

# Challenges and Opportunities for Introducing end to end Electricity Market in Sri Lanka: Lessons from International Case Studies.

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**Abstract**—This paper analyzes the challenges and opportunities for introducing an end-to-end electricity market in Sri Lanka, drawing lessons from international case studies. The Sri Lankan electricity sector faces several issues, including a state-controlled utility that is not financially efficient, hesitant to innovate and failure to stick with a fixed policy. The paper reviews literature on electricity market liberalization and analyzes case studies from Denmark, Australia, Pakistan, Japan, California and other countries to identify the requirements, benefits, and drawbacks of an end-to-end electricity market. The analysis includes a SWOT analysis of the Sri Lankan power sector, specific challenges that may arise in the Sri Lankan context, and suggestions to overcome them. The paper also discusses the impacts of an electricity market on different stakeholder groups, including consumers, producers, employees, and policymakers. The conclusion highlights the main findings and arguments, suggestions for policymakers and other stakeholders, and key lessons that can be learned from other countries experiences.

**Index Terms**—End to end electricity market, Market liberalization, Sri Lanka, International case studies

## I. INTRODUCTION

The Sri Lankan electricity sector has experienced significant growth in generation and consumption in recent decades, with a future target of a higher share of renewables by 2030. The power sector in Sri Lanka has undergone two phases of reform. Phase 1 began in 1983 with the creation of the Lanka Electricity Company (LECO) and the introduction of independent power producers (IPPs) and small power producers (SPPs). In 2002, the Public Utilities Commission of Sri Lanka (PUCSL) was established as the power sector regulator by Public Utilities Commission of Sri Lanka Act, No. 35 of 2002. However, political opposition prevented the full implementation of the act until 2009, when the Electricity Act No. 20 was ratified. This act authorized less restructuring of the Ceylon Electricity Board (CEB) than originally proposed

by the electricity reform act No. 28 of 2002, with the CEB transmission entity serving as the single buyer. This is the current structure(see Figure 1) of the electricity sector of the country. In the meantime Sri Lanka's power generation mix has shifted from hydro to a mixed hydrothermal system, with the share of nonconventional renewable energy (NCRE) increasing to 10% by 2013 [1]. The electrification rate has also improved significantly.

Still, the efficiency and reliability of the Sri Lankan power sector are widely questioned in addition to its financial losses. The failure to follow the generation expansion plan resulted in a generation deficit, and scheduled power interruptions island-wide. Since Ceylon Electricity Board(CEB) is a fully state-owned entity, changes in government policy decisions directly affects it. One solution to these problems is to introduce an end-to-end electricity market, which is challenging but has several advantages. This paper analyzes the requirements, benefits, and drawbacks of an end-to-end electricity market in Sri Lanka, drawing lessons from international case studies.

## II. LITERATURE REVIEW

An end-to-end electricity market is a system where all stages of the electricity value chain, from generation to consumption, are fully competitive and coordinated in real-time [2]. This is challenging but has its own advantages, such as providing more accurate and cost-reflective pricing signals to market participants, leading to greater efficiency and innovation.

Several countries have undergone electricity market liberalization, with varying degrees of success. Denmark, for example, has successfully implemented a real-time electricity market [3]. Denmark has a higher share of renewable energy in its energy mix as Sri Lanka and has successfully introduced an end-to-end electricity market, which has led to increased

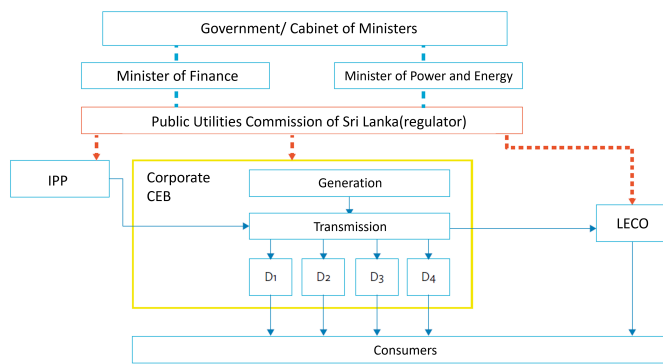


Fig. 1. Structure of Electricity Sector of Sri Lanka [1]

efficiency and reduced costs [4]. Similarly, Australia has implemented a national electricity market that is based on a real-time trading platform [2]. Australia is geographically isolated and has a similar population size to Sri Lanka, making it relevant to the country's context. The Australian market has undergone several reforms over the past few decades and has seen significant improvements in efficiency and innovation as a result [2].

Japan is a country with a unique electricity market structure, where more than ten vertically integrated electric power companies operate independently [5]. In addition, Japan's electricity market includes both 50Hz and 60Hz systems, as well as a mix of natural gas, nuclear, Hydro, coal, and petroleum power plants [5]. Despite these challenges, Japan has been able to improve the efficiency of its electricity market through deregulation and the introduction of competition [5].

The power sector in Pakistan has undergone major reforms and restructuring since the adoption of the 1994 policy that opened up the power market to private investment. While the policy attracted significant investment and added almost 4,500 MW of generation capacity, the cost-plus tariff methodology it established was seen as the starting point for the circular debt crisis in Pakistan [6]. Despite the implementation of a single buyer model and the separation of the Central Power Purchasing Agency from transmission and dispatch, Pakistan still faces inadequate capacity and other constraints [6], resulting in frequent blackouts. Demand for electricity has been driven by increasing population, access, and low consumer tariffs due to government subsidies. The privatization of Karachi Electric has shown improvement, particularly after a management takeover in 2009 by Abraaj Capital, reducing network losses from 35 percent to about 20 percent [6]. However, Pakistan's power sector still faces numerous challenges that need to be addressed for sustained progress [6].

California is another example of a region that implemented electricity market liberalization, but with mixed results. Following the 1996 Electricity Crisis, California restructured its electricity market in 1998, aiming to introduce competition and reduce prices for consumers. However, the implementation was plagued by several issues, such as a lack of investment in

infrastructure, uncertainty about regulations and rules. [7]. The market's collapse in 2000-2001 led to widespread blackouts, skyrocketing prices, and the eventual bankruptcy of the state's largest utility [8]. The California example highlights the importance of careful planning, timing, and anticipating potential challenges in implementing electricity market liberalization [7]. Investors need to have confidence in the regulatory framework and rules, and it is crucial to have reliable and adequate infrastructure in place to prevent blackouts and ensure that markets operate efficiently.

According to the literature, there are several requirements for a successful end-to-end electricity market, including the availability of real-time data on generation and consumption, the ability to forecast demand and supply accurately, and the existence of robust transmission and distribution infrastructure [9], [10]. However, there are additional technical and non-technical challenges in the context of developing countries such as capital requirements and the issues of cross-subsidies, which can create distortions in pricing signals and hinder market efficiency. [11]

The benefits of electricity market liberalization include increased efficiency, lower costs for consumers, and increased investment in research and development [12]. In addition, the introduction of competition can lead to increased innovation and the development of new technologies [13]. However, there are also potential drawbacks to market liberalization, such as the risk of market manipulation and the potential for higher prices for consumers [13].

Opportunities for the introduction of an end-to-end electricity market in Sri Lanka include the potential for increased investment in renewable energy production [14]. Private sector companies may be more willing to invest in renewable energy production if they can sell excess energy in a competitive market. In addition, the introduction of competition may lead to higher reliability and lower costs for consumers, as companies compete to offer the lowest prices.

### III. SRI LANKAN ELECTRICITY SECTOR

The Sri Lankan electricity sector is dominated by the Ceylon Electricity Board (CEB), a state-owned utility responsible for generation, transmission, and distribution of electricity throughout the country.

#### A. Strengths and Weaknesses

Strengths of the Sri Lankan electricity sector include:

- A high electrification rate of over 99% as of 2019 [15].
- CEB has more than 50 year experience in Sri Lankan power sector.
- CEB has thousands of skilled workforce who have served the utility for decades.
- A diversified generation mix that includes thermal, hydro, and renewable sources [15].
- Plans for expansion of renewable energy sources, particularly solar and wind power [14].

Weaknesses of the Sri Lankan electricity sector include:

- Reliance on costly thermal power generation due to limited domestic energy resources [15].
- Dependence on imported fuel, particularly oil, for thermal generation [15].
- Inadequate generation capacity, leading to frequent power outages [15].
- The CEB being a government’s own organization, the autonomy in making critical decisions is significantly limited. Construction of some essential power plants (Ex. Sampur Coal Power Plant) which were in the CEB Long Term Generation Expansion Plan(LTGEP) was halted as a government decision.

### B. Opportunities and Threats

Opportunities for the Sri Lankan electricity sector include:

- Potential for increased domestic energy production through the development of renewable sources(See Figure 2). [14].
- Increasing interest and investment in energy efficiency measures and distributed generation such as small hydro and rooftop solar. [15].
- Foreign companies or countries who need to offset their greenhouse gas emission can purchase carbon credits from green projects in Sri Lanka. This will enable the economically nonviable renewable project to become economically viable [15].

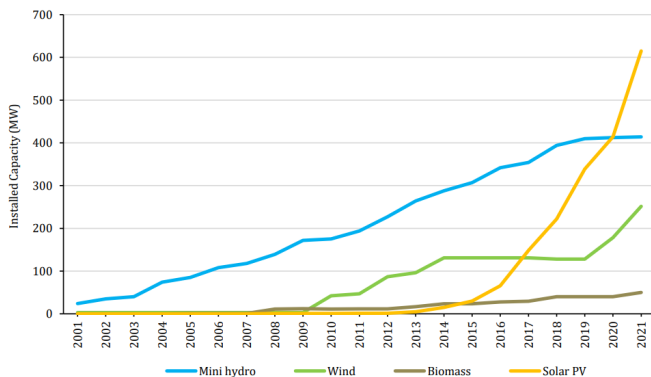


Fig. 2. Growth of Non Conventional Renewable Energy Sector in Sri Lanka [14]

Threats to the Sri Lankan electricity sector include:

- Volatility in global oil prices, which can significantly impact the cost of thermal power generation [15].
- Limited financial resources for investment in infrastructure and technology upgrades [15].
- Economic instability in the country which can affect investor confidence. [15].

The Figure 3 shows a summary of the SWOT analysis of Sri Lankan electricity sector.

## IV. CHALLENGES OF FORMING ELECTRICITY MARKET IN SRI LANKA

Sri Lanka is a developing country facing numerous challenges in the power sector, particularly with regard to the

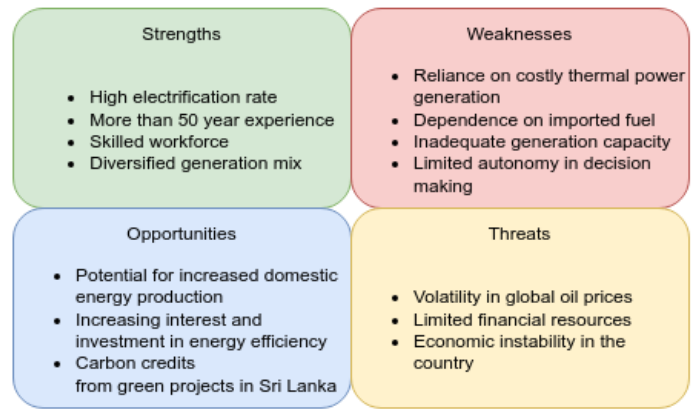


Fig. 3. SWOT Analysis of Sri Lankan Power Sector

formation of a competitive electricity market. The country has long relied on power sector subsidies and faces governance issues that can hinder the growth of a robust electricity market. Similar to Pakistan, Sri Lanka is grappling with issues of economic instability but in March 2023, the International Monetary Fund (IMF) granted its first tranche to the country, providing some measure of stability and future advantages for foreign investors. Despite these opportunities, Sri Lanka still faces significant challenges in forming a functional electricity market.

### A. Cross Subsidies

One of the primary challenges hindering the operation of a free electricity market is the presence of cross-subsidies, where wealthier customers end up subsidizing electricity prices for poorer customers. This can lead to higher prices and distortions in the market as well as an increase in demand [6], [15]. In the case of Pakistan, the government implemented a system of cross-subsidies where high-paying industrial and commercial customers subsidized low-paying domestic customers. However, this led to increasing electricity prices and eventually to the accumulation of circular debt, as the government was unable to pay for the subsidies [6]. Such policies can also disincentivize private investment in the sector, as investors may be hesitant to invest in a market with such distortions [6]. Therefore, it is crucial to address the issue of cross-subsidies in order to ensure a level playing field and attract private investment in the electricity market.

### B. Capital Costs

Another challenge is the high capital costs required to develop the necessary infrastructure for an electricity market. This can pose a significant barrier to entry for potential investors. End to end electricity market requires real-time monitoring and controlling of generation and demands. The Information Technology related infrastructure expenses required to achieve this are significant. In addition, deregularising generation can result in unexpected fluctuations in the power system parameters. Therefore additional high-end controlling equipment and battery banks will be needed to maintain the

power system stability. When both the country as well as electricity sector of the country is facing financial challenges financing this capital costs is quiet challenging.

### C. Lack of Competition/Managing Competition

The lack of competition or the challenges in managing competition is another significant barrier to developing a functional electricity market. In many cases, there is limited competition due to the dominance of a few large firms in the industry [7]. For example, in California, the energy crisis of the early 2000s was partially attributed to the lack of competition in the market [7]. To address this challenge, policymakers need to promote policies that encourage competition and ensure fair market practices. Similarly, in Mexico, there have been concerns about the lack of competition in the country's electricity market, with the government recently taking steps to increase competition and private investment.

In contrast, other countries have successfully managed competition in their electricity markets. For example, in the United Kingdom, the government implemented reforms in the 1990s to promote competition and reduce the dominance of the country's regional electricity companies. As a result, the country now has a diverse range of electricity generators and distributors, and consumers can choose from a variety of providers.

### D. Regulatory Challenges

Regulatory challenges can pose a significant barrier to entry for potential investors in electricity markets. Regulations can be complex, and the process for obtaining permits and licenses can be time-consuming and expensive.

Another challenge is the need to balance the competing interests of different stakeholders. For example, regulators must balance the interests of consumers, who want affordable electricity prices, with those of utilities, who need to generate sufficient revenue to cover their costs and earn a profit. In some cases, regulatory decisions may also be influenced by political considerations.

One example of the challenges associated with electricity market regulation is the experience of California in the early 2000s [7]. California's electricity market was deregulated in the late 1990s, with the goal of promoting competition and reducing prices. However, a combination of market manipulation by energy traders and flawed regulatory decisions led to a series of rolling blackouts and skyrocketing electricity prices. The crisis prompted the state to re-regulate its electricity market and implement new rules to prevent similar incidents from occurring in the future.

The electricity sector in Pakistan underwent various policy and regulatory changes. In 1995, the government issued a policy to attract private investment into small hydropower projects, but it failed to attract any investment. In 1996, partial privatization of the Kot Addu power plant was undertaken, selling 36% of the Water & Power Development Authority(WAPDA)'s shareholding to a strategic investor. In 1997, the power wing of WAPDA was unbundled into 12 incorporated

state-owned entities, and the National Electric Power Regulatory Authority (NEPRA) was established. However, NEPRA's tariff setting authority was limited, as the distribution tariff actually charged differs from the calculated tariff. The Pakistan Electric Power Company Limited (PEPCO) was created in 1998 to oversee the unbundling and privatization of WAPDA components, but it later hindered the reform process. Policy and regulatory changes in the electricity sector(see Figure 4) in Pakistan have had an impact on attracting private investment and the effectiveness of the unbundled entities.

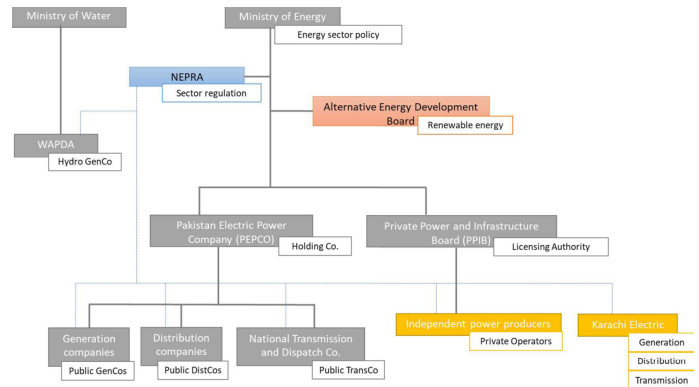


Fig. 4. Structure of Pakistan Electricity Sector [6]

### E. Technical Challenges

In Sri Lanka, the formation of an electricity market faces several technical challenges. One of the critical challenges is the management, sharing, and security of data for the proper functioning of the market. Efficient data management is essential for planning and operation, as well as for transparency in pricing and billing. Furthermore, the country faces limitations in infrastructure development, including system control centre capabilities, which need to be improved to ensure optimal market functioning. Addressing these technical challenges is crucial for a successful electricity market implementation in Sri Lanka. When meeting customer demand and supply in real-time, there are some challenges related to optimal power flow which considers losses.

### F. Economic Instability

Economic instability can pose a significant challenge to forming a successful electricity market, as a stable economy is necessary to attract investment and ensure the long-term viability of the market. Pakistan is an example of a country that has faced economic challenges that have impacted its electricity sector. In 2018, Pakistan was facing a financial crisis that had led to power outages and limited electricity supply [6]. The government of Pakistan responded to these challenges by implementing a number of reforms to improve the efficiency and financial stability of the electricity sector, including restructuring the sector to reduce losses and increase revenue, and improving governance and accountability.

As per Figure 5, there is a significant relationship between the growth of electricity demand and the national GDP in Sri

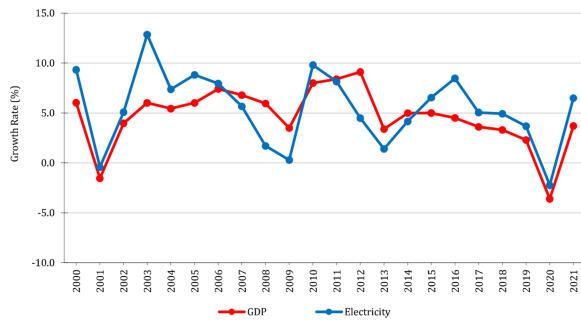


Fig. 5. Relationship between GDP and Electricity demand of Sri Lanka [14]

Lanka. Therefore considering the Sri Lankan scenario, it is crucial to maintain good economic stability throughout the market transition period.

### G. Stakeholder Reaction

The stakeholders in the electricity sector include the power producers, employees in power companies, policymakers and consumers. Resistance to change from stakeholders can pose a significant challenge to implementing an electricity market. California's experience with electricity market deregulation in the late 1990s is an example of how stakeholder resistance can impact market implementation. The California electricity market faced a number of challenges following deregulation, including market manipulation by energy companies and high electricity prices, which led to public outcry and political backlash [7]. The California experience highlights the importance of effective communication and education efforts to address stakeholder concerns and ensure a smooth transition to a new market structure. In Sri Lanka, the employee unions have a significant power to influence or in some cases alter the policy decisions. One major reason for the failure of previous attempts to restructure the Ceylon Electricity Board was this employee reaction.

Consumer education is essential to ensure that consumers understand how the electricity market functions and can make informed decisions. Argentina's experience with electricity market liberalization in the 1990s highlights the importance of consumer education in market liberalization. The liberalization of the Argentine electricity market led to increased competition and reduced prices but also created confusion among consumers who were not familiar with the new market structure [7]. To address this, the government of Argentina implemented a consumer education campaign to explain the new market structure and provide information on how to compare electricity prices and choose a provider.

### H. Limited Infrastructure

Limited infrastructure, particularly in rural areas, can pose a significant challenge to providing reliable electricity access to all citizens. Pakistan is an example of a country that has faced infrastructure challenges in its electricity sector. In 2018, Pakistan had a significant electricity supply-demand

gap, particularly in rural areas where access to electricity was limited [6]. To address these challenges, the government of Pakistan implemented a number of initiatives to improve infrastructure development, including the construction of new power plants and transmission lines, and the expansion of renewable energy sources such as solar and wind power.

### I. Managing Supply and Demand

Managing supply and demand is a key challenge in any electricity market, and Sri Lanka must find ways to balance these needs effectively. Pakistan's experience with load shedding, or planned power outages, highlights the challenges of managing supply and demand in an electricity market. In 2018, Pakistan was facing a significant electricity supply-demand gap, which led to load shedding and limited access to electricity in some areas [6]. The government of Pakistan responded to these challenges by implementing a number of measures to improve supply-demand balance, including reducing losses in the electricity transmission system, implementing energy conservation measures, and increasing the use of renewable energy sources. Distribution Generators are an efficient concept to reduce transmission losses. Integrating distributed generators in an end to end electricity market while ensuring demand and supply is challenging.

### J. High Electricity Prices and Market Manipulation by Energy Companies

High electricity prices and market manipulation by energy companies can pose significant challenges to an effective electricity market. California's experience with electricity market deregulation in the late 1990s is an example of how market manipulation can impact market implementation. Following deregulation, energy companies engaged in market manipulation by artificially increasing electricity prices and creating electricity shortages [7]. To address these challenges, the government of California implemented measures to increase transparency

In the context of Sri Lanka Public Utilities Commission of Sri Lanka or a similar independent authority should be enforced with the required power and regularization framework to prevent this undesirable behavior

## CONCLUSION

In conclusion, Sri Lanka faces numerous challenges in forming a functional electricity market. The presence of cross-subsidies, high capital costs required to develop the necessary infrastructure, lack of competition or the challenges in managing competition, regulatory challenges, and technical challenges are some of the significant barriers to developing a functional electricity market. To ensure a level playing field and attract private investment in the electricity market, it is crucial to address these challenges. Policymakers need to promote policies that encourage competition and ensure fair market practices, and regulators must balance the interests of consumers with those of utilities. Efficient data management is essential for planning and managing the electricity market.

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Despite these challenges, Sri Lanka has some opportunities for foreign investors, and addressing these challenges can help the country develop a robust electricity market.

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