THESIS REVIEWER'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**Analysis of the effectiveness of the use of positioning system in solar photovoltaic installations**
Author's name:	**BSc. Kirillova Daria**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Economics, Management and Humanities
Thesis reviewer:	Ing. Vojtěch Bagin
Reviewer's department:	ČEZ Obnovitelné zdroje, s.r.o.

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

How demanding was the assigned project?

The assignment can be graded as challenging, since several technical and economic aspects of photovoltaic technologies had to be addressed. As a quite challenging part can be found out the development of a mathematical model and simulation of PV tracking system.

Fulfilment of assignment **fulfilled**

How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.

The Author fulfilled the assignment, according to the guidelines.

Methodology **partially applicable**

Comment on the correctness of the approach and/or the solution methods.

The overall approach chosen by the Author was correct and appropriate.
However, the sections 4., 5. and 6. are a bit confusing and the detailed calculations are very often misleading, since they are not corresponding to previously calculated inputs/outputs, which put the overall results in question. In these sections I would highly recommend using hourly based model for PV yield simulation and household consumption. The annual household consumption calculation seems very overestimated and probably wasn´t compared to any real consumption.
Investment decision making approach based on NPV is correct, but only cost based approach was used, which does not give full picture for investment decision making and based on given results none of the PV systems should be invested in.
If these shortcomings are eliminated, the use of this Thesis in real application will also highly increase.
On the other side the Author well described the currently used PV tracking systems.

Technical level **E - sufficient.**

Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?

Technical level is the biggest weakness of the Thesis, since many of the calculations are uncleared and results of these calculations are unused or different values are used in the next steps, which is confusing, and it is not cleared which values were used and why some outputs were calculated. For example, in Table 4.2 annual electricity consumption was calculated but in section 4.4 a different annual consumption was declared, which is lower than annual consumption calculated in Table 5.3.
Another example can be calculation of solar modules, when on page 48 a number of 53 PV modules is calculated for stand-alone fixed tilt PV system, however in Table 4.4, on the next page, 159 PV modules are stated. All these inaccuracies put the Reviewer in doubt about the data used in the calculations.
Also, the economic part of the Thesis seems unfinished and misinterpreted. Only cost based NPV is used, which do not represent the savings from own produced energy as revenue. Based on this assumption a final economic comparison can be biased and can´t be used for real investment decision making.
I would recommend comparing the global horizontal irradiation and PV production with at least one of the solar simulation software, such as PVGIS, PV*SOL or PVSyst in order to obtain a more real data, since it seems that the approach

used is not taking into account other aspects, such as cloudiness, temperatures etc. Also, an hourly data can be generated by such a software and can be used in further analysis, for example batteries usage.
I would also recommend comparing the calculated annual electricity consumption, since the value seems quite overestimated.

Formal and language level, scope of thesis	**D - satisfactory.**
Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?	
The Thesis is organized in a logical way. All tables and pictures are clearly noted. The language is clear and understandable, however some exact technical terms/standards could be used to describe everything precisely. Where I have found limits of the Thesis is the graphical part. Many of the graphs and pictures are hardly to read and the units are sometimes missing. Also the tables style could be united.	

Selection of sources, citation correctness	**A - excellent.**
Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?	
The selection of sources is adequate and amount of used literature is very good. The bibliographic citations meet the standards.	

Additional commentary and evaluation (optional)
Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.
Please insert your comments here.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.

The Thesis analysis a usage of solar tracking systems for residential installation. The Author very well described types of tracking systems and created a mathematical model of solar irradiation. In the next stages the Author applied these results to analyze technical and economical usage of such a system for a household.

The biggest weakness of the Thesis is its real usage for real decision making, due to several uncertainties and questionable approaches and assumptions.

Firstly, in many formulas unknown inputs are used or the results are unused in the later stage, which might be looking like the Author used some data to get required results. As an example of this issue a PV module calculation can be highlighted, when on page 48 a number of 53 PV modules is calculated for stand-alone fixed tilt PV system, however in Table 4.4, on the next page, 159 PV modules are stated. Also, regarding PV modules Sila Solar 350 Wp module is mentioned in Table 4.3 but in Table 5.1 & 5.2 HEVEL HJT 310 Wp module is used.

Secondly used and calculated results are not realistic. A yearly consumption of 26 MWh was calculated for a household with 4 people, with central system district heating assumed as well as hot and cold water supply. Compared to real data this consumption is about 6times higher than I would be expected, which forced author to use a 15kW backup diesel generator.

Comparing the calculated yearly solar irradiation for a Brno location the calculated results also look quite inaccurately. The Author stated that yearly irradiation in Brno region will be about 2500 kWh/m^2, comparing this results with commonly used software a value of 1850 kWh/m^2 for two-axis tracker were obtained. I would highly

recommend to compare/use simulation software's, such as PVGIS, PV*SOL or PVSyst at least for results comparison.

Thirdly a NPV model for investment decision is very poorly used and does not represent the real situation. Only cost based method is used, which means that in cash-flow only costs for buying electricity from grid is considered and revenues for not-buying this electricity isn´t considered. Based on this approach none of the variants seems profitable and investor shouldn't decide for any of these variants, however the Author made some serious statements based on this model.

Lastly the formal and graphical level of the Thesis is not on a sufficient level. I would highly recommend to do not use Russian language in the text nor rubles for an investment calculation, since it is very confusing and hard comparable with European standards. The tables style is not unified. Some of the graphs and figures are hardly readable or the units are missing. On the other side the Thesis is organized in a logical way and all tables and pictures are clearly noted.

To give and overall grade is very difficult since the solar irradiation modelling seemed very challenging but then the Thesis looking as it was stacked together and each parts are not following each other.

Questions to be answered:

1) Could you please describe differences between fixed tilt and solar tracking system, according to daily production diagram? What are the pros and cons of each system?
2) How was the household consumption calculated and would you please describe and compare Table 4.2 and Table 5.3?
3) How were the batteries and the accumulation implemented into the model?
4) Could you please describe a cash-flow calculation and investment decision making approach?
5) Please, explain your statements under Figure 6.1, on page 62, about most advantageous solution?
6) Could you please describe discount rate sensitivity analysis, since in your case with increasing discount rate NPV is also increasing?

The grade that I award for the thesis is **E - sufficient.** / **F - failed.**

Date: **7.6.2022** Signature: