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HYBRID ENERGY SYSTEM BASED ON THE MIX OF FOSSIL AND RENEWABLE ENERGY RESOURCES

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Abstract: *In the article, the authors present the approach of combining energy production systems, sub-systems by obtaining specific advantages, facilitating the efficient conversion of resources subject to advanced energy-thermal treatment, and solutions are proposed for the creation of a "photovoltaic - other combining resources" matrix. obtaining the generational energy mix. The paper describes the endogenous economic growth through the knowledge of hybrid technological processes, the technical and technological changes in the field of energy, the relational implications in the field and advances the proposal of a hybrid energy system based on the mix of geothermal energy resources from closed coal mines) and renewable energy resources solar. Also, the breakdown of energy/geothermal heat sources recovered from galleries and long-front abattoirs as lots of a sub-system of energy production in a hybrid energy system based on the mix of geothermal mining and renewable solar energy resources is reported. The authors conclude that the addition of the "hydrogen production" sub-system to the hybrid energy system based on the mix of fossil and renewable energy resources represents extensive conceptual and operational specific development.*
Keywords: *renewable energy, hybrid energy system, mix of energy resources, mining geothermal energy*

1. Introduction

The realization of energy becomes more and more extensive conceptually and operationally, which implies the call for associations, compositions, articulations, etc. between different systems and subsystems, varied infrastructural and from the perspective of providing primary energy resources to formalize the set of commendable values (outputs) in the general energy system, local, regional, global.

The use of renewable energy sources comes back as a general societal task from the provisions of the Renewable Energy Directive (D 28/2009/EU) and the Energy Efficiency Directive (D 27/2012/EU).

Added to these are provisions from the Energy Performance of Buildings Directive (D 31/2010/EU) which activates the requirement to improve energy performance in Europe's built infrastructure.

Romania has harmonized its domestic legislation in the field with the European one regarding renewable energy sources, efficiency and energy performance of buildings.

The document entitled European SET-Plan - Towards a European Strategic Energy Technology Plan, includes for Romania a model of requirements that transposed through legislation the achievement by the year 2025 of the levels of 20% reduction in greenhouse gases, 20% decrease in energy through efficiency, 20% of the required to come from renewable sources and 10% from bio-fuels.

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European directives on minimum energy performance standards, regulations on reducing CO_2 emissions for vehicles, energy performance labeling are complementary documents that show the increased attention paid to the field of energy from production, distribution, to consumption.

The combination, for example, of two systems (geothermal mining and solar) allows the fruition of specific advantages, covers the requirements of seasonality in operation, facilitates the efficient conversion of resources subject to processing, advanced energy-thermal treatment.

The more responsible use of the available energy raw material, the optimization of production cycles and, as such, the reduction of emissions through the continuity of combustion (avoiding the critical start/stop moments of the energy conversion system, technical, technological, organizational complementarities, - all represent the initial parameters of formalization of hybrid energy systems.

2. Research from the specialized literature

The study of future energy scenarios, according to the authors Novo, R., et al., (2022), [1], needs "a time frame of an open-source energy system model".

If the achievement of local, zonal, global energy sustainability includes industries and fields with a mining, electrical, thermal, transport profile, etc., this accompanied by decarbonization leads to transversal benefits such as the reduction of mortality caused by pollution, stable costs of energy supply, materials, new jobs etc. In context, the authors show that forecasts of long-term evolutions of energy systems are needed to address the most appropriate decarbonization pathways, cost-effectively and reliably.

Also, the authors note that by modeling the energy system the need for energy storage "grows linearly in terms of power capacity, but exponentially in terms of energy quantity" and suggests the formalization of "reserve capacity options with feed mechanisms -backs".

Gupta, A., et al, (2011), [2], points out that a hybrid power system can be cost-effective and presents an integer linear mathematical programming model to design its reliable operation, cost optimization (minimization of the objective function of cost in relation to energy demand and possible restrictions).

In fact, it is about creating a "photovoltaic - other resources to combine" matrix, obtaining the generational energy mix.

In numerous papers, studies and scientific reports it is shown that hybrid energy systems each comprise two or more variants of electricity generation based on renewable energy in combination with (decreasing) use of fossil fuels.

On the other hand, according to the authors Sinha, S. and Chandel, S.S., (2014), [3], the analysis of hybrid systems is complex and frequently requires software tools to design, optimize and measure their economic viability. In this context, the need for the development of new conversion technologies is felt, for renewable energy in the analysis it is possible to use time series to establish the energy potentials pursued, scheduled to be reached.

Often, specialized software is used, for example, System Advisor Model (SAM), and Hybrid Optimization of Multiple Energy Resources (HOMER) can be used for dimensioning the hybrid energy system. (Bhandari, B., 2015), [4]. In this framework, two or more renewable energy sources used together provide efficiency and balance in energy supply.

Recently, Thirunavukkarasu, M., et al., (2023), [5], through in-depth research shows that it is essential to evaluate hybrid energy systems "using economic and sizing criteria, optimization techniques based on classical methods, intelligence artificial intelligence, hybrid algorithms and software tools'.

The mining industry contributes 4–7% to global greenhouse gas emissions from electricity consumption for the mining process.

Ampah, J.D., et al., (2023), [6], resort to investigating the technical, economic, environmental and social feasibility in the situation of adopting renewable energy sources for the coal mining process, using HOMER Pro software. [7]

In this context, sensitivity analyzes are needed to measure the performance of energy systems under current and future uncertainties.

Gaitan, N.C., et al., (2023), [8], conclusively presents an intelligent energy management system solution for multiple renewable energy sources as a formalizing premise for hybrid systems in the field.

There are also proposals for energy management systems with a hybrid platform in which photovoltaic and wind generators are associated with energy storage infrastructures based on fuzzy logic control, with stochastic optimization mechanisms of the binary function type "Energy production system - Energy storage system".

One can call, for example, to algorithms with "balance optimizer" tasks, when energy sources are activated according to demands, and the surplus is efficiently stored.

The software HOMER (Hybrid Optimization of Multiple Energy Resources), [7], simulates the dimensioning of the mentioned binary energy system.

In conclusion, Zohuri, B., (2018), [9], shows that hybrid renewable energy systems "are becoming popular as stand-alone power systems for providing electricity in remote areas".

3. Scientific research methodology and theoretical-scientific support

In the context, extensive documentation was used regarding the achievements in the field of harmonizing the requirements in question with the resources and the delimitation of the problem classes and models in the field. The methodological basis of the research includes a range of analytical and synthesis approaches specific to the investigated area.

The deep and systematic analysis of the quality of the environment and the formalization of the Integrated Management System, (SIM), are basic subjects of research among scientists from the industrial-productive, engineering, managerial and economic fields in developed European countries.

A structure of an energy system is based on: 1) regions, delimited areas for supply and demand, 2) energy resources, fuels, 3) technologies of exploitation and energy utilization, and 4) spaces, energy storage infrastructures, warehouses, all these elements being found in time parameters.

Analyzing the situation in the field of organization and management of environmental quality, safety and health at work in the Valea Jiului Carboniferous Basin (Bărbulescu, Ad., 2022), [10], exemplarily, methodologically, the generic causes of the appearance of mining environmental disturbances are identified such as:

- the concern of the executive of each mining unit for immediate functional interests;
- the national and ministerial managers (environmental protection and occupational health) and those in the capacity of owners of mining enterprises are separated from the zonal management of environmental quality, safety and occupational health in the coal mining area;
- the management of each mining enterprise frequently acts in the name of the interests of its own organizational entity and less in the zonal, integrated interest;
- the costs for actions on the stated directions of interest for the area as a whole are borne by the state budget, not by the executive or the management of the mining companies.

As such, methodologically, the need to develop a new theory of environmental quality management is motivated by the complexity of the processes that dominate the mining units and the economic, productive and social environment in the coalfield area, with the potential for generalization in other areas where natural energy resources are exploited.

In this way, the proposal of a Processing and Management Center for Environmental, Safety and Occupational Health Information Decisions was developed within an Integrated Management System. (Bărbulescu, Ad., 2022), [10]

4. Results and discussion

4.1. Technical and technological changes in the field of energy. Relational implications

Technical change, with premises for the formalization of hybrid technical systems, refers to the modification of production techniques at the level of an entity (company, sector, industrial branch, etc.), based on the results of research and development and on knowledge (learning "about"...) from innovation / innovation. (Gâf-Deac, I.I., 2022), [11]

Technical change is introduced in the economic-productive systems, in those of energy production, in order to define the diffusion and development of a new technology, which will determine programmed ("targeted") changes on the lower "relative price" factor in hybrid technological structures.

In general, endogenous technical change is used in modeling to indicate technical changes, but also technological changes within the model, to the extent that they manifest with visible doses of neutrality. (Gâf-Deac, I.I., 2022), [11]

Technological change represents the application of new scientific knowledge and principles on production techniques, determining effects on economic activity.

The Schumpeterian vision of technological progress is found in the sequence of three evolutionary stages, formalized by: 1) invention, 2) innovation and 3) diffusion of knowledge. (Radu, S.M., 2021), [12]

Technological change becomes recognized if an economy (Δe) is recorded on an input (i) that causes a decrease (δp) on the constant price factor (p):

$$[(\Delta e) * (i)] \xrightarrow{(\delta p)} \min (p)$$

Technological progress can be modeled with the help of endogenous and exogenous factors of technology. There are no strict boundaries between technical and technological change for the realization of hybrid energy systems, but on the contrary, a certain inter-change is noticeable.

4.2. Endogenous economic growth through knowledge of hybrid technological processes

The new theory of economic growth can be based, in ensuring its applicative continuity, on neutral technological progress (marked by neutrality), especially in the field of energy.

Neutrality does not mean the autarky of energy engineering learning/knowledge and, as such, informational externalities influence the endogenized growth process.

When investments for research and development in hybrid energy systems based on the mix of fossil and renewable energy resources are oriented towards obtaining profit from "newly technological" activities, the theory of endogenous technological changes starts from the assumption of employment in competitive markets, being visible the tendency to establish monopolistic conception.

If one witnesses the quasi-continuous increase in quality, or based on the demand for energy from the existing capacities, as performance it is deduced that technological externalities play a modifying role in production, causing reductions in recoveries, in a marginal context, related to investments (the capital invested in the systems hybrid energy based on the mix of fossil and renewable energy resources).

In other words, the operation of the existing energy capacities is prolonged and, as such, the recovery of capital expenditures is redistributed over a longer period of time.

Aspects related to integrated management systems (IMS) of environmental quality, safety and health at work in hybrid energy systems based on the mix of fossil and renewable energy resources require that different standards of management systems be found in application solutions in a single comprehensive, integrated system. Studies, researches and the results of scientific investigations in the field on an international level show that the implementation does not occur directly, through imposed regulation, but through articulations, compositions, compatibility between factors, parameters, between causes and consequences in a system of advanced knowledge and decisions in the face of anthropogenic factors.

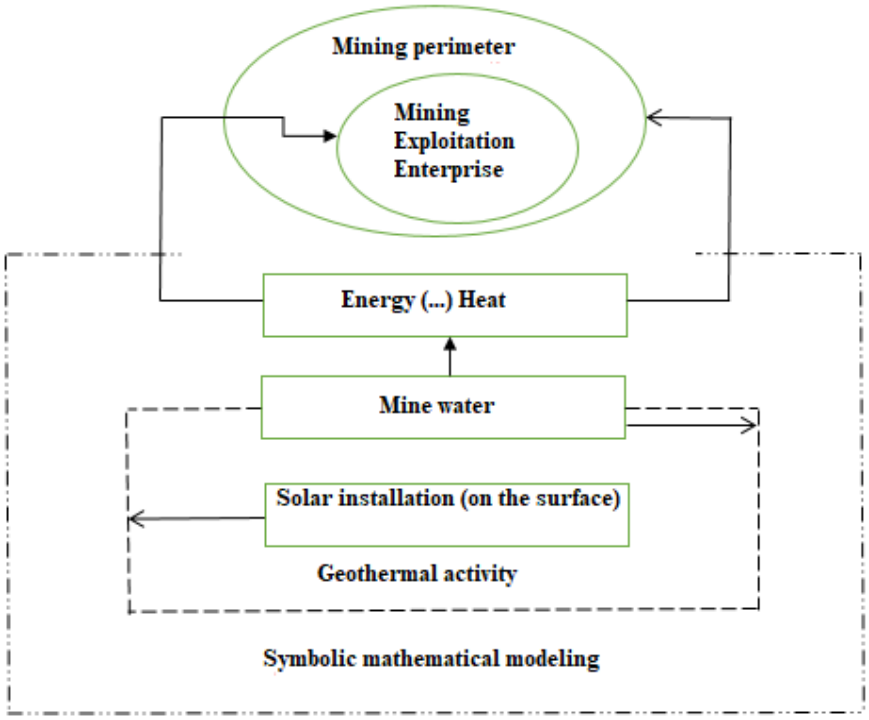

Figure 1. Proposal for a hybrid energy system based on the mix of geothermal energy resources from closed coal mines (Jiu Valley, Aninoasa Mine case) and renewable solar energy resources (Source: Mvongo Mvodo Charles Rostand, 2018/2020), [13]

Consequently, there is a need to identify new perspectives in relation to the current management methods of hybrid energy systems based on the mix of fossil and renewable energy resources, to influence the pro-active commitment of managers through more active participation in decisions, organization and management on efficient, programmed directions of energy and environmental problems.

We find that there is a need to identify, develop and create new theoretical and practical tools in order to establish how to apply measures to prevent anthropogenic effects from critical situations by formalizing hybrid energy systems based on the mix of fossil and renewable energy resources. (fig. 1)

The application extension of the proposal in fig. 1 is explained by the breakdown of energy/geothermal heat sources recovered from galleries and long-front abatements from the underground mine investigated for the connection of energy production sub-systems in a hybrid energy system based on the mix of fossil/geothermal mining and renewable energy resources. (fig. 2)

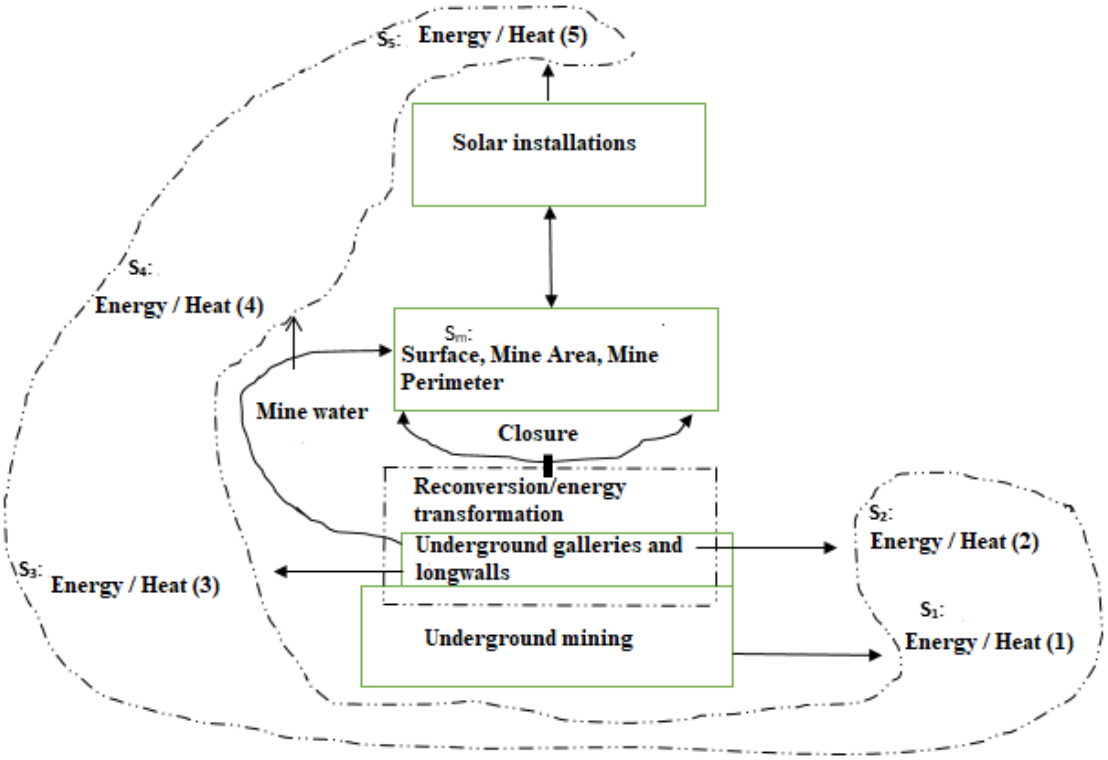

Figure 2. Decomposition of energy/geothermal heat sources recovered from galleries and long-front abatements as sets of an energy production sub-system in a hybrid energy system based on the mix of energy resources geothermal mining and solar renewables
(Source: Mvongo Mvodo Charles Rostand, 2018/2020), [13]

In underground mining spaces, the atmosphere is frequently hot (up to 30°C) and humid, and some overheating conditions represent risks for the life and integrity of workers.

Air conditioning (refrigeration) systems, water coolers and heat exhaust are often configured at the return of the ventilation system.

As such, assurances and responsibilities are necessary in the opening and closing phases of exploitation works regarding possible geothermal situations to confront/protect people and the deposit.

A geothermal installation refers to the set of equipment that allows the geothermal exploitation of a deposit of caustobiolitic fossiliferous substances.

Open (for example, fluid circulating in an open circuit in underground aquifers) or closed (horizontal, vertical or hybrid closed-circuit heat exchanger, fluid circulating in pipes, returning energy from the pipe) geothermal heat exchangers are useful, circuits primary (heat pumps) and secondary (associated equipment), intermediate.

The installation sites of geothermal heat exchangers must avoid the geological destabilization of the land and the risks of groundwater pollution, ensuring the tightness between geological horizons, karst areas with underground voids, soluble rocks, areas with risks of landslides.

In a broader context, in the first phase the energy from hybrid energy systems based on the mix of fossil and renewable energy resources can be used in the production area for the commissioning of some electrolysis facilities to obtain hydrogen in the range of clean fuels found on the agenda of decision-makers and developers of modern energy strategies. (fig. 3)

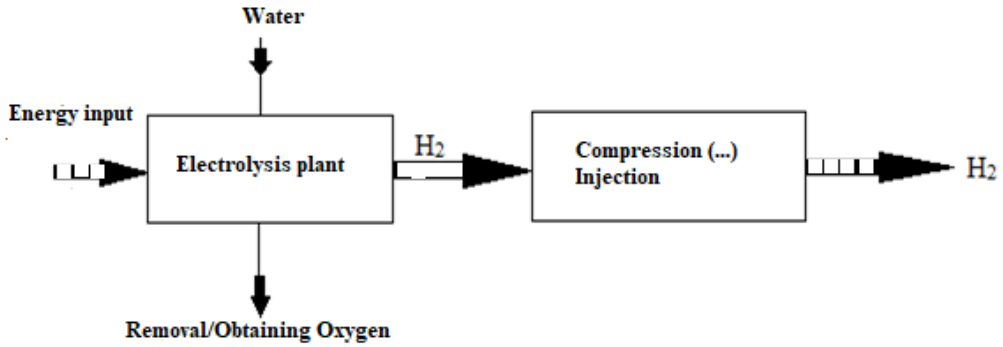

Figure 3. Energy from hybrid energy systems used to start up some electrolysis plants to obtain hydrogen (Source: Mvongo Mvodo Charles Rostand, 2018/2020), [13]

The addition of the "hydrogen production" sub-system to the hybrid energy system based on the mix of fossil and renewable energy resources represents extensive conceptual and operational specific development.

A strategy is considered "integrating matrix"/"matrix of connections" and tactics, especially under official regulatory influences, are the ones that can cause strategic stagnation or, on the contrary, the "transfer" of strategy with positive effects.

In this framework, the idea of resorting to investment disempowerment in the energy-mining field in Romania is launched. (Scutelnicu, I.P., 2022), [12]

In fact, a hybrid energy system based on the mix of fossil and renewable energy resources is of real importance, priority and opportunity in conditions of overlapping crises dominated by the energy crisis.

5. Conclusions

From the scientific investigations for the present theme results the requirement to establish new alignments in relation to the management of hybrid energy systems based on the mix of fossil and renewable energy resources.

The production of hydrogen included in the hybrid energy system based on the mix of fossil and renewable energy resources represents specific development in the field.

The proposal of a hybrid energy system based on the mix of geothermal energy resources from closed coal mines and renewable solar energy resources is pioneering in the field.

It is recommended to capitalize on the sources of energy/geothermal heat recovered from galleries and long-front abatements from underground mines to be found in hybrid energy systems based on the mix of renewable resources in combination with the classic, fossil ones.

We consider that through the creation of hybrid energy systems based on the mix of fossil and renewable energy resources, a contribution is made to the investment disempowerment in the energy-mining field in Romania.

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