Brno University of Technology
Faculty of Electrical Engineering and Communication
Technická 3058/10, 61600 Brno 16

Supervisor’s Statement of Master's Thesis

Department: Department of Electrical Power Engineering Academic year: **2020/21**
Student: **Bc. Robin Filip**
Study programme: Electrical Power Engineering (N0713A060006)
Specialization: without specialization
Supervisor of the Master’s thesis: **Ing. Martin Paar, Ph.D.**
Opponent of the Master’s thesis: **Professor Matti Lehtonen**

Title of Master’s thesis:

EV smart charging and BESS in increasing the PV hosting capacity of distribution networks

Total assessment:

I recommend this Master’s thesis for defense.
Total number of points: 98.

Verbal evaluation and remarks:
The Master’s thesis “EV smart charging and BESS in increasing the PV hosting capacity of distribution networks” written by Robin Filip is focused on hosting capacity and how it is influenced by uncontrolled or controlled electric vehicles (EVs) charging or battery systems (BESSs). The analysis examined three type of low voltage network: predominantly rural, intermediate and predominantly urban.

The thesis is divided into 4 main parts, introduction with description of the topic, methodology, the results of simulations and discussion of the results. The introduction is focused on the definition of hosting capacity, general information about EVs and BESSs, part of this chapter deals with short feasibility analysis of BESS utilization and description of research objectives. The second part describes the methodology that is composed of inputs design e.g., considered parameters of EVs, description of the model with its constrains or the worst hours concept that reflects the worst conditions from point view of hosting capacity. The results are in the third part of the thesis that covers different models as uncontrolled or controlled charging EVs or BESSs and also combination of EV charging and BESSs. Part of this chapter is focused on BESS utilization with basic cost evaluations. The last chapters deal with discussion and the conclusion chapter where final evaluation is made.

The Master’s thesis is ranging from the definition of hosting capacity, selecting size of batteries for electric vehicles and for battery system, via simulation of residents arriving time or distribution network constrains and the basic cost evaluations. This shows the range of topics that were implemented to the thesis. The core of the simulations uses the Monte Carlo method that is process with high demand for time, the concept of the critical worst hours was selected. But the worst hours concept has in this thesis two weaknesses, low numbers of evaluated hours per year and selection focused only on hosting capacity so some of the worst conditions in the evaluated network could be missed. On the other hand, both problems were addressed by the author in the discussion.

For the design of electromobility simulations following issues should be mentioned. Firstly, the prediction of cars' numbers with different powertrain (EV, not-EV and plug-in hybrid EV) for Finland for years 2030 and 2040, showed on Fig. 2.1. Based on current European Union’s plan for ban of new cars with internal combustion engine in 2035 these numbers can be considered as conservative. The second issue is the selection of the cars that only reflect current situation. The author does not consider the future trend of bigger capacity of batteries. The weakness of this approach can be seen in case if the review would have been made of the car selection for year 2016. This problem is bypassed by the author by length of daily mileage but it does not consider “the laziness" of cars’ users who do not want to charge cars with higher battery capacity daily if they would not be pressed for e.g., by tariffs. The simulation also considers only workdays with 20% of EV charging out of the analyzed system. There is no explanation how the value of 20% has been found. The next problem can be seen that only households are considered in the simulations and EV charging was designed only for afternoon or evening time. It does not consider residents working at home or companies that can charge employee's electric car during the day. On the other hand, this can be intended as the worst scenario.

With home charging two problems were found. Firstly, the home chargers are considered for charging all EVs, excluding 20% that are charged outside evaluated network, but it is possible only for specific car owners which have garage or parking place equipped with charging point. High level of home charging can be considered for rural areas but this presumption for urban areas is not fully valid. The second issue is that the author considered among home chargers also 1-ph charging with power 7.4 kW with high probability 27%. This type of the chargers would lead to high unsymmetric loads of the low voltage distribution network specially in case of rural areas.

As problematic should also be mentioned “Short feasibility analysis of BESS utilization” that deals with 10 years evaluation and time value of the money is not added to calculation. It can be viewed as quite high simplification. The last pointed issue is the gain of photovoltaic panels with parameter base on theoretical value 1955 kWh/kWp for South Finland, it gives system higher production than in reality and it leads to lower values of hosting capacity.

Minor problem might be discomfort for the readers with the abbreviations E1 to E7 at graphs with results, represents the breach of the parameters limitation. The explanation of these abbreviations is not possible to find in close text all the time. More intuitive abbreviations of limitations would be suitable. And at last, the small mistake in the conclusion that EU considered 0% CO_2 emission in 2035 for cars, in reality it is just for newly produced cars.

Despite mentioned shortcoming, the Master’s thesis went deep into the problematic and many aspects were considered, the side analyses for the input parameters were made, e.g., testing of variation of battery size, or the analysis with three types of the home heating (storage heating, district heating and direct electric heating). It shows author’s effort to consider many aspects of the model. The thesis’s clear structure and good description for the steps of evaluations should be appreciated as well. Last but not least should be mentioned that the evaluation and discussion clearly describe the issues and limitations of the results.

Finally, the Master’s thesis fulfils all points of submission and it has high quality of graphic design, therefore I award it with 98 points.

Questions for the defense:

1. Based on work on the thesis what is the author’s general opinion about possibility of integration of high numbers of electric vehicles to current distribution network? Only short general point of view.
2. The thesis was focused on situation of Finnish distribution networks, according to author’s knowledge of Czech networks how the selected approach in the thesis should be different for Czech distribution networks? Mention only main differences.
3. The selected EV reflect the current situation, how the development in battery technology could affect the results?
4. Did author consider different approach for home charging between rural and urban areas?
5. In thesis the author considered 20% of the charging outside of evaluated networks, how the value was selected?

Ing. Martin Paar, Ph.D.
Supervisor