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Towards a Sustained Use of Renewable Energy Sources in Romania

Adriana Alexandru, Cristian Tantareanu, and Elena Jitaru

***Abstract*—**The paper presents the potential for RES in Romania and the results of the Romanian national research project "Romania contribution to the European targets regarding the development of renewable energy sources - PROMES". The objective of the project is the *development of energy generation from renewable energy sources* (RES) in Romania by drawing up *scenarios and prognosis* harmonized with national and European targets, RES development *effects modeling* (environmental, economic, social etc.), research of the *impact of the penetration of RES into the main*, implementation of an *advanced software system tool for RES information recording and communication*, experimental research based on *demonstrative applications*.

The expected results are briefly presented, as well as the social, economic and environmental impact.

***Keywords*—**Energy policy, Internet, renewable energy sources, potential.

I. Introduction

THE substantial growth of the energy global consumption during the last decades conducted to an intensive exploitation of the traditional no-renewable resources, decreasing their life time and amplifying their devastating effects on environment. At the same time, the focus of these resources in some areas has increased the dependence of imports of those areas and the need to ensure energy security. In response to all this and especially to the fluctuate in the supply of energy (manifested in the recent past in Russia as the main distributor), the European Union has proposed to take measures to diversify suppliers, distribution channels and technologies used, as well as for increasing cooperation and solidarity between states.

In this context, Renewable Energy Sources (RES) are an unlimited alternative, which being used effective, can reduce dependency of energy from the outside and ensure coverage of internal demand. Moreover, renewable sources comply with the provisions of protection of the environment and criteria for ensuring sustainable development. Kyoto Protocol [1] has established standards to reduce global emissions of greenhouse gases harmful to the environment, and by Directive 2001/77/EC and regulations that have followed have fixed the European objectives for amplification of renewable sources in primary energy consumption for years to come [2].

For our country, preparations for accession to the European Union, and the integration itself have also implied the increasing interest in incorporating renewables in the indigenous energy production. Romania has also adopted all EU decisions and has established its own strategy depending on the available potential, aiming to achieve a sustainable development of the energy sector by using a mixed energy balance, reducing pressure in the economy due to the increasing price of the imported primary energy resources, promotion of private investment, the development of competitive market of energy and environmental protection.

II. Potential for RES In Romania

The theoretical potential for RES in Romania is huge but the full theoretical potential is definitely not technically practicable and neither economic feasible.

The existing utilisation of RES in Romania is primarily in the hydro power and biomass sectors; biomass is addressing mainly the residential sector (Fig. 1).

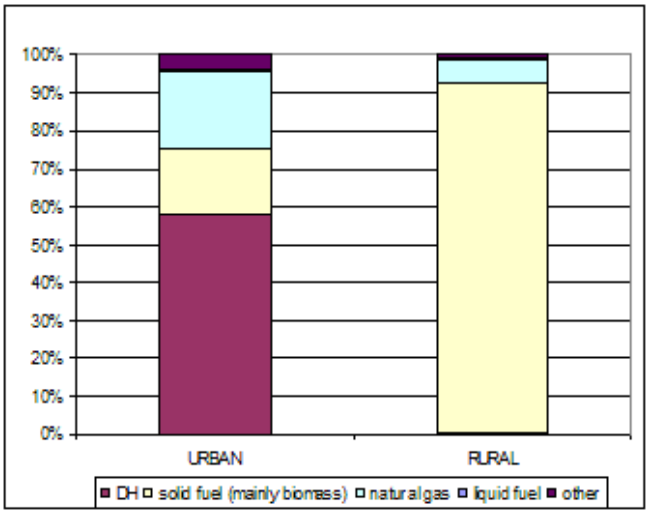

Fig. 1 Heating Systems in the Residential Sector in Romania in Urban and Rural Areas

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Adriana Alexandru is with the National Institute for Research and Development in Informatics, 8-10 Averescu Avenue, 011455 Bucharest, Romania (corresponding author to provide phone: +40-744-777-558; fax: +40-21-224-11--21; e-mail: adriana@ ici.ro).

Cristian Tantareanu is with ENERO - Centre for Promotion of Clean and Efficient Energy in Romania, 51 Feroviarilor str., Bucharest, Romania (e-mail: c.tantareanu@enero.ro).

Elena Jitaru is with the National Institute for Research and Development in Informatics, 8-10 Averescu Avenue, 011455 Bucharest, Romania (e-mail: jitaru@ ici.ro).

Other areas of RES utilization are poorly developed. Production of biofuels is rapidly increasing and is estimated to count for 2,326 GWh (200 toe) in 2008.

Potential and present use of the RES in Romania are presented in Table I [3]. The Romanian strategy establishes as a target for Romania that 33% of the overall electricity consumption would based on renewable sources by the year 2010.

TABLE I
POTENTIAL AND PRESENT USE OF RES IN ROMANIA

Renewable Energy Source	Energy potential, TJ/year	Present Use	
		TJ/year	% of the potential
Solar energy:			
- thermal	6 0 000	0	0%
- photovoltaic	4 320	0	0%
Wind energy	82 800	36	0%
Hydro Energy,	144 000	59 400	41%
of which > 10MW	122 400	57 780	47%
of which < 10MW, LHHP	21 600	1 620	8%
Biomass	318 000	116 000	36%
Geothermal energy	7 000	216	3%
Total, incl. LHPP	**616 120**	**175 652**	**29%**
excl. LHPP	**493 720**	**117 872**	**24%**

The domestic energy consumption by 2010 is estimated to be at 65 TWh per year, resulting in a needed for E - RES of around 21.5 TWh per year (33% of 65 TWh/year). The large hydro plants may contribute with some 17 TWh, leaving the rest of 4.5 TWh to other E - RES. Without improvements of the support mechanisms, it is anticipated that the 33% target will not be achieved [4].

A new updated strategy on energy development was issued in 2007 [5]. This strategy suggests new targets for generation of E - RES of:

- 35% in the year 2015
- 38% in the year 2020.

Considering the forecast increase in domestic electricity consumption, the production of E - RES (without large hydro) should be 8 TWh in 2015 and 14 TWh in 2020. On medium and long term, the focus should change from wind and small hydro resources use to biomass and PV solar resources.

The new strategy on RES is focusing more on small hydro and wind, as the leading sources and technologies to achieve the target. By 2015, development of off-shore wind energy projects will start. As of today, Romania has less than 10 MW of installed wind power capacity and is one of smallest wind energy producers in Europe.

The market mechanism to help RES development is the Green Certificate quota (Table II).

TABLE II
MANDATORY QUOTAS FOR E - RES

Year	2005	2006	2007	2008	2009	2010-2012
E-RES quota %	0.7	2.2	3.74	5.26	5.78	8.3

The quota is imposed on the power supplier, trading electricity between the producers and consumers.

The RES quota for Romania, as suggested in the recent RES Directive proposal is 24%, starting form 17,8% in 2005.

The first scenarios to fulfill the quota were developed within different national and European R&D projects, including the PROMES project.

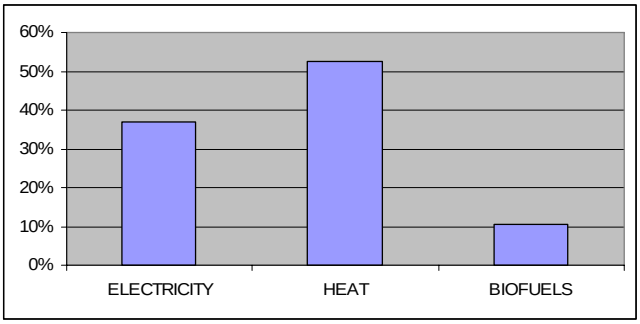

Fig. 2 Contribution of renewables to the Romania quota in 2020

Regarding electricity from RES, additional to large hydro, small hydro biomass CHP and wind should have the most significant contributions (Fig. 3).

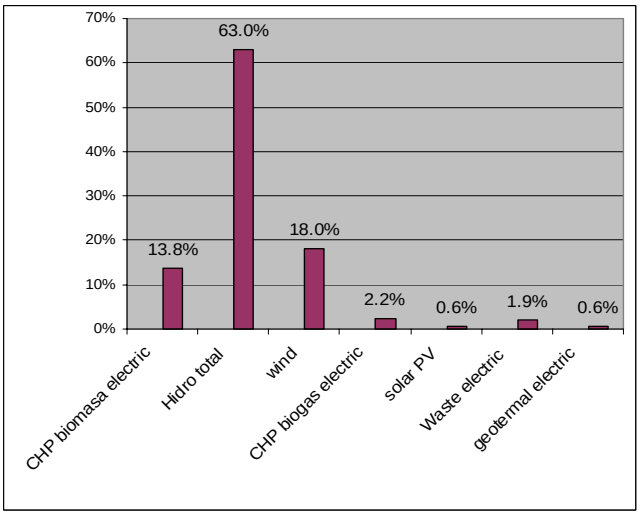

Fig. 3 RES to produce electricity by 2020

The potential of solar energy results from the quantity of energy from solar radiation, which in Romania has an average value estimated at 1100 KWh/m^2/an. The regime of the geographical distribution of the potential of solar energy shows that over half of the surface of Romania receives an average annual flow of 1,000 kWh/m2/year [6].

Solar radiation with values greater than 1200 kWh/m2/year is recorded on an area greater than 50% of the total area of Romania [6]. The use of solar energy potential is to be made by:

- Solar thermal systems for heating and hot water housekeeping for individual dwelling or centralized mini installations up to 1434 tep (tonnes of oil equivalent);

• Photovoltaic systems used primarily to supply electricity to some isolated consumers with small energy needs – up to 1200 GWh / year.

A relevant Romanian application is the solar thermal system integrated into the Mangalia city DH (Fig. 4). 360 m2 solar collectors are producing here around 200 Gcal/year, covering some 70% of the domestic hot water need of the local hot water circuit.

Fig. 4 Solar thermal system in Mangalia city

Up to now, the most relevant Romanian application is the 30 kW PV plant on the Polytechnic University Bucharest (Fig. 5).

Fig. 5 PV plant on the Polytechnic University Bucharest

Important wind energy projects, totaling some 1500 MW are in the final stage of preparation.

Wind potential in Romania is fit for wind energy projects on the Black Sea littoral, the sea off-shore and on the mountainous areas. A wind potential, in commercial terms, of several thousands MW may be identified (including off-shore). Good sites for wind farms are estimated to offer mean wind speeds between 6.6 and 7.4 m/s, at WT hub heights.

By 2020 some 6 TWh should be produced by wind energy. A possible development scenario for wind energy is presented in Fig. 6 and Fig. 7.

III. The Objectives of Promes Project

The *general objectives of the project* are: promotion of RES use in Romania for inclusion in the EU policy of the domain and setting up a multidisciplinary research partnership.

The *specific objectives of the project* are:

• Implementation an informatic tool for advanced modeling concerning RES development;

• The use of the tool for the elaboration of scenarios and prognosis for RES development in Romania for meeting European targets;

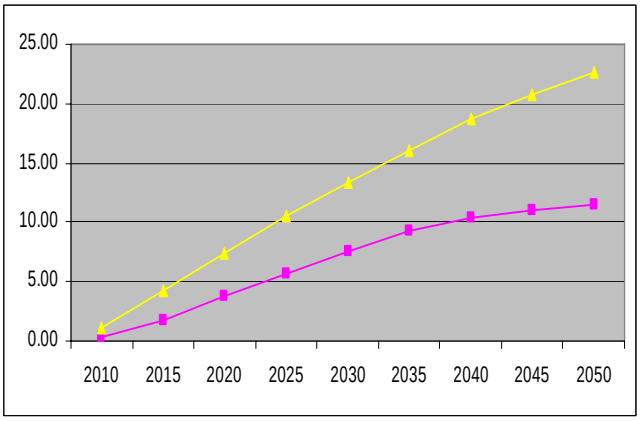

Fig. 6 On shore wind energy projects development

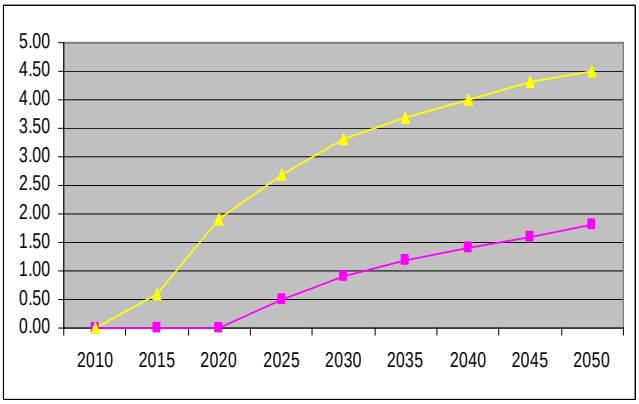

Fig. 7 Off shore wind energy projects development

• Development of support mechanism of RES in the frame of electrical energy market;

• Identification of optimal zones for the installation of different types of RES, as well as of optimal generation capacities by integration RES into the grid, fixing the problems of their connection;

• Design and implementation of the software for a web based system for recording and communication of RES information (databases with available installations, producers, installers, legislation, grants, on-line library, on-line learning);

• Increase the level of understanding of consumers, decision factors, specialists about the opportunities, the advantages of promoting the use of RES for energy

production in the context of sustainable development, integrated at the European level;

- Demonstrative applications concerning the use of RES in Romania;
- Active dissemination of the results.

As *measurable objectives* we mention: Connection of Romanian research in RES domain with similar European projects (e.g. EIE KYOTOINHOME, SUSPLAN, RES2020 or GreeNetIncentives projects) and proposals for the improvement of financial mechanism for RES promotion on the market, in the context of an open energy market integrated at European level.

IV. Expected Results

Elaboration of an ensemble of strategies which harmonizes the actual framework of energy production/use in Romania with the European targets for RES production. The analysis will be based with the specific approaches of the Global Emission Model for Integrated Systems (GEMIS) developed at Oko Institute.

The elaboration of these strategies will be supported by the *elaboration of development scenarios for energy production*, with will be put in concordance with the elaboration of SDE (Systems with Discrete Events) models, which have to describe the complex systems for stand alone or grid connected energy production. Energetic systems modeling, with dedicated Object Oriented Temporal Petri Nets tools, will allow to perform complex comparative analysis which describe the energy production in different descriptive contexts. The elaboration of the model will take into consideration life cycle analysis and also the complexity of the system based on the component subsystems. The repetitive performance of such analysis will allow the development of databases which, by specific analysis will permit the *elaboration of prognosis for the development / implementation of RES systems*. These researches will allow the establishment of the development directions for our country, related with the domain specific EU targets.

Concerning the *distributed generation and the integration of RES into the developed systems*, the characteristics of different types of technologies will be identified in order to perform a detailed analysis of different scenarios of the connection of these energy sources to the grid (the analyses will be performed using dedicated software, validated at international level). The structure of the grid used for energy distribution will be analyzed for identification of optimal zones (from technical point) for the injection of the prognosis power into the grid., will be analyzed the standards for electrical equipments and the quality standards of the electrical energy in which have to be included the different types of distributed generation, realistic solutions for power supply of the isolated places will be identified, the influence of RES on the reliably of electricity distribution system will be analyzed, the impact of wind and PV generators on the functionality of the distribution system will be analyzed, the power supply reliability for the consumers will be analyzed if hybrid sources are used (wind-PV, wind-electrical energy accumulation, PV-electrical energy accumulation, wind-PV-electrical energy accumulation). The actual trend for reability will be taken into consideration, which involves the use of reliability values in risk management algorithms.

The project intends to create an *advanced informatic system for information recording and communication regarding RES* and its economic effects (data bases referring to RES installations, producers, laws, grants, on-line library, on-line training- electronic card concerning the RES field use) with the purpose of protecting the environment by diminishing carbon dioxide emissions. The informatic solution will have in mind as main purposes the performance, scalability, platform independence and system accessibility. The proposed informatic system will be composed of a complex tool of interconnected databases, a programme system aimed at assuring the organizing of this data and an Internet access system for them. The newest platforms and software products destined to the development of Internet- accessible data bases (ASP.NET, SQL Server, JAVA, OLAP etc) will be used. The application's architecture will be modular, having the possibility of extension with new functionalities, without the disturbance of the existing components or the demand of reorganizing the data available in the system.

Demonstrative applications promoting the use of RES for energy production:

1.an application attached to the Solar Amphitheatre of Valahia University of Targoviste with the role of *calculating and displaying of environment parameters* influenced by the production of electrical energy. An electronic device will calculate the contribution to the reduction of carbon dioxide out of the produced quantity of energy and a large-dimension display will permanently indicate these values.

2.a Photovoltaic system with the power of 1500 W placed at the Galati University with the purpose of promoting the RES in the environment restricted areas.

3.a wind microtourbine post with the maximum power of 2kW, connected to the public network by a switcher and integrated in the supervising system of electric and environmental parameters will be assembled in the headquarters of the Electric Engineering Faculty.

4.a *hybrid system* made of Photovoltaic modules, Pb-acid batteries, diesel auxiliary generator and a Sunny Island switcher, at the same time with the possibility of also connecting a combustion pile system or/and a cogeneration power station. The hybrid system's main aim is the impact over the educational environment on one hand, being used as a didactical material for the Electric Engineering Faculty's students, and the obvious exterior impact provided by the supply of an intelligent illumination system in the area during the night with the public display of electric parameters on the other.

All these physical applications will also be covered by virtual advertising, by these means designing software *applications* which will interact with users from all over the

world, *assuring both tailored information for the general use and technical detailed information for specialists*, all structured in a way that facilitates the training and the building of competences in the field.

V. Conclusion

The project to be developed will have a significant *social impact.* There will be supplied optimal solutions for power supply of remote consumers. The developed demonstrative system will supply information for general use, but detailed technical information for specialists as well, structured in a way to facilitate the training and education in the field.

The modern info system on RES, web based, will bring the interest of the young generation for energy and environment issues and will facilitate individual expertise improvement by modern education methods. There will be created new local jobs by implementing RES project, also showing new technologies.

By rising awareness on RES use need, it may be obtained an *economic impact* on long term by RES development. The impact will be as important as the users region is less developed and more isolated. There will be offered practical solutions for implementing new technologies. The supplied information may orient potential investors what regards the economic and technical feasibility of the project they intend to develop. The duration to find good RES sites will be shorter. The *scientific impact* consist in obtaining a more experienced research team, with members rising their own research expertise and able to recommend them in national and international R&D similar projects.

The achievement of the projects goals will have a technical impact and on the energy policy too, by presenting low cost technical solutions, which could be the starting point for new projects, research oriented or introducing new informatics tools and by presenting basic information for a strategy to a rapid RES development. Each MWh produced by RES avoids the import of 0.286 toe.

An *environmental impact* is obtained by raising the electricity production from RES. Each RES produced MWh reduces the GHG emissions by 480 kg under the Romanian electricity production mix. Also it is avoided the pollution of remote areas by supplying power by diesel fuelled systems.

References

[1] ***, “Kyoto Protocol”, *www.wikipedia.com*.
[2] Ministerul Industriei şi Resurselor, “Sursele regenerabile de energie între Directiva Europeană 77/2001 si realitate”, *www.tmt.ugal.ro*, 2003.
[3] Ministerul Industriei şi Resurselor, “Strategy for the Renewable Energy Sources Utilisation in Romania”, Bucharest 2004.
[4] M. Matei, M. Marinescu, A. Stanca, L. Matei, C. Sălişteanu, I. Udroiu, “Promovarea surselor regenerabile de energie-componentă a politicii de dezvoltare durabilă în România”, www.agir.ro, *Buletinul AGIR nr. 1/2007 ianuarie-martie*.
[5] Ministerul Industriei şi Resurselor, “Strategia energetică a României pentru perioada 2007-2020”, *www.enero.ro*, 4 septembrie 2007.
[6] Ministerul Industriei şi Resurselor, “Sursele regenerabile de energie între Directiva Europeană 77/2001 şi realitate”, *www.tmt.ugal.ro*, 2003.

Adriana Alexandru is graduated the Faculty of Automatic Control, University Politehnica of Bucharest (1976) and the Faculty of Mathematics, University of Bucharest (1982). Since 1998, she is Ph. D in Applied Informatics in UPB. She is Senior Researcher 1st degree at National Institute for Research and Development in Informatics, Bucharest and Professor at Valahia University of Târgoviste.

She coordinated several national projects in the field of energy efficiency and renewable energies and was scientist in charge of 10 European projects in PECO, INCO COPERNICUS, SAVE, IST and EIE programmes. She is author of 3 books, coauthor of 2 books and wrote over 100 articles published in Romania and abroad.

Prof. Alexandru is member of ISES, EHPA VDI, Evaluation Board for RELANSIN, INFOSOC and CEEX projects, and evaluator for FP V Programme.