Cost Implications of Rooftop Solar PV with Batteries on Industrial and Commercial Customers in Sri Lanka

Degree of Master of Science in Electrical Engineering

Department of Electrical Engineering

University of Moratuwa

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Dissertation submitted in partial fulfillment of the requirements for the Degree Master of Science in Electrical Engineering

Department of Electrical Engineering

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DECLARATION

I declare that this thesis is my work and to the best of my knowledge and belief there is no material incorporated therein previously submitted for a Degree or Diploma in any other university or institute of higher learning, without giving the proper acknowledgement to that effect. It also does not contain any material previously published or written by another person except where due acknowledgement is made in the text.

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The above candidate has carried out the research for the Master thesis under my supervision.

Signature of the supervisor: Date: 25-12-2022

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Prof. J. R. Lucas

ABSTRACT

Electricity is one of the key factors for the business of industrial and commercial customers in a particular location. Therefore, the Government and local authorities have introduced special tariff schemes to provide electricity in a cost-effective manner. On the other hand, the tariff structures are focused to reduce the stress for the grid operation by the utility provider.

With the advantage of being a tropical country, Sri Lanka is having higher solar irradiation throughout the year and most of the electricity consumers are willing to install rooftop solar systems into their facility. The excess solar production can be sold back to the utility provider by several methods, as preferred by the consumer.

However, the utility provider is facing many difficulties related to the technical and financial perspective, to absorb the total solar production by the consumers. Therefore, in this research, the management of the own solar production by the consumer, either grid connected or in islanded operation mode, has been speculated.

The research is primarily focused on real-time based management of solar generation which is allocated for loads, charging, controllable load dispatching, and shedding is decided. Finally, the load is matched with the available power sources in the basis of optimum cost. As the optimization technique, quadrature optimization has been used.

A selected industrial purpose customer and a general-purpose customer were used to analyze the data. Calculation of the unit costs for the solar energy and battery bank was done based on the LCOE formula and this represents the lifecycle cost of the energy sources based on the lifetime energy generation. The program is used to calculate the optimum battery capacity for an industrial and a general-purpose customer in Sri Lanka with the financial values in 2018 as indicated in annex 7. Also, in both cases the effect of the solar energy generation was varied to identify the change of the profit of the installations. It could be observed that when reducing the daily solar power generation, profit was drastically reduced. As an example, in relation to the data for Case B and Case E when solar generation was reduced by 17% profit was reduced by 24% for GP customer. Furthermore, the calculations were made to identify the profit changes for BST which represent the actual cost for the utility in 2018. In this case the average profit for each case was reduced by 150% ending with a loss for the investment. Also, the calculation was done for the new financial figures in 2022 November and the profits were reduced by 330% and the investment is found to be not feasible with the available figures.

In conclusion, the method proposed is feasible to use to evaluate the initial investment for solar PV systems and battery energy storage (BES) systems. However, the tariff rates as well as the financial figures like fuel cost, exchange rate formulate a considerable impact on the result. Therefore, the financial figures provided in 2018 provides a profit generation but in 2022 the optimized solutions are not feasible due to changes of the financial figures. However, the method provided in this thesis can be used to calculate feasibility of solar and battery installation for any customer.

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List of Abbreviations

CEB - Ceylon Electricity Board

PV - Photovoltaic

IP - Industrial Purpose

GP - General Purpose

LOCE - Levelized Cost of Energy

BSES - Battery Stored Energy Systems

DERs - Distributed Energy Resources

GA -Generic Algorithm

DE -Diesel Engines

BS -Battery Storage

SOC - State of Charge

RES - Renewable Energy Sources

DOD -Depth of Discharge

DC -Direct Current

DR - Demand Response

MD - Maximum Demand

BST - Bulk Supply Tariff