Eco-innovative Solutions for Revigorating the Rural Communities in the Black Sea Region

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Abstract

The proposed research paper has been developed under the frame of the BSUN Regional MSc Program on the Management of Renewable Energy Sources that involves students from 5 Universities from the Black Sea Region.

The research subject aims the evaluation of the impact of national policies related to the supporting and promotion of projects on renewable energy in the Black Sea region countries and the analysis of the key factors that could contribute to the sustainable development of rural areas.

The research team is proposing a reference methodology that could be used in the multi criteria decision phase of renewable energy projects proposed to be developed in the rural areas.

Three case studies are developed for comparative analysis between Romania, Moldova and Ukraine. Using the results of the comparative analysis there are proposed possible pathways and actions to enhance the policies and action plans at the national and local levels.

1. Introduction

The date of October 31st 2011 was designated by the United Nations as a symbolic date for declaring officially that the World Population has reached 7 billion people. This was done based on interpolated data from the original 5-year period estimates prepared by the Population Division [1]. But, looking at the plot from figure 1, we can see that there has been an amazing increase of population in the last Century and a tripling of population during a single generation.

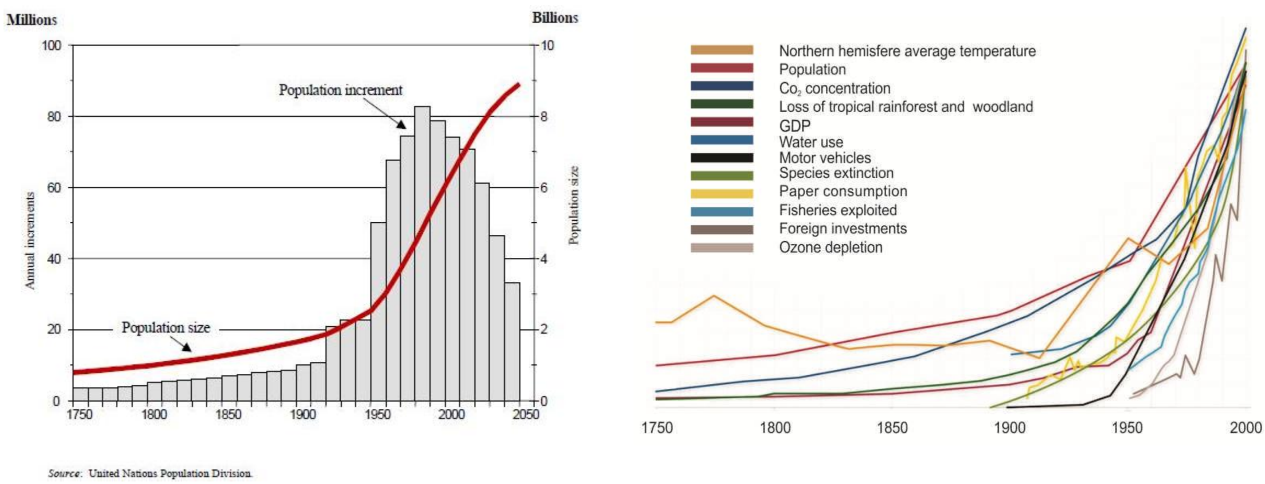

Figure 1. (a) The evolution of the World Population size;

(b) Evolution of consumption indicators and environment degradation indicators.

The impacts of such an evolution are extremely complex and at present, there is no comprehensive understanding of the dependencies between consequences such as the degradation of the environment or climate change and the intimate factors that are connected to such consequences.

Traditional environmental policies and measures focus on dealing with specific problems as presented in figure 2 a. In certain respects, this approach has been quite successful. For instance, it contributed to cleaning up water pollution, taking dangerous products off the market, recycling certain products, and slowing the acceleration of climate change.

Today, more than 95% of the resources lifted from nature are wasted before the finished goods reach the market and many industrial products - such as cars - demand additional natural resources while being used [2].

This means that continued reliance on traditional "environmental technologies" is no longer enough. However, sufficiently decoupling production and consumption from nature requires new systems, goods, services, processes, and procedures for meeting human needs.

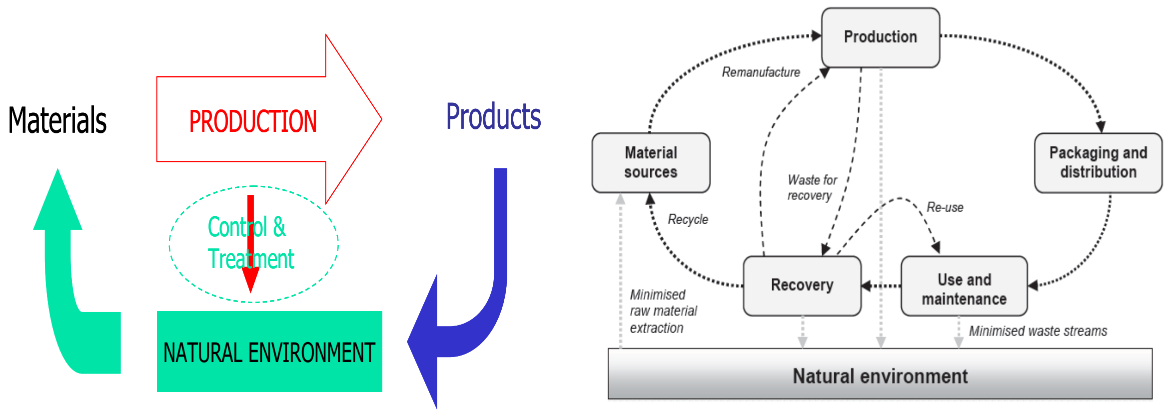

Figure 2. The shift from traditional environmental technologies –(a), towards a lifecycle approach - (b), with minimization of the impact on the environment during the entire lifetime of the product.

In such a context, the need to consider the entire lifetime of the development of the product or services is obvious. The analysis and optimization of each single element of the value chain integrates in the objective function, the minimization of the environmental impact. Many examples exist where incremental improvement of existing technologies has increased resource productivity two to four times. This approach opens new perspectives to the implementation of the sustainable development concepts

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2. The concept of sustainable development

The strategic mix for the implementation of sustainable development concepts includes three main pillars that are intimately bundled together [3]:

- To continue improving the efficiency of the use of resources;

- To re-engineer the industrial, economical and social processes in order to be consistent with the natural cycles;

- To educate the people to have a fundamental new understanding of welfare, shifting from opulence towards sufficiency.

Fig.3 The reference framework for analysing the sustainability of projects at different scales

The scientific research activities carried out within the last almost 90 years led to a sophisticated framework for analysing human activities that is presented in figure 3. The reference framework is structured on 3 coordinates as Economical, Ecological and Socio-Institutional. For each of this dimensions have to be known detailed indicators and parameters with related functions.

The very high degree of the interdisciplinary, the need of access to a large pool of data sources and the need of detailed knowledge of relations between parameters makes the approach complex and cumbersome.

The term ‘environmental innovation,’ or shortly ‘eco-innovation’, relates to innovations aiming at a decreased negative influence of innovations on the natural environment.

Eco-Innovation means the creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimal use of natural resources (material including energy carriers, and surface area) per unit output, and a minimal release of toxic substances [4].

3. The Green Economy

In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.

Practically speaking, a green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services.

As is written in the outcome document the SDGs must be “Action oriented, concise and easy to communicate, limited in number, inspirational, global in nature and universally applicable to all countries while taking in to account different national realities, capacities and levels of development and respecting national policies and priorities”.

By analyzing the proposed things, we could see the concerns for an interdisciplinary approach on food, water and energy security, but also subsequently we can see the concerns on the eradication of poverty and inclusive wealth [5].

The choice of primary goals have to lead to strategies, policies and action plans and for measuring progress on SDGs it will be required an agreed set of indicators for use at national, regional and international levels, both in developed and developing countries.

The current research project has been dedicated to the analysis of the complexity of factors that are interrelated within one of the chapters of SDGs, namely the Sustainable Energy Security in Rural Areas.

4. Ecosystem services

The reference approached that has been used for performing the case studies is centred on the concept of Ecosystem services.

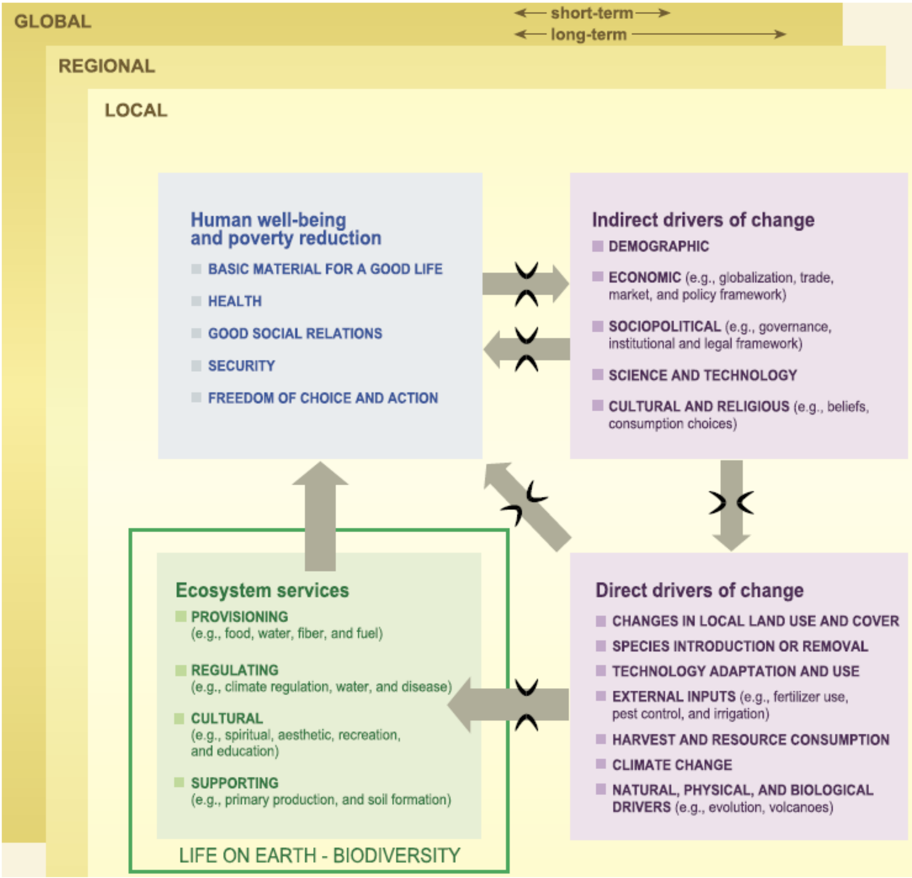

Figure 4 Ecosystem Services matrix

As it is presented in Figure 4, the decision based on Ecosystem services consist on a multi criteria decision process taking into account aspects related to ecology, technology, society and economy. Basically, the ecosystem services are defined as benefits people obtain from ecosystem and distinguishes four categories where the supporting services are regarded as basis for the services for the other three categories.

Taking into account the matrix presented in figure 4 the methodology for developing the case studies consists on the following phases:

a. Evaluation of ecosystem factors in selected rural areas, as following: land, water, forest, solar, wind, geothermal etc.
b. Analysis of the demographics and social conditions
c. Opportunities for economic development
d. Selection of the key development factors
e. Definition of the eco-innovative solutions
f. Life cycle assessment for each solution
g. Economical assessment for each solution
h. Value engineering of the selected solutions
i. Multi criteria decision for the selection of the optimal solution

The outbound of the methodology is centered on the value engineering and multi criteria decision for the selection of the optimal solution.

Value Engineering can be defined as a process of systematic review that is applied to new product designs in order to compare the functions of the product required by a customer to meet their requirements at the lowest environmental impact consistent with the specified performance, cost and reliability needed.

The structure of the criteria is presented in figure 6 and the weighting factors is presented in figure 7.

The results of value engineering offer the reference set of criteria and the weighting factors that could be used in the multi criteria decision making.

The methodology has been followed by the researchers in the evaluation of each case in order to have comparable results and to quantify aspects that might be relevant from the policy perspective.

5. The Black Sea Region

For the purpose of the present study there were selected three generic countries as following:

ROMANIA – is a EU member country that ranked as the seventh in terms of population, with the significant list of natural resources as: (agriculture land – 14,7 mil ha, oil and gas reserves – covering 17% of the needs) but also the GDP per capita of 12 808 $ at around half of EU 27 average.

UKRAINE is a former Soviet Union member country with significant resources in terms of agriculture land (42 mil ha), iron or, coal, uranium and the competitive heavy industry. The GDP per capita is 7374$

MOLDOVA is a EU neighbour country, negotiating at present the status of candidate country to EU. The GDP per capita is 3415 $, also, it has a very poor resources. Moldova is very vulnerable to the stability of the workforce.

Figure 5 The geographical positions of the case studies

The communalities of the selected three countries that are relevant for the present study, consist on the lack of capacity to implement coherent policies in agriculture that led to the dramatic deterioration of rural communities.

Another aspect that has been studied is related to the **national policies** on sustainable development.

Moldova: It was elaborated the project of Government Decision regarding the approval of National Action Plan regarding Renewable Energy for the years 2013-2020 (NAPRE). One technical support which is financed by the EBRD is the reviewing feed-in tariff methodology.

Feed-in tariffs (FITs) is a system for promoting of electricity produced from renewable energy sources and also contribute to the development of technologies for producing energy from RES. The system allows to the producers to market the renewable energy in the distribution network at a predetermined fixed tariff and on a set period of time. Prices collected from distributors are superior to those marketed in traditional energy network, which allows to the investor a reasonable timeframe for investment recovery and an appropriate profit.

Ukraine: Factors that encourage these activities are: Law of Ukraine "About alternative sources of energy", implement of feed in tariff for electric power – Law of Ukraine "About electric-power industry", Kyoto Protocol, tax benefits for import of equipment, increase in demand of energy, Law of Ukraine "About tourism". Factors of inhibition: high price of equipment, high price of feed in tariffs for consumers.

Romania: Green certificates policy is beeing used in Romania to promote generation of electricity from renewable resources. The certificates are issued to the generating companies for each megawatt-hour of renewable electricity generation. The companies may sell the certificates in a market, and the revenues from certificate sales provide an extra incentive to invest in new generating capacity. Proponents argue that this market-based incentive can be designed to support government mandates for a growing fraction of electricity generation from renewable sources.

6. **Case studies**

Romania

1. Evaluation of ecosystem factors: land, water, forest, solar, wind,

Tataru village is located in the southern part of Constanta County, Romania, at 40 km far from Constanta city. It has a surface of 1,6 km^2.

The climate is a temperate one. The winters are mild and short and the summers are droughty and hot. The value for annual average precipitation is 463 mm.

The value for solar irradiation at inclination is 2220 Wh/m2/day in January and 6420 Wh/m2/day in July. Wind speed average is 6,5 - 7,5 m/s at 50 meters high.

The vegetation is represented by the prairie, aspect that determined the fields to be put in value by agriculture purpose, sustained also by the soil richness which is a chocolate and levigate chernozem. In the same time, agriculture is inhibited by the lack of streams or other sources of fresh water. Also, the water table is located at a high depth, and its use implies important amount of money and large quantity of electric energy.

2. Analysis of the demographics and social conditions

In Tataru village are living 700 habitants from which: 330 persons are working in the agriculture field, 100 persons are commuting to Constanta to work, 10 - workers in the public sector, 50 unemployed, 110 inmates and 100 pupils.

The low living conditions from Tataru village impose to take prompt action. A way would be to offer to the population facilities for developing an efficient agriculture. It is rational thinking that almost all the habitants depend on the agriculture activities. Another way would be to assure a cheaper electric energy.

3. Opportunities for economic development

One of the best opportunities for economic development is the agriculture potential. For more than half of population the agriculture is the main source of income and employment. Besides the harvest, from the agricultural area, it results 11532 tons of biomass/year.

4. Selection of the key development factors

1st solution:CHP plant based on Organic Rankin cycle, burning biomass and producing electricity (for supply the local consumers and for feeding the national grid) and heat (for using in a pellets plant belt dryer)

2nd solution: pellet boiler producing heat for heating vegetables greenhouse and pellets production

3rd solution: installation of an irrigating system whose pumps being feed with power from a wind turbine

5. Definition of the ecoinovative solutions

1st solution: a Turboden 4CHP plant was chosen for power-409 kWh and thermal energy-1835 kWh production, 7000 hours/year. It consumes 7112 tones /year biomass from the total amount of 11 532 tones. The rest of 4420 tones will be transformed in pellets through a belt dryer with the capacity of 450 kg /hour. It remains also 1446kWh of thermal energy to be used in different ways (locals heating, vegetables greenhouse heating or supplementary pellets production if it will be find a bigger amount of biomass)

2nd solution: an EcoHornet pellet boiler was chosen to produce thermal energy for heating a 10.000 m^2 of vegetables greenhouse and for producing 675 kg/h of pellets through a belt dryer
- boiler's thermal energy production is 5300kWh, with the consumption of 175 kg of pellets/hour.
- it has been chosen to combine the greenhouse heating with the pellets production because of the fact that in summer, when the greenhouses does not need a supplementary heating, the thermal energy to be used in an efficient way.

3rd solution: the solution for raising the agriculture in the area is to start irrigating. A 2500 cubic meters basin filled with water from precipitation and from 4 water well, can be used for the need of 200 ha. The 4 submersible pumps which are pumping the water from the well to the basin and the other 4 centrifugal pumps which are pumping the water from the basin to the irrigating system, with a total power of 180 kW, will be feed with electricity by a 400 kW wind turbine.

6. Life cycle assessment for each solution

The life cycle methodology assessment has been applied and the results are presented in the table from paragraph 7

7. Economical assessment for each solution

	1st solution	2nd solution	3rd solution
Investment cost	400kW CHP plant 817.000€	4725kWh th. energy pellet boiler 741.000€	400 kW wind turbine 530.000€
	500 kg/h pellets plant 54.000 €	1250 kg/h pellets plant 118.000 €	4 water wells drilling 51.000 €
	yard and buildings 53.000 €	10.000 m^2 of greenhouse complete equipped 345.063 €	storage water basin 40.480 €
	salaries for employers 28.728 €	salaries for employers 60.648 €	salaries for employers 37.110 €
	11.532 tones of biomass 138.384 €	11.532 tones of biomass 138.384 €	9 km water transport pipes 86.000 €
			pumps 14.520 €
	different other costs 52.200 €	different other costs 304.392 €	different other costs 27.000 €
Total	**1.143.312 €**	**1.707.487 €**	**786.110 €**
Yearly costs	**219.312 €**	**363.542 €**	**60.990 €**
Incomes	electricity sale- 50 €/MWh 140.000 €	280 tones of tomatoes 191.000 €	tariff for irrigating water supply 500 €/ha
	green certif.-150 €/MWh 420.000 €		7 months 165 kWh sell 41580 €
	450 kg/h pellets, 7000 h 267.750 €	675 kg/h pellets, 7000 hours 401.625 €	green certificates incomes at price of 100 €/MWh 83.160 €
Total incomes	**827.750 €**	**592.695 €**	**224.740 €**
Other types of incomes	possibility of improving 1446 kWh thermal energy by producing supplementary pellets, by heating locals houses or vegetables greenhouses	the possibility either for locals, either for the nearest city population to eat healthy by furnishing with bio vegetables at a cheap price	the possibility for all the village habitants to irrigate the gardens and other 100 hectares out of village at a price of 500 €/ha; helping in this way 300 locals
Payback period	**2 years and 7 months**	**7 years**	**5 years**
Employers	2 engineers, 4 workers	3 engineers, 25 workers	2 engineers, 4 workers
Life cycle assesment	Emissions: flue ash-149,89t/year, NxOx-57,66t, CO-11,532t/year SO2 -171,3t/year Benefits	CO_2- 40,95t/year, NO_2-81,46t/year, SO_2- 2,45t/year, particulates - 35,96t/year	- erosion of soils-20-30% of cultivated area - uncontrolled pumping of water can cause water table lowering

8. Multi criteria decision

The multi criteria decision has been applied and the results are presented in the figure 8.

Moldova

1. Evaluation of ecosystem factors: land, water, forest, solar, wind,

The analyzed village is Septelici located in the central part of Soroca County, Republic of Moldova, at 14 km far from Soroca city and 2.5 km far from Dniester river. It has a surface of 1,9 km^2.

The climate is temperate continental. Winters are mild and short and the summers are droughty and hot. The value for annual average precipitation is 463 mm.

The value for solar irradiation at inclination is 1070 Wh/m2/day in January and 5965 Wh/m2/day in July.

The vegetation is represented by the plainfield, aspect that determine to be put in value by agriculture purpose, sustained also by the soil richness which is a levigate chernozem.

2. Analysis of the demographics and social conditions

In Septelici village have been registered 434 households and 1.086 people, 48.25% are males and 51.75% female.

344 persons are working in the agriculture field, 180 persons are working in Soroca or abroad, 44 - workers in the public sector, 50 unemployed, 160 children and 358 pensioners.

3. Opportunities for economic development

In the village operates 5 public institutions: village Hall, Lower secondary school, garden, culture House, library - medical point and 3 food stores

There is a non-working zootechnical farm where, 30 years ago, were 2000 cattle.

Agricultural and forestry sector: forest plantation - 33.5 ha, Orchards (apples) - 215.00 ha, Gardens - 99.00 ha, sown area - 655.98 ha.

Total local biomass, annually 1528 t / ha

4. Selection of the key development factors

1st solution: CHP plant based on Organic Rankine Cycle, burning biomass and producing electricity (for supply the local public institutions and for feeding the national grid) and heat (for heating the local public institutions and for using in a pellets plant belt dryer)
2nd solution: 2000 cow manure turn to profit by obtaining biogas from which to produce electricity and heat for local public institutions supply and for feeding the national grid
3rd solution: PV plant for local public institutions electricity supply

5. Definition of the ecoinovative solutions

1st solution: a Maxxtec CHP 91 kW plant was chosen for the local public institutions supply with 56,5 kWh of electricity and 191 kWh of heat. It consumes 190 kg biomass / h, 6500 hours / year. The rest of electricity - feeds the national grid. The heat in surplus - for pellets production. In this case it is necessary an extra 3527 tons of biomass.

2nd solution: a BIOMATE biogas plant was chosen for turn into value the 110 daily tons of mix manure by producing 692 m^3 of biogas from which to obtain 810 kWh electricity and 1356 kWh heat through a Viessmann CHP plant. 56,5 kWh electricity would supply the local public institutions, the rest would be used for feeding the national grid. The heat also - used for the local public institutions and for production of pellets.

3rd solution: the installation of a PV plant consisting on 500 Uni Solar panels, each of 136 W for providing 56,5 kWh, 8 hours / day to the local public institutions. The price is 91,5 € for each panel.

6. Life cycle assessment for each solution

The life cycle methodology assessment has been applied and the results are presented in the table from paragraph 7

7. Economical assessment for each solution

	1st solution	2nd solution	3rd solution
Investment cost	81 kW CHP plant 160.000€	biogas plant 1.389 000 €	68 kW PV panels 45.750 €
	500 kg / h pellets plant 68.000€	CHP plant 1.670.000 €	three phase inverter 70 kW 11.300 €
	Hot water distrib. system 15.000€	Hot water distribution system € 15.00	backup batteries 12 V 205 Ah 25 pieces 6500 €
	salaries for employers 24.300 €	salaries for employers 39.400 €	salaries for employers 11.172 €
	4762 tones of biomass 57.144 €	200 kg / h pellets plant € 35.000	connecting to the grid 850 €
		1528 tones of biomass 18.337 €	sustaining structure 950 €
	different other costs 119.081 €	different other costs 210.392 €	different other costs 3870 €
Total	**442.383 €**	**3.410.792 €**	**85.172 €**
Yearly costs	**117.740 €**	**152.340 €**	**14.240 €**
Incomes	locals electricity feeding 56,5kWh, 6500 h/year 36.725 €	locals electricity feeding 56,5kWh, 6500 h/year 36.725 €	local public institution electricity feeding 56,5kWh, at 0,1 €/kWh 23.194 €
	feed in tariff price for 24,5 kWh, 6500 h/year 23.887 €	feed in tariff price for 753,5kWh, 6500 h/year 489.775 €	
	locals thermal energy feeding 657,4 Gcalories 3780 €	locals thermal energy feeding 657,4 Gcalories 3780 €	
	407 kg/h pellets, 6500 h 224.867 €	175 kg/h pellets, 6500 h 97.410 €	
Total incomes	**289.259 €**	**627.690 €**	**23.194 €**
Other types of incomes	facile way of heating the institutions at the same price	grows the farm efficiency	solar energy peak power generation coincides with peak energy demand
	independence and security in energy supply	the residues after obtaining biogas - a natural way of fertilizing the soil	require minimum operating or maintenance costs
	clean way of producing energy, efficient way of using biomass		
Payback	**2 year and 8 months**	**7 years and 2 months**	**9 years and 6 months**
Employers	1 engineers, 5 workers	2 engineers, 5 workers	2 technicians
Life cycle assesment – Emissions	flue ash 61,9t/year, NxOx-23,81t/year, CO- 4,762 t/year, SO2 - 7,143 t/year	Nox - 449,8kg / year, CO - 224,9kg/year, CnHm-44,98kg/year,	greenhouse-gas emissions 9.277,6 kg/year cadmium emissions 185,5g/year
Life cycle assesment – Benefits		reduction of CO2 emissions: 8-10 times.	eliminates the burning of -86.166kg/year coal - 152.015 kg/year CO2 saves 443m^3/year of water

8. Multi criteria decision

The multi criteria decision has been applied and the results are presented in the figure 9.

Ukraine

1. Evaluation of ecosystem factors: land, water, forest, solar, wind,

The analyzing locality from Ukraine is Luchiste village that is situated in the South Cost of Crimea and subordinated to the city council of Alushta.

The total area of the village is approximately 0,72 km2 (71,8 ha).

The direct distance to Alushta city is 4 km, the direct distance to Simferopol is 35 km.

The climate is submediterranean. Winter is rainy and cool, summer is dry and hot. The annual precipitation is 340-430 mm, total incoming solar radiation at the horizontal surface is 192,2 kWh/m2 /day in July and 33,17 kWh/m2/day in December.

The main ecosystem services that can be provided by analyzing area are (8 cases): high amount of solar radiation during the year, picturesque mountain landscapes, clean drinking water from springs, biomass yield of grapevines, high annual yield of grapes and fruits, biomass yield of cattle and horses, biomass yield of pastures and woodlands, vacant building lots.

2. Analysis of the demographics and social conditions

Village population constitutes 1044 people. Most of people (20-50 years old) work in the tourism field (3 stud farms, excursions, construction and service of cottages and touristic hostels) the rest of them work in the agriculture (vineyards and orchards). Pensioners work in the households (dairy products, meat, fruits and vegetables). 20 persons work in the village council, 15 persons work in the secondary school.

3. Opportunities for economic development

In the village there are 8 public institutions: village council, secondary school, culture house, library, church, village department of viticulture, post office, medical point; 3 food stores; 3 stud farms with about 40 heads of horses in each one. Agriculture sector: vineyards – 149 ha; orchards – 3 ha; shrub and tree plantations – 42 ha; arable land – 90,3 ha. high amount of solar radiation during the year –production of electricity using solar panels;

4. Selection of the key development factors

1st solution: briquetting plant based on biomass of dry grapevine, used either for burning in boilers for heat production either in CHP plant for heat and electricity

2nd solution: turning to profit **6043.5 t/year** of cattle manure combined with biomass from grape processing by feeding the 35 daily tourist with electricity and heat

3rd solution: PV plant for the touristic hostels electricity supply

5. Definition of the ecoinovative solutions

1st solution: the biomass potential of the 576 ha - area of vineyards is 403,2 tons/year of dry biomass with water content of 30%. The solution of turn to profit this potential is a briquetting plant. The capacity is 50kg of briquettes/hour, 6500 hours/year. After that the briquettes can be sold or used in a boiler for touristic hostels heating.

2nd solution: a ZORG biogas plant was chosen for turn into value the 16,55 daily tons of mix manure by producing 107,5 m^3 of biogas from which to obtain 125 kWh electricity and 200 kWh heat through a Viessmann CHP plant, 6500 hours/year. 122,5 kWh electricity and 73,5 kWh heat would supply the local touristic hostels, the rest would be used for feeding the national grid. The heat in surplus can be used for pellets production or greenhouses heating.

3rd solution: the installation of a Yingli Solar PV plant consisting on 250 Uni Solar panels, each of 142W for providing, 120 days/year to the local touristic hostels. The price is 110,5 € for each panel. The rest of produced energy will be sell to the national grid at the price of 0,25€/kWh as the feed in tariff.

6. Life cycle assessment for each solution

The life cycle methodology assessment has been applied and the results are presented in the table from paragraph 7

7. Economical assessment for each solution

	1st solution	2nd solution	3rd solution
Investment cost	50 kg/h briquette plant 11.300€	biogas plant 58.000 €	35,5 kW PV panels 27625€
	activity yard and building 9200€	CHP plant 73.000 €	three phase inverter 35 kW 9000 €
		Hot water distribution system 21.000€	backup batteries 12V 205 Ah 13 pieces 3500€
	salaries for employers 14.360€	salaries for employers 20.500€	salaries for employers 9.360€
	403,2 tones of biomass 4840€	6043,5 tones of manure 54.400 €	connecting to the grid 640€
	consumed electricity 2350		sustaining structure 830 €
	different other costs 4.030 €	different other costs 7.400 €	different other costs 3200€
Total	**46.080€**	**234.300€**	**54.195€**
Yearly costs	**22.450€**	**74.900 €**	**11.240 €**
Incomes	50kg/h pellets, 6500 h 29.250€	local hostess feeding electricity 122,5kWh/day, 120 days/year 1470€	local hostess electricity feeding 25kWh, at 0,1 €/ kWh, 4 months /year 2950€
		feed in tariff price for 122,85kWh, 6500 h/year 103.808€	
		locals thermal energy feeding 344,2 Gcalories 1970€	national grid feeding 25kWh, at - 0,25 €/ kWh,feed in fotovoltaic, 8 months/year 14.750 €
Total	**29.250€**	**107.248€**	**17.700€**
Other types of incomes	independence and security in energy supply	an average of 150 kWh heat, 6500 h/year can be improved by producing pellets or heating greenhouses	solar energy peak power generation coincides with peak energy demand
	clean way of producing energy, efficient way of using biomass	the residues after obtaining biogas - a natural way of fertilizing the soil	require minimum operating or maintenance costs

<table>
<tr><td>Payback period</td><td colspan="2">6 year and 8 months</td><td>7 years and 3 months</td><td>8 years and 4 months</td></tr>
<tr><td>Number and specialization of employers</td><td colspan="2">1 technician,2 workers</td><td>1 engineers,3 workers</td><td>2 technicians</td></tr>
<tr><td rowspan="3">Life cycle as sesment</td><td>Emissions</td><td rowspan="3">flue ash 0,95t/year,
CO 45,5 t/year,
NO_2 0,25 t/year.</td><td>Nox - 69,8 kg / year,
CO - 34,9 kg/year,
CnHm 6,98 kg/year,</td><td>greenhouse-gas emissions 7.080 kg/year
cadmium emissions 141,6 g</td></tr>
<tr><td rowspan="2">Benefits</td><td rowspan="2">reduction of CO2 emissions: 8-10 times.</td><td>eliminates the burning of
-32.878kg/year coal
- 58.021 kg/year CO2</td></tr>
<tr><td>saves 169,1 m^3/year of water</td></tr>
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8. Multi criteria decision

The multi criteria decision has been applied and the results are presented in the figure 10.

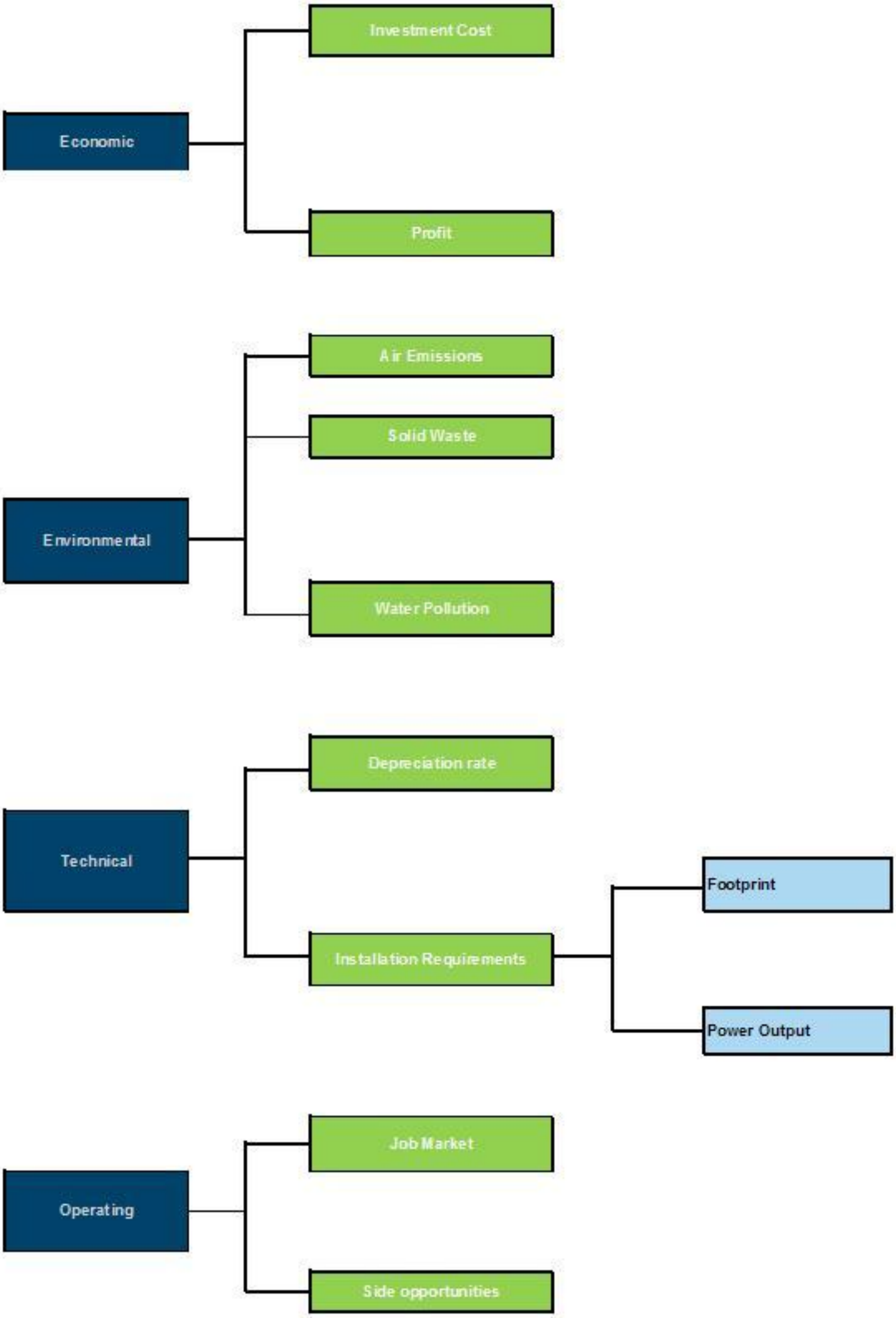

Figure 6 - The hierarchy of criteria for Value Engineering

Economic		Environmental		Technical		Operative	
Investment Cost	9,92%	Air Emissions	12,20%	Installation requirements (footprint)	1,08%	Job Market	8,27%
Profit	19,84%	Solid Waste	5,15%	Installation requirements (power output)	6,48%	Side opportunities	33,10%
		Water Pollution	1,30%	Depreciation Rate	2,65%		

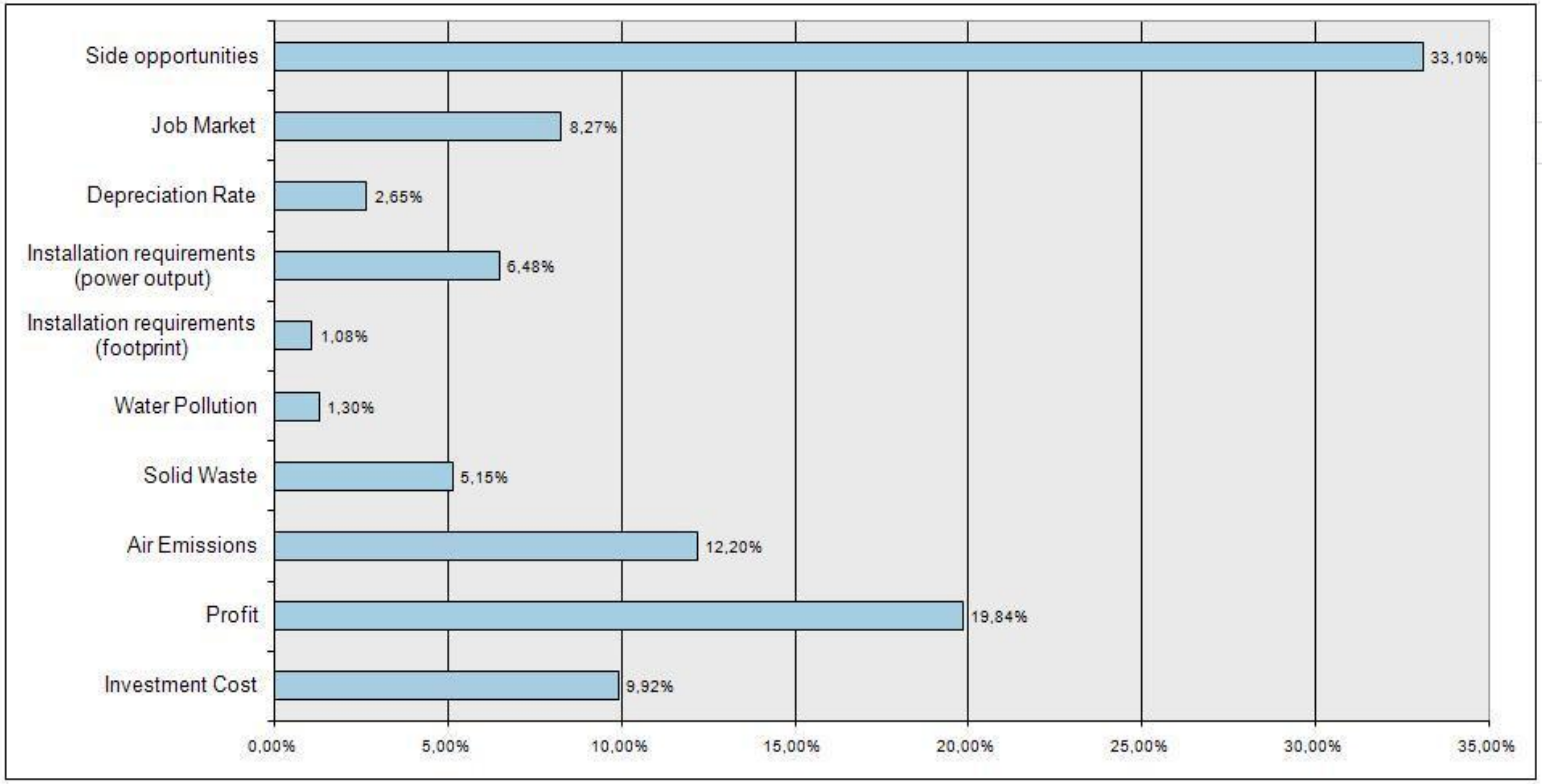

Figure 7. Criteria Ranking

Values	1.143.312,00 EUR	304.219,00 EUR	240 t equiv CO2	150 t waste	Medium	5000 m2	1200 kW	Low	6 jobs	Low
	1.707.487,00 EUR	229.153,00 EUR	123 t equiv CO2	36 t waste	Medium	15000 m2	2300 kW	Medium	28 jobs	Medium
	786.110,00 EUR	163.750,00 EUR	10 t equiv CO2	3 t waste	Medium-High	3000 m2	400 kW	Medium	6 jobs	Very High

Case (Romania)	Investment Cost	Profit	Air Emissions	Solid Waste	Water Pollution	Installation requirements (footprint)	Installation requirements (power output)	Depreciation Rate	Job Market	Side opportunities
Case 1: CHP Plant	7	10	1	1	6	9	7	10	1	2
Case 2: Pellet Plant, Green House	1	6	6	8	6	1	10	7	10	6
Case 3: Irrigating System	10	1	10	10	3	10	1	7	1	10

Criteria	Investment Cost	Profit	Air Emissions	Solid Waste	Water Pollution	Installation requirements (footprint)	Installation requirements (power output)	Depreciation Rate	Job Market	Side opportunities
Importance	10%	20%	12%	5%	1%	1%	6%	3%	8%	33%

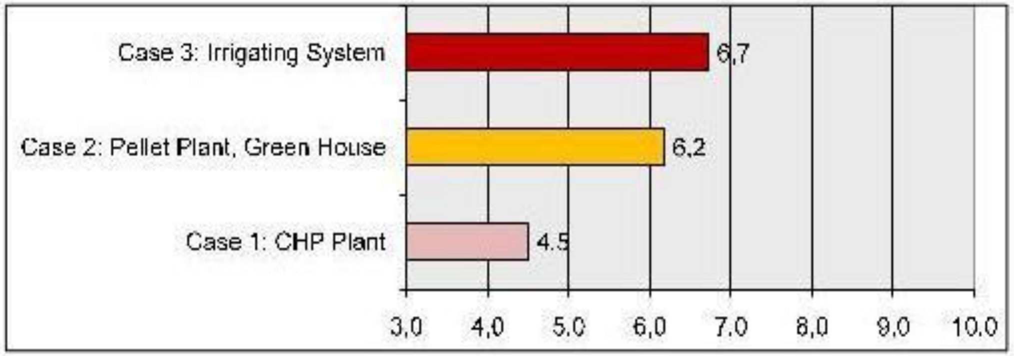

Figure 8. Multi criteria decision results for Tataru case study

Values	442.383,00 EUR	171.519,00 EUR	97 t equiv CO2	Medium	Low	3000 m2	200 kW	Medium	6 jobs	Medium
	3.410.792,00 EUR	475.350,00 EUR	5 t equiv CO2	Medium	Medium	5000 m2	1500 kW	High	7 jobs	Medium
	85.172,00 EUR	8.954,00 EUR	1 t equiv CO2	Very Low	Low	500 m2	50 kW	Low	2 jobs	Low

Case (Moldova)	Investment Cost	Profit	Air Emissions	Solid Waste	Water Pollution	Installation requirements (footprint)	Installation requirements (power output)	Depreciation Rate	Job Market	Side opportunities
Case 1: CHP Plant	7	6	1	5	10	5	7	6	9	6
Case 2: Biogas Plant	1	10	9	5	6	1	10	1	10	6
Case 3: PV Plant	10	1	10	10	10	10	1	10	1	1

Criteria	Investment Cost	Profit	Air Emissions	Solid Waste	Water Pollution	Installation requirements (footprint)	Installation requirements (power output)	Depreciation Rate	Job Market	Side opportunities
Importance	10%	20%	12%	5%	1%	1%	6%	3%	8%	33%

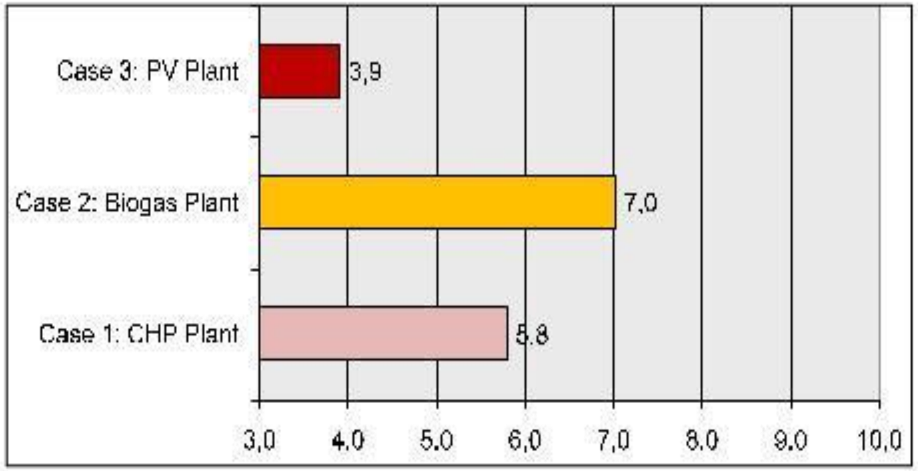

Figure 9. Multi criteria decision results for Septelici case study

Values	46.080,00 EUR	6.800,00 EUR	47 t equiv CO2	Medium-Low	Low	3000 m2	150 kW	Medium	3 jobs	Medium
	234.300,00 EUR	32.348,00 EUR	10 t equiv CO2	Medium	Medium	5000 m2	200 kW	High	4 jobs	Medium
	54.195,00 EUR	6.460,00 EUR	1 t equiv CO2	Very Low	Very Low	500 m2	40 kW	Low	2 jobs	Low

Case (Ukraine)	Investment Cost	Profit	Air Emissions	Solid Waste	Water Pollution	Installation requirements (footprint)	Installation requirements (power output)	Depreciation Rate	Job Market	Side opportunities
Case 1: Briquette plant	10	1	3	7	9	5	4	6	6	6
Case 2: Biogas Plant	1	10	9	5	6	1	10	1	10	6
Case 3: PV Plant	10	1	10	10	10	10	1	10	1	1

Criteria	Investment Cost	Profit	Air Emissions	Solid Waste	Water Pollution	Installation requirements (footprint)	Installation requirements (power output)	Depreciation Rate	Job Market	Side opportunities
Importance	10%	20%	12%	5%	1%	1%	6%	3%	8%	33%

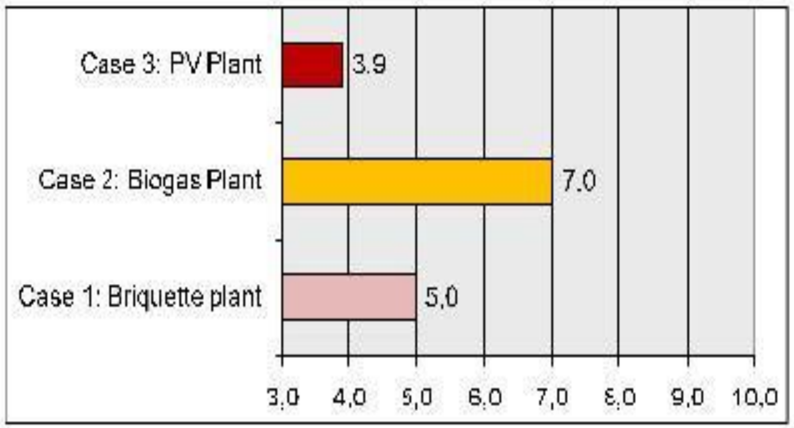

Figure 10. Multi criteria decision results for Luchiste case study

7. Conclusions and recommendations

The results of the studies conducted in the three cases demonstrate the similarities between the three countries in terms of costs of equipment and labour. The similarities in terms of cost of equipment is the result of the deindustrialization that followed the same pattern in all three countries in the last 20 years. As a result of this process, all three countries are dependent on equipment manufactured abroad. The level of labour cost is comparable due to similar development patterns specific to economies with low margins and low labour cost.

In terms of renewable energy sources we have three situations as following: Romania with the most generous system of subsidies based on Green Certificates, Ukraine following the system of feed-in tariffs and Moldova that has not yet implemented but is envisaging a scheme with feed- in tariffs. In the case of Romania there are no correlations with other policies like industrial policy or agriculture policy. In the case of Ukraine there is a system of offset that is imposing a contribution of local economy and is mainly targeting the industry.

Analysing the results of the three cases it might be seeing that the best solution was not centred on the use of renewable energy. In each of the three cases the best solutions are related to the integration of renewable energy into a factor for developing an opportunity in the local economy: wind energy for irrigation in Tataru, the neutralization of biomass residues for production of electricity and heat in Septelici and the development of tourism opportunities by using the local biomass resources in Luchiste.

As a consequence, we consider that the main conclusion of this project might be a recommendation for developing countries interested in the support of rural communities to use the policies on sustainable energy intimately connected with the policies related to agriculture, tourism and rural development.

8. The context of the study

Under the frame of the Black Sea Universities Network, the aspects of sustainability are a continuous concern. Since 2011, the Black Sea Universities Network coordinates the UN "Academic Impact" Hub on sustainability [5]. The BSUN mission is to facilitate the transfer of knowledge from Universities to different other partners in promoting sustainability. A number of selected projects are monitored and offer the possibility to transfer the best practices and experience. The selection of projects has been made during the International Conference on "Education & Governance for Sustainable Development", organized under the frame of UNAI in Constanta, Romania between March 16 and 19, 2011.

Under the frame of BSUN it has implemented the BSUN joint master degree on Renewable Energy Sources, involving the following universities: Ovidius University of Constanta, Istanbul Technical University, Taurida National University from Simferopol, Technical University of Moldova, Technical University from Varna.

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