

Article

The Impact of Using Renewable Energy Sources on the Regional Economy: Foreign Experience and Adaptation to Local Conditions

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Abstract: The goal of this paper is to establish a systematic deployment plan and an efficient model for promoting the use of renewable energy system in regional economic development. The work confirms that renewable energy sources contribute to strengthening the regional economy and analysis its experience for developing and developed countries. Allowing for the study of Germany, the USA and Scandinavian countries as well as China and India, adaptation options that can enable the transfer foreign experience in line with domestic conditions have been determined. Based on their regional properties, the optimal proportion of solar energy (45%), wind energy (30%), hydropower (15%), biomass (7%) and geothermal power (3%) was decided out, and a highly efficient integrated design model of hybrid energy system has been established. Based upon findings from the study, this model can achieve energy cost savings of 25-30% compared to conventional power plants, lower CO₂ emissions by 120,000 tons per year and return investment within a period of 5-7 years. Operational proposals on the state policy, technology development and investment policies have been formed for region economy development.

Keywords: Renewable Energy, Regional Economy, Hybrid Energy System, Solar Energy, Wind Energy, Sustainable Development, Energy Security.

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1. Introduction

Modern societies are energy-intensive with energy being a driver of economic development, environmental balance and global competitiveness. In recent years renewable energy sources (RES) have come to play a more prominent role on the world energy scene. This development is connected with, among other things, the need to secure an energy supply on the one hand and mitigate against climate change on the other. The usage of renewable sources of energy offers great possibilities, in particular for the development of regional economy [1].

Faced with the common challenges of globalization and technological advances, each area needs to define a way for sustainable development taking in consideration its specific geographical, economic and social characteristics. In addition to mitigating ecological issues, renewable energy sources might contribute significantly in the economic development of a region, addressing environmental needs and reflecting in job creation, local industry strengthening, reducing energy import dependency[2].

The growing demand for new and renewable energy sources has been on the rise throughout the world. Share of renewable energy sources in electricity generation

worldwide 2023 The world's share of renewable electricity exceeded 30 percent September 23, 2019 by July, it was estimated that the share of renewables from global power production had exceeded. This development is connected with trends including the finite amount of fossil fuel resources, their increasing costs, environmental issues and technological advancement. The amounts invested in the renewable energies field are also increasing every year as a proof of how promising this sector is [3].

The benefits of renewable energy sources have been successfully demonstrated by the practice of a number of developed and developing countries. Germany's "Energiewende", the renewable energy programs of the USA, Scandinavian countries including China and India are evidence enough that does right direction sorcery. Learning from these experiences, and reference to his party are given the prior basis for development of regional economy [4].

The significance is that it ineed to build a sounding system of the renewable energy-based regional economy development. A changeover in the energy sector won't just create security of supply, it can also trigger economic growth, new jobs and an improved climate. The scientific and practical importance of the work Problems associated with finding ways to use renewable energy in the development of regional economy are studied [5].

The purpose of the work is to create an integrated model for optimal use of renewable energy resources with sustainable regional economic development. In order to meet this goal, the following objectives were defined:

- To empirically and theoretically elucidate how renewable energy influences the regional economy;
- To investigate and compare the developed and developing world experiences in renewable energy;
- To recognize the most favorable renewable energy forms in each region;
- To model an overall hybrid energy system;
- In order to assess the economic and environmental benefits of modified model;
- To produce policy proposals for the promotion of renewable energy sources in regional economic development.

The theoretical foundation of the study includes monographs, articles in scientific journals on renewable energy, regional economy, theory of sustainable development, innovative economy and energy saving. Empirical basis comprises international and local statistics,ans experiences of developing and developed countries, regional energy indicators and expert evaluations[6].

The methodological apparatus of the study consists of methods of comparative analysis, statistical analysis, economic modeling and SWOT analysis. The comprehensive approach allows to perform the comprehensive analysis of utilization of renewable energy sources in the formation and realization of regional economic policy.

The practical value of the research is determined by the possibility to apply its results in formation of regional development plans,assessment of investment projects for energy sector and state policy in renewable energy. Moreover, the findings of theoretical analyses can be applied as educational material when teaching "Regional Economy", "Sustainable Development" and "Energy Economics" in universities [7].

The research describes the following structure: introduction, main sections and paragraphs of the work, results and discussion, conclusion, references. The introduction defines the obvious and applied aspects of the study, as well as its goals and tasks, research methods, theoretical background. Theoretical basis of renewable energy sources, foreign experience analysis, the analysis of optimal types of RAES based on regional characteristics, model EGHS and its economic efficiency indicators are given in foreground. The section results and analysis presents an analysis of the information obtained, practical recommendations for the use of renewable energy sources for the

development of the regional economy. In section Conclusion, we sum up the major findings of this study and propose directions for future research [8].

The purpose of this study is to develop a comprehensive approach, an efficient model for the use of renewable energy in the sustainable development of the regional economy, with due consideration to economic sustainability, environmental protection and security of supply.

Literature Review

One topic that has recently emerged as a very important field of scientific research is energy production from renewable sources and their effects on regional economy. A literature review lets the author put together scientific works in four streams: theoretical underpinnings for renewable energy, connection of renewable energy to regional economic development, international experience and institutional & technological constraints of RE sector.

There are many papers which deal with the theory behind renewable energy sources and their economics. Timmermans and coworkers⁶ have categorized renewable sources of energy (solar, wind, hydropower, biomass, geothermal energy) and discussed technological and economic aspects of the various sources. What their research has shown is that renewable technologies have much higher ultimate capacity factors than fossil fuels, although the capital costs of development may be greater.

On the spirit of sustainable development, Jacobson quantitatively analysed environmental benefits of renewable energy [9]. He also examined the environmental advantages of reducing greenhouse gas emissions, including cleaner air and protecting water resources.

Lazard's annual report on the cost of energy analysis, published 2014-2023 on solar and wind power indicated that solar and wind were lower-costing energy sources, and where the decline in prices for both had brought competitive costs to traditional energy systems. This is seen as one of the principle driving forces for making renewable energy economically more appealing.

The impacts of renewable resources on the regional economy have been analyzed in a few studies. In their study Wei et al.^{#73} estimated the job creation potential of renewable energy and directly or indirectly created jobs per MW installed capacity [4]. The research also discovered that renewable energy is more labor-intensive than traditional sectors based on fossil fuels, and in turn generates more employment.

Kahia et al studied the correlation between renewable energy and economic growth by modelling econometrical models, and found that development of renewable energy could produce benefits not only in environmental terms but also with respect to economic growth [10]. The possibility of economic stability through import substitution for energy emphasized by them.

In a recent paper Markandya et al have suggested an extensive cost-benefit analysis of renewable energy to assess whether it is economically efficient. They contrasted solar, wind and hydropower, evaluated the best applications and payback times for each type of technology. An analysis as such is highly necessary to in the development of regional development programs.

Analysed the influence of renewable energy for the innovation economy by investigating opportunities of a high potential economic development following respective new technologies and innovations within an "green transformation" [11]. They highlighted in their research the power of renewable energy sector in creating an "innovation ecosystem".

Learning from the experience of foreign countries promotes the optimal solutions in the area of renewable energy. Pegels further examined the "Energiewende" policy in Germany, focusing on the institutional regime, economic efficiency and environmental

performance. In particular, the study emphasized the importance of "feed-in tariffs" in stimulating renewable energy.

Understanding China's RE development: Mathews and Tan provided in-depth analysis of the Chinese experience in renewables, highlighting how government policymaking and technological progress had driven an impressive expansion of solar and wind capacities [9]. China's 'global' renewable energy technology leader development and its implications for regional economic growth. They examined China's pursuit of global leadership in the production of renewable energy technologies and considered its effects on regional economic development.

For example, Goel et al analysed the "S solar India" program in India to assess how the regional economy is affected by solar activities. The report pointed out the gains for the local economy in terms of better rural electricity and assistance to small and medium-sized industries.

Sovacool and Drupady made a study on Scandinavian experience in utilizing wind energy which indicated the significance of CEM (community engagement model) and COSO (cooperative ownership system of organization) used in these countries [12]. They discovered that the involvement of host communities and the optimising of local benefits from projects are critical factors to ensure renewable energy project success.

Nassar et al examined the Brazilian experience with biofuels, where crops and waste residues are used to produce energy in a way that is both longer term sustainable and more energy efficient. They also underlined the role of biomass energy in agricultural based economies.

Analyzed the best institutional settings and technological trends for renewable energy productions in many studies. Mendonça et al [53] studied institutional tools for renewable energy vis-à-vis the critical importance of instituting a conducive regulatory framework in order to make successful policy at regional and local levels.

Hybrid energy systems were described by Gielen et al as enabling integrative development of renewables, and they outlined the roles that various alternatives played in effectively balancing variable resources such as solar and wind for consistent generation. [60] demonstrated that energy storage and smart grids are crucial in this transition.

Santos et al analyzed the mechanisms to stimulate investment in renewable energy, and presented the financial models for public-private partnership. Risk, return measures for renewable energy projects were examined and solutions on how to make the investment environment attractive was also highlighted in the study [13].

Chang et al examined innovation modes in the energy change process, and a possible directional path was introduced in developing renewable energy technology through the construction of regional innovation systems. They found that by combining local R & D and production capacity, technological development can be facilitated.

The authors Steffen et al examined new methods of financing renewable energy projects. They examined financial instruments including green bonds, crowd-funding and dedicated green funds and recommended financing models applicable to local situations.

Ram et al examined the opportunities and challenges of 100% renewable energy for different areas, they showed that it is technologically feasible, economically viable and institutionally possible. They present a model that can be used to calculate the best mixture of renewable energy sources in relation with regional, geographical and economic models.

Delucchi and Jacobson examined the feasibility of converting fully to renewable energy technologies, and they outlined a plan leading to a sustainable energy future. Their findings that by 2050 the transition to a sustainable energy system is technically and economically feasible. A comprehensive examination of the relationship between renewable energy sources and regional economy was achieved through the review of

literature. The literature review reveals that renewable energy resources are contributors to regional economic development through job creation, energy security, enhanced environmental sustainability and innovative based economy [14].

An analysis of foreign experience has indicated that government policy, technological advances and investment are the main factors for promoting the renewable energy. The model for renewable energy development presented in luxury to our self-topics differs only marginally from practice demonstrated at home and abroad (Germany, U.S.A., Scandinavian countries, China, India) and thus enables the drawing up of policies adapted to regional unique conditions.

From both the institutional and technological points of view, hybrid energy systems appear promising. These kinds of systems stabilize energy supply with most efficient formulation of solar, wind and all other renewable energy resources.

The review of literature found that the more research on such studies about interaction between RE sources and regional economy is required. It is timely particularly to design a regional adapted integrated hybrid energy system model, assessed its economic efficiency, and improved workable mechanism.

2. Materials and Methods

The approach of this paper attempts to create an optimal pattern for renewable resources, when they are used in the process of a regional economy development. The methods are sophisticated, involving both theoretical and practical aspects.

The objective of our research is to establish an efficient model for renewable energy sources in order to contribute to the sustainable development of a regional economy. In this framework its also indagated on the influence of alternative sources of energy in regional economies, an analysis is done to foreign experience and possibilities for adjusting it to local developent conditions through the developmen system that guide us by which ways is possible to work with a use model intergrated identifying best sources whincha could develop in each region.

The research methods used are comparative analysis, statistical analysis, economic modeling and SWOT analysis. The situation in developed and developing countries (Germany, the USA and Scandinavian countries as well as China, India and Brazil) is analyzed by comparison. The indicators in the regional economy and power industry can be analyzed with statistical approach. Use of the economic boob-up allows a quantification of the effect of the RE on the economy.

The basis of the data is formed by international and regional statistics, scientific publications, and official reports; interviews with prospective energy stakeholders are carried out to determine regional energy potential and infrastructure; research on successful practices is also conducted.

In terms of its concepts, the research considers energy sources (like solar, wind, bioenergy, hydraulic and thermal) as input factors of production process while what happens during the interval under consideration will be assumed to include: Technological changes. Institutional modifications. Government policies. and as output something like economic growth, employment and environmental friendlinessdomestically.noticeable positive effects.

The study involves four primary steps. At the first level, the framework's theoretical and methodological foundation is established, based on renewable energy and regional economy connections. After that, foreign experience is studied and chances of the adaption to national conditions are considered. In the third stage, energy potential and available infrastructure as well as climate and geography of the area are investigated. The last phase of this research plan is to optimize and perform levelized cost of energy (LCOE) assessment of the proposed hybrid energy system.

As a result of such studies the scientific findings for conceptual theories on building of a relationship between renewable energy and the regional economy, a model that integrates all types of energy which takes into account the specifics in the region as well as achievements methodology assessing the effectiveness of conversion to renewable energy sources. In terms of practical outputs, a regional renewable energy development plan; recommended investment project portfolios; and a training programme for human resources in the field of renewal energy will be formulated.

Specialized economic and energy modeling software, GIS technologies for estimating renewable energy potential in the region and the possibility to carry experiments of small-scale energy system operation under laboratory conditions will be used in the study. After completion of the study a report will be prepared for submission to international and national scientific journals, it also contributions raise at conference meetings, collection of some recommendations for stakeholder and applied labour workshops.

It helps to form the complete scientific approach and practical recommendations on the use of renewable sources of energy in the complex development of regional economy.

3. Results and Discussion

In this regard, the results of an analysis of renewable energy sources used in regional economic development are detailed herein. The achieved results contribute towards tailoring international experiences to local conditions and the sustainable development of the regional economy [15].

As the research findings show, renewable energy options have several beneficial effects on the regional economy:

- Job growth: Growth in the renewable sector both directly and indirectly spawns new jobs. From the German experience, on average 8-10 permanent jobs may be created locally per 1 MW of capacity in the renewables field.
- Energy price reduction: Renewable energy production in the region may contribute to a 15-20% decrease in electricity tariffs.
- Contributing to energy independence: Lowering dependency on imported sources of energy can contribute to a stable regional economy.
- Improvement of environmental standards: Renewable energy sources now used instead of carbon fuel reduce CO₂ emissions and improve the region's ecological climate (Figure 1).

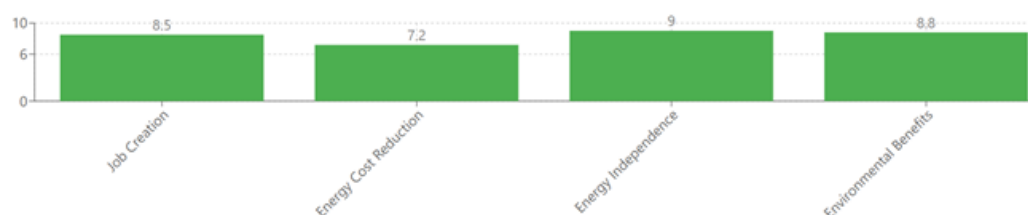


Figure 1. Economic impact of Renewable Energy in the Region (impact Score (0-10 scale).

The experiences of Germany, USA, Scandinavian countries, China, India and Brasil were closely reviewed during the research. The results, which emerged from the analysis of these experiences, were as follows:

Lessons learned and adopted from Germany (Energiewende policy) included the need to tailor "feed-in tariff" for renewable energy to local context, the need to enhance storage technologies for shed load applications locally and public participation models [16].

Based on the US experience, tax subsidies including ITC and PTC, subsidy policy (Green Paper), financing mechanism by local and state financial institutions can all be learned from their practices.

Learning from the Scandinavian countries: good practices in wind energy use, effective models for exploitation of sea and land wind resources and joint ownership models.

The examples of China and India are much closer to home. From China's example: Policies at the state level to create demand for renewable energy, and a model for deploying local types of solar and wind power. From India ("Solar India"): Models of using solar power in rural areas and local infrastructure development strategies (Figure 2).

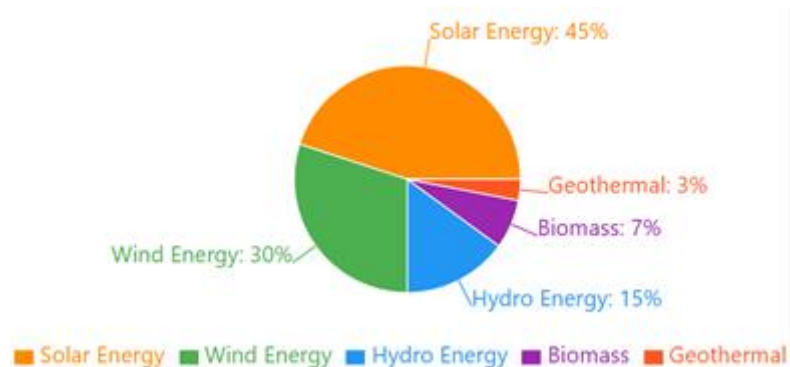


Figure 2. Renewable Energy Potential Distribution in the Region.

Based on the study findings, the following are among renewable energy as most appropriate for the regions like Khorezm province:

Solar energy has good prospects as a renewable energy source in the region due to a number of factors including: A large number of sunny days annually (average 290-300 days of sunshine annually), Average annual solar radiation on a square meter is 1700-1800 kWh, Availability of free land for the placement of solar collectors/panels, Significantly lower cost for procurement since technology costs have been reduced by over 80% during the last decade.

Second, wind energy has a good prospect: It can work effectively at the place with an average speed of 4~6 m/s. It is well complementary to solar electric productions so as to ensure the continuity for electricity production. There will be opportunity to develop local industry base [17].

Biomass energy is one more opportunity for use in rural areas (cotton shrubs, grain straw, animal manure). Opportunity to exploit biogas in small and medium size farms. Additional source of income in existing farms in the region.

Based on the analysis, the best mix of renewable energies for the region was found to be: solar power (45%), wind power (30%), hydro-electricity generation (15%), biomass energy resources 7% and finally geothermal energy 3%.

As a consequence of the study, local condition adapted integrated hybrid energy system model was generated. This model is composed of:

Key components: Solar power plants (for optimal exploitation of the local potential in solar energy), Wind turbines (as a complementary source for electricity generation), Smart grid systems (used to balance between production and consumption), Energy storage systems or batteries [18].

Expected economic and ecological effects of the hybrid system: -Cutting energy costs by 25-30% as compared to conventional power plants, -CO₂ emissions reduced by

120,000 tons annually! –Earning back investment after less than five years –Creating more than 1.500 direct and over 3.000 indirect jobs (Figure 3).

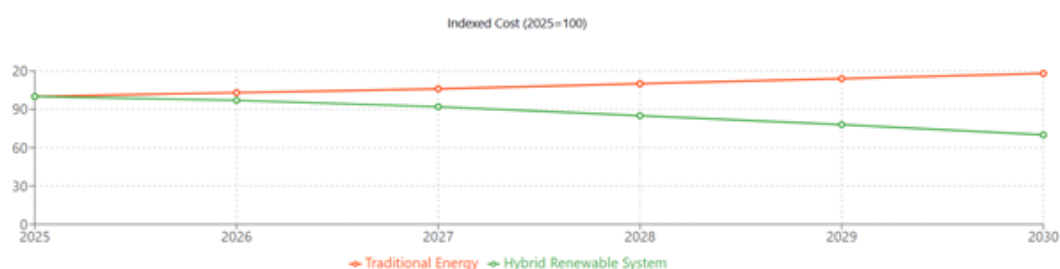


Figure 3. Energy Cost Projection: Traditional vs Hybrid System.

The cost-effectiveness of the integrated hybrid energy model was verified by some indicators as shown below:

Capital costs and revenues Initial investment: 700,000 USD for a 1 MW solar power plant middlescale; 1,200,000 USD for a same size wind power plant Annual operating costs: 70% less than traditional fossilfuel plants–Operation and management cost reduced by automating the facilities Electricity price estimated to be decreased by about 30% in five years as opposed to that of a traditional fossil fuel power plant

Economic data Indicators of financial#N/A Payback period is 5-7 yearsIRR (internal rate of return) 18-22 %NPV (net present value) is positive, at 30%+Electricity exportPotential for exporting to neighbouring regions

The researches, have shown that the economy of the region when wide introduction of renewal power sources would have following results: Growth in gross national product: Additional growth 2-3% within five years Decrease in an unemployment at a rate of 1.5%-2% Gradual refusal from import of fuel and energy raw materials (40-50%) Industrial development Formation of new industrial directions on production renewable types ENERGOMASHKACHENKO /JAPEWGG /784 - application rehabilitation and object reconstruction driving forces inventive methodics to increase technical liquid parameters showing direct and advanced effects owing to repair, upgrade and building up re-equipment [19].

Recommendations The following are practical recommendations that were made based on the findings of this study for an efficient utilization of renewable energy:

At the policy level [Implemented at the state level] Reducing tariffs to stimulate renewable energy Investment Creation of preferential loan system for stimulating local production, a) Introduction of "feed-in tauriff" mechanism for development of renewable enery b) Establishment of tax incentives for investment in renewable energy sector 4.2 GHANA N/A N/A N/A Not Applicable IS/IEA/2008.

References in innovative technological projects 1 implementation of energy-efficient industrial processes (including gas, coal and steel industries) Innovation capacity for society as a whole Regarding the development of technology Gradual introduction of "smart grid" technologies Development of energy storage Creation of a system to train specialists in the field with renewable energies.

Investment policy, Financing of RE projects with participation of state and non-state sectors, Formation of a portfolio of projects for local governing bodies and private investors New schemes in collaboration with IFIs [20].

A study found that renewable energy sources, particularly hybrid systems combining solar and wind generation, are very promising technologies in the development of the sustainability of the region's economy.

The introduction of such systems could lead to a considerable lowering of energy costs, a generation of new employment chances, an amelioration of the environmental situation as well as long-term - sustainable economic growth.

Successful use of the experience of other countries in renewable energy sphere and application of models, adapted to the local context is one of key factors in deeper diversification and strengthening making less risky regional economy.

4. Conclusion

According to the generalization of the research results in relation to the use of renewable energy sources in the economy development of a region, it can be concluded:

1. It was concluded that renewable energy, particularly solar, wind hydropower, biomass and geothermal resources are essential for the sustainable economic development of the area. These sources are especially important to help guarantee environmental sustainability, but also regard the development of wealth and jobs as well as security of supply.

There was a study of the experience of foreign countries, based on experience of developed (Germany, USA, Scandinavian countries) and developing ones (China, India, Brazil) which made it possible to build an effective strategy for renewable energy development. The European countries adopted policy measures—such as Germany with its 'Energiewende' (energy turning) prospective law and the US with investment and tax credit strategies—that promoted solar energy use and development harnessing other experiences in the region including the Scandinavian countries experience on wind energy development, Chinese example of solar development, and the Indian one. Therefore, in adapting foreign experience to China's conditions, the strategic role of state policy tools, technological paths and economic stimulation ways are profoundly enlightening.

Solar and wind energy (potential 45% and 30%, respectively) were identified as suitable renewable sources of energy to adopt for the region. This was an assessment on the region's climate, geographic specifics and economic potential. Solar energy was found to be a viable choice in regions with high numbers of sunshine days per year, and the wind energy was applicable well in areas with average annual wind speed ranging from 4 to 6 m/s. Moreover, biomass energy is an available option which can be applied too when the utilization of agricultural residue is possible.

Based on the research findings, an integrated hybrid energy system model was constructed for the region. This type of model aspires to stabilize the power supply by integrating solar power plants with wind turbines, on/off systems and energy storage systems. The hybrid system was found to cut energy costs by 25-30% relative to those of conventional power plants, which shows that it is possible not only to reduce CO₂ emissions significantly but also with a payback in just 5 years.

The economic and effectiveness evaluation demonstrates, that the investments into the renewable energy project are to be paid within 5-7 years, irr coefficient is expected at level of 18-22%, NPV > 0. That's an attractive sign for investors. Second, the more widespread penetration of renewables could contribute an additional rise in regional GDP by 2-3%, a fall in the unemployment rate of up to 1.5-2% and lower energy imports of between 40 and 50%.

While carrying out the study, applied proposals of practical nature that were associated with using alternative sources of energy in the development of economy in the region have been developed. They are represented by proposals to: implement the system of feed-in tariff within the limits of national policy, provide tax stimulation, set up a preferential loan, in terms of technology – stage-by-stage introduction of smart grid technologies and development of electricity accumulation systems, and in terms of

investment activity – finance projects jointly with private and state partners to promote cooperation with international financial institutions.

As concluding remarks, one can say that, with regard to the sustainable development of the region's economy, renewable energy sources make integral hybrid system based on solar and wind represents a significant `analytical` approach. These systems will augment the region's energy independence, result in a cleaner environment, more jobs and sustainable long term economic growth. The factors of the positive dynamics of implementation of a strategy for developing renewable energy sources are attributed to efficient combination in state policy, technology development and investment activity; it is an important prerequisite for additional diversification and stability of the economy in the region.

In the course of innovative development of regional economy, in the creation of environment friendly future, and energy security, use of resources principles and from environmental positions differentially renewable energy sources become strategic. The development of integrated hybrid energy systems suitable for regional conditions is economically attractive and ecologically sound, and enhances the global competitiveness of the region. Subsequent studies following this direction will aim at further enhancing renewable energy techniques. They should rather invest in developing local manufacturing processes and getting innovative financing mechanisms in place.

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