OPINION

***on the dissertation** of Prof. Dr. Eng. **Aleksandar Georgiev Georgiev** on the topic:*
"Evaluation of mixed installations with alternative energy sources"
for obtaining the scientific degree "Doctor of Science" in Scientific field 4. „Natural sciences, mathematics and computer science", Professional field: 4.2. „Chemical Sciences", Scientific specialty „Processes and apparatus in the chemical and biochemical technology"
by Prof. Dr. Eng. Aleksey Dimitrov Benderev

General information about the procedure

This opinion was prepared on the basis of Protocol №1 of 13 January 2022 of the Scientific Jury on the procedure for defense of a dissertation for the degree of "Doctor of Science" of *Prof. Dr. Eng.* ***Aleksandar Georgiev Georgiev***, appointed by order of Order РД № 15-539 / 29.12.2021 of the Director of ICE-BAS. The candidate has submitted the required documents in accordance with the requirements of the Law on Chemical Engineering and the Regulations for its application at the Institute of Chemical Engineering - BAS. His dissertation was reviewed at an extended colloquium, at which it was recommended to start a procedure for his defense.

Brief biographical data of the candidate

Aleksandar Georgiev graduated in 1981 from the Technical University, Sofia, majoring in „Heat and Nuclear Energy". In 1984 he won a full-time doctoral competition at the same university and in 1987 he defended his dissertation on "Energy Conversion Technologies and Systems" and received the degree of "Candidate of Technical Sciences" (now "Doctor"). In the same year he won a competition and was appointed as a research associate II degree at the Institute of Meat Industry, Sofia, and since 1988 he has been engaged in research and teaching at the Department of „Mechanics" at the branch of Technical University - Sofia in Plovdiv, initially as a senior assistant, and later as an associate professor. At various times he was a visiting researcher at the University of Siegen in Germany and the Technical University of Federico Santa Maria, Chile. During the period 2011-2013 he was a lecturer at the European Polytechnic University at the Department of Green Energy and since 2021 he has been elected Professor of "Processes and Apparatus in Chemical and Biochemical Technology" at the Institute of Chemical Engineering, Bulgarian Academy of Sciences. Professor Georgiev has completed a number of specializations and courses in prestigious research centers in Germany, England, Chile, Italy, Spain. He has been the leader of 8 scientific and applied research projects and has participated in more than 10 as a contractor. He is the author and co-author of 116 scientific publications, including 1 monograph and has found over 800 citations of his works. He has an active teaching activity, as he was the head of 2 doctoral students. He is the main organizer of several major international conferences related to alternative energy sources and has been a guest editor of 8 specialized publications of renowned scientific journals.

Analysis of the dissertation

Relevance of the topic

Global problems with climate change and negative impacts on the environment are becoming increasingly important for humanity. One of the most significant problems is the supply of energy, mainly from fossil fuels. In this regard, in recent years there have been increasing opportunities to provide "clean" energy from so-called "alternative" or "renewable" energy sources. In this regard, the candidate focused on clarifying some

important and topical issues related to the search for innovative technical solutions to find and implement effective solutions for the use and combination of different types of approaches to provide alternative energy.

Content of the dissertation

The presented dissertation is based on many years of research of the author, a significant part of which are presented in his publications. It contains 345 pages of text, including used literature sources (229 titles), as well as a list of publications and reports on the topic of the dissertation. The text is well illustrated, including 29 tables and 201 figures. The dissertation is structured in Introduction, 4 chapters, General conclusions and Main contributions.

The *Introduction* examines the relevance of the research and sets out the reasons for choosing the topic and structuring the proposed dissertation.

The *First chapter* is entirely focused on the literature review prepared by the author, as the main attention is paid to the features of elements included in systems for obtaining clean energy, as well as different types of such systems. Attention is paid to their technical features, the way they work and the mathematical approaches used to predict their operation and evaluate their effectiveness.

Second chapter - based on the review made in the previous chapter, Prof. Georgiev presents the goals and objectives he has set in the development of his work.

In the *Third Chapter* the object of study are components included in systems of alternative energy sources - vacuum solar collector with flat absorber and heat pipe, and various types of thermal storages. Their technical features, results of field experiments conducted by the author, analytical and model solutions for forecasting temperatures and evaluating their effectiveness, taking into account the influence of various factors. Along with the study of the processes that take place in the technical components, the issues with the influence of the thermal properties of the geological environment have been studied in the case of underground thermal energy storages.

The *Fourth chapter* is one of the most important in the presented dissertation, because it deals with generally mixed installations for the use of alternative energy sources. Along with the technical formulations and theoretical foundations, attention is paid to the field research, numerical modeling and simulations, analytical calculations to characterize the processes and to determine the indicators characterizing the conversion, concentration, storage and energy use. Estimates of efficiency and the influence of various factors on them have also been assessed. In his dissertation Prof. Georgiev has considered the following mixed systems:

- *Solar collectors with water storage*
- *Refrigeration installation with built-in solar collectors and thermal storage*
- *Borehole thermal energy storage (BTES) with solar collectors*
- *Photovoltaic-thermal (PV/T) installations*
- *Ground source heat pump (GSHP) system with solar collectors*
- *Ground source heat pump (GSHP) installation using phase change materials (PCM)*
- *Mixed micro-cogeneration system with photovoltaic panels and Stirling engine for local heating*

In the sections *General Conclusions* and *Main Contributions* the candidate has summarized the main results and indicated the most important of them.

Contributions and significance of development

The main contributions formulated by the candidate are well reasoned and are divided into:

Scientific contributions - to them he includes detailed studies of the specifics of individual components and mixed systems with alternative sources, for this purpose created mathematical models and computer programs for simulations of ongoing processes in different modes, as well as verification of results with data obtained in conducted field experiments;

Scientific and applied contributions - based on field experiments, application of analytical methods and numerical modeling are simulated processes in different mixed systems with alternative energy sources, energy efficiency assessments are made and forecast indicators characterizing the possibilities for their use are determined.

Applied contributions - based on the results obtained, proposals have been made to increase the energy efficiency of individual units and systems. Methods have been developed for calculating their thermal characteristics with a view to their optimal use. Proposals have been made for new, more efficient constructions of mixed systems with alternative energy sources.

The results presented in the dissertation are important for the selection of technical schemes and for efficient and full use of alternative energy sources. They are of great interest both to scientists in the field of research on heat transfer processes and to practitioners in the design, development and construction of efficient technologies and technical means for the utilization of alternative energy sources. Also of interest are the studies on the connection between some of the considered mixed systems and their components with the geological and hydrogeological environment, as well as the prepared numerical solutions and model simulations for utilization and the expected changes in the natural thermal field of the earth layers and groundwater.

Abstract and publications on the topic of the dissertation

The abstract is prepared according to the requirements and reflects the most important moments of the dissertation. Prof. Aleksandar Georgiev has presented his current results, which are summarized in the work presented so far, in 36 publications in the period from 1989 to the present. 15 of them have been printed in the last 5 years. 15 articles have been published in renowned journals with Impact factor, and 11 - in specialized international journals or collections of reports from prestigious international conferences. The candidate for the degree of "Doctor of Science" has so far found 244 citations of his publications related to his dissertation.

Implementation of scientometric indicators

According to the accepted scientometric requirements in the "Regulations for the implementation of the Law on the Development of the Academic Community in Bulgaria", to obtain the degree of "Doctor of Science", the candidate must score at least 350 points, which includes 100 points that he would receive after the defense of current work (indicator Б). The remaining points are obtained from the summation of points for a defended doctoral dissertation (indicator A), from publications (indicator Д) and citations (indicator Е). In the analysis of the presented materials it was established that Prof. Al. Georgiev, with a successful defense collects 674 points. Of these, 50 points are on indicator "А". The points on indicator "Д", which are formed as the sum of the points for each article divided by the number of authors, are 266 (with a required minimum of 100 points), and on indicator Е collects 258 points.

Critical remarks and recommendations

The presented dissertation contains processing, analysis and summary of an impressive amount of field and laboratory data and it is quite normal to have some discussion points, but I accept that some of them represent the author's view of the

candidate. Given that his work is complex, he has to comment on a number of issues that are indirectly related to the issues considered, but relate to other branches of science. In such cases, the text uses terms that are based on direct translation from English, not those adopted in Bulgaria. Of course, these notes in no way diminish the quality of the presented dissertation.

I welcome Prof. Georgiev's plans to focus some of his future research on clarifying regional specifics and creating a cadastre of the various geothermal conditions on earth in Bulgaria.

Personal impressions

I know Prof. Georgiev as the main organizer of the series of prestigious international conferences "Alternative Energy Sources, Materials and Technologies", where he proved his rich and comprehensive experience in the field of alternative energy sources, his exceptional ability to work, responsibility, good communication and precision in his work.

Conclusion

The presented dissertation is an extremely useful for the society completed scientific research, which summarizes his achievements in the field of alternative energy sources for the period from 1989 to the present. The obtained results are extremely relevant for both science and practice and are closely related to current trends to reduce harmful emissions due to the widespread use of fossil fuels. This is their social significance.

The conducted procedure fully meets the regulatory requirements. The formulated contributions are well argued and correctly present the achievements of the author.

In conclusion, I believe that the work fully meets the requirements of Art. 6 (3) of the Law on the Development of Academic Staff in the Republic of Bulgaria and the Regulations for its implementation and ***I propose to the esteemed Scientific Jury to award Prof. Dr. Aleksandar Georgiev Georgiev the degree of "Doctor of Science" in Scientific field 4. „Natural sciences, mathematics and computer science", Professional field: 4.2. „Chemical Sciences", Scientific specialty „Processes and apparatus in the chemical and biochemical technology".***

Sofia, February 13, 2022.

Prepared by :

(Prof. Dr.Eng. Aleksey Benderev)