



PRE-FEASIBILITY STUDY ON DEVELOPMENT AND IMPOSING REGULATIONS ON MICROGRID SYSTEMS



Public Utilities Commission of Sri Lanka

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Executive Summary

The increasing demand for affordable, reliable, and sustainable energy solutions in Sri Lanka underscores the critical need for microgrid systems. Microgrids as localized energy systems capable of operating independently or in connection with the main grid, present a transformative opportunity to address energy challenges. This study explores the feasibility of microgrids in Sri Lanka, focusing on the requirement of robust regulatory frameworks to ensure safety and harness the broader economic benefits.

Given Sri Lanka's rapidly evolving electricity sector, it is crucial to take initiative-taking measures to prepare the regulatory aspects of Microgrids to align with the local context. This proactive approach will help address the unique needs and challenges faced in Sri Lanka's electricity system and ensure the effective integration of Microgrids into the broader energy landscape. By developing the right regulations and frameworks, Sri Lanka can facilitate the deployment of Microgrids in a manner that is safe, reliable, and in line with the national energy goals.

The study employed a three-pronged methodology to comprehensively analyze the regulatory requirements for microgrid systems.

1. *Global Practices and Case Studies*

Evaluated international experiences with microgrid implementation across various jurisdictions.

2. *Financial Viability Assessment*

Conducted a financial analysis using a local industry as a case study to identify economic benefits.

3. *Industry Survey*

Engaged stakeholders to understand challenges faced by investors in microgrid development within Sri Lanka.

This study has found the following key findings that needed immediate and effective solutions.

- **Microgrid Potential in Sri Lanka**

Sri Lanka's abundant solar resources provide immense potential for adopting microgrids across various scales and applications. Daytime renewable energy curtailments, and grid instability due to the high penetration of renewable energy faced by system controllers can be avoided from the use of microgrids. Therefore, Microgrids can enhance energy reliability, support renewable energy integration, and reduce dependence on centralized grid infrastructure. On the other hand with rising electrification and energy demand, microgrids can address gaps in rural and semi-urban areas.

- **Present Regulatory Landscape.**

There are no specific regulations for microgrids in Sri Lanka. Pilot projects have relied on ad-hoc exemptions from generation licensing requirements and few projects are in isolation. The lack of feed-in tariffs for multiple resource types and rigid grid interconnection policies limits the broader adoption of Microgrids.

- **Technical and Economic Viability**

Microgrids can integrate renewable energy sources like solar, wind, and biomass with advanced controllers to optimize performance. The Simulations indicated that microgrids can reduce energy costs, enhance system resilience, and provide long-term economic benefits under supportive regulatory environments.

- **Global Lessons**

Insights from microgrid implementations in the USA, Canada, and Europe highlight the importance of clear policies, incentivized tariffs, and stakeholder collaboration. Business models such as utility-owned, landlord-owned, and cooperative frameworks could be adapted to Sri Lanka's context.

The study proposed remedies for the identified barriers.

- **Development of proper Regulatory Frameworks**

Introducing microgrid-specific regulations addressing licensing, grid interconnection, tariff structures, and safety standards is much needed to safeguard all stakeholders. It is essential to set up mechanisms for microgrids that enable them to trade energy with the grid and take part in ancillary services markets.

- **Technical Guidelines**

The technical standards and guidelines for microgrid design, operation, and maintenance shall be established for the wide adoption of microgrids. It is needed to encourage the industry sector to integrate advanced technologies, such as battery storage and intelligent controllers, to maximize efficiency as they are the potential party that is suitable to integrate MG with self-investments.

- **Stakeholder Engagement and Pilot Programs**

This concept has been adopted worldwide and some countries in top of the development of microgrids. However, it is needed to involve all stakeholders such as utilities, policymakers, private investors, and community organizations in the planning and implementation of microgrids in Sri Lanka as one unwise decision may negatively affect the development of microgrids. Expanding microgrid pilot projects to prove technical feasibility and assess regulatory requirements in each scale is necessary.

In summary, Microgrids hold immense potential to revolutionize Sri Lanka's energy sector by enhancing reliability, integrating renewables, and fostering sustainable growth. However, achieving this requires a proactive approach to set up robust regulatory frameworks, incentivize investments, and align with global best practices. By addressing these challenges, Sri Lanka can position itself as a leader in microgrid adoption, meeting both local energy needs and broader sustainability goals.

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1. Introduction

The increasing demand for reliable, affordable, and sustainable energy solutions in Sri Lanka highlights the need for innovative energy systems that address the limitations of traditional centralized grids. As the country faces challenges such as energy reliability, renewable energy curtailment, and rural electrification, microgrids emerge as a transformative solution.

Microgrids, defined as localized energy systems capable of operating autonomously or in conjunction with the main grid, offer significant advantages. They enhance energy security, integrate distributed renewable energy sources (e.g., solar, wind, and biomass), and reduce dependence on centralized power infrastructure. For Sri Lanka, with its abundant renewable energy resources, adopting microgrids aligns with national energy goals and global trends toward decarbonization.

Currently, there are no specific regulations governing microgrids in Sri Lanka. Individuals or entities wishing to connect a microgrid to the national grid must obtain a generation license from the Public Utilities Commission of Sri Lanka (PUCSL). However, most small-scale or pilot microgrid projects connected to the grid have been granted special exemptions from this requirement on a case-by-case basis. Similarly, community-based renewable energy (RE) projects have been exempted based on the manner and quantity. For instance, rooftop solar installations under the Sooriya Bala Sangramaya initiative were allowed without the need for a generation license. Additionally, the current regulatory framework permits only transmission license holders to purchase and sell electricity. Grid interconnection for energy sources other than solar PV remains uncommon, and there is no feed-in tariff mechanism in place for projects utilizing multiple energy resources connected to the grid.

Regulators worldwide want some guarantee that microgrids will benefit society before approving their installation and operation and that they won't be able to exploit regulatory gaps to exploit their customers, break the law on the environment, or avoid taking part in social programs. Traditionally, regulatory restrictions have been the means of providing these assurances. In the event of exchanges between owners and customers, contractual arrangements might also be used to supply them. Many laws and regulations that empower

microgrid development and RE integration have been established worldwide. USA, CANADA, and EUROPE countries are forefront regarding this.

Additionally, the technical rules that govern how microgrids connect and operate raise important policy questions. The costs associated with deploying microgrids can be heavily influenced by the specifics of these technical rules. Therefore, these rules must be established through an open standards-setting process and enforced fairly. In the U.S., significant efforts have led to the development of widely accepted standards across states. In certain situations, microgrids may be classified as public utilities, which can have serious regulatory and financial implications. It's important to carefully examine the criteria under which microgrids are classified as utilities and the rules they must follow in each case, as these details can significantly impact their economics and feasibility.

Global experiences suggest that nations planning to implement and advance microgrids should [29], Implement laws and regulations addressing important potential areas that call for regulatory interventions, such as ***defining microgrids, the process for development, interconnection, tariff setting, services, operations (especially when operating in an islanding mode), energy and money transfers, billing and collection, and the roles and responsibilities*** associated with operating and connecting to the national grid, as well as the agencies in charge of access to the national grid and competition. Some major regulatory requirements are,

- ***Create standards for the operation, management, organization, execution, and provision of services to end users.***
- ***Create guidelines and standards to allow microgrids to interface with the larger electrical grid and guarantee secure grid functioning.***

This report examines the feasibility of microgrids in the Sri Lankan context, focusing on the critical need for regulatory frameworks. It highlights how appropriate policies and technical guidelines can unlock the potential of microgrids to support energy resilience, economic development, and environmental sustainability.

2. Background on Micro Grids

This section provides the necessary and summarized technical and operational information related to microgrid concepts which benefits the non-technical and non-familiar readers of this report.

2.1. Definition of Microgrids

There are many definitions for microgrids. Sometimes, they are referred to as mini-grids. The fundamentals of advanced microgrid design by Sandia National Laboratories, USA, define microgrids as follows [1].

A simple definition of a microgrid is a set of loads with local generation that can be isolated from the main electric grid. Microgrids can be single-customer solutions, may serve several customers as a partial feeder microgrid, or may encompass a full feeder or substation.

The most advanced distributed energy resource (DER) solution currently on the market is a microgrid. The US Department of Energy describes the microgrid as ***"A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid"*** [5]

Smart grid systems tend to develop bidirectional power flow arrangements more safely. The microgrid system can be considered as a key sub-system in the Smart grid concept.

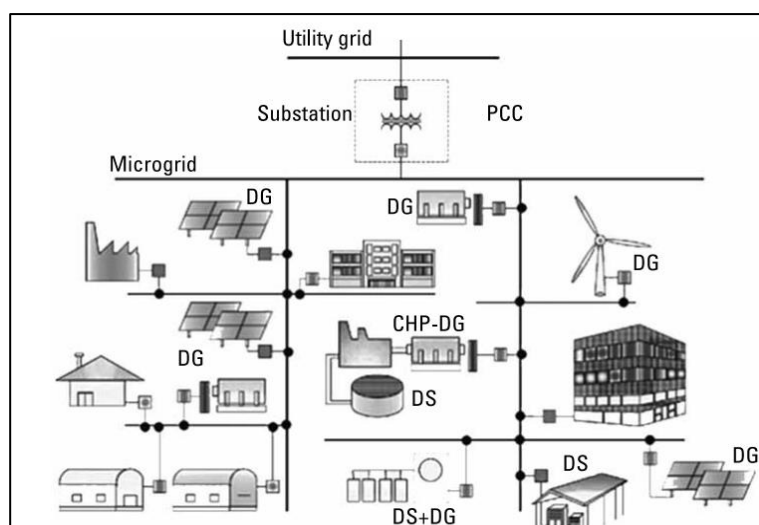


Figure 1; Typical Smart Grid⁶

The cost of constructing microgrids can be decreased by utilizing backup generators, switchgear, and electrical distribution feeders that are already present on the property. The local generation that results from a microgrid is frequently safer and easier to protect, and it lessens dependency on distant substations and transmission lines.

Microgrids are into three basic types:

Type 1: Microgrid for Backup Only

- Operates only when the main electric grid is down.
- Generation is sized to cover critical loads only.

Type 2: Always Islanded Microgrid

- Never connected to the main electric grid (e.g., a remote system far from the main grid)
- Has enough local generation to cover all local loads.

Type 3: Hybrid Microgrid

- Operates grid-connected part of the time and islanded part of the time.
- Operation mode is determined by factors including costs, main grid outages, fuel supplies, etc.
- Has enough local generation to cover all local critical loads, may have enough generation to cover all local loads.

Generation resources on microgrids are distributed energy resources (DERs). DERs can include diesel and gas engines, microturbines, fuel cells, PV, wind, biomass, and energy storage. These local generation resources enhance reliability by providing power to the microgrid's critical resources when the microgrid is islanded. When not islanded, excess generation may be able to be sold back to the utility to offset DER capital and operation costs. DERs can also be used as peak shaving devices, operating only when the microgrid loads are large and it is desired to reduce net consumption from the utility. Microgrid implementation may require the following types of alterations to typical infrastructure associated with drawing power from the main electric grid.

- Additional transformers/breakers/controls to existing generator resources (backup generators, PV, etc.)
- New generation resources (generators, PV, etc.)
- Static switch/main breaker
- Sectionalizing switches/breakers
- Energy storage –
- Microgrid controls
- Protection
- Building load reconfiguration
- Load shedding
- New feeder

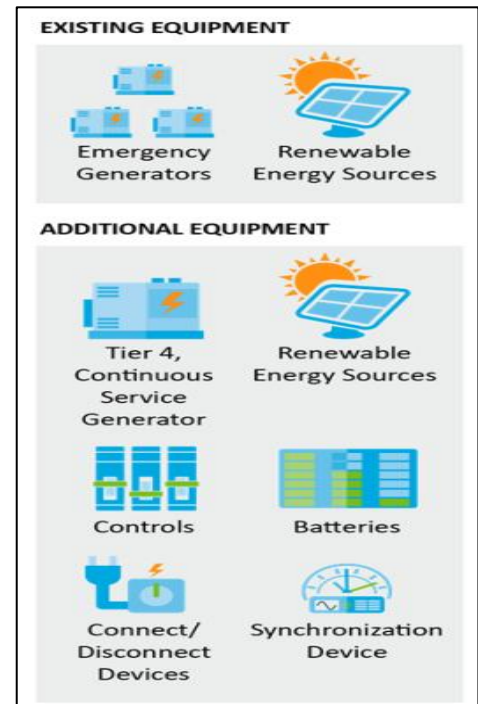


Figure 2: Equipment requirement³

2.2. Microgrid Market

Numerous forecasts and analyses have been done regarding the growth of the microgrid market. The size of the worldwide microgrid market was estimated at USD 36.05 billion in 2023, and by the end of 2032, it is projected to have grown to approximately USD 168.64 billion, with a compound annual growth rate (CAGR) of 18.7% [25]. Microgrids have become increasingly sophisticated with the addition of high-speed control platforms and forecasting systems. Many factors, such as finance and cost concerns, are being contested in several national and international forums to grow the industry. Because of the increasing rate of electrification in the region, particularly in rural and semi-urban regions, the Asia-Pacific region is anticipated to dominate the market throughout the forecast period [24].

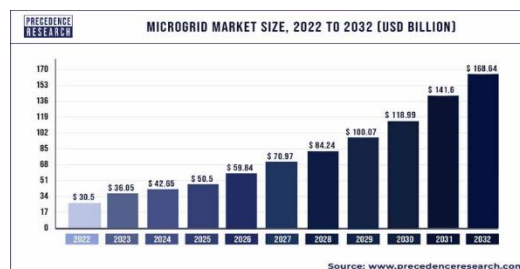


Figure 3: Microgrid Market growth²⁶

Microgrid projects are complex. They require strong expertise in technology selection, financing solutions, local codes and regulations, utility requirements, and customer procurement policies.

2.3. Different Microgrid Applications

In general, microgrids are classified according to their attributes, traits, and uses. This covers their modes of operation as well as the kinds of fuel or energy sources they require. Integrating renewable energy, enhancing community resilience, or pursuing other goals like cost savings could be the main objective. Despite the lack of precise definitions for microgrid subclasses, several uses, and varieties of microgrids are included below.

- Grid-connected or Continuously Islanded.
- Size or Complexity
- Renewable Microgrid
- Community Resiliency Microgrids:
- VPP Microgrid
- Hybrid microgrids

2.4. Utility interconnection

During regular operations, a well-designed microgrid can be used as a resource to independently control power usage and save costs from the commercial utility provider. In exchange for assistance in regulating the grid loads, developers can utilize the microgrid to bargain with the utility for alternative rate structures. Some key points can be addressed through interconnection agreements are followed. [3]

- Control of Demand Charges.
- Power Factor Correction
- Contract Revision. (On-Call Demand Reduction, Fixed Reduction on Preset Schedule)

2.5. Safety in Microgrids

Microgrids make use of standard hardware and technologies. As a result, they don't pose any serious new safety hazards in terms of machinery and usage. There are three main things to consider. They are,

- Electrical Safety
- Integration
- System Grounding

2.6. Designing a Microgrid System

SNL (Sandia National Laboratory) developed many guidelines, since 1990 as the USA adopted the microgrid systems much from the 90's. One of the methodologies they developed for the microgrid system designing is Microgrid Conceptual Design Methodology (MCDM). Its goal is to offer a methodical methodology to determine whether a microgrid solution is viable. An example of a conceptual microgrid design is the 10% to 20% solution. A realistic configuration and cost estimate for the generation, storage, distribution, operation, and management required over the system's lifetime are included. A conceptual design approximates the final microgrid design by utilizing estimates, assumptions, and accessible inputs. Although the design is not fully developed, specified, or approved, it offers enough information to calculate costs and start the procurement process. A good design must consider the following fundamental components: cost-effectiveness, sustainability, dependability, safety, and security. Understanding and defining them for a particular set of objectives and within a particular jurisdiction is crucial.

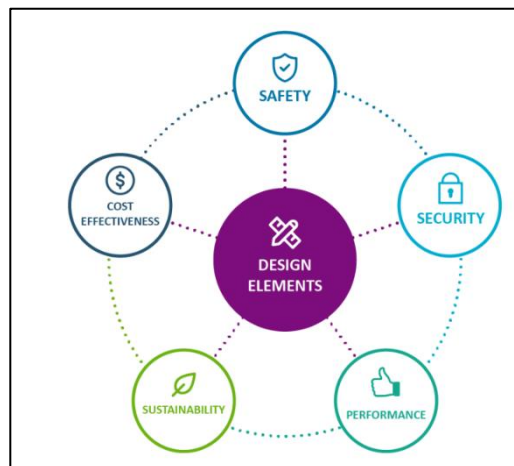


Figure 4: Key pillars of microgrid design

2.7. Microgrid Controller market

Many market players are developing sophisticated MG controllers. The cost of MG controllers is significantly based on the complexity of the controller and the microgrid, with a

median controller cost of \$155k per MW, but a range of \$6.2k to \$470k per MW. [4]. The Controller is the brain of the MG system which controls all the components to meet desired requirements of MG. Sophisticated communication is the main weapon that has controllers to give better performances. The IEC standard followed by the controllers is IEC 61850. The first edition of IEC 61850 [9–11] has found widespread application outside of the confines of electrical substations. The creation of standardized virtual data models and the development of data exchange processes based on these models are the main components of this protocol that advance interoperability across devices from various vendors. Stated differently, IEC 61850 specifies models for the data organization that devices must adhere to, across all device types and manufacturers, in addition to the protocol element definitions.[6].

MG controllers provide various kinds of functions. Designers should choose the correct controller required as per the application. Some of the features are,

- Spinning reserve management
- System step load capacity management
- Generator scheduling and configuration management based on various measures like runtime, hours, service intervals, etc. (highly configurable)
- Generator single contingency event management
- Generator overload protection
- Wind turbine or solar PV generator power/reactive power limitation
- Energy storage management of excess renewable energy
- Manage load demand and Feeder reclosing and feeder rotation.
- Feeder shedding based on generator overload instead of under frequency.
- Feeder management in cooperation with protection relays
- Balance of plant management
- Renewable energy maximization and stabilization
- Demand management, Monitoring and reporting

The major players in the microgrid market are Schneider Electric, General Electric (US), ABB, Siemens, Eaton, Schweitzer engineering laboratories, and Honeywell.

2.8. Business models

The success of a new microgrid system is still heavily dependent on the economic model that supports it. The business models used in the matured MG market in the USA are depicted in the following figure.[4]

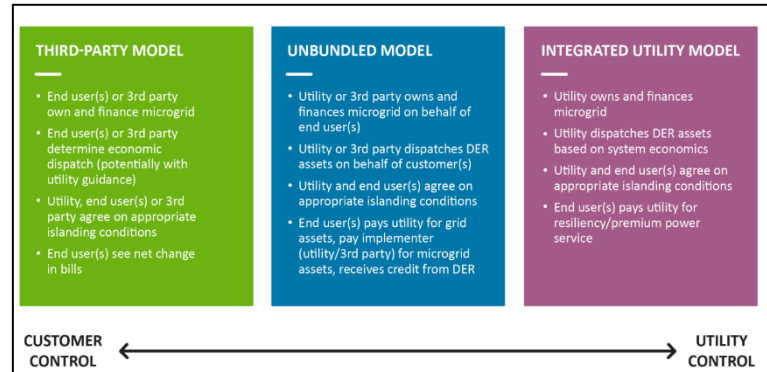


Figure 5: Business models in USA MG market ⁴

2.9. Benefits of Microgrids

The ability of a microgrid to operate as a controlled entity has two key implications. First, it can offer complex services, such as managing variable renewable energy generation. Second, it can coordinate with other entities in the network, including other microgrids or sites with generation capabilities and controlled loads. Within the microgrid itself, there are clear benefits, including the potential for providing clean and affordable energy under local management.

For microgrids to effectively provide benefits to the high-voltage grid such as ***demand response and ancillary services*** the markets for these services must also allow for microgrid participation. One promising opportunity is that microgrids can act as aggregators for potential ancillary service providers. For instance, they can collectively manage electric vehicles, stationary batteries, and building equipment to offer combined services to the grid. In this scenario, the contractual agreements between vehicle owners and the microgrid will require regulatory oversight. Microgrids offer a unique opportunity to manage power quality and reliability (PQR) locally. The regulatory and technical environment will greatly influence how this technology is implemented. Importantly, microgrids could evolve as a mechanism for exchanging low-carbon electricity. The generation and demand within the microgrid are integrated to enable customers to manage or shed loads effectively, optimizing the performance, cost, and reliability of the microgrid during grid disturbances.

2. Methodology

This study was conducted in three stages.

1. Global Practices and Case Studies

In the first stage of the method, it has been gathered the technical operational, and other information on microgrids and valuated international experiences with microgrid implementation across various jurisdictions.

2. Financial Viability Assessment

In the second stage, the sample industry cost-benefits analysis was conducted to find the financial viability of converting the existing system into a microgrid system using local industry.

3. Industry Survey

Engaged stakeholders to understand challenges faced by investors in microgrid development within Sri Lanka. Additionally, stakeholder input was gathered through industry surveys to validate findings and incorporate expert perspectives.

2.1. Case Studies on Microgrid Regulation

1. Case Study from USA

In 2004, a more extensive survey among USA state regulators was conducted to better understand the regulatory environment for microgrids [30].

However, regulators have noted, either explicitly or implicitly, that not all microgrid applications are viewed the same way under the law. The key differences that regulators focus on are not necessarily the technical aspects of microgrid installation and operation, as is often assumed, but rather the ownership structure and business practices of the microgrids and specifically, how they generate revenue. In that study, five distinct models were identified to categorize microgrids based on their ownership and business practices. These models aim to reduce confusion and promote clearer policy discussions and development.

The five models are,

- **Utility Model** – The distribution utility owns and operates the microgrid to lower costs for customers and provide reliable power to specific users within the system.
- **Landlord Model** – A single landlord installs and operates a microgrid on-site, supplying power and/or heat to tenants under a contractual lease agreement.
- **Co-op Model** – Multiple individuals or businesses cooperatively own and operate a microgrid to meet their own electricity and/or heating needs. Customers voluntarily participate and are served under a contract.
- **Customer-Generator Model** – A single individual or business owns and manages the microgrid, providing electricity and/or heat to themselves and neighboring customers. Neighbors voluntarily join the microgrid and are served under contract.
- **District Heating Model** – An independent company that owns and operates the microgrid, selling power and heat to multiple customers. Customers voluntarily participate and are served under contract.

The same study found that even in states where microgrid owners may have the legal right to install and operate, there are still several restrictions on how the microgrid can be structured and how its business can function. Three commonly cited stipulations for microgrids seeking non-utility status are,

- The microgrid owner(s) or operator(s) must be the primary consumers of the electricity generated.
- Microgrid customers must be located on or adjacent to the site where the power is generated.
- A microgrid may serve only a limited number of customers.

For a microgrid to be economically viable, it must be interconnected with the local electric grid and allowed to buy and potentially sell electricity. However, utilities have been hesitant to permit distributed energy resources (DERs) to connect to the grid, often citing concerns about safety and system stability. While these concerns can be valid, system operators and regulatory

authorities have developed procedures that fairly assign responsibilities and burdens of proof to customers, generators, and the utility.

When properly designed, these procedures outline the timeline and responsibilities for both parties, as well as contingencies in case either party fails to meet its obligations. They provide all MG owners with the assurance that, if they meet certain pre-defined standards, they will be able to interconnect within a reasonable timeframe. At the same time, they give utilities confidence that MGs will not negatively impact their system or their other customers.

Social Benefits

The study found out that, before allowing microgrids to be installed and operated, most regulators seek assurance that microgrids will benefit society and not exploit regulatory loopholes that could lead to customer mistreatment, environmental law violations, or avoidance of social programs. These assurances are typically provided through regulatory controls, and in the case of interactions between owners and customers, they may also be enforced through contractual agreements. This section examines the extent to which microgrids are or could be, subject to regulatory oversight.

Customer Interactions

One of the key roles of regulators is to protect the public from unreasonable rates, poor service, and negligence that could pose safety or health risks. However, it is debatable whether this responsibility extends to customers who voluntarily choose to receive electricity and heat from an independent microgrid. While some regulators have raised concerns about how microgrid companies might serve their customers, it remains unclear how this relationship is governed under current regulatory law.

The study recommended following regulations to adopt MG concepts within the USA.

- Formalize the definition and legal rights of micro-grids.
- Require utility tariffs for microgrids.
- Adopt standardized interconnection procedures that apply to microgrids.

- Limit system and utility risk.
- Formalize the responsibilities of microgrid owners.

Most of the other studies highlight that the economic viability of microgrids largely depends on the incentives set by tariffs and market opportunities. Therefore, developing effective mechanisms for microgrids to trade energy and services with the larger grid is a crucial policy goal. This issue is more complicated than it appears for three main reasons.

1. Tariff Sensitivity: Microgrid economics are extremely sensitive to the specifics of tariffs and related agreements.

2. New Services: Most of the services that microgrids can provide to the larger grid, like local voltage support, are either new or traditionally supplied by large generating stations. Consequently, the definitions of these services often reflect the capabilities of large plants rather than those of microgrids.

3. Localized Benefits: Most of the benefits of microgrids are localized, making them difficult to quantify. This presents not only a technical challenge but also raises important equity considerations.

The rules, tariffs, and contracts governing payments in both directions are likely to be the most significant factors driving microgrid development. Therefore, a comprehensive policy analysis of the technical basis for these regulations is essential.

2.2. Technical and Financial Evaluation of MG System

2.2.1 Converting existing industry into MG.

In this case, one industry was selected to assess the technical and financial feasibility of a microgrid (MG) system. The analysis primarily focuses on the feasibility of converting the existing system into a microgrid. This industry already has access to a nearby biomass power plant, and the study plans to integrate both the biomass plant and a new rooftop solar (RT) system (940kW) into a single microgrid. The capacity of the biomass power plant is 1 MW, while the industry's transformer capacity is 1.2 MW. The current grid export rate for electricity from the biomass power plant is approximately 20 LKR per unit, while the average electricity price consumed by the industry, based on the industrial tariff in January 2023, is 37.24 LKR per unit. The total energy requirement for the proposed system is 342,140 kWh per month. The following table shows the average annual generation of the biomass power plant.

Table 1: Monthly Generation of Biomass Power plant

Month	Average Monthly Generation(kWh)
January	14,407
February	113,969
March	116,959
April	93,984
May	97,723
June	94,700
July	99,700
August	139,300
September	110,900
October	79,400
November	66,700
December	153,640

The following table shows the Generation of each source and required demand per year.

Table 2: Demand and available Generation of MG

Item	Unit	Amount
Required Annual Electricity Generation for MG	MWh	4106
Rooftop System Annual Generation	MWh	1319
Expected Biomass Power Plant Generation	MWh	4380
Actual Annual Generation of Biomass Power Plant (average)	MWh	1182

As this study only focuses on integrating existing systems into the MG system it has taken present performances of the system to further analysis. The reduced energy generation of Biomass Power plants can be attributed to three main factors: a decrease in the plant-rated capacity over time, scarcity of raw materials, and the requirement of raw materials for the production process. The financial evaluation of the proposed microgrid system was conducted based on these generation patterns. Most biomass power plants typically operate with a plant factor ranging from 30% to 50%. According to the collected information, the plant is currently operating at approximately 10%-15% plant factor with lesser than designed plant factor.

This interconnection was planned to minimize relocation of existing DG, Switchgear boards, and re-arrangement of cabling. The master and slave controllers will be finalized to meet the expected outcome. Microgrid controller costs per megawatt vary significantly based on the complexity of the controller and the microgrid, with a median controller cost of \$155k per MW, but a range of \$6.2k to \$470k per MW [4]. Therefore, for the proposed microgrid system, estimated to be of medium size, the cost is projected to be \$235k per MW. The tax imposed on the controller was not taken for the study. Additional distribution system augmentation costs are also factored in. No other expenditures were considered as the analysis only considers the profit from self-use. Other O&M costs and overhaul costs were not included as they already needed to be conducted. Assumptions made in this analysis include steady Biomass Power plant generation

throughout the next 20 years and an annual 2% reduction in electricity prices. The analysis yielded the following results. No battery storage is considered in this analysis.

Table 3: Excel base financial analysis of MG with annual tariff reduction

Financial Analysis	
Investment / LKR	290,917,701.00
Initial Monthly Generation (kWh) of MG	1,291,998.08
Solar PV Tariff (Rs/kWh)	34.50
Savings due to self consumption (LKR/kWh)	17.00
Annual reduction of savings due to tariff reduction	2%
Cost of Funds	18.17%
NPV	(LKR 3,861,024.50)
IRR	17.79%
ROI	-1.33%



Figure 6: Cumulative profit of proposed MG

It was observed that a negative NPV. Moreover, the IRR was less than the discount rate. This is because the analysis expected a 2% annual tariff drop. It was also noted that the results were better with a flat utility rate for the entire 20 years.

Table 4: Excel base financial analysis of MG without annual tariff reduction

Financial Analysis	
Investment / LKR	290,917,701.00
Initial Monthly Generation (kWh) of MG	1,291,998.08
Solar PV Tariff (Rs/kWh)	34.50
Savings due to self consumption (LKR/kWh)	17.00
Annual reduction of savings due to tariff reduction	2%
Cost of Funds	18.17%
NPV	LKR 13,123,819.75
IRR	20.01%
ROI	4.51%

Following the initial analysis, a more detailed feasibility study was conducted using HOMER simulation software. The assumptions made during the simulations are as follows.

The reduced installed rated capacity of the Biomass Power plant power plant is 600 kW. However, as major rehabilitation for the Biomass Power plant power plant was not considered in this design, the installed rated capacity for the next 20 years will be maintained at 500 kW.

- The utility tariff remains constant over the operating period.
- The conversion rate from US dollars to Sri Lankan rupees is 330 LKR per USD.
- The daytime selling price is set at 34.5 LKR (as the total PV system capacity exceeds 500 kW), while peak and off-peak selling prices are set at 20 LKR.
- Raw material feeding rate is continuous throughout the day, at 2500 kg/hour.
- The number of operating days is 10, with a shutdown time of 20 days per month.
- All generated steam is used for power generation.
- Fuel price is considered at half, as power generation is a byproduct of the charcoaling process.
- Only distribution system maintenance costs are considered, as the existing system already covers said costs.
- Daytime exports are only allowed, assuming that only solar PV will be exported.

Other financial and economic parameters are taken as per the economic condition of Sri Lanka in the 4th quarter of 2023.

Other parameters used in the simulation are mentioned in the following table.

Table 6: Information used in Homer Simulation

Description	unit	Value
MG controller cost	LKR	66,000,000.00
Fixed capital cost	LKR	100,000,000.00
Fixed O&M/year	LKR	5,000,000.00
Initial capital cost for Distribution system modification	LKR	34,000,000.00
Peak Load (kW)	kW	760.00
Diesel Generator Initial Cost	LKR	5,500,000.00
Diesel Generator Replacement Cost	LKR	15,000,000.00
Diesel Generator O&M/hour	LKR	200.00
Diesel Price -Average	LKR	350.00
Biomass Power plant downtime	Hours/Month	480.00
Biomass Power plant operating hours	Hours/Month	240.00
Biomass Power plant's new Distribution system O&M cost	LKR/Hour	354
Biomass Power plant factor	%	13%
Estimated Plant factor for 500kW Installed Capacity	%	33%
Discount rate	%	18.17%
Inflation	%	10%
Available Biomass	tone/month	1,500
Coconut shell Feed rate	kg/hour	2500
Coconut shell requirement per month	tone	600
Coconut shell price	LKR/kg	10
Average Electricity price	LKR/kWh	37
The annual Electricity requirement of MG	kWh	4,105,680

Monthly Electricity requirement of MG	kWh	342,140
Daily Electricity Requirement	kWh	11,405
LI Battery Capacity	kWh	100
Unit cost of LI Battery	LKR	110,000
O&M cost of BESS	LRK/year/kWh	2,725

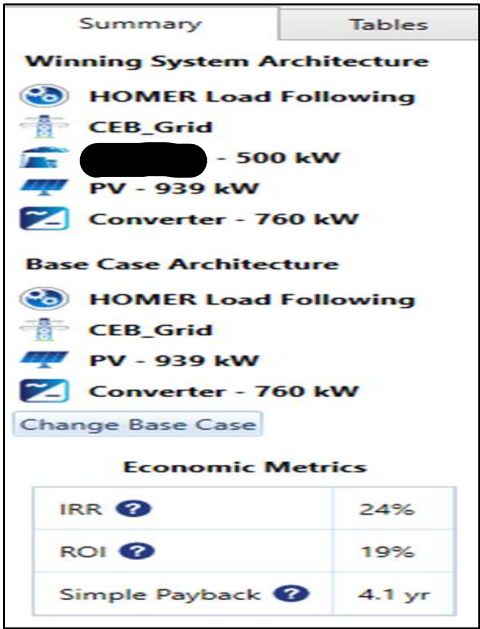


Figure 7: Summary of Simulation

HOMER can be utilized to assess the financial feasibility of an investment by optimizing microgrid design. Homer software facilitates identifying different optimized scenarios that maximize the financial benefits. Therefore, various scenarios were simulated to obtain optimized results. The analysis conducted via HOMER yielded the following outcomes: A payback period of 4.1 years, an Internal Rate of Return (IRR) of 24%, and a Return on investment (ROI) of 19% concerning the additional investments after rooftop system installation. These results suggest that investing in the microgrid system is a viable solution for the industry.

The Levelized Cost of Energy (LCOE) is 30.96 LKR per unit in the lowest-cost system. In this analysis, the Battery Energy Storage System (BESS) was not selected by the simulation. Both Excel-based calculation and HOMER simulations indicate that adding BESS to the industrial setting is not a viable solution under the current tariff structure and rooftop solar (RT) schemes.

In summary, it is observed that medium-scale industries are still not viable for adding BESS to their operations under the present conditions and tariffs. Without incorporating BESS, neither the industry nor the grid operator can fully realize the benefits of establishing MG

systems, as BESS is a key technology for storing excess renewable energy, particularly solar PV power, and other ancillary services.

Therefore, when planning to convert existing systems into a microgrid (MG), several cost components are required to be considered. It is necessary to properly analyze the performance of existing power sources, such as diesel generators (DG), biomass plants, and other control systems, as well as additional costs for controllers, rewiring, Battery Energy Storage Systems (BESS), and taxes. Hence, an in-depth technical analysis is required to accurately identify the real cost-benefits of converting the existing system into a microgrid.

2.2.2 Anticipated Large-Scale Capacity of Microgrids in the Sri Lankan Context

This section focuses on evaluating the potential of microgrid (MG) system capacities that can be integrated into the Sri Lankan context. According to recent data from two standby generator suppliers, it has been observed that over 1,000 MW of standby generator capacity is distributed across the country. Additionally, industries are inclined to install rooftop solar PV systems to reduce their energy costs and meet carbon reduction targets. The latest Long-Term Generation Expansion Plan (LTGEP) by the Ceylon Electricity Board (CEB) highlights a cumulative Battery Energy Storage System (BESS) capacity of 900 MW in the next planning horizon. This section aims to explore the possibility of industries installing and operating BESS through MG systems, rather than relying on separate Independent Power Producers (IPPs) to meet the upcoming battery storage requirements. To add more flexibility in defining the MG systems the easiest way is to define as per the capacity. This study proposed three categories of MG systems according to their capacities.

- MG > than 1 MW
- 100kW < MG < 1MW
- 100kW < MG

Let's consider the MG systems greater than 1MW and connected to the distribution Network. The proposed conceptual design is as follows.

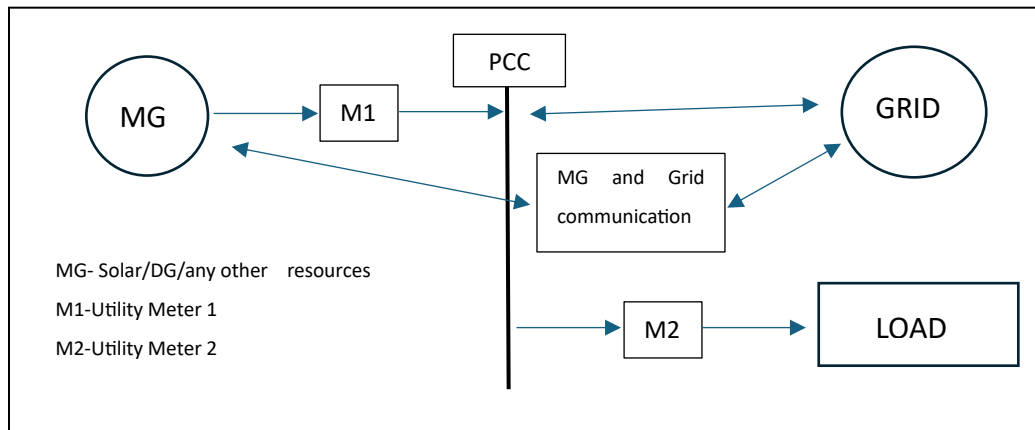


Figure 8: Proposed MG conceptual interconnection

At present, most power plants with capacities over 1 MW are connected to the grid through the Standard Power Purchase Agreement (SPPA) model, where the utility and generator sign an agreement for energy purchase. However, some of these power plants are located far from load centers, leading to increased energy losses and inefficient land use.

Under the existing SPPA model, any industry with a capacity greater than 1 MW can connect to the grid, and the utility pays for the energy delivered through their MG. However, this model proposes that instead of using their delivered energy for self-consumption, industries can meter the energy delivered to the grid (M1) and receive payment to recover their investment in the MG. Industries will continue to pay for the energy consumed from the grid based on the applicable tariff, metered through a second meter (M2).

Advantages of the Proposed Method

- Continuous Operations
 - Industries will be able to operate year-round in all modes (on-grid and off-grid), ensuring uninterrupted business operations.
- No Utility Investment in BESS
 - The utility will not need to invest in Battery Energy Storage Systems (BESS), as industries will handle the BESS investments themselves.
- Improved Monitoring

Each microgrid will be connected to the distribution control centers, allowing the utility to monitor system variations more effectively.

- Integration with Demand Response Programs

The utility will be able to attract MG systems to participate in Demand Response programs, enhancing system flexibility.

- Enhanced Flexibility and Black Start Capability

The utility will benefit from greater operational flexibility and improved black start capability, which can assist in restoring the grid after outages.

- Reduced Curtailments of Renewable Energy (RE)

Since industries can operate their systems in off-grid mode, the curtailment of renewable energy will be minimized, allowing for better utilization of RE resources.

When determining the tariff for the proposed microgrid (MG) systems, only investments related to renewable energy (RE) should be considered. Industries should ensure that any newly installed diesel generators (DG) are capable of continuous operation, even though DGs will not be used for day-to-day operations under this model. The tariff is required to be designed to recover only RE investments.

Additionally, the utility will only pay for the units of energy generated by the MG while connected to the grid. Energy generated in off-grid mode will not be compensated by the utility. Industries will also be paid by utility companies for services related to demand response programs and black start support, with rates for these services pre-agreed by both parties under separate contractual terms and should be mentioned under SPPA.

Anyway, this kind of technical interconnection arrangement requires high-end communication and technological involvement. Therefore the proper interconnection arrangements required to be established to make it safer and efficient.

Capacities between 100 kW and 1 MW can be encouraged by offering a separate consumer tariff specifically designed for MG industries. Microgrids smaller than 100 kW can be also derived by the separate attractive tariff. However, the proper installation standard and the battery disposal mechanism are required to be established to maintain long-term

sustainability. By implementing these kinds of schemes, private-sector investments can be significantly increased. The utility is only required to develop such schemes to adopt the technology and increase the renewable energy share as outlined in the Long-Term Generation Expansion Plan (LTGEP).

2.3 Industry Survey on MG concepts and development in Sri Lanka.

There are only a few companies and professionals currently active in the microgrid industry. As a result, a pilot microgrid project was established on the University of Moratuwa premises as part of a funded initiative. To gather industry perspectives on the ongoing development of microgrids, a Google survey was conducted. The list of questions in the Google survey is attached in Annexure 01.

This section analyzes the responses from seven industry experts regarding regulatory barriers affecting microgrid development in Sri Lanka. The respondents consist of professors from the University of Moratuwa, directors of energy companies, and specialists in the field, providing a comprehensive view of the current challenges and potential solutions. A summary of the responses is as follows.

Respondent Demographics

- Academic Sector: Two professors from the University of Moratuwa
- Private Sector: Five directors/managers from energy companies
- International Development: One energy efficiency specialist
- Experience Range: 9-20 years of professional experience

Expertise Level: All respondents indicated being "Very Familiar" or "Familiar" with microgrid concepts.

2.3.1. Key Findings

1. Primary Regulatory Challenges

The survey identified several critical regulatory barriers as follows.

- a) Lack of Specific Framework

- Absence of clear regulations for microgrid operations
- Undefined ownership structures and boundary methodologies
- No standardized approval processes.
- Communication and information barriers between stakeholders
- Equal opportunities and non-discrimination concerns
- Lack of standardized contracts for collective and self-consumption
- Absence of clear guidelines for energy communities

b) Grid Interconnection Issues

- Unclear technical requirements for grid integration
- Absence of standardized interconnection protocols
- Uncertainty in hybrid system approvals
- Anti-islanding requirements unclear.
- Peak shaving and duck curve management needs
- Energy storage system regulations lacking
- Insufficient guidelines for demand response programs

c) Tariff Structure Problems

- Current tariff structures negatively impact financial viability.
- Lack of specific microgrid tariff considerations
- Need for better integration of ancillary services value.
- Need for Time-of-Use Feed-in Tariffs
- Lack of special rates for solar export
- Insufficient incentives for energy storage
- High duties and taxes affecting implementation costs.

2. Project Impact Examples

Respondents provided specific examples of regulatory framework impacts.

- An ADB-initiated sustainable tourism microgrid project faced delays due to regulatory uncertainties.
- A factory's attempt to couple existing solar PV with generators was halted due to unclear approval processes.
- Project financing difficulties due to uncertain regulatory environment.

3. Community and Social Aspects

a) Implementation Challenges

- Public awareness and acceptance
- Community engagement in decision-making
- Local capacity building needs
- Social equity considerations

b) Proposed Solutions

- Community microgrid promotion
- Public education programs
- Stakeholder consultation processes
- Local government involvement

4. Technical Implementation Requirements

a) Grid Integration

- Power quality standards
- Protection schemes
- Communication protocols
- Modeling and simulation requirements

b) Operational Considerations

- System maintenance requirements
- Performance monitoring
- Emergency response protocols
- Safety standards

5. Market Development

a) Business Models need to be defined

- Community ownership structures
- Public-private partnerships
- Energy trading mechanisms

- Service provider frameworks

b) Financial Mechanisms

- Investment Incentives
- Risk mitigation strategies
- Insurance schemes
- Project financing options

6. Capacity Building Requirements

a) Technical Training on

- System design and implementation
- Operation and maintenance
- Troubleshooting and repairs
- Safety protocols

b) Knowledge Development on

- Research programs
- International collaboration
- Best practice documentation
- Case study development

3. Recommended Solutions

Technical Recommendations

1. Establish comprehensive grid interconnection standards
2. Implement uniform technical requirements
3. Develop clear protection schemes and communication protocols
4. Create standardized modeling and simulation requirements

Policy Recommendations

1. Create a single point of contact ("One-Stop-Shop") for approvals
2. Establish a governing board comprising key stakeholders

3. Develop standardized contracts for community microgrids
4. Implement specific targets for energy communities

Financial Recommendations

1. Revise tariff structures to support microgrid development
2. Introduce financial incentives and subsidies
3. Create special rates for solar export during peak hours
4. Develop mechanisms to value ancillary services

2.3.2. Recommendations extracted through the survey.

The survey results indicate that microgrid development in Sri Lanka faces significant regulatory challenges that require a comprehensive policy response. The key barriers identified are,

- ***Regulatory Uncertainty***
- ***Technical Integration***
- ***Financial Viability***

To address these challenges, a coordinated approach involving multiple stakeholders is necessary. The development of a national microgrid policy framework, the establishment of clear technical standards, and the creation of supportive financial mechanisms are crucial steps toward facilitating microgrid development in Sri Lanka.

Recommendations for Future Action were obtained through the survey.

1. Immediate Term

- Establish a dedicated regulatory framework for microgrids.
- Create standardized technical specifications and develop clear approval processes.

2. Medium Term

- Implement new tariff structures and create financial incentive programs.
- Establish training and capacity-building programs.

3. Long Term

- Develop comprehensive grid integration standards.

This analysis suggests that while significant barriers exist, there is a clear path forward through coordinated policy action and stakeholder engagement.

3. Conclusion

The Pre-Feasibility Study on the Development of Microgrid Systems in Sri Lanka provides a comprehensive analysis of the technical, financial, and regulatory challenges involved in deploying microgrids within the local energy landscape. The study emphasizes that, while the global microgrid market is rapidly expanding due to increasing energy demands and the need for decentralized, resilient energy systems, the Sri Lankan context presents unique challenges. These include the absence of regulatory frameworks, inadequate financial incentives, and technical gaps related to grid integration.

The key findings of the study underscore the need for targeted actions to facilitate the adoption of microgrids, especially within industrial sectors where renewable energy integration and energy security are critical. Also, Utility can more benefit through getting controllability of its high-demand consumers through MG systems. The implementation of microgrids is seen as a viable solution to address the country's growing energy demands, reduce dependence on centralized generation systems, and promote sustainability through renewable energy integration.

3.1 Key Findings

1. Technical and Financial Viability of Industrial Microgrids

The technical and financial analyses, particularly the case study on integrating a biomass power plant with rooftop solar, demonstrate that industrial microgrids in Sri Lanka are technically feasible and offer potential financial returns under the right conditions. The current energy pricing policies and lack of incentives for battery energy storage systems (BESS) limit broader economic viability.

2. Absence of Regulatory Frameworks

The study highlights that Sri Lanka currently lacks a comprehensive regulatory framework for microgrids. Existing pilot projects operate under special exemptions, and the absence of standardized regulations for grid interconnection, ownership models, and tariff mechanisms poses a significant barrier to the widespread deployment of microgrids. Without a clear regulatory environment, the potential of microgrids to contribute to grid resilience and energy security remains untapped.

3. Grid Integration and Technical Challenges

The successful integration of microgrids into the national grid requires robust technical standards for voltage and frequency regulation, grid stability, protection schemes, and communication protocols. The study identifies the need for clear guidelines on these aspects to ensure that microgrids can operate both in islanded mode and while connected to the main grid without compromising grid stability.

4. Market Potential for Microgrids in Industrial Applications

Globally, the microgrid market is experiencing rapid growth, with the Asia-Pacific region projected to dominate due to increasing electrification and renewable energy initiatives. In Sri Lanka, industrial microgrids present a particularly viable opportunity, given the high energy demand in this sector and the potential to integrate renewable energy sources such as biomass and solar photovoltaics (PV). However, unlocking this potential requires tailored regulatory policies and financial incentives.

5. Pilot Projects as Proof of Concept

To bridge the gap between technical potential and real-world application, the study advocates for one or two pilot projects focusing on industrial microgrids. These pilots would provide critical insights into system controllability, technical integration, and financial performance in the Sri Lankan context. Additionally, pilot projects would help inform regulatory frameworks and guide the development of microgrid-specific policies, particularly about tariff structures and grid interconnection standards.

3.2 Actions to Be Taken

Based on the findings, the following actions are necessary to enable the deployment of microgrids in Sri Lanka, particularly in the industrial sector.

1. Establishment of a Comprehensive Regulatory Framework

a. Definition and Legalization of Microgrids

A comprehensive regulatory framework is required to define the legal status of microgrids, their ownership structures, and the roles of stakeholders. This framework should establish guidelines for microgrid development, grid interconnection, energy trading, and operational standards.

b. Grid Interconnection Standards

The development of technical standards for grid interconnection is crucial. These standards should specify voltage, frequency control, and protection schemes to ensure that microgrids can safely integrate with the main grid. Additionally, the interconnection protocols must address the dynamic nature of microgrid operation, including transitions between islanded and grid-connected modes.

c. Tariff Design and Financial Models

The regulatory framework must include tariff structures that incentivize microgrid development. Time-of-use tariffs, feed-in tariffs for renewable energy, and compensation for ancillary services such as grid support and demand response should be introduced. This will ensure that microgrids are financially viable and that operators are compensated for their contributions to grid stability.

2. Introduction of Financial Incentives and Support Mechanisms

a. Subsidies and Incentives for Renewable Energy and Storage

To promote the adoption of renewable energy in microgrids, financial incentives such as subsidies, tax exemptions, and concessional financing for capital investment in solar PV, biomass, and battery energy storage systems (BESS) should be introduced. Given that BESS currently lacks financial feasibility, providing targeted incentives will help drive down costs and enhance the operational flexibility of microgrids.

b. Public-Private Partnerships (PPP)

Encouraging PPPs will be critical in mobilizing private capital for microgrid projects. Such partnerships should focus on shared investments in renewable energy generation and storage, fostering collaboration between the public sector, industry, and international development agencies. The model discussed in Chapter 2 will encourage the private sector (industries) to invest in MG systems.

3. *Technical Standards and Infrastructure Development*

a. Establishment of Grid Compatibility and Communication Protocols

The development of standardized communication protocols, such as those based on IEC 61850, will be essential to ensure interoperability between microgrid components and the national grid. This includes advanced microgrid controllers that can manage real-time data, control generation, and load, and optimize performance across various operating conditions.

b. Promotion of Advanced Microgrid Controllers

The deployment of sophisticated microgrid controllers is key to ensuring controllability and reliability in both islanded and grid-connected modes. Controllers should be capable of managing voltage and frequency stability, load balancing, and energy storage systems while providing real-time monitoring and reporting functionalities.

c. Pilot Projects to Test Feasibility and Controllability

Pilot projects are essential to validate the technical and financial models proposed in the study. By focusing on industries with access to renewable energy sources such as biomass and rooftop solar PV, the pilots will provide valuable data on system performance, controllability, and financial viability. These projects will also help identify any regulatory and technical bottlenecks that need to be addressed before scaling up microgrid deployment. The outcomes of the pilot projects should be used to refine regulatory policies, particularly in areas related to tariff structures, grid interconnection protocols, and operational standards. The data will also inform the design of future financial incentives and support mechanisms to optimize microgrid economics.

3.3 Implementation Plan

Phase 1: Immediate Actions (0-12 months)

1. Regulatory and Policy Formulation

- Draft and propose regulations that define microgrid operations, ownership models, and grid interconnection protocols, ensuring alignment with international best practices.
- Evaluating the performances of existing MG projects within Sri Lanka and identifying the gaps.
- Collaborate with stakeholders including industry, utilities, and financial institutions to finalize a tariff structure that incentivizes microgrid adoption while ensuring grid stability.

2. Initiation of Pilot Projects

- Identify industrial sites for the pilot projects and secure partnerships with relevant industries and technology providers.
- Implement the necessary infrastructure, including renewable energy generation, microgrid controllers, and grid interconnection points.
- Begin monitoring and data collection to assess the performance of the pilot microgrids.

Phase 2: Medium-Term Actions (12-24 months)

1. Pilot Project Evaluation

- Analyze the technical, financial, and operational data collected from the pilot projects to assess feasibility and identify potential challenges in controllability, system efficiency, and economic performance.
- Use the data to inform the finalization of the regulatory framework and to adjust financial models and tariff structures as needed.

2. Scaling Financial Incentives

- Based on the pilot project results, implement broad financial incentive programs, including subsidies, low-interest loans, and tax exemptions for microgrid development in the industrial sector.

- Introduce special tariffs for energy export and demand response services provided by microgrids.

3. Establishment of Technical Standards

- Finalize and enforce technical standards for grid interconnection, communication protocols, and protection schemes.
- Promote the deployment of advanced microgrid controllers that enhance system stability and operational flexibility.

Phase 3: Long-Term Actions (24-48 months)

1. Nationwide Microgrid Deployment and Continuous Policy Review and Innovation

- Expand successful pilot projects into broader industrial applications and encourage the adoption of microgrids in other sectors.
- Develop a national microgrid development roadmap that prioritizes renewable energy integration, energy storage, and decentralized generation in rural and underserved regions.
- Continuously monitor the performance of microgrids and update regulatory frameworks, financial models, and technical standards in response to technological advancements and market conditions.

The Pre-Feasibility Study on Microgrid Development for Sri Lanka concludes that microgrids, particularly in industrial applications, offer a technically and financially viable solution for improving energy security, integrating renewable energy, and reducing grid dependency. However, the absence of a regulatory framework, inadequate financial incentives, and technical barriers to grid integration remain significant obstacles. By establishing a comprehensive regulatory framework, introducing targeted financial incentives, and conducting pilot projects to assess feasibility, Sri Lanka can unlock the potential of Renewable Energy to achieve national targets.

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ANNEXURE 01

Identified Regulatory Barriers in Microgrid Development in Sri Lanka

Microgrids are localized energy systems that can operate independently or in conjunction with the main power grid. They consist of distributed energy resources (DERs), such as solar panels, wind turbines, and energy storage systems, along with control systems that manage the energy flow within the microgrid. Microgrids are designed to enhance energy reliability, improve energy efficiency, and integrate renewable energy sources more effectively.

The global microgrid market is gradually increasing. However, in Sri Lanka, the promotion and development of microgrids have not seen significant progress. The Public Utilities Commission of Sri Lanka (PUCSL) is currently conducting a preliminary study to identify the requirements for specific regulations pertaining to microgrids. In line with this initiative, PUCSL is conducting this survey to identify the potential regulatory barriers hindering microgrid development in Sri Lanka.

The results of this survey will be instrumental in evaluating the regulatory environment for microgrids and promoting the microgrid concept in the country. Your valuable insights and expertise will help us understand the challenges and propose solutions to facilitate the growth of microgrids.

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* Indicates required question

Email *

Record eerpucsl@gmail.com as the email to be included with my response



1. Professional Background :

1.1 Name : *

Your answer

1.2 Organization : *

Your answer

1.3 Position / Title : *

Your answer

1.4 Years of Experience : *

Your answer

1.5 Contact Information (optional) :

Your answer

2. Awareness and Perception :



2.1 How familiar are you with the concept of microgrids? *

- Very Familiar
- Familiar
- Somewhat Familiar
- Not Familiar

2.2. In your opinion, how important are microgrids for the future of Sri Lanka's energy sector? *

- Very Important
- Important
- Neutral
- Not Important

3. Regulatory Challenges and Barriers :



3.1. What do you perceive as the main regulatory challenges for microgrid development in Sri Lanka? (Please select all that apply and elaborate if possible) *

- Lack of Specific Regulations and Framework
- Unclear Licensing and Permitting Process
- Grid Interconnection Standards
- Tariff Structures
- Financial Incentives and Subsidies
- Legal and Policy Uncertainty
- Environmental Regulations
- Other:

3.2. Can you provide specific examples or experiences where the absence of a regulatory framework has impacted microgrid projects? *

Your answer

4. Licensing and Permitting :



4.1. How challenging is the current licensing and permitting process for energy projects in Sri Lanka in the absence of specific microgrid regulations? *

- Very Challenging
- Challenging
- Neutral
- Easy
- Very Easy

4.2. What specific aspects of the licensing and permitting process do you find most burdensome for microgrid projects? *

Your answer

5. Grid Interconnection :

5.1. Are there clear guidelines for grid interconnection for microgrid projects in Sri Lanka? *

- Yes
- No
- Somewhat



5.2. What improvements do you suggest for establishing grid interconnection standards for microgrids? *

Your answer

6. Tariff Structures :

6.1. How do current tariff structures impact the financial viability of potential microgrids in Sri Lanka? *

- Positively
- Negatively
- Neutral

6.2. What changes in tariff structures would you recommend to support microgrid development? *

Your answer

7. Legal and Policy Environment :



7.1. How does the current legal and policy environment affect microgrid projects in Sri Lanka? *

- Significantly
- Moderately
- Slightly
- Not at All

7.2. What specific legal or policy measures would you propose to facilitate microgrid development? *

Your answer

8. Environmental Considerations :

8.1 Are environmental regulations a potential barrier to microgrid development in Sri Lanka? *

- Yes
- No
- Somewhat

8.2. How can environmental regulations be designed to balance ecological protection with the promotion of microgrids? *

Your answer



9. Recommendations and Additional Insights :

9.1. What recommendations do you have for policymakers to develop a regulatory ^{*} framework that supports microgrid development in Sri Lanka?

Your answer

9.2. Are there any other potential barriers or considerations not covered in the ^{*} previous questions that you believe are significant?

Yes

No

9.2.1. If Yes Please Specify :

Your answer

10. Additional Comments :

10.1. Please provide any additional comments or insights you may have on the topic of microgrid development and regulatory barriers in Sri Lanka.

Your answer

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