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

<table>
<tr><td>Project Acronym</td><td colspan="2">R.E.S. INTEGRATION</td></tr>
<tr><td>Project Full Title</td><td colspan="2">Rural sustainable development through integration of renewable energy technologies in poor European regions</td></tr>
<tr><td>Contract number</td><td colspan="2">FP6-509204</td></tr>
<tr><td>Type of action</td><td colspan="2">Specific Targeted Research Project</td></tr>
<tr><td>Project duration</td><td colspan="2">1st November 2004 – 31st October 2007</td></tr>
<tr><td>Project coordination</td><td colspan="2">AUA – Agriculture University Of Athens, Greece</td></tr>
<tr><td>Contact persons Greece
AUA</td><td>Spyros Kyritsis - coordinator
75, Iera Odos str.
11855 Athens - GREECE
T. +30-210-5294001
F. +30-210-5294023
skir@aua.gr
www.aua.gr</td><td>Loukia Geronikolou
75, Iera Odos str.
11855 Athens - GREECE
T. +30-210-5294046
F. +30-210-5294032
gelou@aua.gr
www.aua.gr</td></tr>
<tr><td>Document's title</td><td colspan="2">DELIVERABLE No 3: Inventory of RES Technologies</td></tr>
<tr><td>Date</td><td colspan="2">30 September 2005</td></tr>
</table>

Project supported by the European Commission
within the 6th framework Programme

Specific measures in support of
International Co-operation - Western Balkan Countries (INCO-WBC)

http://www.cordis.lu/fp6/inco.htm

BIOMASS ENERGY		NATIONAL SITUATION
General description of the technology		**Solid Municipal waste management** - Refuse Derived Fuel (RDF) production. RDF will be used for electricity production in the central power stations of the island. The guiding principle here is to recover as much as possible of the solid materials for recycling and use the rest of the Municipal Solid Waste as a coal/oil substitute to generate electricity. Mechanical processing/sorting plus conversion of wet stream(organic matter) to liquid/gas fuel and compost product: diversion up to 65%. RDF plants are similar to conventional thermoelectric power plants with the exception that they have superior gas handling equipment than many caol-fired power plants. The plant is equipped with dry scrubbers and bag filters and emits much less NOx and SO2 per kWh produced.
General information of the resource to be exploited		Solid waste produced per year is estimated to be according to permanent population and visitors in the island as follows: Permanent population: 4771 x 365 Kg/year x 20% = 348 t/year Tourists: 4000 x 70 days x 1 kg/day x 20% = 56 t/year TOTAL: 404 t/year
Possible application and routes	**Estimated power to be installed**	The additional power will be installed in the mining industry beside the electricity generators. The unit will also generate heat for drying mining products. PPC nominal power during summer, which is the peak demand period, is 8 MW.
	Estimated energy production	The estimated electricity production is around 550-kWh per ton of RDF, i.e. 222 MWh/year The estimated useful heat is around 200 MWh / year
	Estimated energy distribution all year round	Electricity and Heat production from RDF is distributed evenly during the whole year, with exception the months of July and August, where the RDF production is nearly doubled.
General data on costs		Capital investment is estimated to be 300,000 € for processing 500 tons/y of Municipal Solid Waste.
Energy objectives		The energy objective set at national level is the integrated management of total solid waste produced and substitution of fossil fuels in power generation. The waste management regime is under reconsideration. Some RDF is produced and given to industry. Cement industry burns used tires. Initial stages of recycling plan implementation. Obligations for packaging: 50-65% exploitation, 25-45% recycling by the end of 2005. >60% exploitation, 55-80% recycling by the end of 2011.

Environmental & sustainability issues	a) Minimization of waste generated b) Materials recovery for recycling c) Energy value recovery by combustion and generation of electricity d) Landfilling under controlled conditions Energy saving, sustainable waste management, protection of land and water resources from pollution. Implementation of sustainability principles e.g. the polluter pays**.**
Socio-economic benefits	1) Decrease in consumption of fossil imported fuel of around 610 t crude oil until 2015 2) Protection of the Environment by integrated management. Less emissions during the electricity production 3) Employment of local people from the chain of solid waste management. 4) Energy cost reduction at local level 10) Economic valorization of Municipal Solid Wastes

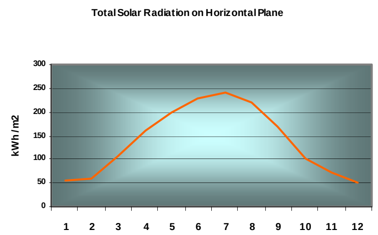
BIOFUELS	NATIONAL SITUATION
General description of the technology	Production ≈ 950,000 toe/y. 3.3% of total energy demand. Mostly burning. Biogas production around 40,000 toe. **BIOFUELS** For the selected region it is foreseen the production of oil crops (sunflower as more suitable for the semiarid conditions of the island). Mechanical extraction of the oil from oil seeds and use of produced sunflower oil in diesel engines of local vehicles with additional components annexation. By products (crop residues) will be used for heat generation, and oil cake as feedstock for animal husbandry.
General information of the resource to be exploited	With a growing forestal component (about 21% of country's surface), and with lots of agricultural areas not operating due to community rules regarding farm surplus, a great potential exists. By 2010, 5.75% of fuel consumption should be biofuels. For the needs of the region arable land will be used. Plantation of 500 ha in a first phase and 1400 ha in a second phase of sunflower.
Estimated power to be installed	Average annual yield of sunflower oil is around 1.5 t/ha or 1.334 TOE/ha

<table>
<tr><td rowspan="2"></td><td>Estimated energy production</td><td>In the investigated region, annual production of biomass will be around 750 m^3 at first phase and 2100 m^3 at the second phase, or 667 TOE and 1868 TOE for the first and second phase respectively per year. At the second phase total motor diesel consumption of the island will be almost covered by sunflower oil.</td></tr>
<tr><td>Estimated energy distribution all year round</td><td>Sowing of sunflower takes place during May and harvesting during September. The oil, after oil extraction from the seeds, will be available October and consumed during the whole year.</td></tr>
<tr><td colspan="2">General data on costs</td><td>For crop production existent equipment is enough, except from the oil press that could operate under municipal charge. The cost of seed production amounts to approximately 0.6 €/l with 0.03 €/l oil extraction cost.</td></tr>
<tr><td colspan="2">Energy objectives</td><td>By 2010, 5.75% of fuel consumption should be biofuels. Nevertheless, such a possibility is not boosted at national level, no decisions in agricultural policy matters are yet available. A campaign is needed to popularize this option.</td></tr>
<tr><td colspan="2">Environmental & sustainability issues</td><td>• Difficult balance in biomass demand/offer
• Difficult coordination of different subjects involved in biomass chain
• Good justification is needed to produce fuel instead of food if arable land is used.</td></tr>
<tr><td colspan="2">Socio-economic benefits</td><td>Involvement of agricultural subjects in energy market
Diversification and development of income resources in agricultural sector
Realization of a new field of business in rural and depressed areas, generating workforce demand.
Contribution to farm diversification
Utilization of under-used agricultural land</td></tr>
</table>

Mini Hydro Energy	NATIONAL SITUATION
General description of the technology	In national level there are 459,000 toe/y electricity production from hydro or 350 GWh. 69 MW total installed capacity (0.63 % contribution to total installed capacity). In the region there will be used mini-hydro power of above 100 kW but below 1 MW. Hydro turbines that will probably be used are Kaplan and Pelton.
General information of the resource to be exploited	The resource will be pumped water with excess electricity from wind turbines in 70 m Head or water from dams. Situation is under study.

Possible application and routes	**Estimated power to be installed**	No of small hydro plants (SHP): 40 in Greece. The estimated power to be installed in the selected region is between 100 and 150 kW.
	Estimated energy production	Estimated energy production from mini hydro power would be between 720 and 1080 MWh per year.
	Estimated energy distribution all year round	Energy distribution throughout the year is half affected by the rain distribution throughout the year.
General data on costs		Average SHP production costs: 2.4 – 4.2 Eurocents/kWh Range of investment costs: 1000 – 2000 Euro/kW Typical operating and maintenance ratio of 3% -5% Compensation scheme: Feed in tariff Price for sale to the grid (Eurocents/kWh): For interconnected system 6.29. For non interconnected islands 7.78 Payback time on investment is between 10 and 25 years.
Energy objectives		Whole production of renewable energy shall reach 12% of total energy (now 5%) and 20% of electricity before 2010
Environmental & sustainability issues		Offers efficiency, grid stability, flood control, reduced emissions in the atmosphere, reduced land requirements and it is renewable. Special attention should be given to mitigate possible impacts on landscape, water resources, ecosystem and wildlife, water quality and other parameters. Defining the minimum reserve flow is a crucial. Problems constitute the lack of investment money and unsolved land property rights.
Socio-economic benefits		Secured supply, flood control

SOLAR ENERGY PV	NATIONAL SITUATION
General description of the technology	• Multicristalline silicon pv modules – 12% efficiency • Monocristalline silicon pv modules – 15% efficiency • Amorphous silicon pv modules – 5% efficiency Few installations in Greece accounting for 100 toe/y production
General information of the resource to be exploited	The country benefits from relevant solar irradiation data (around 5,0 kWh/sqm daily irradiation on horizontal plane). Thus specific productivity of PV systems is almost 1350 kWh/kWp installed.

<table>
<tr><td rowspan="3">Possible application and routes</td><td>Estimated power to be installed</td><td>Due to big capital costs for installation of PV Systems, and the choice to mostly exploit the wind energy of the island, PV will be used for electricity production only in remote areas, not connected to the grid, with installed power up to 20 kW.</td></tr>
<tr><td>Estimated energy production</td><td>Estimated energy production for the needs of rural remote areas of the western part of the island, will be in distributive installations and will amount up to 30 MWh/year for each.</td></tr>
<tr><td>Estimated energy distribution all year round</td><td>

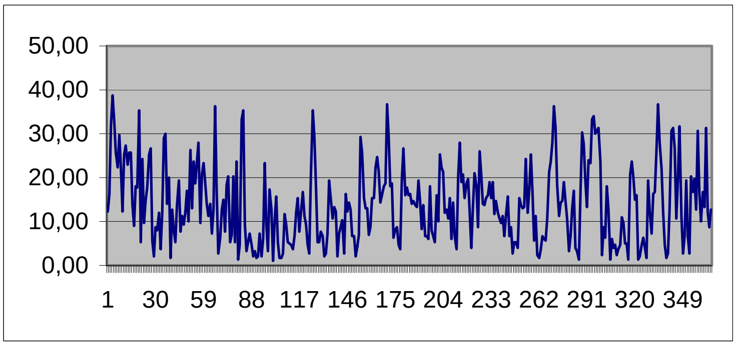
(Diagram of monthly irradiation data in Milos island)</td></tr>
<tr><td colspan="2">General data on costs</td><td>Investment cost around 6.000 – 7.000 €/kW$_p$ for standard installations (depending on the size of the system), operating costs around 100 €/year for a useful life of 30 years, and annual generated energy 1000 kWh, production cost is around 0.33 €/kWh</td></tr>
<tr><td colspan="2">Energy objectives</td><td>Photovoltaics produce electricity for lighting and small power consumptions especially for decentralized production. Whole production of renewable energy shall reach 12% of total energy (now 5%) and 20% of electricity before 2010.</td></tr>
<tr><td colspan="2">Environmental & sustainability issues</td><td>• Largely accepted implementation in urban and also rural areas
• Reduced maintenance costs
• Ideal for remote areas not connected to the grid.

Cons:
• High energy amount required to produce pv modules
High material costs</td></tr>
<tr><td colspan="2">Socio-economic benefits</td><td>Local market opportunities, Job creation, Security of energy supply, Rural development, Income for government through taxes, Minimum environmental pollution, Use of free solar energy</td></tr>
</table>

SOLAR ENERGY	NATIONAL SITUATION
General description of the technology	Glass shielded plate collectors - largely widespread

		Vacuum collectors – less adopted
General information of the resource to be exploited		At the end of 2000 the surface area of the solar collectors in operation in Greece amounts to 2.96 millions m^2, 61.8%, of which are located in Central Greece, 27.6% in Northern Greece and 10.6% in Crete. Production: 1.15 TWh which accounts for 8.1 % of electricity consumption in housholds. Regarding the use of solar systems, 99% of them are small scale systems for domestic hot water, 0.75% are large scale systems for hot water in the tertiary sector (hotels, hospitals and swimming pools) and 0.17 % (5,118 m^2) are large systems for hot water, air-conditioning and space heating in industry.
Possible application and routes	**Estimated power to be installed**	In order that the region ensures necessary heating of sanitary water in remote areas that will not connect with district heating of geothermal energy, there is need of around 700 m^2 with energy production to be able to reach 800 $kWh/m^2/y$
	Estimated energy production	Estimated energy production in region would amount to 560 MWh/year
	Estimated energy distribution all year round	Same monthly irradiation data in Milos island.as in PV systems diagram
General data on costs		700-900 €/m^2 (turn-key installation). For a surface area of approximately 100 m^2 and heat yield of 55000 kWh Total annuity is 7490 €/y and heat price comes to 0.14 €/kWh.
Energy objectives		Whole production of renewable energy shall reach 22% (now 16%) before 2010
Environmental & sustainability issues		• Largely accepted implementation in urban and also rural areas • Reduced maintenance costs • Avoided emissions from present installations: 1263 (ktones)
Socio-economic benefits		Due to current prices of conventional fuels, interesting values of payback time can be reached in short period Local market opportunities Security of energy supply, Rural development, Income for government through taxes, minimum environmental pollution

WIND ENERGY	NATIONAL SITUATION
General description of the	• Average power of wind generators installed: 600 kW

technology		• Three-blade rotor wind turbine represent 80% of the total • The general trend is oriented to install more powerful generators (up to 2 MW each)
General information of the resource to be exploited		465 MW of wind farms are installed at the end of 2004. The wind intensity is mitigated by the mediterranean sea, and by different geographical characteristics of various regions Acceptable values of wind speed are exploitable in some mountains and coastal areas, as well as in almost all the aegean islands. Weibul parameters in Milos island Scale parameter C = 6 m/sec, Shape Parameter k = 1.5, mean wind speed 7.11 m/sec
Possible application and routes	**Estimated power to be installed**	Technically exploitable potential: more than 180,000 GWh/y The calculated maximum installable power connected to the grid in Milos amounts to 20% of the P.P.C. capacity. Nominal power in Milos during the summer is 8 MW. Currently installed capacity of wind turbines in the island is 3x600 kW. New wind turbines will be installed for Desalination of sea water. Estimated capacity 2.5 MW
	Estimated energy production	Estimated energy production by new installations is ~ 4500 MWh that will produce from 900000 m^3 fresh water with recovery to 300000 m^3 fresh water without recovery.
	Estimated energy distribution all year round	 Distribution of wind speed in knots all year round
General data on costs		Installation costs: 900-1300 €/kW (depending on site's morphological characteristics) Plant costs of a 500 kW wind turbine is around 950 €/kW. Additional costs 30%, operating costs 3% p.a. , the period of redemption as well as the production costs vary with the average annual wind speed. (period 5-15 years, production cost 0.05 – 0.153387 € / kWh)
Energy objectives		Whole production of renewable energy shall reach 12% of total energy (now 5%) and 20% of electricity before 2010

<table>
<tr><td colspan="2">Environmental & sustainability issues</td><td>Highly economically and environmentally sustainable. Obstacles for its widespread implementation is faunistic and landscape-preservation complaints.</td></tr>
<tr><td colspan="2">Socio-economic benefits</td><td>The investments in wind generation are rewarded in the “green certificate” market
Wind farms can satisfy energy needs of local communities, involving a direct participation of local workforce and stakeholders</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">GEOTHERMAL ENERGY</td><td>NATIONAL SITUATION</td></tr>
<tr><td colspan="2">General description of the technology</td><td>• Great potential especially in north Greece and some islands. For the time being restricted in pilot applications for heating and thermalism
• 69 $MW_{(th)}$/y, with main applications SPA and healing baths (~50%), and heating of greenhouses and soils (~50%).
• Present production: 40 TWh
• Not used for electricity production (peoples’ reaction because of smell).
• Call for investments in the field by the government.
In Milos geothermal energy will be used for district heating and desalination of sea water.</td></tr>
<tr><td colspan="2">General information of the resource to be exploited</td><td>Although the great geothermal energy potential is recognized, no extensive exploitation exists. It is used mostly for Spa and healing baths. Legal issues are recently regulated in order to start exploitation of resources. Reactions from people have been reported in the past but not the best technologies were applied.</td></tr>
<tr><td rowspan="2">Possible application and routes</td><td>Estimated power to be installed</td><td rowspan="2">By cooling the upper 2km of the hot rocks below Zefyria, Vounalia and Adamas in Milos by 90 ºC would release 5 x 10^{18} J of heat (or 141 million TOE), which justifies the commissioning of 260 MWe geothermal power plant. In parallel, the evaluation showed that the minimum heat flow from deeper rocks cannot be less than 87.8 MWth. This value is slightly higher than the natural conductive heat flow towards the surface of the island, which has been estimated as 77 MWth due to the convective heat flow component.
Low enthalpy geothermal energy will be also used driven water desalination unit producing 75 to 80 m3/h drinking water</td></tr>
<tr><td>Estimated energy production</td></tr>
</table>

	Estimated energy distribution all year round	Available all year round 24 h/day
General data on costs		The investment costs could be paid back in a period from 6 months – 2 years. Cost of heat production 0.005 – 0.05 €/kWh.
Energy objectives		Whole production of renewable energy shall reach 12% of total energy (now 5%) and 20% of electricity before 2010. For Geothermal energy before 2010 1000 MW_e installed power, and 5000 MW_T
Environmental & sustainability issues		• Thermal Pollution • High content of geothermal fluids in certain substances that might be harmful • Depletion of geothermal field Important to cover needs but also create new opportunities in agriculture and tourism two major sectors in the country. Could cover water needs through desalination systems, a very important issue for semi arid islands like the target region.
Socio-economic benefits		The government rewards the investments in geothermal systems. Opportunities for agricultural production all year and prolongation of the tourist period. New income for people in remote areas.