Analysis of the Technical and Economical Aspects of Contingency Power and Spinning Reserves

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***Abstract*—Contingency power and spinning reserves are critical components of power systems worldwide, providing a vital role in maintaining system reliability and stability. In this paper, we analyze the technical and economic aspects of contingency power and spinning reserves, with a specific focus on Sri Lanka. We examine the current state of contingency power and spinning reserves in Sri Lanka and discuss anticipated structural reforms. Our analysis suggests that there is a significant potential for improving the technical and economic aspects of contingency power and spinning reserves in Sri Lanka. We propose a set of recommendations for policymakers to promote these improvements**

***Index Terms*—Reforms, Policies, Contingency power, Spinning reserves**

I. Introduction

Electricity is a critical infrastructure that underpins the economic and social development of nations. The stability and reliability of power systems are essential to ensure that businesses, households, and essential services have access to electricity when they need it. In this context, contingency power and spinning reserves are critical components of power systems worldwide, providing a vital role in maintaining system reliability and stability.

Sri Lanka has made a significant progress in developing its power sector over the past few decades. However, there are still challenges to overcome, including a lack of adequate contingency power and spinning reserves. The country has experienced frequent power outages due to various reasons such as lack of investment in infrastructure, hydrological uncertainties, and the increasing demand for electricity. As a result, there is a growing need to analyze the technical and economic aspects of contingency power and spinning reserves in Sri Lanka.

II. Present Performance and Challenges of Sri Lanka power sector

Contingency power and spinning reserves are essential components of power systems. Contingency power refers to the power generation capacity that can be quickly dispatched to meet the unexpected increase in demand or the sudden loss of generation. Spinning reserves refer to the generation capacity that is already connected to the grid and can be quickly dispatched to meet the sudden loss of generation. Contingency power and spinning reserves play a crucial role in maintaining the frequency and voltage stability of power systems.

In Sri Lanka, the state-owned Ceylon Electricity Board (CEB) is responsible for power generation, transmission, and distribution. The installed capacity of power generation is around 4,100 MW, with approximately 55% of the generation coming from thermal sources and 45% from hydro sources [1]. However, the country faces significant challenges in ensuring the stability and reliability of its power system.

The lack of adequate contingency power and spinning reserves has been a significant cause of power outages in Sri Lanka. According to the CEB, the country's peak demand for electricity is expected to reach 5,500 MW by 2025, which is a significant increase from the current peak demand of around 3,000 MW [1]. The CEB has identified the need to increase its contingency power and spinning reserves to meet this growing demand.

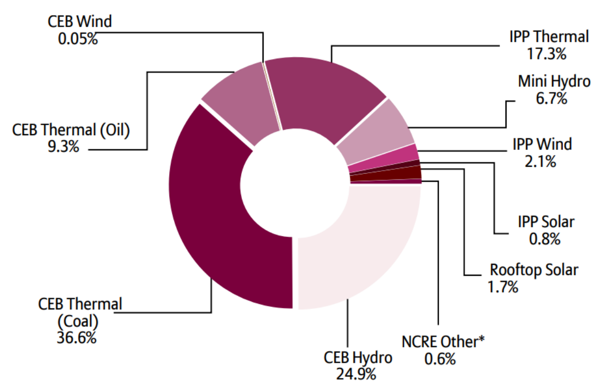

Fig. 1. Net energy generation year 2020 [1]

III. Sri Lanka Power sector reforms

To analyze the technical and economic aspects of contingency power and spinning reserves in Sri Lanka, we conducted a comprehensive review of the literature and analyzed the country's power sector data. We also conducted interviews with key stakeholders in the power sector to gain insights into the challenges and opportunities for improving contingency power and spinning reserves.

A. Contingency Power

The impact of contingency power on anticipated structural reforms can be viewed from a variety of perspectives. In this context, contingency power can be defined as a system's ability to continue operating in the face of a crisis or unforeseen circumstances. Changes in policies or regulations that are expected to occur in the future are referred to as anticipated structural reforms.

One way contingency power can help with anticipated structural reforms by allowing organizations to adapt to policy or regulatory changes. For example, if a new policy requires businesses to meet certain energy efficiency standards, contingency power can assist organizations in maintaining operations while upgrading their systems to meet the new standards. This can help organizations to avoid disruptions to business operations and comply with the new policy.

During the implementation phase of the anticipated structural reforms, contingency power may also be required. For example, if a new policy necessitates upgrades to the power grid or other infrastructure, contingency power can assist in maintaining the power supply during construction or maintenance. This can lessen the impact of the upgrades on the community while also ensuring that critical services are not disrupted.

Furthermore, contingency power can be critical in the event of unforeseen circumstances during anticipated structural reforms. Natural disasters or system failures, for example, can occur during the implementation of structural reforms. During such situations, contingency power can help to maintain the continuity of essential services and prevent further damage.

Finally, the importance of contingency power on anticipated structural reforms cannot be overstated. Contingency power can assist organizations in adapting to policy or regulatory changes, ensuring the continuity of essential services during implementation, and mitigating the impact of unforeseen circumstances. As a result, any anticipated structural reforms must include an element of contingency power. Sri Lanka's power sector has undergone several reforms aimed at improving power generation and delivery. However, better policy, restructuring, and revamping of the power sector are still urgently needed. In reality, each segment of Sri Lanka's power sector, generation, transmission, and distribution, must be repositioned for improved power delivery by implementing the following measures [2]:

- Attract the private sector with better regulations
- Adaption of HVDC power transmission
- Expansion of renewable energy usage for the generation
- Better metering system
- Anti-graft policy
- Mini-grid and distributed generators technology

B. Spinning reserves

A spinning reserve is defined as an "Unloaded generation that is synchronized and ready to serve additional demand" [3]. Since Sri Lanka is an island, the requirement for the spinning reserves is much greater than the countries with interconnected national grids [4]. Sri Lanka's power generation using hydro power and wind power heavily depends on the season. Because of these reasons, it is very important to focus on enhancing the spinning reserve capacity.

One method to enhance the spinning reserve capacity is to encourage private sector participation. To achieve this, structural reforms related to spinning reserves can be used. This may involve the establishment of incentives for the development of spinning reserves and the introduction of competitive bidding processes for the procurement of spinning reserves.

Competitive bidding can be introduced as a component of structural reforms related to spinning reserves. Using competitive bidding, it can be ensured that the spinning reserves are procured at the lowest possible cost, while also ensuring that the spinning reserves meet the necessary technical requirements and performance standards. With appropriately inclusive eligibility rules, a competitive bidding process allows the market to bring forward the technologies that can most cost-effectively provide the required capacity [5]. The process of competitive bidding should have clear rules and regulations in order to offer a transparent route to market for existing and potential new market entrants. Eligibility rules, pre-qualification and collateral rules, bidding process structure, and bidding rules, pricing rule, selection rules, and transparency are to be considered when designing the competitive bidding process.

The incentives can be offered as subsidies and financial aids in order to enhance the spinning reserves. The government can encourage private sector participation by offering subsidies. If the government can provide direct subsidies which can cover some of the costs associated with the installation, operation, and maintenance of spinning reserves, the private investors will be more financially supported. The type of subsidy can be different according to the types of spinning reserves or technologies. As an example, higher subsidies can be provided to the spinning reserves which have a higher capacity factor and faster ramp rates. The capacity factor is an indication of how often a plant is running at maximum power. It measures a power plant's actual generation compared to the maximum amount it could generate in a given period without any interruption [6]. The ramp rate describes the ability of a generating unit to change its output. By having a higher ramp rate, the spinning reserves are able to reach the changes in the power demand in less time duration. A higher capacity factor ensures that the spinning reserves are available when needed, while higher ramp rates ensure that the spinning reserves can respond quickly to changes in demand. Therefore, providing more subsidies to the spinning reserves which have a higher capacity factor and faster ramp rates will help to ensure a reliable and resilient power system. Reducing the taxes for costs for installation, operation, and maintenance of spinning reserves can make the private sector developers more financially viable. It will also make foreign companies attracted to invest in the projects.

Introducing long-term power purchase agreements (PPAs) is another way to attract private sector participants. PPAs are contracts between a power producer and a power purchaser. While PPAs increase the level of revenue certainty, the PPAs can also help to mitigate some of the risks associated with investing in spinning reserves, such as market volatility or changes in regulatory policy.

Establishing a regulatory framework regarding spinning reserves is another approach to enhancing the spinning reserves. It is necessary to introduce clear rules and regulations to establish a regulatory framework. They should include rules and regulations for the development, procurement, and operation of spinning reserves, as well as defining the roles and responsibilities of different stakeholders, such as the government, utilities, and private sector developers. This should also consider rules and regulations regarding the processes such as competitive bidding.

Developing the existing power system also contributes to enhancing the performance of spinning reserves. This includes developing the existing power system through the deployment of advanced control systems and communication technologies. Achieving a seamless integration of spinning reserves with the national grid can be helped by upgrading and modernization of the existing power system. Therefore, when there is a change in the power demand, the spinning reserves will be able to respond to that change in less time making the procedure fast. Another approach is to establish additional infrastructure to enable the deployment of spinning reserves, such as building new transmission lines or storage systems. As an example, implementing energy storage technologies, such as batteries or pumped hydro offers a reliable supply of spinning reserves, enhancing the overall reliability of the power system.

Cost-benefit analysis is a critical component of any structural reform related to spinning reserves. Cost-Benefit Analysis (CBA) measures a project's societal value by quantifying the project's societal effects and making costs and benefits comparable in monetary terms [7]. By conducting a cost-benefit analysis, the costs and benefits of different spinning reserve options, and identifying the most cost-effective and reliable solutions can be evaluated. The costs regarding spinning reserves can be categorized into installation costs, operating costs, and maintenance costs. On the other hand, the benefits can also include the potential benefits of increased system stability and reliability in addition to the avoided costs of power outages and system failures. The costs and benefits of various spinning reserves options must be estimated in order to do a cost-benefit analysis, depending on a variety of assumptions and scenarios. In order to determine the costs and benefits of various spinning reserve designs based on various demand and supply scenarios, modeling tools, and simulations may be used. The costs and benefits of various spinning reserves options must be estimated in order to do a cost-benefit analysis, depending on a variety of assumptions and scenarios. In order to determine the costs and benefits of various spinning reserve designs based on various demand and supply scenarios, modeling tools, and simulations may be used. Any externalities or non-market impacts of spinning reserves, such as the environmental effects of various spinning reserves technologies, as well as any social or economic effects of power outages and system failures, should be considered in the cost-benefit analysis.

IV. Results and Discussion

Our analysis suggests that there is a significant potential for improving the technical and economic aspects of contingency power and spinning reserves in Sri Lanka. We identified the following key areas for improvement:

- Investment in infrastructure: The government of Sri Lanka needs to invest in building new power generation capacity, especially renewable energy sources such as solar and wind, to meet the growing demand for electricity. This will help to reduce the country's dependency on thermal sources, which are costly and polluting.
- Grid integration: The integration of renewable energy sources into the grid can be challenging due to their intermittent nature. Therefore, there is a need for the development of an advanced grid management systems that can help to balance the supply and demand of electricity.
- Market reforms: The power sector in Sri Lanka is heavily regulated, with the government owning the majority of power generation assets and controlling the electricity tariff. However, the government has been implementing market-oriented reforms to increase private sector participation and promote competition in the sector.

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