Doctoral dissertation review
of MSc Pablo Benalcazar Alomia on title: "Method for assessing the impact of energy storage on the operational planning of a combined heat power plant"

1. Formal basis of the assessment

The review was carried out based on the letter from the Chairman of the Discipline Council Environmental Engineering, Faculty of Mining and Geoengineering under the resolution dated 06.07.2020. provided in the writing paper dated 10.07.2020, signed by prof. Marek Cala together with the copy of dissertation.

2. General characteristics of the dissertation

Presented review the doctoral dissertation "Method for assessing the impact of energy storage on the operational planning of a combined heat power plant" was published in English language and Edited in AGH University of Science and Technology Office (Kraków 2020). Essential content of Ph.D. has place in profile permissions doctoral and habilitation faculty. Doctoral dissertation has 158 pages of the text together with cited literature, is consists of six main chapters.

The dissertation is developed in a consistent and logical manner. In the six chapters Ph.D. student provides the following problems:

- the first chapter is an introduction to the main content of the work and include a review of the available domestic and foreign literature, presents the motivation to take up the topic, formulates the main goal of his dissertation and five sub-goals,
- the second chapter presents and describes in detail the issues and elements of cogeneration installations, the Ph.D. student divides the research area into three important elements, which
are: cogeneration technologies, energy accumulation technologies and energy system operation planning,

- chapter three contains an integrated method for assessing the appropriateness of installing an energy accumulator in a CHP installation, which operates according to the following scheme: (i) determination of the energy accumulator capacity based on historical data analysis, (ii) simulation of the operation of a CHP installation with an added energy accumulator, (iii) economic simulation results. The described method is to be applied to a specific CHP installation and should provide not only an answer as to whether the use of an energy accumulator will be profitable, but also give more detailed information on the subject. In this chapter, the graduate uses tools such as: statistical and economic analysis and mixed mathematical programming. In particular, the latter tool deserves special attention due to the complexity and accuracy of this model,

- the fourth chapter contains an analysis of computational examples. The PhD student assumes a CHP installation consisting of two heating boilers, a heat accumulator, a gas turbine and two pulverized coal boilers. The doctoral student describes and justifies the data and dependencies adopted for the calculations, discusses the mathematical model reflecting the elements of the fuel and energy system, important from the research perspective, the mathematical notation of the model and the input data for the tested model in various research scenarios,

- the fifth chapter presents and discusses the obtained results and justifies the validity of the research hypotheses. In particular, it analyzes the technical and economic differences that occur with different reservoir capacities,

- chapter six is a synthetic summary of the dissertation, the doctoral student presents possible further research.

The subject of the reviewed doctoral dissertation is very topical, as there is a need to analyze the possible risks in the operation of domestic generation sources in the conditions of the electricity market and the primary fuel market, as well as changing legal regulations. In this respect, cogeneration systems cooperating with energy accumulators may be of great importance.

3. Critical remarks

In the opinion of the reviewer, the CHP technologies and materials for the construction of energy accumulators are too extensively described in Chapter 2, the more so as only the heat accumulator was tested in this work. No information was noticed in the study that cogeneration systems also produced cold as their third product. In formula 2.2 and others
relating to efficiencies, the% symbol should be added. It seems that well-known economic parameters such as payback period, rate of return on investment, net present value, internal rate of return are described in detail.

The author of the review did not notice some Polish literature regarding the doctoral dissertation, including "Optimization of electricity and heat generation in a gas and steam CHP plant cooperating with coal boilers and a heat accumulator", (Wrocław 2019), by Przemysław Kołodziejak. The first chapters were too extensive in the text of the doctoral dissertation. Moreover, in my opinion, there was no need to include the terms English in the text, and under some figures and tables information that these are own research. The few editorial errors are not a problem.

4. Discussion and polemical remarks

Well, in the current market situation of running energy companies, it is important not only to analyze the operation of technological devices, but also to care for the generation of specific profits from various potential possibilities of a given generating unit. There may be situations when there are urgent needs for electricity supply to the system, then the electricity system operator may suggest a share in the capacity market. This may affect a better financial result if the CHP plant has production capacity.

During the public defense of the doctoral dissertation, I would like its Author to address the following issues:
- Is it possible to control the costs of CHP plants, and thus take care of their economic efficiency, considering the purchase of primary fuel with a lower unit cost outside the country?
- Can the CHP plant participate in the capacity market?
- Should the potential achievable profit be designed in such a way as to obtain the financial capacity to restore the source in the future?
- Is there any interest in the power sector in the developed model?

5. Summary

The subject matter taken up in the work reflects both the research interests and experience of the PhD student, and the obtained results are important both for the power industry and the mining sector. The method presented in this dissertation demonstrates the use of various operational and financial performance of CHP-TES system working in short and long term. The work is characterized by an interdisciplinary approach, has a good scientific and substantive level, and is well-written.
The subject of the reviewed doctoral dissertation is very topical, as there is a need to analyze the possible risk in the exploitation of domestic generation sources with different owners. The main value of the work, in my opinion, lies in a comprehensive methodological approach to the issue of effective management of the operation of a combined heat and power plant with a heat accumulator under market conditions. Moreover, it is also important that the Author expressed his will to continue his research.

6. Conclusion

The presented doctoral dissertation of Pablo Benalcazar Alomia is the culmination and a synthetic summary of his achievements in the mathematical modeling of management of electricity and heat production in cogeneration sources. I believe that the reviewed doctoral dissertation of Pablo Benalcazar Alomia meets the statutory requirements for doctoral dissertations in the relevant regulations and deserves a positive opinion. In view of the above, I submit a request for admission to public defense. This means that the requirements of the current Act on the academic title have been met and academic degrees, which justifies the application for granting the Candidate the academic title of doctor in the discipline of environmental engineering, mining and energy.

Due to the good substantive level of the dissertation, its composition creating a logically thought out and coherent whole, I submit an application for its distinction.