**Suitability and Need for the Proposed Research**

#### **Aim, Significance, and Relevance of the Proposed Laboratory**

The proposed “**IoT-Based Renewable Energy Labraory,PUST”**, to be established within the Department of Information and Communication Engineering (ICE), is strategically designed to address Bangladesh's energy and power challenges from a digital-first perspective. This initiative directly aligns with the national vision for a "Smart Bangladesh" and supports the research and innovation goals of the Bangladesh Energy and Power Research Council (BEPRC). The primary aim is to establish a state-of-the-art research and development hub focused on leveraging **Artificial Intelligence (AI), the Internet of Things (IoT), Big Data analytics, and secure communication networks** to build a resilient, efficient, and decarbonized national power grid.

The energy sector of Bangladesh is at a critical inflection point, targeting a power generation capacity of 60,000 MW by 2041, with an ambitious 40% contribution from clean energy sources. Achieving this goal transcends traditional electrical engineering challenges; it necessitates a profound digital transformation. The large-scale integration of intermittent renewables, the rise of electric vehicles (EVs), and the need for enhanced grid stability demand intelligent, data-driven solutions. This laboratory will serve as the necessary foundation to pioneer these solutions, focusing on the critical information and communication infrastructure that underpins a modern smart grid.

This facility will empower ICE researchers and students at PUST to move beyond theoretical models and engage in hands-on, problem-oriented research. It will provide the essential infrastructure to develop and validate **indigenous software platforms, IoT devices, and communication protocols** tailored for Bangladesh's unique energy landscape. By fostering a new generation of engineers skilled in the convergence of ICT and power systems, the lab will directly contribute to the BEPRC's agenda of Innovation, Incubation, and Entrepreneurship (I2E). Ultimately, it will function as a "living lab"—a collaborative nexus where academia, power utilities, telecom operators, and tech industries can co-create and test the next generation of smart energy technologies, ensuring PUST becomes a key contributor to the nation's sustainable energy future.

### **Relevance to Bangladesh's National Needs**

The proposed “**IoT-Based Renewable Energy Laboratory”** at PUST directly addresses the nation's critical need for a technologically advanced, resilient, and intelligent energy infrastructure. While existing university facilities provide foundational knowledge, they are critically insufficient for research in the digital domains that now define modern energy systems. This lab will bridge a significant national infrastructure gap by creating a dedicated facility for **testing smart grid communication protocols, validating AI-driven energy management algorithms, and developing robust cybersecurity measures for power systems**. This initiative is in direct alignment with the mandates of the Bangladesh Energy and Power Research Council (BEPRC) Act, 2015, and is essential for realizing the vision of a "Smart Bangladesh 2041." Furthermore, by focusing on the intelligent management and reliability of power distribution, the laboratory will make a substantial contribution towards achieving the goals of Sustainable Development Goal 7 (SDG7), ensuring that the universal electricity access Bangladesh has achieved is both sustainable and efficiently managed for the future.

### **Importance of Advanced Tools for Researchers**

The strategic inclusion of specialized equipment is paramount to positioning PUST at the forefront of energy research. The “**IoT-Based Renewable Energy Laboratory”** will provide researchers with hands-on access to a powerful suite of tools, including **IoT sensor networks and communication gateways (LoRaWAN, NB-IoT), a real-time Hardware-in-the-Loop (HIL) digital grid simulator, high-performance computing (HPC) resources for AI model training, and a dedicated cybersecurity testbed for energy infrastructure**. This sophisticated instrumentation moves beyond basic component testing, empowering faculty, postgraduate, and undergraduate students to design, deploy, and validate complete cyber-physical energy systems. Access to industry-standard simulation software for **digital twin creation (ANSYS Twin Builder), communication network modeling (NS-3), and power systems analysis (ETAP)** will enable the generation of high-impact research and the development of market-ready prototypes, directly supporting BEPRC-funded innovation projects and fostering an ecosystem of cutting-edge experimentation.

### **Enhancement and Expansion of Research Scope**

By establishing this advanced facility, the Department of ICE will dramatically expand its research scope, unlocking new interdisciplinary opportunities at the nexus of energy and information technology. The laboratory will transform traditional research areas into digitally-focused domains, such as:

* **Intelligent Renewable Integration:** Moving beyond simple integration to developing **AI-powered forecasting models** for solar and wind generation and **IoT-based control systems** for managing thousands of distributed energy resources (DERs) in real-time.
* **Cyber-Physical Grid Resilience:** Creating **high-fidelity digital twins** of the national grid to simulate and defend against cyber-attacks, ensuring the stability and security of our critical energy infrastructure.
* **Big Data Analytics for Energy Efficiency:** Leveraging data from smart meters and IoT sensors to create sophisticated **demand-side management programs** and optimize energy consumption at a city-wide scale.

Furthermore, the lab will pioneer emerging research fields critical to Bangladesh’s future, including **Vehicle-to-Grid (V2G) communication protocols for electric mobility, application of 5G/6G networks for ultra-reliable grid automation, and blockchain-based platforms for secure peer-to-peer energy trading.** This expanded scope will solidify PUST's position as a national leader in the digitalization of the energy sector.