and vine producers). It could be specially promoted as "environmentally friendly" to be used in the area of Natural Park Vransko Lake that allows only organic agriculture.

Results within Step 2: Selection of the biogas neighbourhood

Sale of energy in the neighbourhood of the biogas plant

Generally speaking, it is fair to assume in all biogas production cases that it will be cogeneration unit with production of heat and electricity. Electricity will be, most probably, sold to the national grid for which, after gaining the Eligble Producer status, one is eligible for the feed in tariff. Feed in tariff for electricity from biogas made upon agricultural feedstock is 1,20 HRK/kWh, increased for annual consumer price index and corrected by correction factor that reflect the share of the domestic component in the project (up to 7% decrease). Contract is signed for maximum of 12 years.

Replacing natural gas is viable as long as biogas is meeting the same characteristics as natural gas does. New legislation on biofuels that will fully transpose EU Biofuels directive is pending which provides opportunity in the near future for utilisation of purified biogas as vehicle fuel.

Biogas Site 1: Business Zone Velika Ciglena

Sale and Purchase of Electricity:

Site name:	Figure	Comments
Distance to the general electric grid in meters:	< 2 km	On the East side
Voltage of the general electric grid nearby in kV:	20 kV	It is also planned to have another grid line on SW side
Space for transformation station on-site in m²:		available

Transformation station and other electricity grid connections will be implemented regardless of the biogas plant development due to basic service of the Business Zone to its clients.

Use of Heat:

	kW	Brief description of heat use (incl. temperature demand)	Distance to heat customer in meters
Plant size in kWel	400		
Heat Supply Total in kWth	500	greenhouses, vegetable drying…	<1 km
Heat Supply Summer	500	vegetables drying	
Heat Supply Winter	330	space heating, greenhouses	
Heat Demand 1 in Summer	0		
Heat Demand 1 in Winter	150		
Remaining Heat Load Summer	500		

Heat demand is already foreseen in planning the business activities to fit cascading process of geothermal heat utilisation. The Zone will sell heat to its clients. They are more or less agricultural type heat demand. Fish ponds are also foreseen. One could assume that all heat will be consumed at the Business Zone.

Biogas Site 2: Međimurska County

Sale and Purchase of Electricity:

Site name:	Figure	Comments
Distance to the general electric grid in meters:	1-5 km	Depending on the exact location
Voltage of the general electric grid nearby in kV:	20 kV	Depending on the exact location
Space for transformation station on-site in m²:		available

Use of Heat:

	kW	Brief description of heat use (incl. temperature demand)
Plant size in kWel	500	
Heat Supply Total in kWth	625	to be estabilshed
Heat Supply Summer	625	to be estabilshed
Heat Supply Winter	412,5	to be estabilshed
Heat Demand 1 in Summer		
Heat Demand 1 in Winter	150	
Remaining Heat Load Summer	625	
Remaining Heat Load Winter	262,5	

	kW	Brief description of heat use (	Distance to heat customer in meters
Plant size in kWel	500		
Heat Supply Total in kWth	625	to be estabilshed	
Heat Supply Summer	625	to be estabilshed	
Heat Supply Winter	412,5	to be estabilshed	
Heat Demand 1 in Summer			
Heat Demand 1 in Winter	150		
Heat Demand 2 in Summer			
Heat Demand 2 in Winter			
Heat Demand 3 in Summer			
Heat Demand 3 in Winter			
Remaining Heat Load Summer	625		
Remaining Heat Load Winter	262,5		

As the project is supported by both local community and feedstock suppliers, it will be to their best interest to suggest them to find heat demand.

Biogas Site 3: Vrana d.o.o.

Sale and Purchase of Electricity:

Site name:	Figure	Comments
Distance to the general electric grid in meters:	< 1 km	At the site
Voltage of the general electric grid nearby in kV:	110 kV	
Space for transformation station on-site in m²:		available

Use of Heat (excluding feedstock from hotels in Biograd na Moru)

	kW	Brief description of heat use (	Distance to heat customer in meters
Plant size in kWel	300		
Heat Supply Total in kWth	375	greenhouses, vegetable dryin	<1 km
Heat Supply Summer	375	vegetables drying and preserving	
Heat Supply Winter	247,5	space heating, chicken house, greenhouses	
Heat Demand 1 in Summer			
Heat Demand 1 in Winter	150		
Heat Demand 2 in Summer			
Heat Demand 2 in Winter			
Heat Demand 3 in Summer			
Heat Demand 3 in Winter			
Remaining Heat Load Summer	375		
Remaining Heat Load Winter	97,5		

Primary sources of heat in Zadarska County are fuel wood and electricity. The heat utilisation will manifest as lower energy bills at business operations in Vrana d.o.o. farm.

Zadarska County is still not covered with natural gas grid. Nevertheless, the planned main natural gas pipeline passes next to the selected site.

Results within Step 3: Selection of the Biogas Site itself

Requirements towards the biogas plant site

Biogas Site 1: Business Zone Velika Ciglena

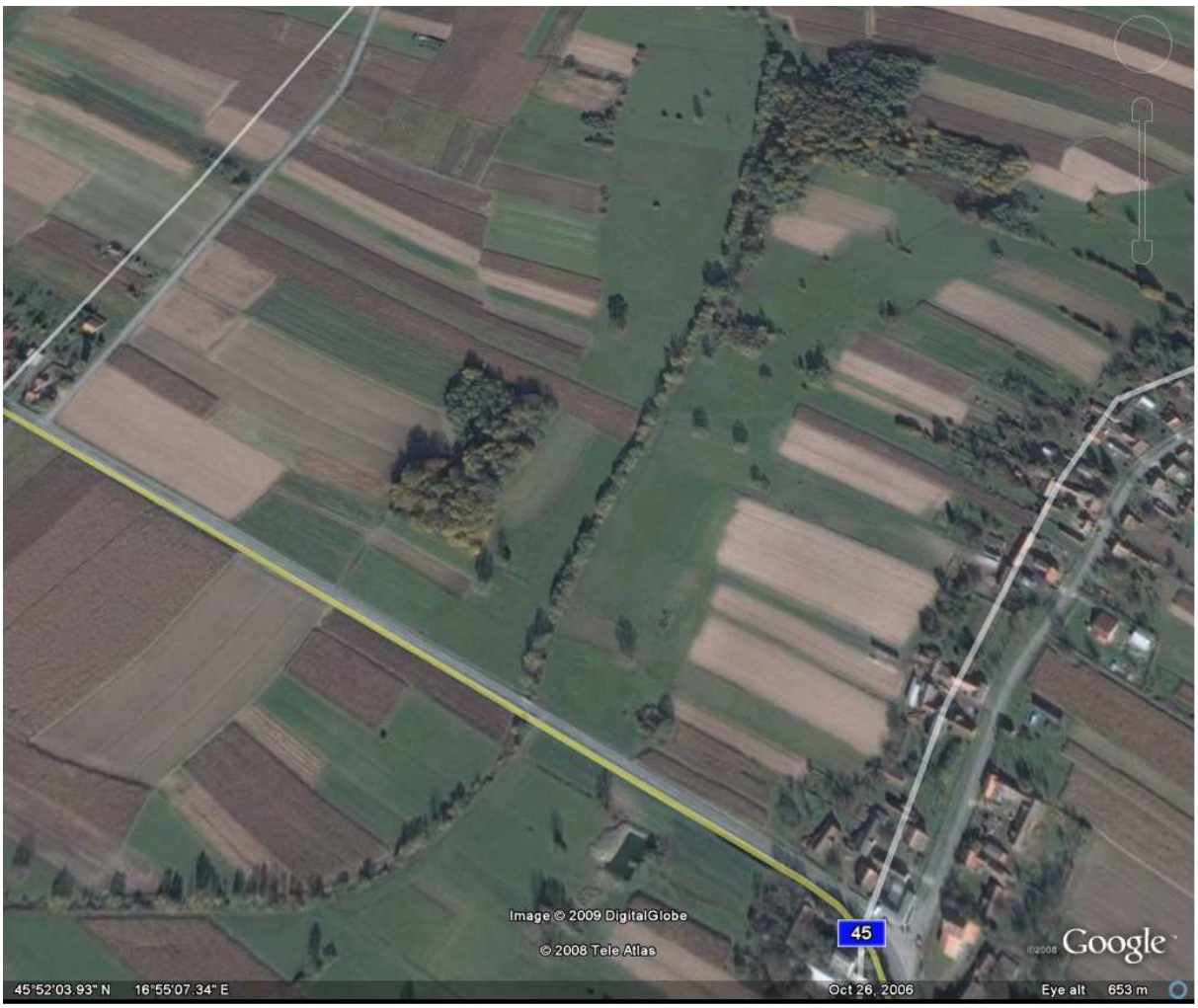

Figure 18 A closer look on geographic characteristics of potential biogas site at Business Zone Velika Ciglena

Available space

Site name: Poslovna zona Velika Ciglena	Figure	Comments
Space for Biogas Plant (in m2)	5 000	The Zone total's area is 128 ha, 64 ha are fore-seen as agriculture area,
Space for the storage of biomass on-site:	yes	To be built
Space for the storage of biomass at the producer	yes	To be built
Space for the sludge storage	yes	To be built

Sufficient Road Access

Site name: Poslovna zona Velika Ciglena	Figure	Comments

Distance to intersectorial road (in km)	< 1 km	

Additional site requirements

Site name: Poslovna zona Velika Ciglena	Yes	No	Comments
Site access for trucks possible	y		
Soil contamination is unlikely	y		
Soil is suitable for industrial construction	y		
Planning instrument prohibits biogas plant on – site		n	
Planning instruments foresees residential, cultural or nature protected areas nearby		n	
Residential, cultural or nature areas do exist in the proximity		n	

Ownership structure

Site name: Poslovna zona Velika Ciglena	
Who is the owner of the selected site:	Developing agency Poslovni park Bjelovar (owned by City of Bjelovar
Will the owner also be the operator of the biogas plant	Poslovni park Bjelovar with possible co-owners
Is there a basic possibility to buy the land	The land is acquired

Biogas Site 2: Međimurska County

Figure 19 A closer look on geographic characteristics of potential biogas site at Međimurska County

Available space

Site name: Međimurska County Site 1	Figure	Comments
Space for Biogas Plant (in m2)	5 000	To be located. Interested parties have indicated available 300 ha in the area between Kuršanec and Nedelišće
Space for the storage of biomass on-site:		To be built
Space for the storage of biomass at the producer	yes	To be built
Space for the sludge storage		To be built

Sufficient Road Access

Site name: Poslovna zona Velika Ciglena	Figure	Comments
Distance to intersectorial road (in km)	< 2 km	Depending on the exact location

Additional site requirements

Site name: Međimurska County Site 1	Yes	No	Comments
Site access for trucks possible	X		
Soil contamination is unlikely	X		
Soil is suitable for industrial construction		X	
Planning instrument prohibits biogas plant on – site		X	
Planning instruments foresees residential, cultural or nature protected areas nearby		X	Whole area of the County is abundant with water. That's why it is necessary to pinpoint 5 000 m^2 of solid ground
Residential, cultural or nature areas do exist in the proximity	X		At proximity of app. 4 km

Ownership structure

Site name: Međimurska County Site 1	
Who is the owner of the selected site:	Joint venure/private public partnership
Will the owner also be the operator of the biogas plant	Yes -
Is there a basic possibility to buy the land	Yes

Biogas Site 3: Vrana d.o.o.

Figure 20 A closer look on geographic characteristics of potential biogas site at Vrana d.o.o.

Available space

Site name: Vrana d.o.o.	Figure	Comments
Space for Biogas Plant (in m2)	5 000	
Space for the storage of biomass on-site:	yes	Own production of feedstock
Space for the storage of biomass at the producer	yes	Own production of feedstock
Space for the sludge storage	yes	

Sufficient Road Access

Site name: Vrana d.o.o.	Figure	Comments
Distance to intersectorial road (in km)	< 1 km	

Additional site requirements

Site name: Vrana d.o.o.	Yes	No	Comments
Site access for trucks possible	X		
Soil contamination is unlikely	X		
Soil is suitable for industrial construction	X		

Planning instrument prohibits biogas plant on – site		X	
Planning instruments foresees residential, cultural or nature protected areas nearby		X	
Residential, cultural or nature areas do exist in the proximity	X		In close vicinity is Vransko Lake Nature Park

Ownership structure

Site name: Vrana d.o.o.	
Who is the owner of the selected site:	Vrana d.o.o.
Will the owner also be the operator of the biogas plant	Yes
Is there a basic possibility to buy the land	The land is acquired

Results within Step 4: Optimising the soft requirements for selected sites

Generally speaking, all biogas sites are selected due to their favourable soft requirements.

Biogas Site 1: Business Zone Velika Ciglena

As previously described, there political support could be found on municipal level. Developer of the Business Zone, Poslovni Park Bjelovar d.o.o. is willing to closely cooperate at IEE BiG>East project as well as to provide support for educational purposed of biogas operation.

Existing know-how is mostly based on word of a mouth. Poslovni park Bjelovar will pursue this project if provided feasible.

Biogas Site 2: Međimurska County

Regional Developing Agency DAN is handling developing issues of Međimurska County, among which is biogas market development. The level of understanding of biogas benefits is rather high and major goal here is to manage chicken litter disposal.

Spatial Planning Office of Međimurska County was first in Croatia to tackle the problem of issuing Location Permit for biogas site.

Biogas know-how is also based on word of a mouth. The developing agency has expressed its full support to training for farmers at their agriculture fair MESAP in 2009.

As previously described, Agromeđimurje d.o.o., Association of chicken producers in Dragoslavec Selo, Association of dairy cows producers in Kuršanec are willing to commit themselves in biogas plant development. Most probably, developing agency will help in optimizing whether it is going to be PPP or joint venture.

Biogas Site 3: Vrana d.o.o.

Vrana d.o.o. is well respected fresh fruits and vegetables, eggs, bovine meat producing company. It has a special person dedicated for biogas project development. Vrana d.o.o. is the most media covered biogas story in Croatia. It was planned to have 1 MW biogas plant. The project failed by breaking up the contract with the project developer. Implementing a biogas plant at Vrana d.o.o. will be strong marketing impact on biogas market development in Croatia.