Open-Source Energy Model for Sri Lankan Power Generation System to Achieve 100% Renewable Energy Target in 2050

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Table of Contents

Abbreviations

LTGEP	Long Term Generation Expansion Plan
CEB	Ceylon Electricity Board
RE	Renewable Energy
NDC	Nationally Determined Contribution
ADB	Asian Development Bank
PUCSL	Public Utilities Commission of Sri Lanka
SLSEA	Sri Lanka Sustainable Energy Authority
UNFCCC	United Nations Framework Convention on Climate Change

Introduction

Sri Lanka, as a country, is currently in an unprecedented precarious situation due to inadequate foreign currency reservoirs. The adverse effects have already impacted the energy sector too since foreign money spent on importing fuel accounts for 27% of the total expenditure on imports. One of the main fuel consuming sectors is the power generation sector, which consumes imported fuel; oil and coal to generate thermal power as its major share, accounting for 63.2% of the total energy generation in 2020 (LTGEP,2021). Therefore, in the short term as well as in the long run, it is recommended to switch to viable and feasible RE options to come out of this crisis situation as soon as possible while bolstering the energy security in the long term. It is important that the optimum energy mix is decided prior to the investment phase.

Even though Sri Lanka is an island nation which is not connected through the electrical grid to another country yet, the energy policies of the government affect the whole globe. Therefore, Sri Lanka, along withthe other 192 parties, has pledged in the Paris agreement to create Nationally Determined Contributions (NDCs) that will lead the country to a carbon neutral future in 2050. Apart from that, high dependency on imported fuel to produce electricity is another major issue that needs to be addressed. Consequently, promoting indigenous resources might seem as the solution. However, given the number of factors and constraints attached to the complications, a straightforward path or a strategy is not expected to ensure energy security. But the decision making on energy policies could be done with convenience through the guidelines provided by an optimization or simulation algorithm, which could analyse different scenarios to present the optimal outcome.

The present study seeks to incorporate the open-source modelling software OSeMOSYS to identify the potential of the power generation sector to become 100% RE powered and possible pathways to achieve the aforementioned climate target. The study will provide us with insights on how the technologies should be occupied and prioritized as well. Additionally, the modelling part will be more focused on the shortcomings in the previous studies, and the developed model will be compared with the existing strategies, which are published by CEB in 2021 and ADB in 2017. The assumptions made while constructing the model are expected to influence the outcome significantly, which is why they need to be justified accordingly. The obstacles that arise while executing the policies should also be considered since they might hinder implementing the optimal scenario.

Literature review

In 2017, Asian Development Bank (ADB) and United Nations Development Programme (UNDP) co-published an assessment of the Sri Lankan power sector (ADB, 2017) with the intention of designing and proposing scenarios and mechanisms in order to achieve 100 percent RE goal in 2050 as Sri Lankan government pledge at the 22nd UNFCCC Conference of Parties in Marrakech, Morocco. The report emphasises the importance of a strategy which has a step-by-step approach to remove fossil fuels from the energy mix and it acts as a foundation analysis for investment pathways for policy makers. It has adopted an assessment framework such that peak electricity demand is met by balancing technologies and ancillary service to meet the optimum investment path.

Kulathunga, 2020 presents a pathway to achieve 80% RE by 2030 in 2019 and has considered four model scenarios to identify the least cost method with the help of PLEXOS (Energy market simulation software). The results of the scenario simulations show that the 80% target can be achieved in several ways. But the study itself recommends optimised modelling instead of conservative modelling to maximize the economic benefit.

Ceylon Electricity Board's (CEB) long term generation expansion plan published in 2021 also summarises four scenarios and compares them with the base case scenario complied with the perceived government policy of achieving a low carbon energy mix by 2030. The Stochastic Dual Dynamic Programming (SDDP), NCP and OPTGEN software tools developed by PSR (Brazil) were extensively used in conducting the system expansion planning studies to determine the optimal Long Term Generation Expansion Plan. The study shows that it is necessary to increase the capacity of coal, renewable and natural gas technologies while adding pump storage technology to the energy mix to decarbonise the energy sector. But there is a conflict between the Nationally Determined Contributions (NDCs) revised in July 2021 with CEB's LTGEP due to the capacity addition of coal. Furthermore, investigations have to be done in order to find out the feasibility of adapting 100% RE by 2050.

So far, several OSeMOSYS models have been developed by the energy policy research community to optimize the power generation sector in certain areas of the world. Most of them are focused on cost optimization and decarbonization pathways while discussing the viability.

Attanayaka, 2018 has modeled the Sri Lankan electricity sector from 2018 to 2050 and has done a scenario analysis to find the least cost pathways to cater the demand while adding a higher share of RE. Even though the study is outdated due to the policy changes of the government, cost fluctuation of the technologies as well as commodities and possible future energy integrations such as Indian High Voltage Direct Current (HVDC) interconnection, the majority of the technologies, commodities, and constraints remain the same in 2022.

The small island developing state, the Dominican Republic's OSeMOSYS model is another study which has been carried out to understand the alternative scenarios for the expansion of renewable energy sources in the energy mix of the country. The approached method is similar to the methodology used in Attanayaka, 2018 since it analyses three different scenarios compared to the base case scenario. Most importantly, the study concludes that the open-source tool OSeMOSYS alone has the maturity, performance capacity, and flexibility necessary for long-term planning in energy systems. Besides, the software allows flexibility of sectoral coupling between different energy networks, which is a useful feature for future work. Models made for individual countries (Quevedo, 2022; Boke,2022; Moura,2017; Olsson,2021) can conveniently be collaborated to create larger models (Barnes,2022; Taliotis,2016; Rana,2022; Henke, 2022) reducing overall cost attached.

Research design and methods

The study will provide us with a quantitative analysis of the electricity sector in Sri Lanka. The required data for the optimization will be extracted from the primary and secondary sources published by the following government and international organizations.

1. CEB
2. SLSEA
3. Ministry of Environment
4. ADB
5. PUCSL

The open-source software, OSeMOSYS will utilize the data and constraints for the optimization process. The model spans from 2020 to 2050. The power generating technologies that are currently existing and the ones which has been proposed in the past will be taken into account as candidate technologies. Demand from the consumers should be identified and categorized in the model as end users of the electricity. Capital cost, fixed and variable operation and maintenance cost salvage value of technologies and cost of carbon will be considered for the cost optimisation.

When analysing output results, it is necessary to weigh in the assumptions which were made during the modelling process. The prices associated with various technologies and the amount of electricity that end users demand may differ from the estimates made by the original sources. Therefore, the guidelines and the recommendations given by the study should be further researched through feasibility assessments. A summary of the methodology is shown in Figure 01.

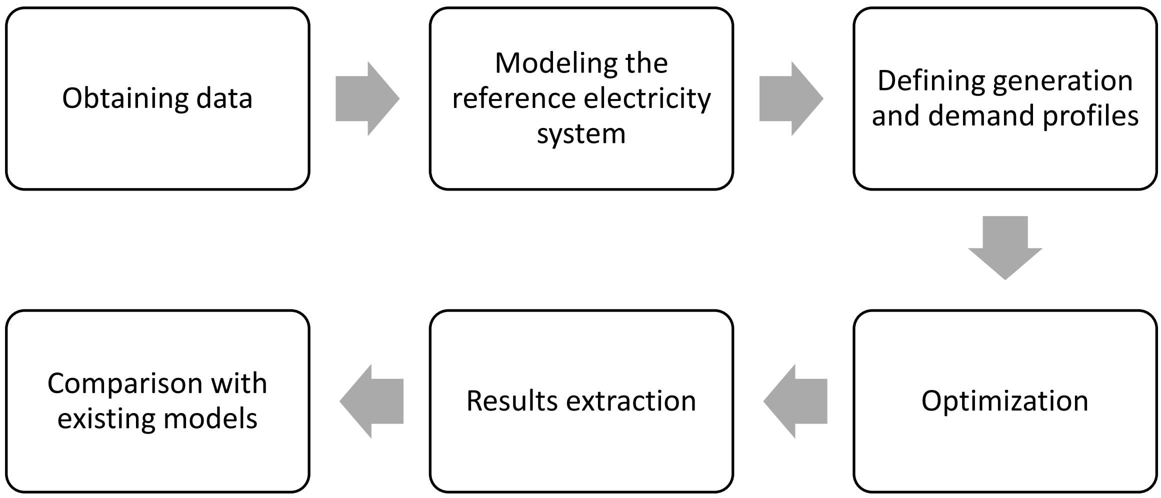

Figure 01 : Methodology

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