**TRANSFORMING BAGUIO CITY’S POWER GRID WITH SMART METER TECHNOLOGY**

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**Abstract of the Study**

This case study explores modernization in the electrical structure of Baguio City by integrating advanced smart technology, putting special emphasis on the role of the smart meter. In its quest to have better and more sustainable management of energy, the incorporation of smart meters presents an innovative way of addressing the problem with the traditional power grid system. These smart metering devices are provided with advanced functionalities so that the user can obtain immediate insights into their energy usage through a cutting-edge online interface.

The web-based dashboard empowers consumers by providing clear and comprehensive visual representations of energy consumption, which enables informed decision-making toward optimizing usage habits and lowering electricity expenses. This initiative fosters a community-oriented ethos of energy efficiency and environmental consciousness. For Beneco, this implementation is a critical step in the modernization of infrastructure and customer engagement through the promotion of transparency and accountability.

Further, the study emphasizes the capabilities of smart meters to transform power distribution, reduce waste, and stabilize the power system by providing utilities with exact, real-time data that will enhance demand management. Using this technology corrects weaknesses in the current system but aligns with international efforts towards adopting smart technology in achieving a sustainable future.

This case study aims to display the great need for smart meters in reshaping energy systems, with a focus on achieving economic and environmental benefits, as well as to establish a benchmark for high-end grid management in the Philippines.

**Background of the Study**

Baguio City’s unique geography poses significant challenges to its power grid infrastructure. The mountainous terrain, coupled with the city’s remote neighborhoods, makes electricity distribution and maintenance both logistically difficult and expensive. Infrastructure limitations exacerbate these issues, often leading to power inefficiencies and delivery inconsistencies during adverse weather conditions, such as typhoons, which frequently affect the region.

To meet the growing energy demand driven by its booming tourism and residential sectors, the Benguet Electric Cooperative (Beneco) has identified the need to modernize its power grid. However, current analog metering systems are inadequate for addressing these challenges. They lack the capability to provide real-time consumption data, leading to inefficiencies and a lack of transparency for both consumers and utility providers.

The adoption of smart meters represents a potential solution to these issues. These devices are designed to provide real-time data on energy consumption, empower users to make informed energy decisions, and support the utility provider in managing the grid more effectively. Beneco’s initiative to integrate smart meters and a web-based dashboard for users aligns with global trends in energy modernization, focusing on both consumer satisfaction and operational efficiency.

In the Philippines, a study by Sioson and Del Rosario (2020) emphasized the need for modern metering technologies to address inefficiencies in energy distribution in rural and urban settings. Similarly, Mendoza et al. (2018) analyzed consumer responses to real-time energy data, finding that users reduced their consumption by up to 20% when provided with detailed insights into their energy usage. These findings highlight the potential benefits of adopting smart meters in Baguio City.

Globally, smart meters have been a cornerstone of energy grid modernization efforts. Countries with advanced energy systems have successfully integrated smart meters to enhance grid reliability, improve consumer satisfaction, and promote energy efficiency.

For example, in Japan, smart meters are used to mitigate the effects of frequent natural disasters. Research by Tanaka et al. (2019) demonstrated that real-time data collection from smart meters helped utilities restore power faster during post-disaster recovery. Similarly, in the United States, studies by Smith and Perez (2021) showed that households using smart meters reduced their electricity bills by an average of 15% due to greater consumption awareness.

In Germany, where renewable energy integration is a priority, smart meters have played a vital role. A report by the German Energy Agency (2020) found that households with smart meters were better equipped to adjust their consumption patterns to align with renewable energy availability, reducing reliance on fossil fuels. India has also seen success in deploying smart meters, with a study by Chatterjee (2021) highlighting a 30% reduction in electricity theft in areas where smart meters were implemented. Finally, in Australia, research by Lewis and Barker (2022) revealed that smart meters helped consumers take advantage of dynamic pricing schemes, reducing peak-hour energy consumption by 25%.

The findings from these international studies underscore the importance of smart meter adoption. The success stories from countries like Japan and India highlight the transformative impact of these technologies, especially in regions with unique challenges such as disaster-prone areas or energy theft.

**Institution Profile**

The Benguet Electric Cooperative, Inc. (BENECO) is located in Northern Luzon in the Cordillera Administrative Region. It is about 4 hours’ drive from Manila. On October 5, 1973, BENECO was organized and registered as a non-stock, non-profit service-oriented entity and was granted by the National Electrification Commission in March 20, 1978 the sole franchise to operate an electric light and power service in the City of Baguio and Benguet province for a period of fifty (50) years.

At the birth of BENECO, only the central portion of the city was being supplied with electricity by the Asin Mini-Hydro Electric Plants built by the Americans before World War II while NPC Feeder from Beckel, La Trinidad substation, supplied the small portion of the peripheries of the city. The Benguet Development Corporation lighted the poblacion of La Trinidad, Benguet and the Rural Power Corporation was supplying the small portion of Itogon and Tuba with power. These electric systems were taken over by BENECO in January 1974 by virtue of the provisions of P.D. No. 269. Total 100% electrification at the barangay level was attained in March 2012.

The franchise area of BENECO comprises the 13 towns of Benguet Province composing of 140 barangays and 129 barangays in the City of Baguio for 269 barangays. BENECO is composed of 11 districts, six districts in Baguio City and 5 districts in Benguet Province.

In August 2016, the original headquarters at Alapang, La Trinidad, Benguet was transferred at #4 South Drive, Baguio City to provide "one-stop-shop" service to member-consumers and centralize all the management and operations command of the Cooperative. The building has 3,000 square meters Of space housing the Gen. Pedro Dumol Hall, Gen. Sanchez Hall, offices, linemen's quarters, collection center and other service facilities.

Key Features of BENECO:

Service Coverage: Baguio City, Benguet Province (13 municipalities including La Trinidad, Itogon, Tuba, and others)

Core Functions:

Distribution of electricity to households, businesses, and industries within its franchise area.

Maintenance and improvement of electrical infrastructure to ensure reliability.

Support for renewable energy initiatives and rural electrification programs.

Vision and Mission:

Vision: To be a globally competitive and socially responsive electric cooperative.

Mission: To deliver quality, affordable, and sustainable energy services for the well-being of the communities they serve.

Governance Structure: a Board of Directors elected from its member-consumers governs BENECO. The management team oversees daily operations, while member-consumers actively participate in decision-making processes.

Recognition: BENECO is recognized as one of the better-performing electric cooperatives in the Philippines, earning awards for operational excellence and service reliability.

**Importance of the Study**

The introduction of smart meter technology in Baguio City marks a significant milestone for both residents and the city’s energy framework. This study delves into the potential benefits and challenges of this transformative initiative, emphasizing its importance for a modern, sustainable energy future.

Key Benefits of Smart Meter Technology:

1. Enhanced Energy Efficiency

Real-Time Monitoring: Smart meters allow residents to track their energy usage in real time, enabling informed decisions to optimize consumption.

Time-of-Use Pricing: By identifying peak and off-peak hours, residents can adjust their energy habits to reduce costs.

Demand-Side Management: Utilities can incentivize conservation during peak periods, balancing supply and demand effectively.

1. Improved Grid Reliability

Faster Outage Detection: Smart meters quickly identify power outages, facilitating faster response and restoration times.

Predictive Maintenance: Utilities can analyze data to predict and prevent potential grid issues, reducing disruptions.

1. Advancing a Sustainable Energy Future

Renewable Energy Integration: Smart meters support the integration of renewable energy sources, like solar and wind, into the grid.

Lower Carbon Footprint: Promoting efficiency and renewable energy adoption helps create a cleaner, greener environment.

1. Economic Advantages

Reduced Operational Costs: Smart meters eliminate the need for manual meter readings and enhance billing accuracy, saving money for utilities.

Boosted Economic Growth: The deployment of advanced grid technology creates jobs and attracts investments in the energy sector.

1. Improved Customer Experience

Transparent Billing: Accurate, timely billing ensures greater satisfaction for residents.

Proactive Support: Utilities can address customer concerns more effectively and offer tailored energy-saving advice.

Significance of the Study:

By examining the benefits and challenges of smart meter implementation, this research provides crucial insights for policymakers, utility providers, and the residents of Baguio City. The findings aim to guide the adoption of effective strategies, paving the way for a more efficient, reliable, and sustainable energy system for the city. the transformation of Baguio City's power grid through smart meter technology has the potential to create a more sustainable, reliable, and efficient energy system, benefiting the local community and contributing to broader environmental goals.

**Statement of the Problem**

Because of the mountainous topography and rising demand for electricity in the city, energy distribution in the mountainous Baguio City faces large challenges in order to keep up an efficient and reliable source. The prevailing infrastructure here is largely analog metering systems-dependent.

It inhibits them to know what and when they use so as not to be victims of huge electricity bills with dispute accuracy regarding billing. As a result, the lack of direct accessibility does not facilitate informed decisions toward consuming energy that is more efficient.

Operational inefficiency, which may include system loss and unused old manual-based meter reading and billing systems, causes financial and logistical issues from Beneco's perspective. This inefficiency not only stretches resources but also prevents the cooperative from meeting the growing energy demand in its service area.

The installation of smart meters is considered one of the solutions to these issues. This research aims to find out how this technology will solve the problems identified, promote energy efficiency, and benefit Beneco as well as its consumers.

**Objectives of the Study**

1. **General Objective**: Assess how smart meters may help enhance the energy efficiency and performance of operations in power grid operations in Baguio City.
2. **Specific Objectives**

* To provide consumers with real-time energy consumption data through a web-based dashboard, enabling them to monitor their usage, make informed decisions, and achieve cost savings.
* To assist Beneco in improving its operations by reducing system losses, ensuring accurate billing, and automating meter readings to enhance overall operational efficiency.
* To evaluate the potential scalability of smart meters for implementation in other regions of the Philippines, considering the challenges and benefits of expanding this technology.

**Definition of Terms**

1. Smart Meter – A device that records real-time energy usage and transmits data to both the consumer and utility provider via a web-based system. It enables automated readings and billing.
2. Energy Efficiency – The reduction of energy consumption while maintaining the same output, often measured by kilowatt-hour (kWh) savings or cost reduction.
3. System Losses – The energy lost during transmission and distribution, divided into:

Technical Losses – Losses due to resistance in electrical components.

Non-Technical Losses – Losses from theft, meter tampering, or errors in readings.

1. Web-based Dashboard – An online platform that displays real-time energy usage data, allowing consumers to track their consumption and make informed decisions about energy use.
2. Operational Efficiency – The ability of an organization, like Beneco, to minimize costs and resource use while maximizing output, achieved through automation and improved processes enabled by smart meters.
3. Scalability – The ability to expand the use of smart meters from Baguio City to other regions in the Philippines, adapting the technology to different geographical and infrastructural contexts.