FAKULTA ELEKTROTECHNICKÁ
ZÁPADOČESKÉ UNIVERZITY
V PLZNI

POSUDEK OPONENTA DISERTAČNÍ PRÁCE

Assessment of the Dissertation

Titul, jméno a příjmení studenta: Title, name, surname of student	**Hussein Abdulkareem Saleh Abushamah, M.Sc.**
Doktorský studijní program: Doctoral study programme	**Elektrotechnika a informační technologie**
Téma disertační práce: Topic of the disseration	**Nuclear District Cooling System: Evaluation and Optimization**
Školitel: Supervisor	prof. Ing. Radek Škoda, Ph.D.
Oponent: Opponent	doc. Ing. Vladimír Král, Ph.D.

Zhodnocení významu disertační práce pro obor
Evaluation of the importance of the dissertation for the field

In his work, the author deals with a carbon-free, thermally driven District Cooling System (DCS). This is particularly important and topical in countries with tropical climates, where the energy used for air conditioning represents a significant proportion of total energy consumption and the demand for cooling in these countries is increasing. This issue is addressed comprehensively, starting with the energy source, the necessary infrastructure and, of course, the economic aspect. The work includes the development of a methodology for the design and optimisation of such a system.
The uniqueness of the solution lies in the use of a Small Modular Reactor (SMR) - Teplator as the heat source for the DCS. This concept overcomes existing concepts and solves 2 major problems in air conditioning - high power consumption and CO_2 emissions.

Vyjádření k postupu řešení problému, použitým metodám a splnění určeného cíle
Evaluation of the the problem-solving process, the methods used and the goal to be met

The author has set 3 main objectives for his work. The first is to evaluate the proposed approach to nuclear thermal driven district cooling from an energy policy perspective. The second objective is to assess the power grid under high penetration of thermally driven DCSs. The third objective is to optimise the design and operation of the proposed system and assess its feasibility from an investor's perspective.

Add 1. A comparison is made between the conventional electric-driven and heat-driven approach. The calculation algorithm for both variants is shown in Figure 19 on page 24, followed by a detailed description and calculation procedure including all necessary equations on the following pages.
Add 2. The optimal power flow method is used to achieve this objective. The algorithm is shown in Figure 22 on page 31.
Add 3. The chapter dedicated to this objective contains all the necessary partial calculation equations on the basis of which an economic model can be established and the necessary investment and operating costs can be quantified.

Chapter 3 applies all the algorithms to a typical large-scale network for 5 scenarios. I consider that all 3 objectives above are correctly specified and fulfilled, and that the solution procedures are also correct.

Stanovisko k výsledkům disertační práce a k původnímu konkrétnímu přínosu předkladatele disertační práce
Statement to the results of the dissertation and on the original contribution of the submitter of the dissertation

In his work, the author has proposed a concept for a DCS that is not standard at present. The purpose of the proposed process and concept is to reduce the overall energy consumption, avoiding the double energy conversion (thermal to electrical and electrical back to thermal). The primary energy source used is an emission-free source, i.e. an SMR. This is used to produce the required thermal energy. The proposed algorithms and the case studies and their results presented in Chapter 3, including the sensitivity analysis performed at the end of the thesis, are a valuable part of the thesis. Although the results of the thesis are not entirely general, as the author himself notes in the conclusion of the thesis, the results of the thesis confirm the feasibility and economic relevance of using nuclear heat for district cooling applications.

Vyjádření k systematice, přehlednosti, formální úpravě a jazykové úrovni disertační práce
Statement to the systematics, clarity, formal adaptation and language level of the dissertation

The thesis is clearly and logically structured, the chapters follow each other logically. I am not a native speaker, so I am not fully competent to assess the language level of the work. From my point of view, it has no shortcomings. On the formal side, I would just like to comment on the list of abbreviations, they are not in alphabetical order and as there are many of them in the thesis, especially in the computational part, they make orientation a bit difficult. Some abbreviations are missing from the list (BHT), others are only explained when they appear in the text (OPF, PPGC, TCPG). Formal errors are minimal (e.g. the same description of figures 10 and 11 on page 15).

Vyjádření k publikacím studenta
Statement to student's publications

The author of the dissertation has published 9 articles, 7 of which he is the main author. So the main part of his work is already published. A substantial part of his work has been published in [5]. I consider the publication activity to be more than sufficient.

Celkové zhodnocení a otázky k obhajobě
Total evaluation and questions for defence

I consider the work to be successful and useful in all respects. The author has shown and demonstrated the possibility of using SMR for DCS.

Defence questions:

1. Does a thermally driven district cooling system offer any advantages over the conventional approach of in terms of unused generation capacity in winter in countries with hot climates such as Qatar? (p. 10)
2. What are the COP values for absorption chillers - 0.7 on p. 19, 0.85 [72] in Table 22 on p. 61. What does the specific value depend on?
3. I do not see the connection between the text "Among the options for cold storage (referenced in Table 4)..." and Table 4. Can you explain this? (p. 63)
4. Why was 2050 MW (50% of peak) chosen? (p. 64)

Doporučuji disertační práci k obhajobě
I recommend the dissertation for the defence

ano yes	ne no
	X

Datum
Date **19.12.2023**

Podpis oponenta:
Signature of opponent

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V PLZNI

POSUDEK OPONENTA DISERTAČNÍ PRÁCE

Assessment of the Dissertation

Titul, jméno a příjmení studenta: Title, name, surname of student	**Hussein Abdulkareem Saleh, Abushamah, M.Sc.**
Doktorský studijní program: Doctoral study programme	**Electrical Engineering and Information Technology**
Téma disertační práce: Topic of the disseration	**Nuclear District Cooling System: Evaluation and Optimization**
Školitel: Supervisor	prof. Ing. Radek Škoda, Ph.D.
Oponent: Opponent	doc. Ing Petr Mastný, Ph.D.

Zhodnocení významu disertační práce pro obor
Evaluation of the importance of the dissertation for the field

The doctoral student prepared a dissertation focused on the issue of improving the efficiency of district cooling systems. In the context of current developments in the field of energy, I consider the work to be relevant and beneficial. Above all, in the context of the demand for more efficient use of energy resources and the demand for increasing the efficiency of energy systems. The idea of using a thermal nuclear reactor as a heat source for cooling is not new, but its integration into the energy system is logical and corresponds to the current development trend. The doctoral student based his optimization of cooling on energy-economic indicators and their subsequent comparison in several energy scenarios, which led to the creation of a tool for the design and optimization of district cooling systems.

Vyjádření k postupu řešení problému, použitým metodám a splnění určeného cíle
Evaluation of the the problem-solving process, the methods used and the goal to be met

The doctoral student approached the problem systematically. Based on the initial research of available and applied solutions, he designed a remote cooling system based on the use of a nuclear power plant as an energy source for cooling.
The work had three basic goals - energy-economic assessment of the possibility of using a modular reactor for heating, assessment of the influence of the integration of district cooling into the energy system and proposed optimization of the proposed system in the context of economic-energy parameters.
In my opinion, the focus of the work is primarily focused on the economic context, which does not detract from its quality, but I would rate a deeper solution to the technical details of the dimensioning and construction of the entire system as more significant.
In the context of the work, I note that the doctoral student fulfilled the defined goals of the work and created a general tool for the design of systems with remote cooling using a heat source for power supply.

Stanovisko k výsledkům disertační práce a
k původnímu konkrétnímu přínosu předkladatele disertační práce
Statement to the results of the dissertation and on the original contribution of the submitter of the dissertation

Based on the conducted study and processed analyzes based on the assembled mathematical model of the system, the doctoral student proposed a new strategy for the conception and design of energy systems for district cooling. Based on the modeled scenarios, he evaluated the chosen approaches and defined the boundary conditions for these systems.
The main benefit is primarily in the area of economic optimization of investment costs for these energy systems, and the reduction of the environmental burden associated with the use of a specific type of source (nuclear reactor) is also a significant benefit.
In his work, the doctoral student shows new possibilities for accessing solutions in the field of district cooling.
The dissertation contains the original results of the solution mainly on a practical level - verification of the system's functionality using simulation in MATLAB, a proposal to optimize the energy system with an emphasis on economic advantage.

Vyjádření k systematice, přehlednosti, formální úpravě
a jazykové úrovni disertační práce
Statement to the systematics, clarity, formal adaptation and language level of the dissertation

The individual parts of the presented work logically follow each other - the basis is the research part describing the development in the field of cooling, which is followed by the analysis of technical and economic aspects connected with cooling and heating, including environmental contexts.
In terms of formality and language, the work is at a good level - in some places abbreviations are used in the work, which are clarified only in the following text.
Considering the dynamics of development in the field of HVAC systems, it would be more appropriate for the work if more recent source literature was used - sources from 2004 or 2012 are no longer fully in line with the current direction of development.
I rate the language level of the work as very good and corresponding to the requirements for this type of work.

Vyjádření k publikacím studenta
Statement to student's publications

The student documented nine publications, which are focused on areas related to the topic of the dissertation - I evaluate all the mentioned publications as high quality and demonstrating the scientific qualities of the doctoral student. I especially evaluate publications in impact journals very positively.

Celkové zhodnocení a otázky k obhajobě
Total evaluation and questions for defence

I note that the dissertation is prepared at a good scientific and professional level. The achieved results are original and are important for the expansion of knowledge in the field of Electrical Engineering and Information Technology. The doctoral student demonstrated his scientific erudition with his publication activity. Based on the previous evaluation, I recommend the submitted dissertation for defense and propose to award the author a Ph.D.

Comments and questions for the defense:

1. How is the COP shown in Table 1 defined? Would it be possible to express efficiency by cooling factor (EER)?
2. The author states that CO2 emissions (or Social Carbon Cost) are zero when using Teplátor - under what conditions is this statement true?
3. How will the economics of the proposed system change if it is not possible to use spent nuclear fuel, but it will be necessary to use new (fresh) fuel?
4. What will be the usage time of fresh fuel and spent fuel in a 50 MW thermal nuclear power plant?
5. Several simplifying assumptions are used in the simulations. One of them is the neglect of pressure losses in the pipes during cold/heat transfer - if pressure losses were included, what would they affect?

Doporučuji disertační práci k obhajobě
I recommend the dissertation for the defence

YES

Datum
Date

04.01.2024

Podpis oponenta:
Signature of opponent