R.E.S. INTEGRATION

RURAL SUSTAINABLE DEVELOPMENT THROUGH INTEGRATION OF RENEWABLE ENERGY TECHNOLOGIES IN POOR EUROPEAN REGIONS

Specific Targeted Research Project (FP6-509204)

WORK PACKAGE 2: Identify schemes for IRES implementation

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Contact persons Serbia MFKG	Milorad Bojic, Prof. Faculty of Mechanical Engineering at Kragujevac University of Kragujevac Sestre Janjic 6 34000 Kragujevac Serbia and Montenegro Tel.Fax.+381-34-330196 Mob.: +381-63-8549153 Email bojic@kg.ac.yu
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Table D3-1. RES technology inventory: wood biomass boiler (low and middle power)

BIOMASS ENERGY		NATIONAL SITUATION
General description of the technology		Local wood biomass boilers for heat generation (technology available in Serbia). Boilers would have either low or middle power.
General information of the resource to be exploited		Biomass is from agriculture, general forest and its industry, and short rotation forest. Total biomass potential is around 2.5 MTOE where 1 MTOE originates from forest (cut wood, refuse when biomass is processed primary or secondary). Around 1.5 M TOE originates from agriculture (its solid refuse and cattle manure). Short-rotation forest plantings are currently not existent in Serbia.
Possible application and routes	**Estimated power to be installed**	Total capacity will be around 1000 MW, (4000 boiler units) for production of heat to satisfy local needs.
	Estimated energy production	When these units are installed, the estimated production of heat would be 3150 TJ.
	Estimated energy distribution all year round	Not available.
General data on costs		Total expected investment would be 100 M$.
Energy objectives		The energy objective set at national level is to produce with these installed units heat of 3150 TJ per year from biomass.
Environmental & sustainability issues		1) Rational management of forest and agricultural resources, 2) Preservation of high regions from hydro-geologic disruption, 3) Balance in biomass demand/offer, 4) Difficult coordination of subjects involved in biomass chain, 5) High transport costs
Socio-economic benefits		1) Decrease in consumption of fossil and imported fuel of around 0.1 M TOE by 2015 2) Lower environment pollution 3) New activities for domestic industry 4) Employment of local people (for biomass collection and plant operation) 5) Export of rural energy to towns for heating of their buildings, district heating and industrial activities 6) Local market opportunities and rural development 7) Security of energy supply 8) Energy cost reduction at local level 9) Income for local land owners and farmers 10) Economic valorization of agro-forestry residues

Table D3-2. RES technology inventory: small (high-efficiency) wood stoves for domestic use

BIOMASS ENERGY		NATIONAL SITUATION
General description of the technology		Small (high-efficiency) wood stoves for domestic use (technology available in Serbia) heating and cooking
General information of the resource to be exploited		Biomass is from agriculture, general forest and its industry, and short rotation forest. Total biomass potential is around 2.5 MTOE where 1 MTOE originates from forest (cut wood, refuse when biomass is processed primary or secondary). Around 1.5 M TOE originates from agriculture (its solid refuse and cattle manure). Short-rotation forest plantings are currently not existent in Serbia.
Possible application and routes	**Estimated power to be installed**	Heat capacity of single unit is 6 kW. Overall heat efficiency would be 40% compared to original 20%. Total capacity will be around 24 MW, (4000 stoves units) for production of heat to satisfy heating and cooking. Around 20% of rural households in Serbia is the action.
	Estimated energy production	When these units are installed, the estimated production of heat for cooking for region would be 27768 MWh, meaning if heating efficiency is 40% (6240 t*2.5=15600 t of wood or 520*2.5 =1300 ha of short rotation crops or 10% of agricultural residues at that area (taking into account that lower heating value of wood is 16000MJ/kg and productivity of SRF is 12t DM/ha). This energy production in Serbia would be 830000 t of wood or around 70000 ha of SRC.
	Estimated energy distribution all year round	Estimated agricultural residue availability during year is 30% in July and 70% in October. SRC are available entirely in July.
General data on costs		Total expected investment would be 200x4000=800000€
Energy objectives		No energy objectives are set on national level. Suggested energy objective for region is to recommend that biomass be used for cooking instead of 27768 MWh of electricity in households. To do this, we recommend use of multifunction wood stoves in these households that would simultaneously cook and heat.
Environmental & sustainability issues		1) Rational management of local agricultural residue resources, 2) Balance in biomass demand/possibilities 3) Public acceptability due to problems with biomass manipulation and with tidiness inside a household.
Socio-economic benefits		1) Anual decrease in electricity consumption for around 30000 MWh in the region, 2) Lower environment pollution, 3)

	Intensification of activities and higher employment in domestic stove industry, 4) Higher security of electricity supply, 5) Rural development, 6) Energy cost reduction at local level, 7) Economic valorization of agro-forestry residues

Table D3-1. RES technology inventory: Large gas generating facilities

BIOMASS ENERGY		NATIONAL SITUATION
General description of the technology		Large gas generating facilities (Technology not available in Serbia)
General information of the resource to be exploited		Biomass from agricultural residues, short rotation forest or general forest
Possible application and routes	**Estimated power to be installed**	Estimated power at the region is around 600 kW of heat, but at national level 600x50=30000kW of heat
	Estimated energy production	Estimated energy production at the region is 864000 kWh of heat, but at the national level 864000x50=43.2 GWh of heat
	Estimated energy distribution all year round	There will be uniform production of heat during entire year.
General data on costs		Investment cost at the region is around 30000 €, however at Serbian level it may be 1.5 M€.
Energy objectives		No energy objectives are set at national level. Facility would produce reformer biogas (hydrogen and carbon monoxide) to be used for production of electricity or heat or both.
Environmental & sustainability issues		1) Environmental concern (ash). 2) Public acceptability due to ash and dirt; 3) Sustainability issues related to biomass availability in forestry and agriculture.
Socio-economic benefits		1) Local market opportunities 2) Rural development 3) Security of supply 4) Job creation 5) Additional and diversified income for the farmers 6) Economic valorization of agro-forestry residues

Table D3-1. RES technology inventory: short rotation crops (SRC)

BIOMASS ENERGY		NATIONAL SITUATION
General description of the technology		Production of short rotation crops (SRC) for biomass generation and further combustion, gasification or pirolisis
General information of the resource to be exploited		Arable land. Possible SRC types are willow, poplar, giant red, hemp, switch- grass, and miscanthus.
Possible application and routes	**Estimated power to be installed**	Average annual yield of SRC is around12 t DM/ha or 4.57 TOE/ha.
	Estimated energy production	In the investigated region, annual production of biomass may be 12 tonnes DM/ha/yr x 37141 ha = 445692 tonnes of DM/ year=169,734 TOE. For entire Serbia this amount may be around 23,000,000 t of DM per year.
	Estimated energy distribution all year round	During first three years, SRC is harvested is in October each year and furthermore in October each three years.
General data on costs		Capital Costs may be € 4927/ha (data from UK). They are the following: 1) Cost of cuttings (10,000 per ha @ 22c) € 2200; 2) Ground preparation and planting (€442/ha)= € 442; 3) Fencing - rabbit - €5.16/m - deer - €8.11/m= € 2064; 4) Initial weed control (€ 221/ha)= € 221; 5) Capital costs are reduced in subsequent years because cuttings can be supplied from existing plantings. Some type of fencing will be necessary in most cases. Running Costs may be € 781/ha. The cost consists of the following elements. 1) Weed control is essential in Years 1 and 2 (approx. cost € 221/ha) = € 442. 2) Cutting-back shoots after Year 1 is recommended to encourage higher yields (approx. cost € 339/ha) = € 339. 3) Fence and drain maintenance. Costs negligible. Total capital plus running costs are € 4927+€ 781=€ 5708 Returns are highly variable, depending on market. 1) chip-wood for particleboard - €17.6/tonne standing = € 1061/ha over 5 years (12 tonnes DM/ha/yr). 2. Garden mulches - €295/tonne, bagged and delivered = € 17668/ha gross over 5 years. 3. Energy/electricity markets undeveloped as yet (in Serbia). Economic parameters of investment are unpredictable, but they may be PBP=7.6 years and IRR=13.157.
Energy objectives		Such a possibility is not recognized at national level. A campaign is needed to popularize this energy production.
Environmental & sustainability		Good justification is needed to produce fuel instead of food if arable land is used.

issues	
Socio-economic benefits	1) SRC can contribute to farm diversification and may attract various grants and other payments, 2) It can utilize under-used agricultural land, 3) It can provide employment both for agricultural workers (especially in winter, when harvesting is done and other agricultural work is scarce), 4) It is a robust and durable crop, making it especially suitable for urban fringe and similar areas, 5) It is suitable for sporting and recreational facilities (such as walking or bird-watching), 6) These plantations may also be promoted as visitor attractions, to provide educational opportunities.

Table D3-1. RES technology inventory: sunflower

BIO-OIL ENERGY		NATIONAL SITUATION
General description of the technology		Production of sunflower to obtain bio-diesel for agricultural transport machinery
General information of the resource to be exploited		Arable land. Cultivation gives seeds and wood plant in the ratio 1:1. Seeds are used to obtain 41% of bio-oil and 59% of fodder cake, while wood plant can be entirely used for combustion. Sunflower seeds would give bio-diesel + sunflower fodder cake in the ratio of 41 to 59% meaning 0.861 t of bio-diesel and 1.239 t of fodder cake.
Possible application and routes	**Estimated power to be installed**	Average yield of sunflower in Serbia is 2.1 t/ha= 2.1 t/ha 0.861 t of bio-diesel/t = 1.81t of bio-diesel/ha.
	Estimated energy production	For agricultural purposes at the investigated region, we need 8160.9 t of fossil diesel (9370 t of bio-diesel) for agricultural machinery. This requires production of bio-diesel from 10882 ha of arable land through cultivation of sunflower. For Serbia the amount of used of arable land to satisfy fuel demand for agricultural machinery may be around 585000 ha of arable land.
	Estimated energy distribution all year round	Sunflower is harvested in October, but 30% of agricultural bio-oil consumption may happen spring and almost 70% in fall.
General data on costs		Costs in Serbia in 2005 are the following: sowing 20 €/ha; fertilizers N1 and N2 185.5 €/ha; weed control 12 €/ha; Irrigation 0 €/ha; harvesting 60 €/ha; ploughing 100 €/ha; disk

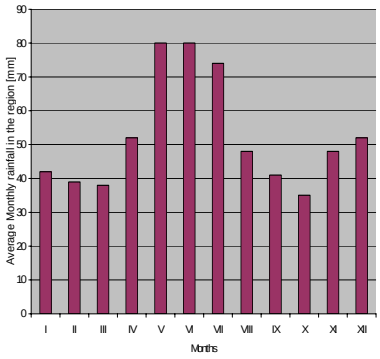
	50 €/ha; transport 10 €/ha. Total cost is 437.5 €/ha. Selling price of seeds in Serbia is around 150 €/t x 2.10 t/ha = 315 €/ha (Nevertheless, yields could be higher). Selling price data for Serbia does not exist because eating-oil factories finance agricultural sunflower production. Subventions of Serbian government are around 50€/ha. This means that farmer obtains 315+50=365€/ha. So the income of the farmer is 365-437.5= -72.5 €/ha meaning that farmer has a loss. However if costs for harvesting, ploughing and disk are not taken into account then income of the farmer would be 365-227.5=137.5 €/ha. Obtained biomass residue is practically 2.1 t/ha. The price of this biomass for combustion is around 174€/t (taken into account that current price of firewood is 27.5 €/m^3, density 500 kg/m^3 and 0.69 conversion of space m^3 to full m^3). If this revenue is taken into account than total revenue is 634 €/ha meaning that the farmer benefit is 489-437.5=51.5€. The price of bio diesel is assumed to be 0.765 €/l (same as fossil diesel) which is 659 €/ha. In commodity exchange of Novi Sad, the price of sunflower fodder cake is around 100 €/t, that is 124 €/ha meaning total of 783 €/ha. Manufacturer of bio-diesel would have revenue of total 783 €, i.e., 783-315=468€/tonne.
Energy objectives	No objective is set at national level. It is suggested that the objective at least be a quantity of bio-diesel that would satisfy needs for agricultural machinery.
Environmental & sustainability issues	1) Justification of fuel production instead of food production 2) Residue problem of long-time bio-fuel tanking 3) Lower IC engine power as heating value of bio-diesel is around 37 MJ/kg-smaller than that of fossil fuel (42.5 MJ/kg). 4) Bio-diesel is hygroscopic (avoid its moisture exposure)
Socio-economic benefits	1) Local market opportunities 2) Local job creation 3) Production of fodder cake and combustible biomass 4) Use of bio-diesel instead of fossil diesel in conventional IC engine does not require extensive technical interventions and expenses

Table D3-1. RES technology inventory: waste-water-treatment gas

BIO-GAS ENERGY FROMWASTE WATER		NATIONAL SITUATION
General description of the technology		Bio-gas from waster water treatment
General information of the resource to be exploited		Wastewater contains manure and other organic and inorganic mater that is produced by rural and non-rural inhabitants. When waste water is processed in special processing plants, one of its by products is bio-gas that can be used for combustion in boilers and IC engines to obtain heat and electricity.
Possible application and routes	**Estimated power to be installed**	Estimated power of biogas obtained from some wastewater plant is determined by a number of equivalent inhabitants (ES) that are served by this plant. Available power per ES is around 20W. Currently in the region, the installed power in use is around 985 KW. We believe that with accelerating of economic activities this power could be tripled without any new investment. However in entire Serbia, the installed power could at least 50 times higher.
	Estimated energy production	Estimated energy production per ES is 172 kWh or 34 m^3 of biogas. Currently in the region energy production is 740 TOE or 1.7 Mm^3. In entire Serbia this production could be minimally 50 times higher which is 37000 TOE.
	Estimated energy distribution all year round	Available energy could be almost uniformly distributed all year around. However this distribution depends on energy use.
General data on costs		Investment in wastewater processing plant is 25 M€ when 125000 ES are served or 200 €/ES. For entire republic the investment can be expected to be around 50 times higher or 1250M€.
Energy objectives		No energy objectives are currently set in Serbia regarding generation of biogas through the wastewater processing plant. However, at Serbia level, there is objective that wastewater-processing plants for should cover at least 70% of territory of republic of Serbia in order that this wastewater does not pollute soil and jeopardize healthy food production.
Environmental & sustainability issues		One of these issues may eventually be accident security with biogas. Furthermore, some problems may exist with odor of manure, and with SO_2 generated by combustion of biogas however plant is usually located to avoid transmitting of this odor to local population. In addition, it is taken care that plant operates with fine-tuning. Local rural population would accept this plant if they might find job in the plant.

Socio-economic benefits	Production of renewable (green) energy Processed polluted water, People employment.

Table D3-1. RES technology inventory: small hydro turbines

Hydro Energy		NATIONAL SITUATION
General description of the technology		Small hydro turbines produced in Serbia. Different turbine types: Caplan, Pipe, Francis, Pelton, Banki, and Oz. Their power is ranged from 1.5 to 100 kW. Their production is small due to small interest.
General information of the resource to be exploited		Currently micro-hydro power plants are scarcely installed usually by enthusiasts. When they are installed, they are not officially recorded.
Possible application and routes	**Estimated power to be installed**	Estimated number of below-100 kW turbines to be installed in Serbia is above 2000, with average power of 7 kW. Estimated number of 100 kW turbines is 150 (to be erected until 2015 according to Serbian strategy for development of energy sector until 2015).
	Estimated energy production	Estimated energy production of these turbines would be 2000 x 7kW x 300 days x 24h = 100.8 GWh=8640 TOE. Estimated energy production of 100kW power plants would be 300 GWh=25714 TOE.
	Estimated energy distribution all year round	 Energy distribution throughout year is similar to the rain distribution throughout the year.
General data on costs		One power plant of 7 kW would in average cost around 8000 E. Power plant would consist of generator, turbine and electro board. This means that required investment would be 8000 x

	2000 = 16 M Euro. Investment in turbine would be one third of that amount. Estimated investment for 100kW power plants would be 130 M$.
Energy objectives	No future energy objectives are known for this production.
Environmental & sustainability issues	1) Lack of investment money 2) No bank credits for this production 3) Unsolved land property rights.
Socio-economic benefits	1) Production of energy 2) Enhancement of voltage conditions in main, 3) Lower energy loss in the main, 4) Local and state market opportunities, 5) Education sector application, 6) Rural development, 7) Security of eletricity supply, 8) Job creation (for production of micro-hydro plants), 9) Energy cost reduction at local level.

Table D3-1. RES technology inventory: solar PV panels

SOLAR ENERGY		NATIONAL SITUATION
General description of the technology		Solar photovoltaic panels (SPVP). SPVPs are not produced in Serbia. In Serbia, monocrystalline silicon SPVPs of 15% efficiency can be purchased that use direct, diffuse and reflected solar energy.
General information of the resource to be exploited		In majority of Serbia, number of sunny days is considerably higher than that in many European countries (above 2000 hours). Annual average daily ammount of global Solar radiation on horizontal surface in Serbia is 13.5 MJ/m2 (3.8 kWh/m2). Installed power of SPVPs in Serbia should be disregarded in structure of production of domestic primary energy.
Possible application and routes	**Estimated power to be installed**	There is no national target, however for the region to satisfy necessary annual lighting needs of 18,26 GWh of electricity, we need around 88000 m^2 of SPVPs. When comparing number of households to number of households in entire Serbia, we need rurally to install of up to 5 Mm^2 of SPVPs.
	Estimated energy production	To satisfy rural lighting needs by solar energy, estimated energy production in region would amount 1.57 kTOE and in rural Serbia around 84 kTOE.

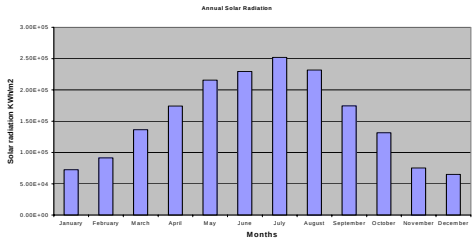
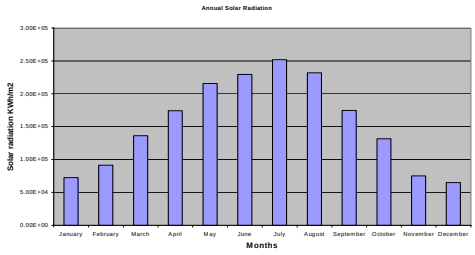
	Estimated energy distribution all year round	 (Diagram of monthly irradiation data in Kragujevac /Knic region)
General data on costs		Current costs can be estimated at 14000 €/m^2 when cost of all needed additional equipment is taken into account. For region we need 1.2 G€ and Serbia 70 G€. These costs can be halved when SPVPs penetrate Serbian market.
Energy objectives		The devices produce electricity for lighting and small power devices. No clear objective is set by «Strategy of development of energy sector up to 2015" although the special priority is given to use of solar energy for decentralized production of heat and electricity.
Environmental & sustainability issues		1) Dust and dirt that can diminish its performance; 2) Low implementation because of high initial costs 3) High energy amount required to produce SPVP modules 4) High material costs
Socio-economic benefits		1) Local market opportunities 2) Job creation 3) Security of energy supply 4) Rural development 5) Income for government through taxes 6) Minimum environmental pollution 7) Use of free solar energy

Table D3-1. RES technology inventory: solar plane collectors

SOLAR ENERGY	NATIONAL SITUATION
General description of the technology	Solar plane collectors produced in Serbia.
General information of the resource to be exploited	In Serbia, there is special suitability and needs to have organized use of solar energy (through its harnessing) in decentralized production of heat. In majority of Serbia number of sunny days is considerably higher than that in many European countries (above 2000 hours). Annual average daily ammount of global Solar radiation on horizontal surface in Serbia is 13.5 MJ/m2 (3.8 kWh/m2). However, more reliable data are needed for different locations). Installed power of

		solar plane collectors in Serbia should be disregarded in structure of production of domestic primary energy.
Possible application and routes	**Estimated power to be installed**	There is no national target, however for the region to satisfy necessary heating of sanitary water we need around 20000 m^2 (annual average of instantaneous collector efficiency is taken 45%). When comparing number of households to number of households in entire Serbia, we need rurally to install above 1 Mm^2 of solar plane collectors.
	Estimated energy production	To satisfy heating of sanitary water, estimated energy production in region would amount 1.6 kTOE and in Serbia around 86 kTOE.
	Estimated energy distribution all year round	 (Diagram of monthly irradiation data in Kragujevac /Knic region)
General data on costs		Current costs can be estimated to 800 €/m^2 when cost of all needed additional equipment is taken into account. For region we need 16 M€ and for Serbia 800 M€
Energy objectives		Solar thermal devices are used to produce low-grade heat for heating of sanitary water. No clear objective is set by «Strategy of development of energy sector up to 2015" although the special priority is given to use of solar energy for decentralized production of heat and electricity.
Environmental & sustainability issues		1) Eventual problems with freezing of the system; 2) dust and dirt can diminish its performance; 3) low quality of devices that can yield to their malfunction.
Socio-economic benefits		1) Local market opportunities 2) Job creation 3) Security of energy supply 4) Rural development 5) Income for government through taxes 6) minimum environmental pollution