Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Timur Saifutdinov

PhD Program: Engineering Systems

Title of Thesis: Optimal siting, sizing and technology selection of energy storage systems for power system applications

Supervisor: Prof. Janusz Bialek

Date of Thesis Defense: 20 January 2020

Name of the Reviewer: Neal Wade

I confirm the absence of any conflict of interest	**Signature:**  **Date: 19-12-2019**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Extensive literature review covering electrical energy storage technologies, the services that electrical energy storage can provide to the electricity supply system and methods for siting sizing and technology selection of electrical energy storage.

Details of linearized formulations to describe energy storage characteristics, including degradation are provided. Where linearization is not possible, alternative formulations are found. Linearization of power-flow equations by DC-power-flow formulation is described. Load and generation modelling principles are outlined.

Through these reviews the candidate demonstrates a thorough comprehension of the requisite concepts and methods upon which their work has been built.

Issues dealt with in this thesis are well articulated; inclusion of degradation for cycling and idle states, thermal model, scalability of MICP formulation.

The inclusion of complex degradation factors within the MICP provides a novel dimension to a mathematical programming approach to the electrical energy storage siting, sizing and technology selection problem. Consideration of break-even costs for second-life batteries in the same application provides an interesting comparison.

More significant corrections

Section 3.2 – Use of the augmented Lagrangian relaxation procedure is not explained. The steps to reach (3.19) are not clearly identified. Similar for alternating direction method of multipliers leading to (3.21)

Unclear in section 4.2.2 how the daily operation costs of circa. £3.5M translate to an annual revenue of circa. £30M. Cannot see where the profit side of this equation is provided.

It is stated that there are 18 applications that storage can be applied to – how many of these can be evaluated using the method that has been developed in this thesis, given, e.g. the linearization of the power-flow equation, which limits power flow solutions to the transmission network, or the segmentation of the demand profile to allow the algorithm to operate?

Can the candidate give some assurance that the single example of the algorithm delivering a result proves that this method works consistently under a range of conditions?

Less significant corrections

Referencing requires improvement in areas of introduction/ earlier part of literature review

Typographic/grammar corrections noted in review copy of thesis

Add tabular summary of service requirements distilled from text

Each constraint from (3.22) to (3.35) requires a line of text above stating what it's for.

Summary

This thesis develops a method that is relevant to the problem that has been tackled and provides insights into the question of siting, sizing and technology selection for energy storage. It is a useful contribution to the state-of-the-art which shows awareness of its place within the existing literature. As such it is recommended that a formal thesis defense should follow.

Provisional Recommendation
☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*
☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*
☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*