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Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Andrey Churkin

PhD Program: Engineering Systems

Title of Thesis: Game-theoretic approach to cooperation stability analysis in cross-border power interconnection planning

Supervisors: Prof. Janusz Bialek and Prof. David Pozo

Date of Thesis Defense: 19 November 2020

Name of the Reviewer: Prof. Henni Ouerdane

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 18-10-2020**

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

- **Brief evaluation of the thesis quality and overall structure of the dissertation**

The doctoral thesis *Game-theoretic approach to cooperation stability analysis in cross-border power interconnection planning*, submitted by Mr. Andrey Churkin, focuses on the methodological development of the so-called transmission expansion planning of cross-border power interconnections. The approach chosen by Andrey Churkin is that of cooperative game theory, a particular emphasis being put on cooperation stability. The thesis manuscript contains 7 chapters, including the (long – 53 pages!) introduction and the (concise) conclusion summarizing the main findings and giving a sketch of a path forward, followed by a comprehensive list of references used throughout the manuscript. The doctoral thesis boasts a well-balanced content where the concepts used by the author, the methodology he

developed and his ideas are very well explained, so that the added value of the research results appears upon reading.

I commend Mr Andrey Churkin for his efforts to properly present the technical content of his research work and convey its main messages to the reader.

- **Relevance of the topic of dissertation work to its actual content**

The actual content of the dissertation is perfectly in line with the topic announced.

- **Relevance of the methods used in the dissertation**

The cooperative game theory is a suitable tool for the objectives of the doctoral work, which is interdisciplinary, as it involves different aspects of cross-border interconnection planning: electricity trade, costs allocation, incentives, coalition formation, cooperation etc., more formal frameworks such as optimization, and electrical engineering technologies (notably HVDC vs AC). Of particular interest is the citation network analysis, which proves extremely useful for a sound literature review and a balanced development of the research work.

- **Scientific significance of the results obtained and their compliance with the international level and current state of the art**

The work and results presented in the doctoral thesis of Mr. Andrey Churkin certainly are on par with the current state of the art in the field, and even extend it as recognized in particular by the publications in highly rated journal and international conferences, which confirms the interest of the power systems community for this research work.

- **Relevance of the obtained results to applications** (if applicable)

Cross-border transmission expansion planning concerns a wide range of different stakeholders in the power systems industry, like system operators, investors, engineers, but also political decision makers of the countries involved in such projects. The practical impacts of electrical grids interconnection are varied: cost savings, flexibility and stability to name a few; further interconnections also weigh on geopolitical matters because of the international cooperation they entail. I therefore believe that the research work of Mr. Andrey Churkin, will attract attention beyond academia and will serve useful practical purposes. One useful aspect of the framework developed by Mr. Andrey Churkin is that it may facilitate decision-making as practical questions such as potential benefits derived from electricity trade as well as the allocation of costs over the partner countries, necessitate robust quantitative analyses. Importantly, the doctoral thesis includes an actual case study: the electrical interconnection in Northeast Asia.

- **Quality of publications**

The research work of Mr Andrey Churkin has been quite productive in terms of publications and scientific communications. He is first author of:

- One journal article published in the Energy Economics, highly rated Q1 journal, IF=5.203;
- Two conference papers presented at highly reputable international Scopus-indexed conferences: PowerTech (2019), and the International Conference on Asian Energy Cooperation (2017).

The level of the international conferences and the high impact of the above Energy Economics journal clearly warrant the quality and high level of the publications authored by Mr. Andrey Churkin.

Further, Andrey Churkin presented his work at different events held in Russia, Japan, the US, and Germany. He also gave several seminars in Moscow.

This clearly satisfies the publication requirements of the Skoltech Engineering Systems doctoral program.

Andrey Churkin is also the first author of a research article currently under review at Renewable and Sustainable Energy Reviews (Scopus Q1 journal, IF: 12.110), which is among the very best in its category.

Summary of issues to be addressed before/during the thesis defense

The doctoral thesis is very well-written and offers a quite transparent development of the methodology on the one hand, and a rich discussion of the results on the other hand.

Perhaps, a question to ponder over: Mr. Andrey Churkin mentions that a major challenge for the further development of his work would be the development of strategyproof mechanisms of cooperation. A collusion between two or more players, for instance, can affect the mechanism of global cooperation and the collective payoff; a naïve question then would be: could a hybrid cooperative game and non-cooperative game theories approach be developed, if it can make sense?

I also would like to point out that though non-cooperative game theory is mentioned several times in the manuscript, the framework remains fundamentally that of cooperative game theory. The title contains the notion of cooperation stability, but the generic “game-theoretic” formulation in the title may suggest that the work rests on a framework that goes beyond the cooperative game theory. Perhaps the title may be revised to make it more specific, i.e. aligned with the core content; but this is an optional point to consider.

The citation network analysis is one of the pillars of the doctoral dissertation presented by Mr. Andrey Churkin; instead of being embedded in the (hence lengthy) Introduction, it could have been the object of a dedicated, separate chapter.

Particular questions will be asked during the defense as the discussion with the jury members develops.

I see no particular point to address before the defense, and I am pleased to state that the PhD thesis of Andrey Churkin is highly worthy of consideration for the formal defense leading to the award of the PhD degree.

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*