# Opportunities and challenges of solar energy application in energy sector of Sri Lanka

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## ABSTRACT

Although Sri Lanka's current carbon footprint is much less compared to other developing countries, the country's existing and planned economic developments have raised the demand for power, resulting an increased GHG (Greenhouse gas) emission. GHG in Sri Lanka is emitted mostly by the burning of fossil fuels for energy generation including transport. However, the most effective way of reducing GHG emissions from the energy sector is to use renewable energy sources. Solar is in the top list of renewable resources that has much potential to use to meet the demand for electricity generation in the country. The purpose of this study is to evaluate the current status of solar power generation and opportunities, barriers for implementing the programs of solar energy in Sri Lanka. Literature reviews mainly used as the primary tool for this study. Sri Lankan government had set the targets for adding 200 MW to the national grid by 2020, and to increase up to 1000 MW by 2025 of solar electricity. To achieve these targets the prevailing barriers have to be considered.

**Keywords:** Solar PV, Greenhouse gas, renewable energy, Sri Lanka

## Introduction

Access to energy has an important impact on long-term poverty reduction in developing countries.[1] By now, many developing nations and countries in transition's energy mix have been largely dominated by fossil fuels. Today over-dependence on fossil fuels has forced the world to consider global warming and climate change via greenhouse gas, which is a striking issue, and need immediate and long term measures to overcome foreseeable targets. In 1995, Sri Lanka produced 95% of the grid electricity energy needed from conventional hydropower plants.[2] However, the expansion of household electricity and the boost in the industrial sector of the country have forced the country to depend on alternative energy resources such as fossil fuels. In the year 2017, Sri Lanka produced 53.38% of the total electricity requirements from renewable energy sources, out of which 46.56% accounted form large hydro and the rest 6.83% were born by renewable energy sources such as small hydro, wind power, biomass, and solar power.[3]

According to the CEB (Ceylon Electricity Boards) statistical report, Sri Lanka's large reserves of hydropower have already been utilized; other renewables resources have to be promoted in power mix.[4] Today, higher percentage of the energy needed is satisfied through the fossil fuel-based resources. Though Sri Lanka's current carbon footprint is much less than the global value, the country's existing and planned economic developments which in turn raise the demand for power has resulted in an increase in the GHG emission.[16] Based on the published data, transport sector is the main contributor to the GHG emission followed by the energy sector.[15]

The number of national and international obligations related to the energy sector targets has led to reduce the GHG emission level and dependency on fossil fuel in the development process. According to the Energy Policy in Sri Lanka, it is expected to ensure energy security through supplying cleaner, secure, economical and reliable energy to provide convenient, affordable energy services to support socially equitable development in Sri Lanka.[7] This policy is aim to realize Carbon neutrality by 2050. The long term generation expansion plan prepared based on energy policy by Ceylon Electricity Board for the period 2020-2039, focused on the development of renewable energy to achieve the said targets.[3] Further, development of indigenous renewable energy resources is important as it is one of the significant contributor for achieving the National Determined Contribution targets which was committed under the Paris Agreement in COP 21.[16]

In order to move towards energy independence and sustainable development, Sri Lanka should develop a technology-mix using available indigenous energy sources (hydro, solar, wind, bio-mass, etc.), and reduce the use of imported fossil fuels.[3] Hydro-power is already well established in Sri Lanka, and solar energy is at the top of the renewables list.[3] Therefore, this paper evaluates the current status of solar power generation and analyzes opportunities and barriers in implementing solar power projects in Sri Lanka.

## Energy demand greenhouse gas emission & renewable energy potential in Sri Lanka

Sri Lanka, an island country in the Indian Ocean, is transitioning to an upper middle–income economy.[6] Its annual average economic growth was 5.5% from 2001 to 2017. However, the 2017 growth was lower by 3.3% compared with previous years.[5] Sri Lanka's 2017 gross domestic product (GDP) per capita was $4,065.3 (Table 1).[5,6]

As the central bank report (Figure 1) with the economic growth energy demand of the country has been increased in the past three decades. Accordingly, the total electricity demand at the end of 2017 and 2018 has been increased to 13,656 GWh and 14,588 GWh, respectively. This demand is expected to continue as the Sri Lanka pursues economic growth and development.

The growth rate of energy demand particularly driven by the transport and electricity generation sectors (Figure 2).[15] According to the below chart, household and commercial sector appears to be the largest sector in terms of energy consumption when all the traditional sources of energy are taken into account. Further, it shows a decreasing trend while

**Table 1.** Key Economic Indicators, 2017

| Indicator | Unite | Value |
|---|---|---|
| Land Area | $Km^2$ | 65,610 |
| Population | million | 21.4 |
| Population density | $Persons/km^2$ | 326 |
| GDP at current market price | $ billion | 87.2 |
| GDP per capita | $ | 4,065 |
| Unemployment rate | % | 4.2 |

Source: Central Bank of Sri Lanka Statistics Department. 2018. Economic and Social Statistics of Sri Lanka 2018

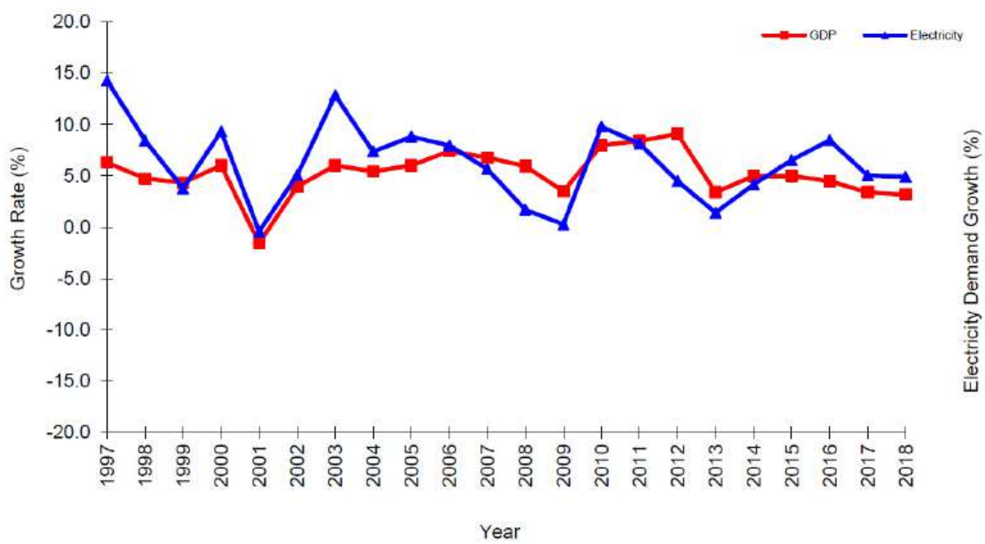


**Figure 1.** Growth rates of electricity demand and GDP from 1997 to 2018

Sources: Central Bank of Sri Lanka Statistics Department. 2018

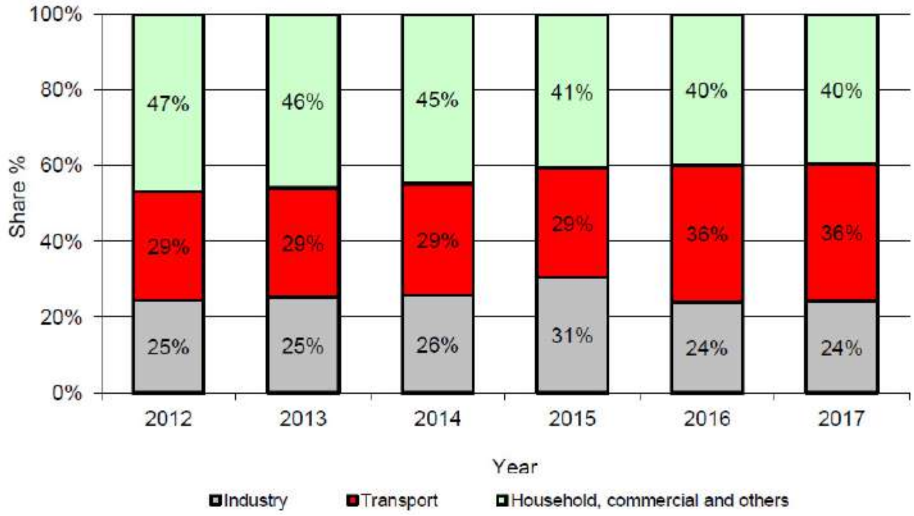


**Figure 2.** Gross Energy Consumption by Sectors including Non-Commercial Sources
Source : Sri Lanka Sustainable Energy Authority

industry and transport sector shows an increasing trend.

This increased dependence has also led to an increase in Sri Lanka's GHG emissions, while amongst the lowest in the world (ranked 194th out of a total 251 countries) as well as in South Asia (0.8 mtCO2e/capita in 2015) has been growing steadily over the past decade (from 0.5 mtCO2e/capita in 2000).[15] Most of the country's energy needs are met through biomass, an indigenous fuel source and imported fossil fuels, such as petroleum and coal. In 2017, petroleum accounted for about 43% of primary energy supply, biomass provided 37%, and coal provided 11%. While Sri Lanka government plans to accomplish it further demand of the energy sector by using renewable energy.[3] Accordingly, the share of Other Renewable Energy based generation is at 11% of total energy generation in the country and its contribution is expected to increase in the future. At the end of 2018, 610.4 MW of other renewable energy power plants have been connected to the national grid and the total comprises 393.5 MW of mini-hydro, 128.5 MW of wind, 51.4 MW of Solar PV and 37.1 MW of biomass-based generation capacities. In addition, the rooftop solar PV capacity with a total of 170 MW that are embedded at the consumer end is also achieving notable growth in its contribution.[2,3]

The long term generation expansion plan illustrated that the projected target of total other renewable energy capacity is planned to increase from 1245 MW in 2020 to 4330 MW by 2039.[3] The total capacity of major hydro resources is expected to increase the first five years by 225 MW with the completion of ongoing hydropower projects and will remain at the same level afterward. The total planned Other Renewable Energy (ORE) capacity will increase to 2700 MW by 2030.[3]

Wind and solar capacity is the significant contributor to the ORE capacity increase whereas moderate growth is expected in Mini-hydro and biomass technologies. Beyond 2023, the major share of the other renewable capacity is mainly by solar power followed by wind power. Other renewable energy segments will become dominant as it will exceed the major hydro capacity by 2022. In the long term, the total ORE capacity is planned to reach 4330 MW by 2039 which comprises 2210 MW of solar and 1323 MW of wind resources.[2,3]

## Solar power in Sri Lanka

### Solar power development in Sri Lanka

In the past recent years, the technology of solar energy and its usage has experienced a phenomenal change and rapid growth. Promotional and encouraging government policies about solar energy technological improvements in less setup and maintenance cost, growing public awareness in environmental issues, easy way to cutting down the users' electricity bills with assured power supply are some of the facts that have facilitated and sustained this strong interest in the minds of the users about solar technology in worldwide.[16] According to the IRENA 2018, world solar energy capacity increased by 94 GW in last year (+ 24 percent) and Asia continued to dominate global growth with a 64 GW increase (about 70% of the global expansion in 2018). This trend was maintained by China, India, Japan and the Republic of Korea and Other major increases presented in the USA (+8.4 GW), Australia (+3.8 GW) and Germany (+3.6 GW). Other countries with significant expansions in 2018 included: Brazil; Egypt; Pakistan; Mexico, Turkey and the Netherlands.[11]

Sri Lanka, is located within the equatorial belt, has substantial potential in the solar resource. As estimated in the solar resource map developed by the National Renewable Energy Laborite of the USA, over most parts of the flat dry zone in Sri Lanka, which accounts for two-thirds of the land area, of solar radiation varies from 4.0 – 4.5 kWh/m$^2$/day (Figure 2).[8] Solar potential of a country leads to having many applications of the country such as solar water heating, solar electricity, desalination, etc.[12] Besides that potential Sri Lankan government sets the targets for electricity generation using solar energy with an adding of 200 MW to the grid by 2020. It is also expected to increase up to 1000 MW by 2025 of solar electricity.[15]

At present, with the facilitation of Ministry of Power, Energy and Business Development (MOPEBD), Ceylon Electricity Board (CEB) and Sri Lanka Sustainable Energy Authority (SLSEA), development of grid-scale solar PV power projects, small scale distributed solar PV projects and rooftop solar PV installations are achieving significant growth in commercial scale. Similar to that, the technical potential of integrating solar PV resources into the power system is assessed by the renewable energy grid integration study conducted by the Ceylon Electricity Board.

### Development of rooftop solar PV installations

Rooftop solar systems are starting to play a prominent role in providing the energy needs of electricity consumers. It is effective for embedded generation located at the end-user. Rooftop solar PV installations can significantly reduce land use and environmental concerns particularly in urban and suburban areas with the availability of rooftop spaces.[13] Several schemes are adopted worldwide to create an enabling environment for small scale and rooftop PV penetration. The "Energy Banking Facility" for such micro-scale generating facilities, commonly known as the "Net Energy Metering Facility" for electricity consumers was introduced in Sri Lanka in 2010 by the Ministry of Power and Renewable Energy, Ceylon Electricity Boards (CEB) and Lanka Electric Company (LECO).[15] This scheme allows any electricity consumer to participate as a producer to generate electricity with a renewable energy source for own usage as well as to export any excess energy. The installed capacity of the generating facility shall not exceed the contract demand of the customer. The consumer is not paid for the export of energy but is given credit (in kWh) for the consumption of the same amount of energy for subsequent billing periods. No financial compensation is paid for the excess energy exported by the consumer. The electricity bill is prepared to take into account the difference between the import and the export of energy. At present, the country has about 14,700 such installations under the Net metering scheme amounting to 106 MW of solar power.[3]

The Government of Sri Lanka (GOSL) has launched an accelerated solar development program in 2016 to promote rooftop solar installations in the country. The objective of the above program is to reach an installed capacity of rooftop solar to 200 MW by 2020. In order to support the GOSL's renewable energy promotional drive, the Net Metering Concept was further enhanced by introducing another two schemes. "Net Accounting" concept is the second scheme initiated. It is an extension to the existing new metering scheme where the consumer is compensated for the exported energy with a two-tier tariff for 20-year period. The generating capacity of the facility is limited to the contract demand of the consumer and this scheme is limited only to solar power generation. The third scheme is the "Net Plus" scheme where the consumer can install a solar PV generation unit and all the generated energy will be exported to the grid. The installed capacity is limited to the contract demand of the consumer, unlike the previous two schemes, there is no linkage between the consumption and electricity generation. Solar PV installations for the above three schemes are restricted to rooftop type installations and to be connected to the low voltage distribution network. The total installed capacity of rooftop solar PV schemes under Net Accounting and Net plus has reached 63 MW at present bringing total rooftop solar PV capacity in the country to 169 MW.[15] These three schemes lead to a change in the role of the traditional electricity consumer and producer. It is also expected to grow further Rooftop capacity in the forthcoming years under the projected solar capacity.[15]

## Development of small scale distributed solar PV project

The increased penetration level of solar PV generation which is intermittent by nature, introduces more variability into the system starting from a finer time scale. One strategy to minimize the inherent variability challenge of solar PV resources is the geographical distribution of solar PV installations as there is greater diversity in variability characteristics in the smallest time scales. Studies conducted by Ceylon Electricity Board have identified that the geographical distribution of solar PV projects across the system can reduce the overall variability levels experienced by the system.[3,8]

In line with the accelerated solar development program of the government, the Ceylon Electricity Board initiated the development of 60 MW with 1 MW Solar PV projects at 20 selected Grid substations through an international competitive bidding process.[3] Extending this initiative, its second phase was launched to develop 90 MW of 1 MW solar PV plants with improved contractual terms to provide more facilitation and flexibility to developers. As a result, a significant number of bids were attracted during this second phase of 1 MW solar development projects. Projects from both phases are currently in progress at various stages in the project development activities. This initiative is expected to continue in the future to develop 1 MW and 10 MW solar power plants in the country. Large scale solar PV part development has its own advantageous in economies of scale and also technical challenges.[3] Large scale solar PV park developments are planned and initial assessments and planning work have been initiated for the Poonyryn, Siyambalanduwa in Moneragala areas. Further, Sri Lanka Sustainable Energy Authority has identified resource locations for large scale development in Trincomalee, Ampara, Monaragala, Hambantota, Kurunegala, and Anuradhapura areas in future years.[15]

## Barriers and Challengers for Solar PV penetration in Sri Lanka

### Grid Integration Barriers

The Sri Lanka Power System today has a maximum demand of about 2100 MW.[15] Therefore, the size of the Power System itself is a barrier to absorbing renewable (mostly mini-hydro, solar PV and Wind) power potential of Sri Lanka. In any case, there are other successful cases of islands with a reasonable penetration of RES-E such as Hawaii, Canary Islands, Tasmania, and Ireland.[11] Additionally, the potential connection of the Sri Lanka power grid to the Indian power grid will probably increase the potential absorption of renewable energy. Balancing possibilities and cost as well as system stability will place a limit on the renewable power absorption. The expertise for the determination of this limit and the capacity to determine this limit, as well as the trustworthiness of these experts, should be established by the Ministry of Power and Energy. This limit is affected both for the total penetration of intermittent RES-E and by the unit/park size.

Most RES-E generation must be must-run in order not to spill the resource, only biomass based generation might be considered as dispatch able. Electricity cannot be stored as electricity. Therefore, electricity demand must be met by the supply instantaneously. Wind and solar generation is intermittent, and may be required to be curtailed to match the demand (or stored and released, nowadays, still not economic) under certain conditions.[9] Moreover, wind and rain occur simultaneously during the monsoon season. The main issue is that no provisions are stated either for wind or solar spilling in current SPPAs; it is "guaranteed" that curtailment will not happen provided that the total installed capacity of intermittent generation is lower than 90 MW.[3] This issue will be perceived as a potential risk by the coming developers because installed capacity is reaching that threshold and because non-curtailment cannot be guaranteed. A compensation mechanism is required.

Any costs of improvements to overcome transmission/distribution constraints at the time of project proposal to CEB have to be met by the project developer at CEB standard rates where available or at CEB work estimates (deep connection charging). Subsequently, because of delays in construction by CEB, the project developer was allowed to do the construction with CEB supervision at 10% of the work estimate.[9] Though deep connection with regulated prices is not a bad approach, the delays in construction seem to be an issue. For small facilities, deep connection charging may be a barrier.

The technical requirements for SPPA have dated from 2000 (CEB Guide for Grid Connection of Embedded Generators). This aspect has been traditionally the most controversial issue when deploying RES-E. Power utilities are concerned of potential impacts from intermittent RES-E development, which may jeopardize the performance of the electricity grid related with the lack of wide spread requirements for RES-E such as Fault Ride-Through, capacity factor, etc. However, in 2008 these rules were complemented/amended with certain grid interconnection requirements for wind facilities, which include these aspects but are mostly limited to distribution systems.[3]

## Institutional barriers

A lack of clearly allocated institutional responsibility (e.g. many different actors involved in the implementation of policies or realization of projects) makes the process more difficult. If there is no agreement among stakeholders about objectives and procedures, institutional disagreement can impede or slow down a fast promotion of solar energy.[9] An attempt has been made to address this by making the representatives of the many stakeholders as members of the Board of SLSEA. The main institutional barrier seems to be the dispute about whether Public Utilities Commission of Sri Lanka (PUCSL) has the right to approve the FITs or not.[8]

In Sri Lanka management of renewable energy sources come under the purview of many institutions, both the government and provincial councils interact. Similarly, the Local Authorities continue to have jurisdiction over the power sector which is also reflected in the Sri Lanka Energy Authority . Local Authorities are eligible for generation licenses over 25 MW capacities. Mahaweli Authority by its Act is also empowered to issue directions and the CEB is obliged to follow its directions.[3] The Water Management Secretariat of the Mahaweli Authority therefore controls the conventional hydropower generation.

Renewable energy use can benefit by research. It is even more relevant today with net-metering, where any electricity consumer premises can be converted to a power generation source using any form of energy resource, be it renewable or non-renewable with the technology available. The National Engineering and Research & Development Centre is involved in appropriate technology designs for Sri Lanka since its establishment in 1974. The universities in Sri Lanka are capable of carrying out the research; the Sri Lanka Sustainable Energy Authority, which has a mandate to foster research into RES-E, should do so in collaboration with these institutions.

## Financial barriers

The power sector has a very large deficit that is supposed to be funded by the Treasury. The present retail tariffs are not fully cost reflective; this implies that generation is not only paid by the consumers but also by the Treasury. Full cost reflective tariffs or until this can be achieved, a transparent subsidy provision by the Treasury through the Bulk Supply Account as it was designed in the past, will increase the perception that the off taker (CEB - T/L) is financially sound, potentially decreasing the return required. Unfortunately, despite of been in approved tariff methodology by PUCSL, the bulk supply account is not yet in place and the mechanism for the government to finance the account is missing.[3,9]

Technology has still not reduced RES-E costs to grid parity. The SLSEA is mandated by law to have a renewable energy fund. The SLSEA can determine the extent of subsidy and therefore, the FIT provided it has the finances to subsidize. However, since this fund is not in operation consumers are paying the full cost of RES-E as PUCSL is allowing full pass-through of RES-E generation cost, leading to an extra burden on the consumer electricity tariffs. Not only is this a financial issue but a legal one, as it is not clear that the full pass-through of RES-E is aligned with spirit of the current legislation, potentially raising legal claims for consumers in the future. This issue should be analyzed by the legal experts of PUCSL. There has been a lot of controversy about the level of FITs, mostly in the case of WPPs. Unfortunately; the only way to test if the current figures are not generating large infra-marginal rents is to develop a more sophisticated mechanism for price discovery, such as tenders.

## Informative barriers

Inexperienced stakeholders and the unawareness among decision makers of the economic, social, and environmental benefits of renewable energy is still an issue in Sri Lanka.[9] Often governmental stakeholders consider renewable energy an expensive investment without acknowledging the short and long term benefits of it. There is a lack of social and political knowledge of the benefit of entering into an energy swap (RES-E are more capital expenditure demanding but decreases the risk of fuel variation in the future) in small isolated fuel-dependent country. Additionally, subsidized electricity prices to some consumers are making the support of renewable energy appear more costly than it actually is. Moreover, the cost of the renewable energy pool (average cost per kWh) has been previous published by PUCSL, which has since been limited to a statement, without clearly identifying the cost in the final Bulk Supply Tariff (BST) summary. Proposals to show the cost break-up (generation, transmission, distribution, levies for renewable energy, surcharges and subsidies, in the consumer bill, are yet to be implemented by PUCSL.[15] Another barrier is civil opposition against renewable energy, often caused by competing interests in land use. Land use management is a critical issue for the potential coming larger WPPs.

## Regulatory barriers

The safety practices existing at present may hinder the connection of net-metering consumers. The classical design of the power system required the user to disconnect and isolate his consumer installation system when using his captive generation. The main reason for this practice is safety. However, in 2010, the SLSEA and PUCSL allowed net-metering. It is necessary to have compatible regulations enacted by the PUCSL. At present, FIT is only allowed for facilities of less than 10 MW.[3,9] This has restricted the advantage of economies of scale especially for wind power and has made interconnection of generation at 33kV a fact as developers do not want to pay for a deep connection.

The threshold of 10 MW seems to be related to technical issues as the lack of clear-cut grid code, where technical conditions requirements are set for RES-E have resulted in constraining the absorption of renewable power to 10 MW per facility by rule. A few RES-E developers have adopted the practice of establishing separate legal entities of 10 MW each at virtual single site to by-pass this requirement. PUCSL should establish the required technical (and operational) regulations in the existing draft Grid Code. This Grid Code should be formally approved as soon as possible. Probably, the main regulatory gap lies in the uncertainty in relation to the promotion mechanism for facilities larger than 10 MW. From 25 MW and beyond, it is clear that price should be the result of a competitive procurement, but no plan for tenders does exist. From 10 to 25 MW, it is even more puzzling.

The inter licensee agreements between CEB owned Generation License/Transmission License and Transmission License/Distribution Licenses, required to make power sector regulations work are still not in place. It is important to increase the transparency of the power sector for attracting private investment at reasonable prices. The agreements between Transmission License and generation licensees is of utmost importance as it may be that in the future, both CEB and private developers may be competing to supply RES-E to the CEB Transmission Licenses. The current Law requires public sector participation for the development of RES-E facilities with an installed capacity beyond 25 MW.[12] This boundary has required the assessment of alternative mechanisms to develop power generators from renewable energy sources enabling private participation while ensuring participation of the public sector. PPP was selected as the main mechanism to comply with this condition. The following headings deal with the current situation of PPPs in the power sector and the foreseeable future of RES-E under this scheme.

## Conclusion

Sri Lanka as transitioning to an upper middle-income economy, demand for the electricity has being increased and it forced the country to depend on alternative energy resources such as fossil fuels. This increased dependence on fossil fuels has also led to an increase in Sri Lanka's GHG emissions. According to the international obligations Sri Lanka Government expected to realize Carbon neutrality by 2050. Therefore, it has focus on developing and adopting indigenous, renewable sources of energy to meet its ever-growing demand of energy. Sri Lanka, being located within the equatorial belt, has substantial potential in solar resource. Solar radiation over the island does not show a marked seasonal variation, though significant spatial differentiation could be observed between the lowlands and mountain regions. Application of solar energy in Sri Lanka to development of grid scale solar PV power projects, small scale distributed solar PV projects and rooftop solar PV installations are achieving significant growth in commercial scale. Distributed solar PV resource development has its own advantages and challenges that require careful consideration. Grid integration barriers, institutional barriers, financial barriers, informative barriers and regulatory barriers are the key challengers for developing solar PV through the country.

## References


[1] ARE, Best Practices of ARE : What Renewable Energy can Achieve in Developing countries, Alliance of Rural Electrification, Brussels

[2] Ceylon Electricity Board, (2017), 'Long Term Generation Expansion Plan', CEB, Colombo

[3] Central Bank of Sri Lanka Statistics Department. 2018. Economic and Social Statistics of Sri Lanka 2018

[4] Ceylon Electricity Board Statistical Report (2017), CEB, Colombo

[5] REN21 (2013), Renewables 2013 Global Status Report, Paris: Renewable Energy Policy Network for 21st Century, REN21 Secretariat.

[6] Economic and Social Statistic in Sri Lanka (2018), Census & Statistic s Department

[7] National Energy Policy & Strategies for Sri Lanka (amended 2019),Ministry of Power & Energy

[8] Public Utilities commission of Sri Lanka (2017), Electricity supply 2020 and beyond

[9] Project on Electricity Sector Master Plan Study in Democratic Socialist Republic of Sri Lanka, Ministry of Power and Renewable Energy

[10] RMA Report, Sri Lanka Environmental Issues in Power Sector(2010), Ceylon Electricity Board.

[11] REN21 (2013), Renewables 2013 Global Status Report, Paris: Renewable Energy Policy Network for 21st Century, REN21 Secretariat.

[12] SLSEA, (2017), 'Sri Lanka Energy Balance', Sri Lanka Sustainable Energy Authority, Colombo.

[13] Sri Lanka energy sector development plan for knowledge based economy 2015-2025

[14] Sri Lanka Transport & Logistics Research and Analysis (2017)

[15] Sri Lanka Energy Sector Assessment, Strategy and Road Map (2019), Asian Development Bank

[16] UNDP Report (2017 Assessment of Sri Lanka power sector