# MY RESEARCH PROPOSAL - Nowrin Lyba.pdf

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# OPTIMIZATION OF HYBRID MICROGRID SYSTEMS WITH REAL-TIME INTEGRATION OF LOAD-SHEDDING MITIGATION IN BANGLADESH

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**Introduction:**

The energy sector in Bangladesh faces one of the biggest obstacles, frequent load-shedding, because of rising electricity demand and an overstrained grid system. The continuous event of load-shedding disrupts people's day to day lives and undermines economic productivity and sustainable growth. Hybrid microgrid systems that incorporate renewable and conventional sources of supply have been considered as a response to this common challenge; though, most studies on microgrid optimization or viability either provide general development theoretical models or highlight cases that are outside of Bangladesh.
Recent studies have not provided a country-specific analytical framework for grid planning in Bangladesh, one that reflects the country's energy demand, infrastructure challenges, and socio-economic realities. Although researchers have examined real-time monitoring, control, and failure management in energy systems, there has been little focus on how these strategies can be applied in Bangladesh.
In fact, much of the existing literature presents fixed simulations and is based on outdated assumptions that cannot capture the transitions in energy consumption from this dynamic, emerging economy.

This research proposal seeks to study the feasibility of implementing real-time monitoring and data-driven decisions based on consumer demand patterns, the intermittent nature of renewable energy supply, and the challenges in integration to deliver the performance and reliability targets of hybrid microgrid systems for improved efficiency. In addition, this study will outline local and national implications by identifying overlooked user factors that may influence load-shedding and the need for a long-term plan, particularly as Bangladesh has committed to sustainable

energy transition. Providing a study that offers genuine foresight into energy losses and new restoration methods will be expected contributions to targeted interventions to reduce load-shedding and push sustainable energy systems in the Bangladesh energy economy.

**Research Questions:**

1. What are the opportunities of real-time monitoring and data integration in increasing efficiency and reliability of hybrid microgrid systems in Bangladesh?

2. What are the primary technical, economic, and infrastructural issues in the application of real-time hybrid microgrid as a way of addressing load-shedding in Bangladesh?

3. What is the best optimised framework to combine real-time monitoring and hybrid microgrids to achieve sustainability, cost effectiveness and reliable supply of electricity in Bangladesh?

**Literature Review:**

Hybrid microgrid systems have received extensive research on them as possible solutions to energy stability and sustainability issues, especially in developing areas.
The overall discussion of the control strategies and real-time monitoring systems shows that hybrid AC/DC microgrids are more efficient and stable in comparison to the all-AC or all-DC systems [1]. Fuzzy Logic Control, Model Predictive Control, and Deep Reinforcement Learning, among others, are highly advanced control approaches that are increasingly being supported by the IoT-driven real-time monitoring that enhances dynamic energy management. Nevertheless, in spite of these improvements, other issues like cybersecurity vulnerabilities and the absence of universal guidelines are still major impediments to adoption.

In Bangladesh, specific research has been more on techno-economic feasibility, as compared to real-time operational strategies. As an example, a study on Kunder Char tested six hybrid energy systems in HOMER Pro and found that on-grid hybrid systems provided the lowest cost results whereas renewable-only systems had zero emission but at high cost [2].
A similar investigation in Pabna also evaluated grid-connected hybrids of PV, biomass and wind, showing that PV-biomass system was the least costly, with a COE of only $0.0232/kWh and reducing emissions by more than 78,000 kg per year.[4]
Likewise, the feedback from a separate study of a stand-alone hybrid system concerning the Bhasan Char relocation camp proved the feasibility of microgrids of renewable dominance, and the tidal energy served as the primary source of power generation. [3]. These contributions prioritize optimization based on cost allocation and resource allocation, but not based on integration of adaptive, real-time control.

These findings are supported by other case studies done in Bangladesh. A survey conducted in remote villages in Bandarban showed that hybrid PV-hydro systems could provide cost-effective and environmentally sustainable electricity, and the on-grid models were economically better than the off-grid designs [5]. Although these works demonstrate the viability of hybrid systems in rural and off-grid cases, they are mostly simulation-oriented and consider the isolated community but not grid integration at the national level.

In general, it can be stated that the current literature reveals that Bangladesh holds high potential on hybrid renewable systems but the existing research is constrained by two crucial gaps. To begin with, they are using fixed HOMER-based simulations that do not consider the variability of real time consumer demand and renewable generation. Second, although control strategies and monitoring systems are popular topics of international studies, how they apply to the unique grid problems of Bangladesh, including the common load shedding and socio-economic constraints, has not yet been explored.

This study attempts to fill these gaps by investigating the ways in which real-time monitoring and data integration can improve the efficiency and reliability of hybrid microgrid systems specifically in Bangladesh.

**Proposed Methodology:**

The present research will adopt a mixed-method approach to examine how real-time monitoring can be integrated with hybrid microgrids in Bangladesh by quantifying technical and economic data on the topic and qualitatively understanding how the energy sector experts view the problem.

**Quantitative Phase:**

8-12 published studies, technical reports, and case studies of hybrid microgrid implementations in the world and in Bangladesh will be collected as the secondary data. The key performance indicators that will be extracted are Levelized Cost of Energy (LCOE), Net Present Cost (NPC), renewable energy fraction, reliability metrics, power loss reduction. Patterns, differences, and trends among different microgrid configurations will be determined through descriptive statistics, graphs and comparative analysis. This step will provide an evidence-based idea of the possible advantages of real-time monitoring and control strategies, and how the performance of various system architectures is different.

**Qualitative Phase:**

Semi-structured interviews (n = 6-10) will be conducted with the engineers, project managers and experts involved in energy who have worked with hybrid micro grid systems in Bangladesh.The interviews will target the practical issues of real-time data integration including technical constraints, infrastructure constraints, economic feasibility and socio-technical barriers. Thematic analysis of responses will be performed to determine whether there are recurring issues, insights, and areas of optimisation opportunities, with particular consideration of contextual aspects in the local context of implementation.

**Data Analysis:**

The quantitative data in the studies will be evaluated by descriptive statistics, regression comparisons and visualization to determine the relationships between cost-effectiveness, renewable fraction and systems reliability in the various configurations.

It will demonstrate the consistency of using real-time monitoring to boost performance indicators such as LCOE and NPC. For the qualitative phase, the transcripts from the interviews will be coded and thematically analyzed to determine common barriers, enablers and contextual information. NVivo or other qualitative analysis programs can be applied to organise codes and guarantee rigour in theme development. Triangulation of the quantitative and qualitative results through the integration of both will ensure that there is a valid result, as well as the formation of a holistic discussion of the technical and socio-economic aspects of the adoption of hybrid microgrids.

**Practicalities:**
The proposed project will be implemented in 8-weeks. In weeks 1-2, the secondary data will be collected in the form of published research and technical reports about hybrid microgrids. The 3rd and 4th weeks will imply carrying out and transcribing semi-structured interviews with the energy experts. Weeks 5-6 will be spent on quantitative and qualitative data analysis, implementing descriptive statistics and thematic coding.
The last two weeks will be left to incorporate findings and draft the entire research proposal. All work will be done in a manner that upholds ethical standards, maintains confidentiality and mentions secondary sources.

**Conclusion:**
This research proposal indicates the dire need to come up with innovative solutions to the continued load-shedding crisis in Bangladesh. The study will seek to reveal the technical advantages, as well as the socio-economic obstacles of adoption by combining real-time monitoring with hybrid microgrids. The project will offer useful recommendations on how to improve efficiency, reliability, and sustainability through a mixed-method approach which will involve the analysis of secondary data and expert views. Finally, the results will help to facilitate a decrease in energy shortages and at the same time ensure that Bangladesh remains dedicated to having a longer-lasting and more resilient power industry.

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