Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Tatiana Chernova

PhD Program: Engineering Systems

Title of Thesis: Specific aspects of peer-to-peer energy market design and operation

Supervisor: Assistant Professor Elena Gryazina, Skoltech

Name of the Reviewer: Marina Dolmatova, Associate Professor of The Practice , Skoltech

I confirm the absence of any conflict of interest 	**Date: 12-11-2024**

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

1. Brief Evaluation of the Thesis Quality and Overall Structure

Tatiana Chernova's doctoral thesis offers a rigorous and comprehensive investigation into the design and operational challenges of Peer-to-Peer (P2P) energy markets within decentralized power systems. The research is distinguished by its technical depth, addressing both the theoretical and practical facets of P2P energy market implementation. The quality of the thesis is high, with clear argumentation and logical progression through the various challenges faced in real-world P2P market scenarios.

The structure of the thesis is methodical, starting with a detailed literature review that provides context and underscores the relevance of P2P markets. The main body of the work systematically tackles different aspects of market design, including network constraints, user preferences, and energy storage integration, as well as addressing uncertainties. Each chapter is well-organized and transitions smoothly to the next, culminating in a conclusion that both summarizes the research findings and outlines future directions.

2. Relevance of the Topic of the Dissertation to Its Content

The thesis topic is highly relevant to the content presented. The subject of P2P energy markets aligns well with the evolving requirements of decentralized energy systems, where individual energy producers and consumers increasingly seek active roles in energy trading. This relevance is reinforced by the specific challenges discussed, such as managing network constraints, integrating diverse user preferences, and addressing the unpredictable nature of renewable energy sources. The research is timely, reflecting a significant shift towards more flexible, consumer-centric energy markets.

3. Relevance of the Methods Used in the Dissertation

The methodology is appropriately chosen for the complex nature of the research questions. The candidate employs a mix of optimization-based frameworks, simulation modeling, and algorithmic development to explore P2P market design across meshed and radial network structures. The use of constrained optimization frameworks and distributed algorithms is particularly effective, enabling the candidate to address feasibility, welfare optimization, and cost recovery in the face of real-world technical and economic constraints.

Furthermore, Chernova incorporates chance-constrained optimization to account for uncertainties inherent in renewable energy sources, demonstrating an advanced understanding of risk mitigation in energy systems. The chosen methodologies are both innovative and relevant to the goals of designing functional, scalable, and efficient P2P energy markets.

4. Scientific Significance of the Results and Compliance with International Standards

The thesis contributes significantly to the scientific field by advancing current knowledge on P2P market design, specifically in relation to distributed, prosumer-driven energy systems. The original contributions, such as the development of a universal, regularization-based approach to incorporate user preferences and network charges, reflect a novel approach to optimizing the trade-offs between technical constraints and user-centric design. These results align well with international research trends and showcase an awareness of the state-of-the-art in decentralized energy management and market-based energy transactions.

The thesis also benchmarks the developed models and algorithms against international standards, as seen in comparative analyses with correction-based algorithms and industry-standard practices. This

scientific rigor ensures that the work stands up to international scrutiny and makes a meaningful contribution to the ongoing development of sustainable, prosumer-centric energy markets.

5. Relevance of the Results to Applications

The practical implications of this research are substantial. Chernova's exploration of P2P markets with energy storage systems and mechanisms for handling market uncertainty have direct applications in current and future distributed energy networks. The algorithms developed in the thesis provide actionable insights that could be used by energy companies, policymakers, and grid operators to facilitate real-world P2P energy trading while maintaining grid stability and security.

Additionally, the application of differentiated network charges and consumer-driven preferences offers a practical framework for enhancing consumer engagement in energy systems. This relevance to applied energy markets makes the work not only theoretically significant but also valuable for practical implementations in the energy sector.

6. Quality of Publications

The publications resulting from this thesis are of quality, with papers published in respected journal and conferences. For instance, publications in the *International Journal of Electrical Power and Energy Systems* and contributions to IEEE PowerTech conferences highlight the scientific community's acknowledgment of this work's relevance and rigor.

7. Summary of Issues to Be Addressed Before/During the Thesis Defense

While the thesis is a strong and well-structured body of work, there are a few areas that could be further clarified or expanded upon:

1. **Scalability of Proposed Algorithms**: Given the complexity of P2P trading algorithms, a more detailed discussion on scalability, particularly in large-scale applications, would strengthen the thesis. Addressing the computational feasibility of the proposed algorithms in larger grids or urban settings with thousands of participants would be insightful.
2. **Consumer Preference Impact**: The candidate might expand upon how consumer preferences (e.g., proximity to suppliers or carbon footprint considerations) affect overall grid efficiency and welfare. An analysis of potential trade-offs between individual preferences and grid optimization goals could be valuable.

Conclusion

Tatiana Chernova's doctoral research presents a valuable contribution to the fields of decentralized energy systems and P2P energy markets. Her work is technically sound, methodologically innovative, and aligned with international standards in the field. The dissertation is well-organized and supported by high-quality publications. With minor adjustments or discussion to address scalability and consumer preference impact, this work will stand as a significant academic and practical contribution to sustainable energy markets.

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*