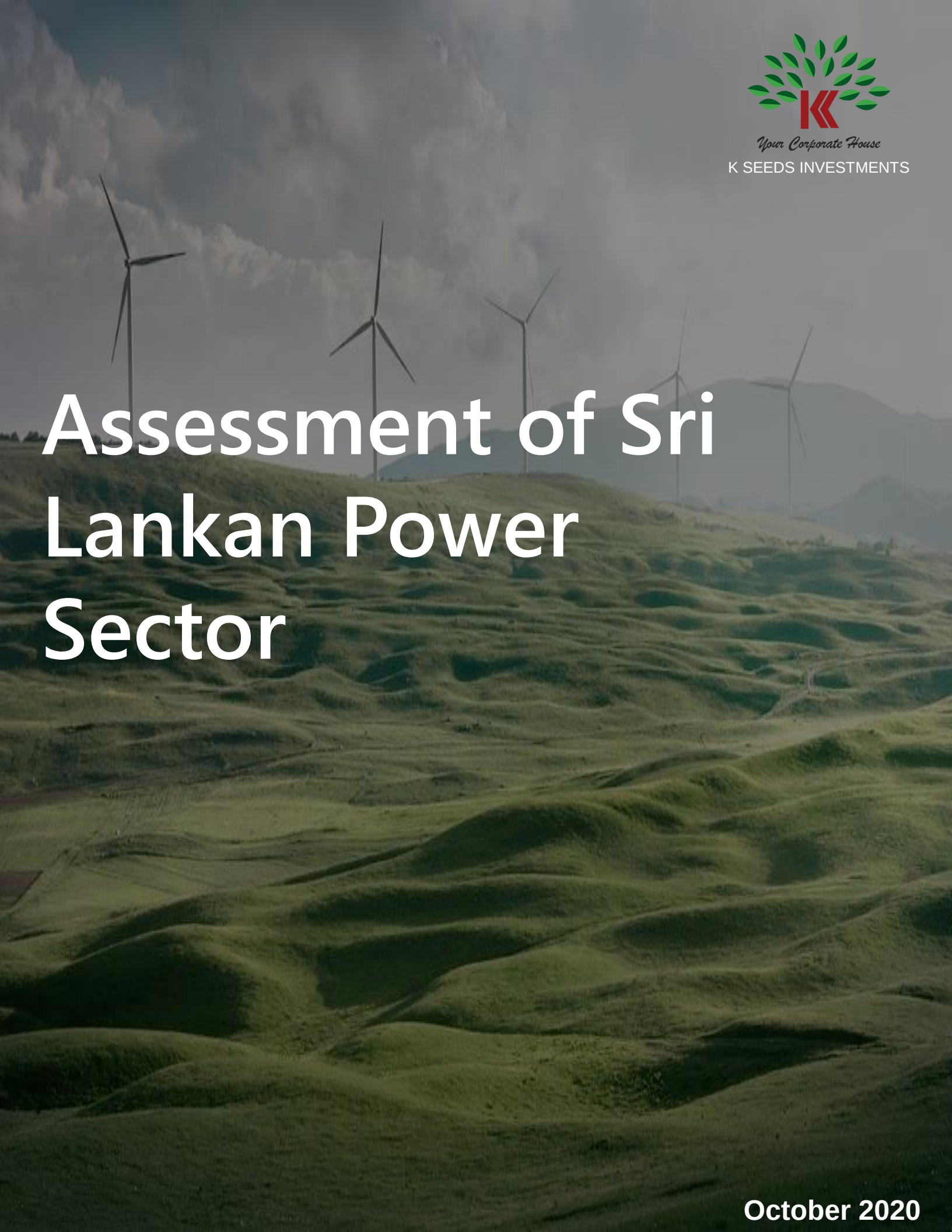

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Assessment of Sri Lankan Power Sector

October 2020

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1. Overview of Sri Lankan Power Sector

Over the past 15 years, electric power use has nearly doubled – from 297 kwh per capita to 531 kwh per capita, and 100 percent electrification has been achieved in Sri Lanka. To meet the increasing energy needs, Sri Lanka will need to look beyond publicly funded projects, increase its share of commercial financing and promote increased involvement by the private sector in the renewable energy sector to end the era of fossil fuel dominance in the energy sector.

Given that the power sector in Sri Lanka is heavily dependent on hydro plants, any change in the monsoon pattern hurts the industry. At that time, country will become increasingly dependent on imported fuel and eventually impact trade and exchange rate balances. CEB spending on liquid fuels was close to USD 0.5 BN per year, and will continue to rise.

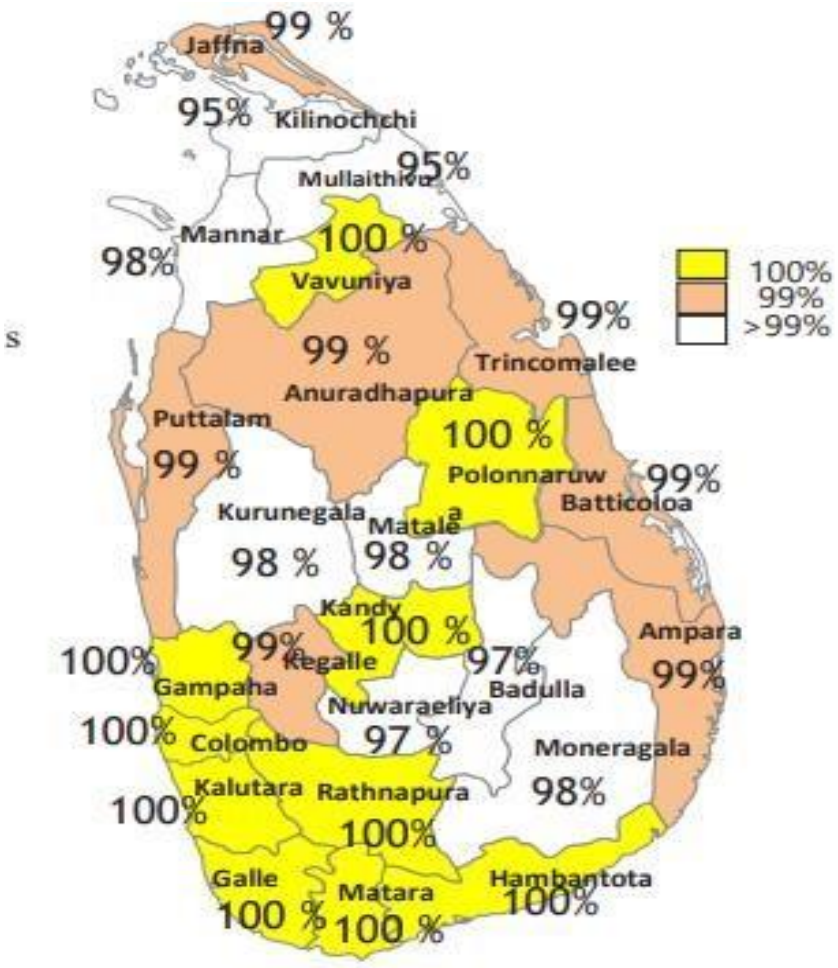
The production of nonconventional renewable energy (NCRE) and liquefied natural gas (LNG) is therefore a must in order to meet long-term energy demand in a sustainable and cost-effective way.

The natural gas sector in the country has been slow to develop and the exploration of domestic gas basins is uncertain. The focus has now shifted to procurement of LNG to fuel the power sector, but there is lack of clarity on the demand for LNG beyond the power sector. In the power sector, LNG is expected to fuel about 700 MW of old oil-fired power plants which are to be converted to gas-fired plants, and about 1,600 MW of new gas plants are also planned in the long term generation expansion plan (LTGEP). However, LNG procurement methodologies and their cost effectiveness are yet to be examined in detail.

1.1 Accessibility to Power

During 2019 CEB reached out to all its prospective customers and hit an electrification pace of 99.7 percent by the end of the year. Over the year the number of buyers rose by 146,360 making the total number of customers as 6,500,641 at the year end. Throughout the year the CEB provided its customers with electricity for the entire 24 hours of the day, except for occasional short-term breakdowns.

FIGURE 01: ELECTRICITY ACCESSIBILITY



Source:Powermingov.lk

TABLE 01: ELECTRICITY CONSUMER BASE 2019

Electricity Consumer Accounts	2018	2019	Increase in accounts 2019
Domestic	5,543,137	5,651,452	108,315
Religious	39,422	40,724	1,302
General Purpose	704,173	739,122	34,949
Hotel	447	470	23
Industrial	62,570	64,241	1,671
Government	4,530	4,574	44
Agriculture	-	56	56
Bulk Supply to LECO	1	1	0
Street Lighting	1	1	0
Total	6,354,281	6,500,641	146,360

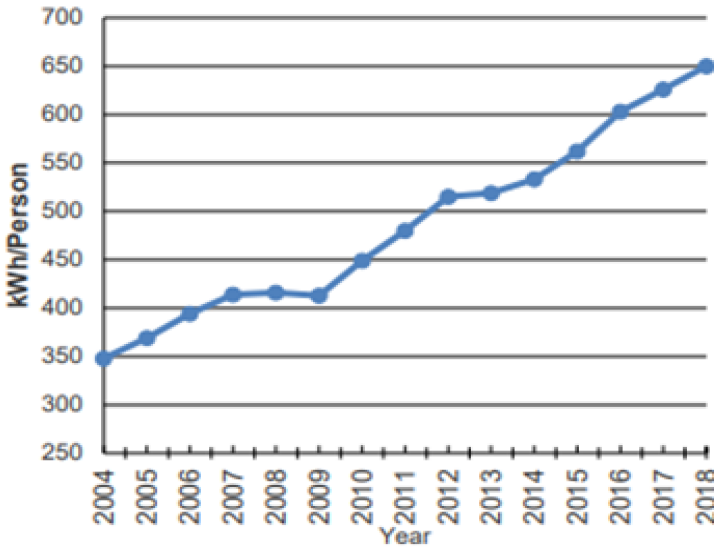
Source: Statistical Digest 2019

1.2 Electricity Per Capita Consumption

The average per capita electricity consumption in 2017 and 2018 were 626kWh per person and 650 kWh per person respectively. Generally, it has been rising steadily; however, in the period 2007 – 2009 amidst the slow down of electricity growth, the per capita consumption has stagnated. A similar trend is observed during 2012 to 2013.

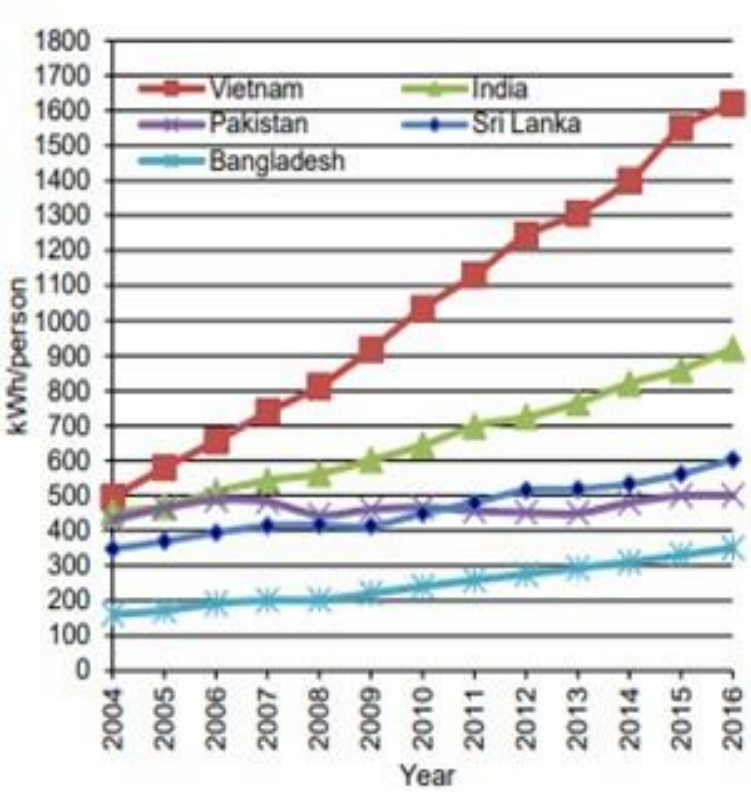
Figure 2 shows Sri Lanka's increase in per capita electricity usage from 2004 through 2018. It is compared to other Asian countries with differences in per capita electricity usage between 2004 and 2016 as shown in Figure 3.

FIGURE 02: SL PER CAPITA ELECTRICITY CONSUMPTION



Source: Generation Expansion Plan - 2019

FIGURE 03: ASIAN COUNTRIES PER CAPITA ELECTRICITY CONSUMPTION:

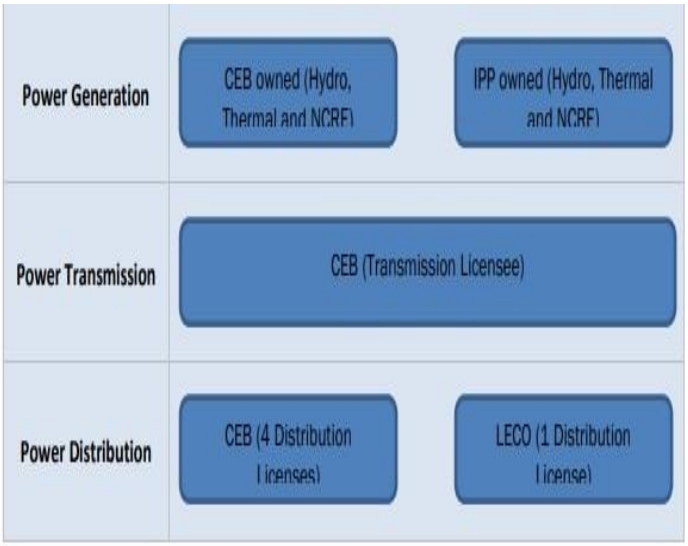


Source: Generation Expansion Plan - 2019

1.3 Power Structure of Sri Lanka

Below figure depicts the key entities involved in the generation, transmission and distribution of power in Sri Lanka.

FIGURE 04: POWER STRUCTURE



1.4 Key Challenges Faced by Sri Lankan Power Sector

- During adverse monsoon seasons, costly power production methods using oil is mostly adopted to offset low hydroelectric power generation, resulting in higher average power generation costs relative to other countries. (~ 8.5 US cents / kWh in 2016, compared to ~ 5.5 in India and ~ 6.5 in Bangladesh).

- A substantial amount of investment is needed to improve the existing power generation, transmission and distribution system. Sri Lanka therefore needs to promote greater involvement of the private sector in the power sector. Sri Lanka will need to mobilize capital investments of about USD 5.0 BN in generation, USD 1.1 BN in transmission, USD 229 MN in distribution, and USD 512 MN in proposed DSM programs to meet its estimated demand for electricity in 2026. Such a large investment cannot be financed only by public sector funding.

- As the composition of world electricity generation moves towards renewable energy (RE), Sri Lanka needs to look at ways of promoting RE growth. While Sri Lanka is blessed with numerous forms of renewable energy resources, there are no research facilities within the country dedicated to RE growth.

- Slow roof-top solar production due to lack of proper customer education and limited options from commercial banks for low cost financing. In spite of having regulations promulgating rooftop solar adoption, Sri Lanka has been unable to generate any gainful momentum in the country's rooftop solar deployment.

The high cost of rooftop solar systems, combined with the lack of affordable financing or business models open to the public to build and use these systems, is one of the primary reasons for this.

• There is a large gap between CEB visionaries and industry developers, which could slow down the industry considerably. Targets and objectives for the power sector have not been completely aligned among stakeholders in the sector. The 2018 - 2037 long-term generation plan was approved in June 2018 following lengthy deliberations among sector stakeholders. Lack of coordination between sectoral entities can continue to delay implementation of the project and hinder commercial finance mobilization.

• Sri Lanka lacks the domestic potential to finance ambitious commercial bank projects. Without funding from multilaterals and low-cost financing by international banks, growth would be difficult to achieve.

• There are a large number of players in the power sector and new licensees are on a tender basis for future projects. As a result, the entrance of new players would be influenced by pricing and the benefit will be marginal.

2. Global Power Generation Trends

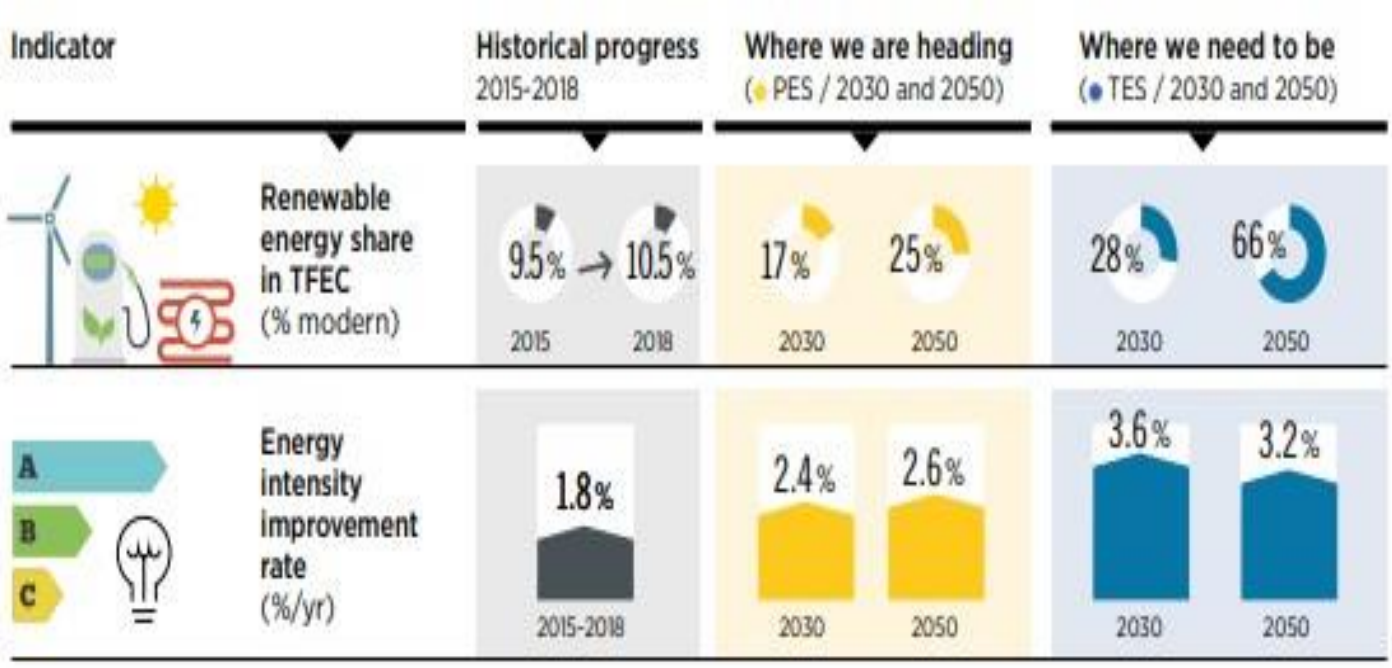
The energy world is changing…

Regionally, over the coming years, Asia Pacific is expected to be a leading contributor to the global power generation market. Growing demand for advanced power generation and distribution infrastructure in Southeast Asian countries and constructive government funding to develop the power generation and distribution networks in emerging economies like India and China are the leading drivers for the Asia Pacific power generation market.

In the coming years, steady growth of the renewable energy sector is likely to be a key feature of the Asia Pacific power generation market, as the area is closer to the equator than either North America or Europe and thus has considerable potential in terms of wind and solar generation. This is further aided by the massive drop in renewable energy costs and using electricity to decarbonize the industry is increasingly desirable, transport and manufacturing industries. The last 10 years have also witnessed a drastic price drop as the experience and scope of renewable energy projects extended.

The global energy market has begun to evolve in encouraging ways, with widespread renewable energy adoption and related technology boding well for a sustainable future. The global demand for new power generation capacity is being dominated by renewable technologies. In many markets, solar power and wind power are rapidly the cheapest source of electricity, and most renewable energy sources would be competitively priced at full cost. In 2019, as renewable electricity production increased by more than the growth in electricity demand, a new milestone was reached, while fossil-fuel electricity generation decreased. This is the first time in decades that the production of fossil fuels has decreased as the total generation of electricity has increased.

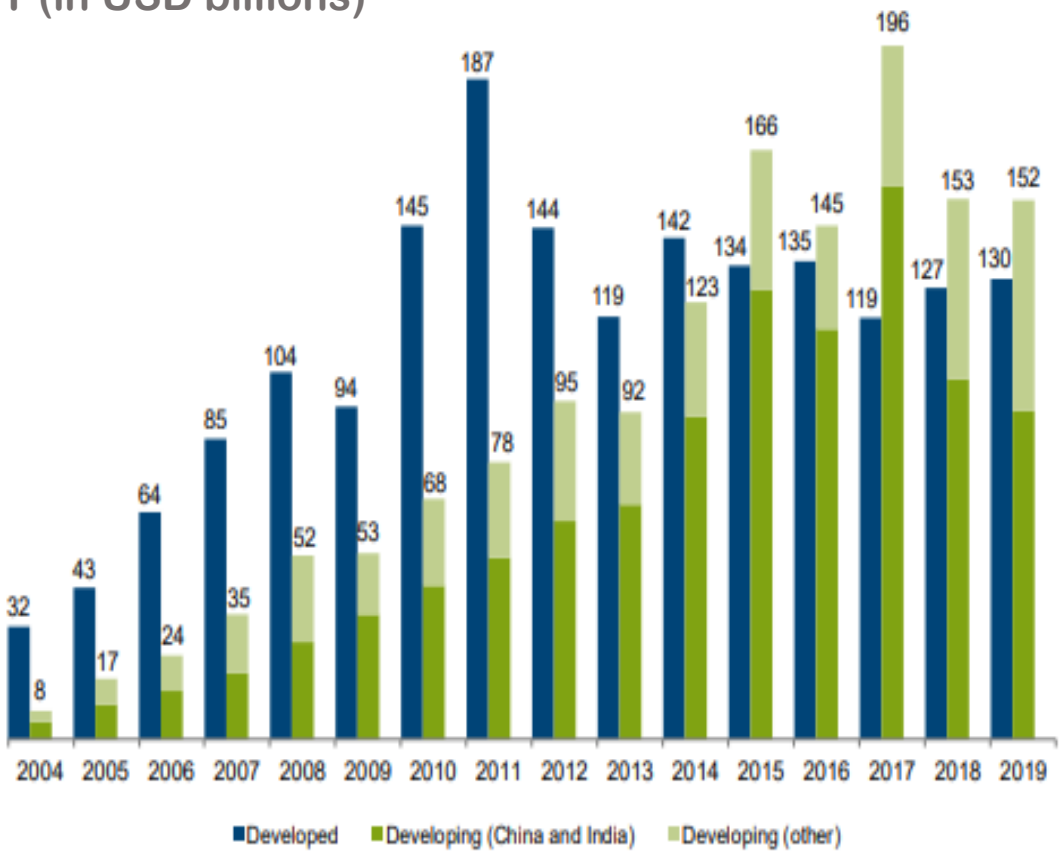
FIGURE 05: RENEWABLES IN THE WORLD'S ENERGY MIX



Source: IRENA Global Renewables Outlook

Developed economies continued to be the early adopters of renewable energy technologies like wind, solar and biomass. Increasingly, however, in the 2010s, and particularly once costs have fallen to parity with fossil fuel alternatives, developing economies have chosen the baton up. Figure 6 shows that, for the first time in 2015, emerging economies accounted for the majority of global investment in renewable energy power, and have retained this since then. In 2019, out of a world total of $282.2 billion, they accounted for $152.2 billion, a 54 percent share. This was the same proportion as in 2018, but down from a 62 percent share in 2017. In 'other developing countries', except China and India, 2019 was the highest number ever for renewable capacity investment. This jumped 17% to $59.5 billion, and for 2016, it was double the equivalent amount.

FIGURE 06: GLOBAL INVESTMENT TRENDS IN RENEWABLE ENERGY (in USD billions)



Source: UNEP, Bloomberg New Energy Finance

Further, a start-up based in New Zealand “Emrod” has developed a method of transmitting electric power securely and wirelessly over long distances without the use of copper wire, and is partnering with Powerco, the second largest power distributor in the world to introduce it.

Emrod currently has a working prototype of its device, but will develop another one for Powerco, with plans to produce by October 2020, and then spend several months in laboratory testing before moving to a field trial. The prototype system is said to be able to supply "quite a few kilowatts" of electricity, but can be scaled up easily. Wireless transmission is, indeed, seen by Emrod as a key enabling technology for renewable energy, which is often produced far from where it is required. This kind of device could be a perfect way to get offshore and remote renewable energy generation products into city grids without the need for giant storage batteries and the like.

3. Power Generation System

3.1 Existing Power Generation System

The country's current generating system is mainly operated by CEB along with substantial private-sector ownership. Until 1996 CEB owned the entire electricity system. As of 1996, the private sector also engaged in producing electricity to meet the rise in electricity demand.

The country's existing generating system has approximately 4,046 MW of installed capacity by 2019 including 610 MW non-dispatchable plants operated by private sector developers. CEB owns the bulk of the dispatchable power, which comprises 1,398.85 MW of hydro and 1,504 MW of thermal generation capacity. Independent Power Producers (IPPs) own balancing dispatchable energy, which is totally thermal plants.

Table 2 illustrates the breakdown of contribution by CEB and IPP in 2019 along with the sources of power generation.

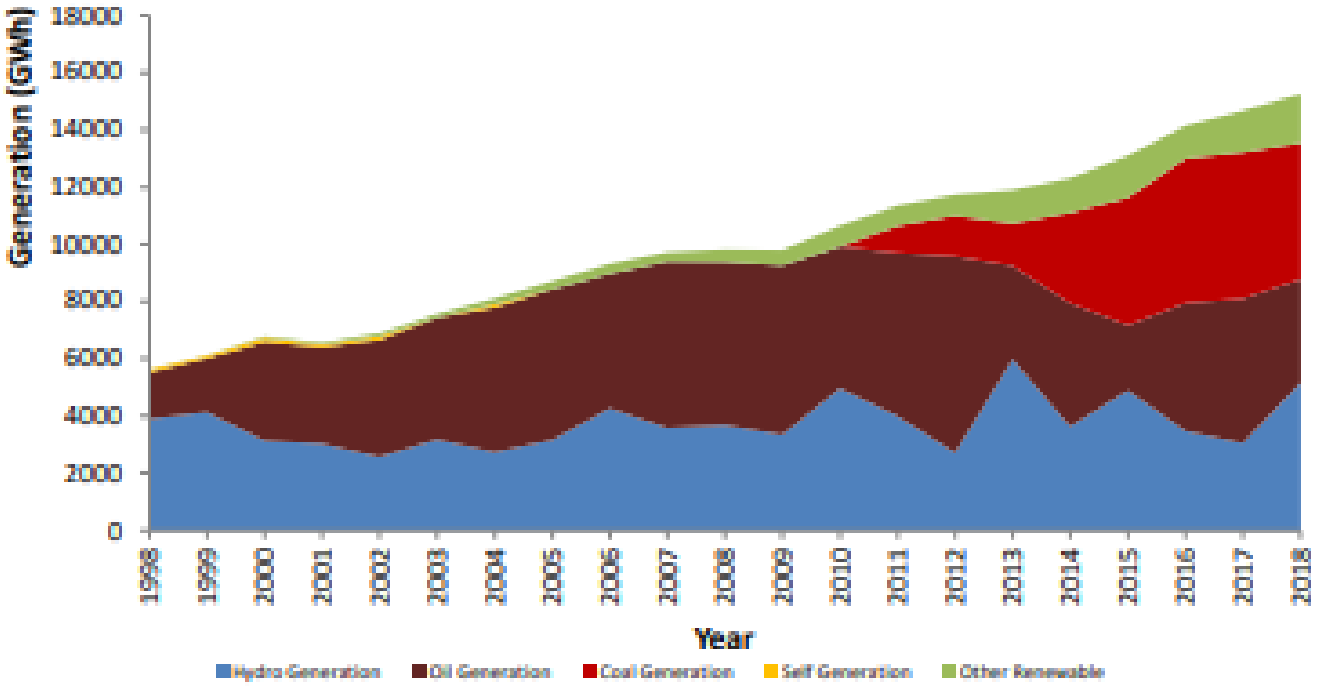
TABLE 02: POWER GENERATION 2019

Ownership & Sources	Generation (GWh)	Percentage of Total
CEB:	11,286	70.9%
Hydro	3,784	23.8%
Thermal (Oil)	2,137	13.4%
Thermal (Coal)	5,361	33.7%
ORE(Wind)	-	-
Small Islands	4.5	0.02%
PPP:	4,636	29.1%
Mini Hydro	1,011	6.3%
Thermal (Oil)	2,875	18.1%
ORE(Wind)	348	2.2%
ORE (Solar, Dendro, Biomass)	220	1.4%
Rooftop Solar	182	1.1%

Source: Statistical Digest 2019

However, the government of Sri Lanka, through the envisaged renewable energy targets and projected generation planning, has been pursuing a shift toward clean power generation, including both NCRE and LNG based generation.

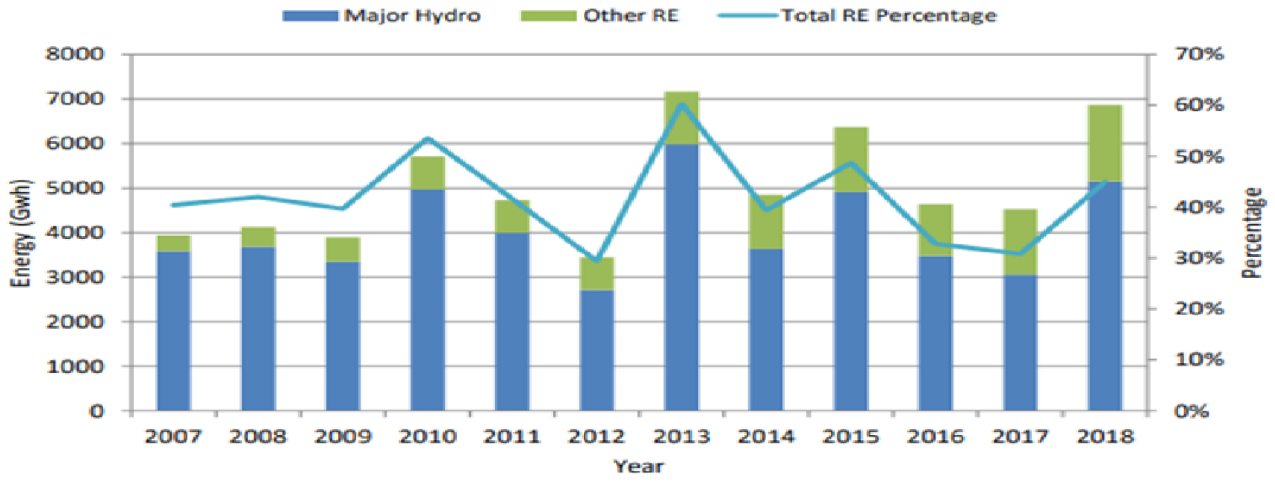
FIGURE 07: POWER GENERATION COMPOSITION OVER THE PAST YEARS



Source: Revised LTGEP

Sri Lankan Power System has operated maintaining 30%-60% share of renewable energy throughout the recent years. This trend will be continued in the future with the optimum amount of renewable energy integration to the system.

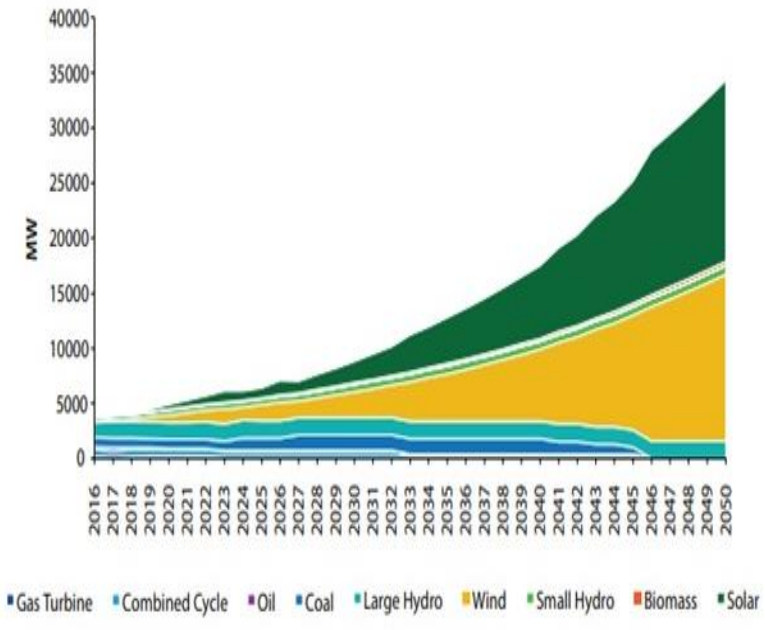
FIGURE 08: RENEWABLE SHARE IN THE RECENT PAST



Source: Revised LTGEP

3.2 Power Generation Expansion System

FIGURE 09: SRI LANKA 2050 ELECTRICITY GENERATION MIX: 100 PERCENT RE



Source: Assessment of Sri Lankan Power Sector, UNDP

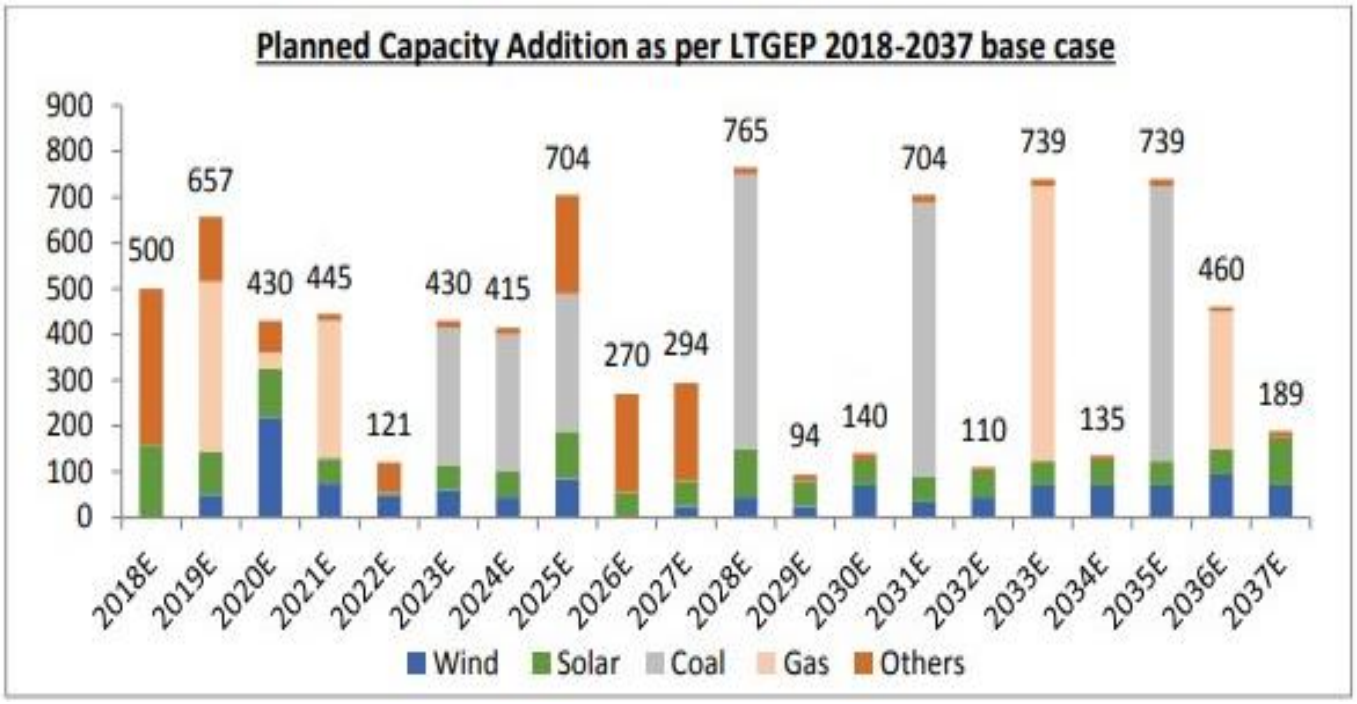
LTGEP 2018-2037 focuses on diversifying the power mix and growing reliance on projects relating to renewable energy and gas. Base case under the 2018-2037 LTGEP provides for:

- 1,035 MW of wind (270 MW), solar (360 MW) and gas (405 MW) projects by 2020
- 1,980 MW of wind (585 MW), solar (690 MW) and gas (705 MW) projects by 2026
- 4,199 MW of wind (1205 MW), solar (1389 MW) and gas (1605 MW) projects by 2037

Additionally, base case also estimates installation of 215 MW of mini hydro, 85 MW of biomass, 822 MW of major hydro, 2.7 GW of coal and 320 MW of oil-based generators up to 2037.

Vision is to pave the way for Carbon neutrality to be realized by 2050 according to the draft Energy Policy. In 2016, the share of renewable energy in power generation was 32%. Power generation facilities are planned and implemented according to CEB 's Long-Term Generation Expansion Plan (2018-2037) to cater for the growing electricity demand. Main concern is given to the construction of optimal power generating plants with minimum impact to the environment and all plans are prepared to meet international obligations including COP 21.

FIGURE 08: PLANNED CAPACITY ADDITION AS PER LTGEP 2018-2037 BASE CASE



Source: Assessment of Sri Lankan Power Sector, UNDP

Capital investment requirement is estimated based on the power generation expansion plan. Total capital requirement includes capital costs expected to be incurred for setting up the generation plants (including both conventional and renewables). Additional investment will be required for operating plants and for fuel related expenditure.

TABLE 03 :CAPITAL REQUIREMENTS OF POWER GENERATION SEGMENTS

All Values in USD million	Power Generation					
	Solar	Wind	Gas	Coal	Others	Total
Short term (till 2020)	360	351	631	-	424	1,767
Medium Term (cumulative up to 2026)	690	761	756	1,100	1,724	5,041
Long Term(cumulative up to 2037)	1,389	1,567	1,881	2,700	2,056	9,564

Source: Assessment of Sri Lankan Power Sector, UNDP

4. Cost of Production, Selling Price, and Demand for Power

4.1 Cost of Production

The average cost at selling point in 2017 and 2018 were Rs. 20.34 per 1 kWh and Rs.19.12 per 1 kWh respectively.

Following table depicts the generation cost of one kwh for several power stations during 2016.

TABLE 04: POWER GENERATION COST OF SEVERAL POWER STATIONS DURING 2016

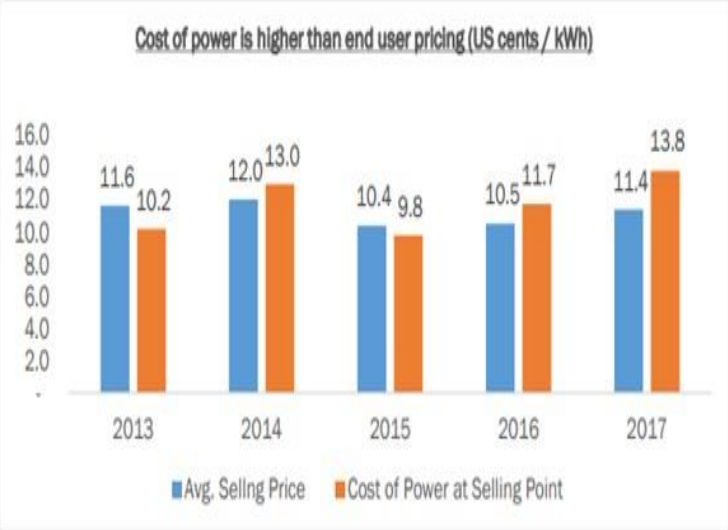
Power Station	Annual Generation (GWh)	Total Cost to CEB (Mn.LKR)	Average Unit Cost(Rs/kWh)
Asia Power	127	4,900	38.61
AES Kelanitissa	795	17,680	22.23
ACE Embilipitiya	387	8,480	21.90
Westcoast	893	29,591	33.14
Northern Power	-	725	
Sapugaskanda A	309	8,194	26.53
Sapugaskanda B	475	10,969	23.11
Kelanitissa Small GTs	45	2,984	66.56
Kelanitissa PS GT 7	263	10,198	38.71
Kelanitissa CCY	781	19,845	25.42
Puttalam Coal	5,068	50,187	9.90
Uthura Janani	98	3,219	32.71
Barge-CEB	356	7,783	21.86
Victoria	589	2,345	3.98
Ukuwela	158	697	4.41
Kotmale	280	2,129	7.61
Upper Kotmale	236	1,770	7.52
Randenigala/Rantambe	466	2,021	4.34
Bowatenna	42	534	12.63
Nilambe	4	136	31.46
Old Laxapana/New Laxapana	669	1,630	2.44
Polpitiya	432	2,201	5.09
Wimalasurendra	85	458	5.40
Canyon	123	720	5.86
Samanalawewa	261	1,868	7.17
Kukule	202	832	4.11
Inginiyagala	42	154	3.68
Udawalawe	16	632	40.69
Renewable	1,208	20,185	16.71
All Hydro	3,603	18,126	5.03
All CEB Thermal	7,395	113,379	15.33
ALL IPP Thermal	2,202	61,376	27.87
All Plants	14,408	213,066	14.79

Source: Generation Performance in Sri Lanka-2016

4.2 Selling Price

The average selling price per unit in 2017 and 2018 were Rs. 16.26 per 1 kWh and Rs.16.29 per 1 kWh respectively.

FIGURE 09: COST OF POWER VS END USER PRICING (US Cents/kWh)



Source: World Bank

4.2.1 End User Tariff Structure

Used for domestic purposes in private residences. There are two types of Domestic Tariff Categories.

1. Block Tariff
2. Time of Use Tariff (TOU):

The optional tariff for domestic consumers

Block Tariff

Consumption blocks are based on a 30-day billing period and the number of units in a block would be prorated according to the number of dates in each billing period.

Domestic Low Users (if monthly consumption is 60 units per month or less than 60 units)

Consumption per month (kWh)	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)
0-30	2.50	30.00
31-60	4.85	60.00

Source: pucsl..gov.lk

Domestic-Users over 60 units per month

Consumption per month (kWh)	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)
0-60	7.85	-
61-90	10.00	90.00
91-120	27.75	480.00
121-180	32.00	480.00
More Than 180	45.00	540.00

Source: pucsl..gov.lk

Optional Time of Use (ToU) Tariff for Domestic Customers

Team of Use (ToU)	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)
Off Peak (22.30-5.30 hrs)	13.00	540.00
Day (5.30-18.30 hrs)	25.00	
Peak (18.30 -22.30 hrs)	54.00	

Source: pucsl..gov.lk

2. Religious and Charitable

The tariff will be charged on Incremental Block Tariff basis. This rate shall apply to supplies of electricity to,

- places of public religious worship including private residences of priests where such residences are associated with or are within the place of public religious worship,

- Homes for aged, orphanages and homes for the handicapped, which are specifically certified by the Director of Social Services as charitable institutions, and the installation should not include any building used for commercial purposes.

Consumption per month (kWh)	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)
0-30	1.90	30.00
31-90	2.80	60.00
91-120	6.75	180.00
121-180	7.50	180.00
More Than 180	9.40	240.00

Source: pucsl..gov.lk

3. Hotels

Customer Category H-1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
21.50	600	

Source: pucsl..gov.lk

Customer Category H-2

This rate shall apply to supplies at each individual point of supply delivered and metered 400/230 Volt nominal and where the contract demand exceeds 42kVA.

Time Interval	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
Peak 18.30-22.30	23.50		
Day 5.30-18.30	14.65		
Off-peak22.30-5.30	9.80	3,000	1,100

Source: pucsl..gov.lk

Customer Category H-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above.

Time Interval	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
Peak (18.30-22.30)	22.50		
Day (5.30-18.30)	13.70		
Off-peak(22.30-5.30)	8.80	3,000	1,100

Source: pucsl..gov.lk

4.Industrial Consumers

Customer Category I-1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Consumption per month(kWh	Energy Charge (LKR/kWh	Fixed Charge (LKR/month	Maximum Demand Charge Per month
<= 300	10.80		
<300	12.80	600	

Customer Category I-2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Time Interval	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month	Maximum Demand Charge Per month(LKR/kVA)
Peak (18.30-22.30)	20.50		
Day (5.30-18.30)	11.00		
Off-peak (22.30-5.30)	6.85	3,000	1,100

Source: pucsl..gov.lk

Customer Category I-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above.

Time Interval	Energy Charge (LKR/kWh	Fixed Charge(LKR/month	Maximum Demand Charge Per month(LKR/kVA)
Peak (18.30-22.30)	23.50		
Day (5.30-18.30)	10.25		
Off-peak (22.30-5.30)	5.90	3,000	1,000

Source: pucsl.gov.lk

5.General Purpose

Supply of electricity to be used in shops, offices, banks, warehouses, public buildings, hospitals, educational establishments, places of entertainment and other premises not covered under any other tariffs.

Customer Category GP-1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Consumption per month(kWh)	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
Less than or equal 300	18.30	240	-
More than 300	22.85		

Source: pucsl..gov.lk

Customer Category GP-2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Time Interval	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
Peak (18.30-22.30)	26.60	3,000	1,100
Day (5.30-18.30)	21.80		
Off-peak (22.30-5.30)	15.40		

Source: pucsl..gov.lk

Customer Category GP-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above.

Time Interval	Energy Charge(LKR/kWh	Fixed Charge(LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
Peak (18.30-22.30)	25.50	3,000	1,000
Day (5.30-18.30)	20.70		
Off-peak (22.30-5.30)	14.35		

Source: pucsl..gov.lk

6.Government

Supply of electricity to be used in schools, hospitals, vocational training institutions, and universities, which are fully owned by the Government and funded through the national budget and provide their services free of charge to the general public.

Customer Category GV-1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
14.65	600	

Source: pucsl..gov.lk

Customer Category GV-2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
14.55	3000	1100

Source: pucsl..gov.lk

Customer Category GV-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above.

Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)	Maximum Demand Charge Per month(LKR/kVA)
14.35	3000	1000

Source: pucsl..gov.lk

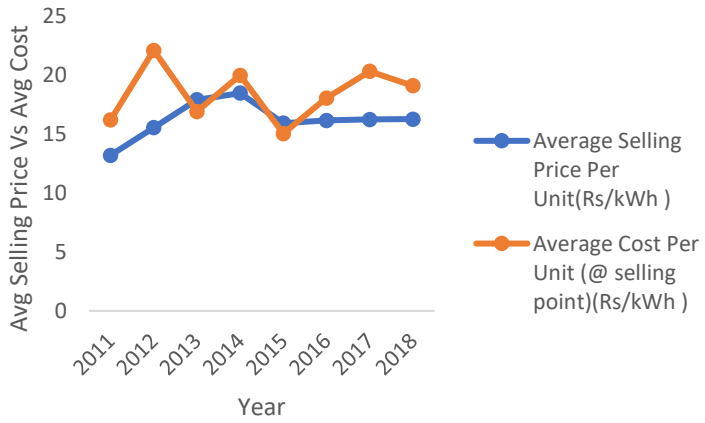
Commission approved Electricity Tariff for the customers who are charging their vehicles at CEB owned charging stations.

Tariff Category	TOU Time Period	Charge (LKR/kWh)
DC Fast Charging	Day (0530-1830 hrs)	50.00
	Peak (1830-2230 hrs)	70.00
	Off peak (2230-530 hrs)	30.00
Level 2 AC Charging	Day (0530-1830 hrs)	30.00
	Peak (1830-2230 hrs)	55.00
	Off peak (2230-0530 hrs)	20.00

Source: pucsl..gov.lk

4.3 Average Selling Price Vs Average Cost at Selling Point

FIGURE 10: AVERAGE SELLING PRICE VS AVERAGE COST OVER THE PAST YEARS

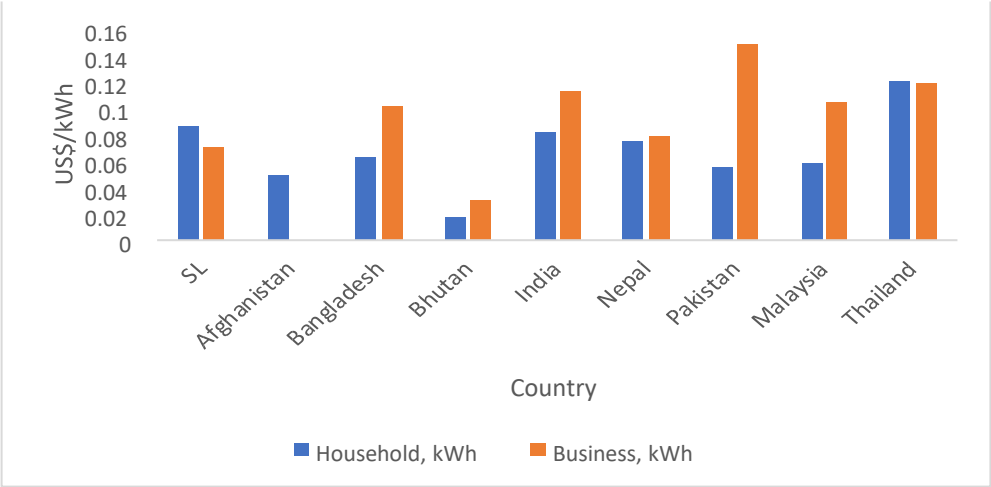


Generally, average cost per 1 kwh at selling point is rising steadily; however, in the period 2015 and 2018 it has been reduced by 24.7 percent, 6 percent respectively. An increasing trend is observed with average selling prices per 1 kwh over the period.

4.4 Comparison of Selling Prices

SL selling prices of 1 kWh for households and Businesses (as at Dec. 2019) is compared to benchmark countries depicted in Figure 11.

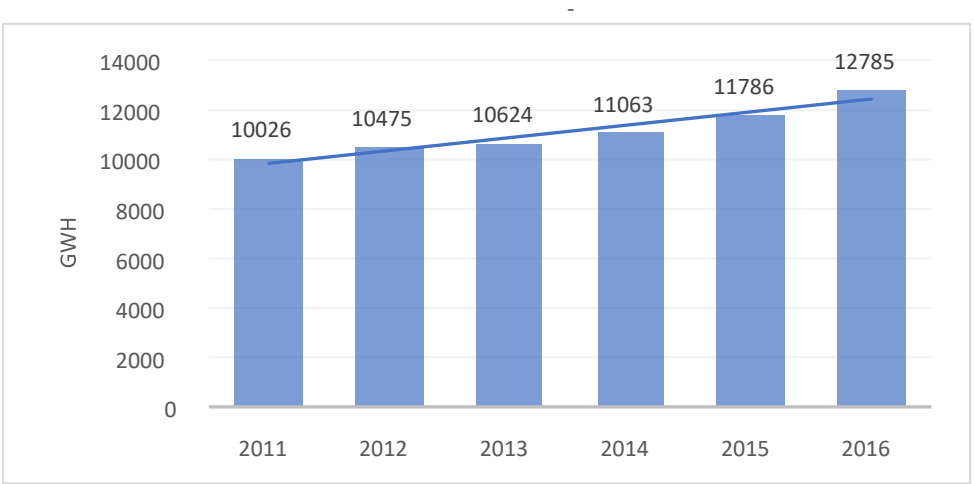
FIGURE 11: SELLING PRICE COMPARISON WITH BENCHMARK COUNTRIES



4.5 Demand for Power

Total power demand in Sri Lanka increased by 12,785 GWh in 2016 during the period 2011-16 at a CAGR of 5.0 per cent. CEB has forecasted power demand to rise to 50.978 GWh by 2044 at a CAGR of about 5.0 per cent.

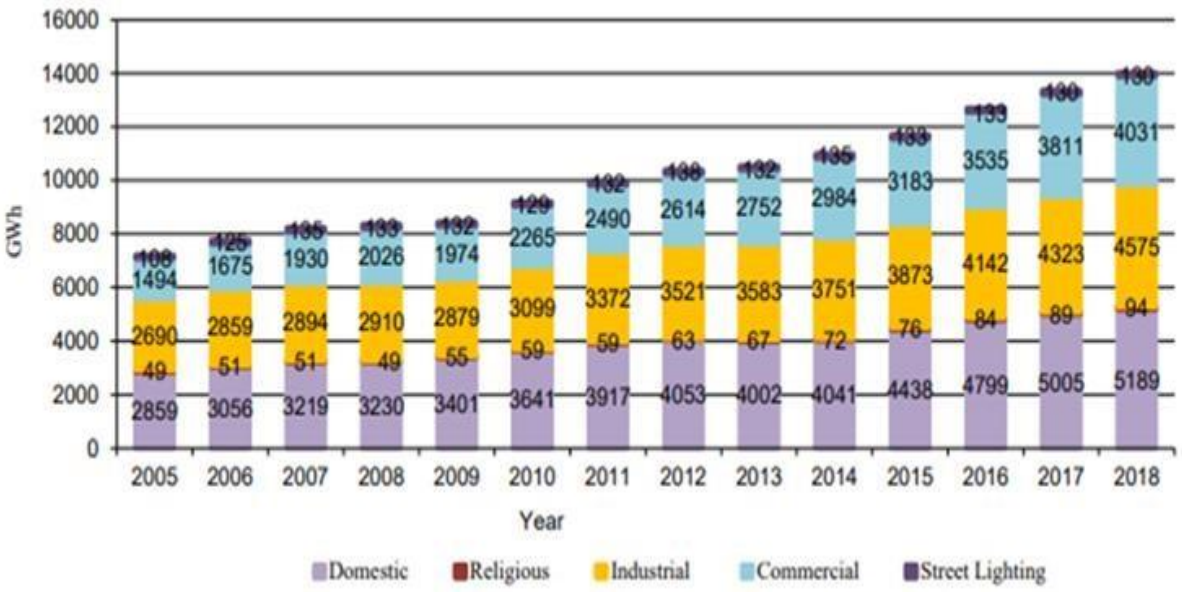
FIGURE 12: POWER DEMAND EVOLUTION (2011-2016)



Source: Sri Lanka Energy Infrasap,World Bank

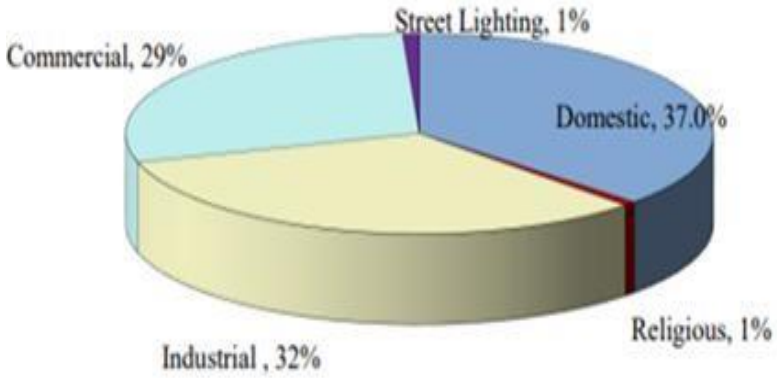
The sectoral contribution to the existing demand is highlighted below.

FIGURE 13: SECTORIAL CONSUMPTION OF ELECTRICITY 2005-2018



Source: Generation Expansion Plan 2019

FIGURE 14: SECTORIAL CONSUMPTION OF ELECTRICITY 2018



Source: Generation Expansion Plan 2019

These Figures reveal that the cumulative industrial and commercial (general purpose, hotel, government) sectors' electricity consumption is much more than the electricity consumption by the domestic sector.

4.6 Demand Projections

The Government has proposed and planned for large scale development projects, which will lead to an increase of electricity demand in the future. The major development plans are mainly identified by Western Region Megapolis Plan and Hambantota Port Development Plan in Southern Region. The Western Region Megapolis Plan identifies following major areas for the development.

- Multi Model Transport Hub (Pettah)
- Administrative Cities Development Project
- Science and Technology City
- Maritime City Development Project
- Colombo Central Business District
- Housing Development
- Horana & Mirigama Industrial Township
- SME Industry
- Colombo Port City
- Transport
- Tourism

The cumulative electricity demand requirements for the identified projects (Maritime City Development Project, Administrative Cities Development Project, Multi Model Transport Hub (Pettah) and Science and Technology City) under the Capital City and Colombo Commercial City development programs of Ministry of Megapolis and Western Development are indicatively estimated as 121MW for 2018-2022, 399MW for 2023-2026 and 508MW for 2027-2030 period.

The Colombo Port City Development Project is a major development project under the Western Region Megapolis Plan and indicate cumulative electricity demand requirement estimated as 30MW by 2020, 177MW by 2025, 313MW by 2030 and 393MW by 2040. Hambantota Port Development Plan in Southern Region also estimated approximately 400MW electricity demand for the initial stage in the present development plan. The Electricity Demand Forecast 2020-2044 was prepared considering the phase development of the above large-scale projects. During the detailed planning stages, it is required to identify the time-based load requirement to determine the load pattern which would impact on actual electricity demand.

Different demand forecast scenarios were planned in the power generation expansion plan 2019, taking into account growth rate variations in the baseline demand forecast, long-term trend approach,

end-user approach, and those listed below.

1. High Load Forecast - The forecast developed considering 1% higher economic growth of the country beyond 2022 and economic sector change based on higher growth in Industrial and Service sector in future.

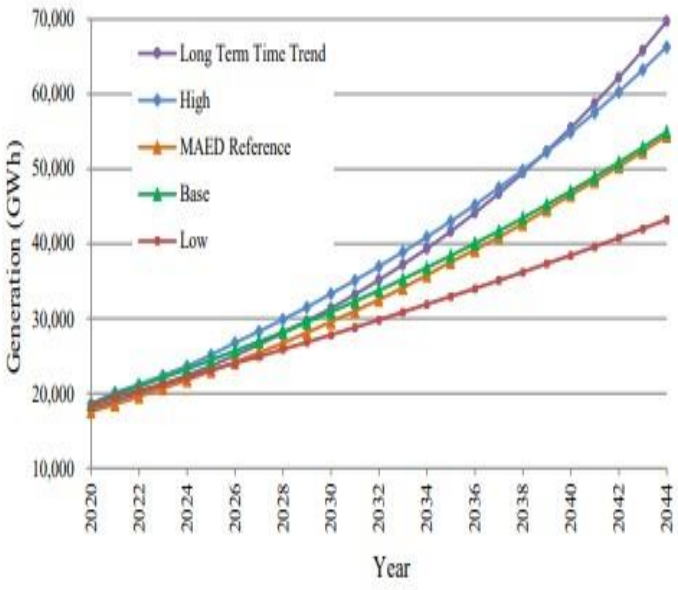
2. Low Load Forecast - The forecast developed considering 1% reduction from the annual growth rate of Base Load Forecast.

3. Long Term Time Trend Forecast - The forecast developed purely based on the time trend approach using the past 25-year electricity demand figures starting from 1993.

4. MAED Load Projection – The projection derived from MAED software by considering end user energy demand data and identifying technological, economic and social driving factors influencing each category of final consumption and their relations to the final energy.

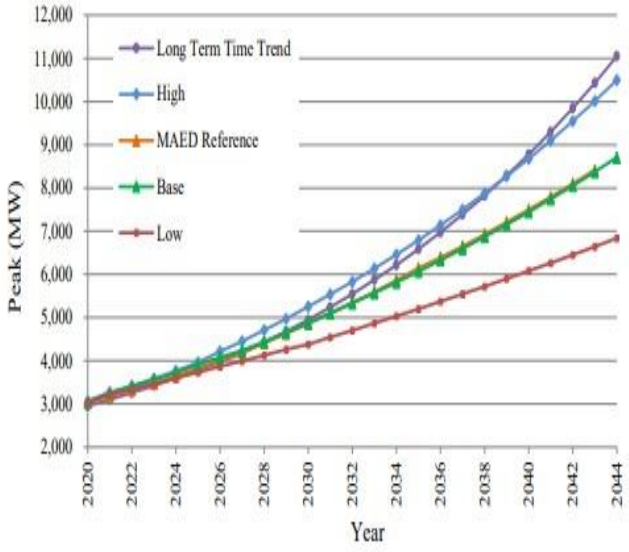
For the above four scenarios, including the Base Load Forecast, Figure 15 & Figure 16 graphically displays the power production and peak load forecast.

FIGURE 15 : GENERATION FORECAST OF LOW, HIGH, LONG TERM TIME TREND AND MAED WITH BASE



Source: Generation Expansion Plan 2019

FIGURE 16 :PEAK DEMAND FORECAST OF LOW, HIGH, LONG TERM TIME TREND AND MAED WITH BASE



Source: Generation Expansion Plan 2019

5. Power Distribution and Collection

4.5 Distribution of Power

Major part of the country's electricity distribution is handled by CEB amounting to 88 per cent of the overall sales volume, while the rest is managed by the subsidiary of CEB, Lanka Electricity Company Ltd (LECO). Distribution licensees are responsible for supplying end user power and receiving end user revenue.

For ease of administration and service, the entire CEB distribution system is geographically divided into four Divisions; Distribution Division 1 (DD1), Distribution Division 2 (DD2), Distribution Division 3 (DD3), and Distribution Division 4 (DD4). The key aim of creating the four Divisions is to achieve benchmark competitiveness that can boost consumer efficiency and supply quality.

Division	Province	Area
Distribution Division 1	North Western	Chilaw,Kurunegala,Kuliyapitiya,Wariyapola,Puttlam and Narammala
	North Central	Anuradapura,Kekirawa and Minneriya
	North	Jaffna,Kilinochchi and Vavuniya
	Colombo City	Colombo North, Colombo South,Colombo West and Colombo East

Division	Province	Area
Distribution Division 2	Eastern	Ampara,Batticaloa,Trincomalee and Kalmunai
	Central Province	Kegalle,Mawanella,Kandy City,Peradeniya,Kundasale,Katugastota,Galagedara,Matale,Dambulla,Nuwaraeliya,Ginigathena,Nawalapitiya
	Western Province North	Gampaha,Kelaniya,Negombo,Jaela,Divulapitiya and Veyangoda

Division	Province	Area
Distribution Division 3	Western Province South II	Bandaragama,Homagama,Avissawella Sri Jayawardenapura,and Horana
	Sabaragamuwa	Ratnapura,Kahawatte,Ruwanwella,Eheliyagoda and Embilipitiya
	Uwa	Badulla,Diyatalawa,Monaragala

Division	Province	Area
Distribution Division 4	Southern Province	Ambalangoda,Galle,Hambantota,Matara,Tangalle,Akuressa(formally Weligama) and Baddegama
	Western Province South I	Ratmalana,Kalutara and Dehiwala

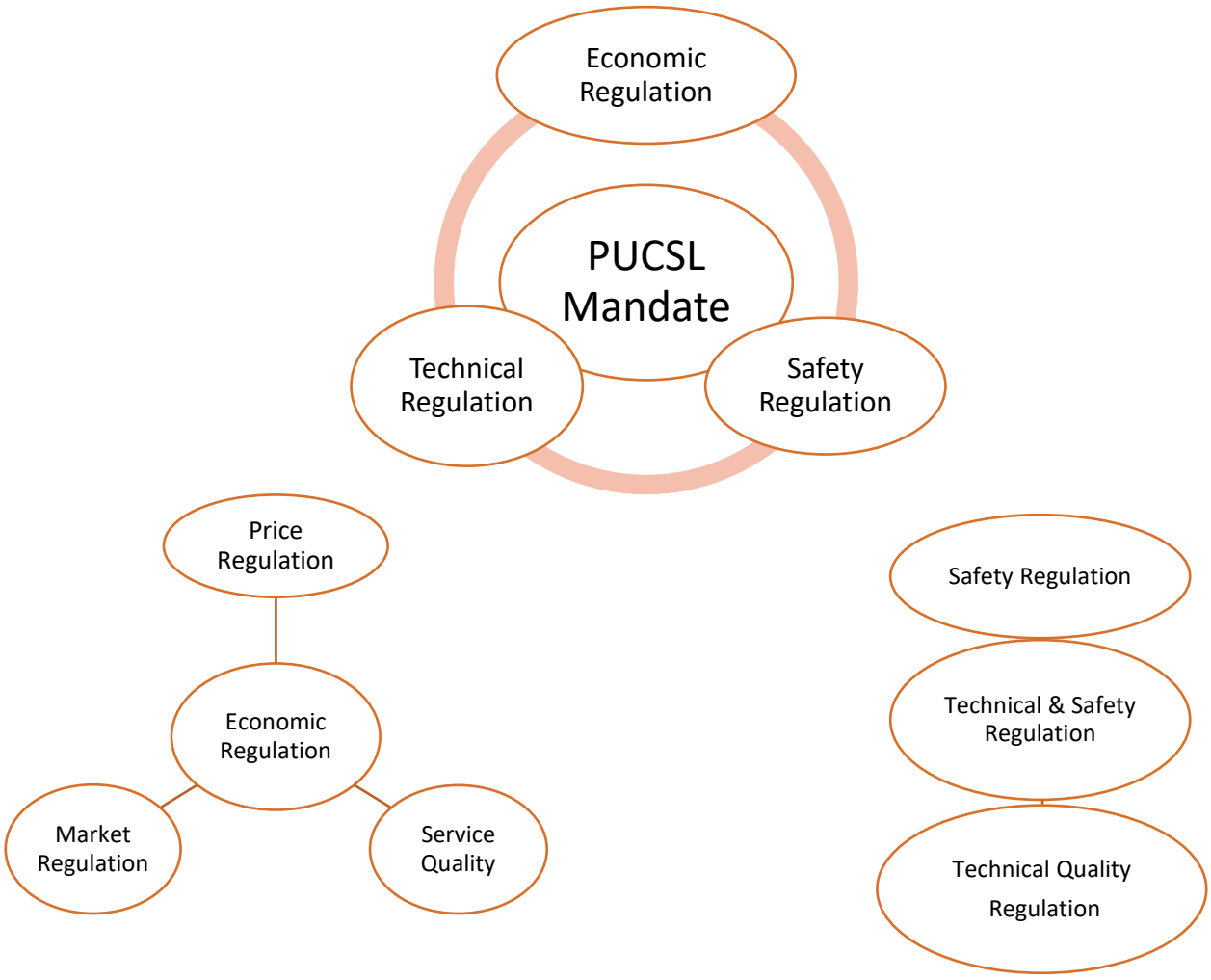
Source:Powermingov.lk

5.2 Collection

The CEB's collection agents, Sampath Bank, National Development Bank (NDB), and National Savings Bank (NSB), have introduced real-time online (OLRT) monitoring of consumer electricity bill payments over the year.

6. Regulator of the Electricity Industry of Sri Lanka

Public Utilities Commission of Sri Lanka (PUCSL) is the economic, technical and safety regulator of the electricity industry. The Commission regulates the industry through licenses, regulations, rules and methodologies.



OUTCOMES OBTAINED BY PUCSL

1. Improved productivity & convenience for electricity consumers.

2. Affordable Price for consumers and sustainable financial stability for licensees.

3. Improved safety of every living being and properties of general public, licensees & operators.

4. Improved environmental conditions for humans, animals and plants.

7. Mini Hydro Projects in the Industry

Sri Lanka is blessed at a local location relative to rains in the interior of, in addition to especially around the central mountainous regions. Heavy rains and the sloping nature of the land have resulted in a series of small and large streams carrying water throughout the year, enabling a variety of reservoirs to produce and meet significant sections of the energy needs of the country. Although the government is carrying out large-scale power generation projects, the private sector has been approved for projects with a capacity of under 10 MW. Many local organizations are pursuing potential locations and selling the generated energy to the Ceylon Electricity Board when the green light is provided, building and installing power plants.

Sri Lanka's history of small hydropower generation extends over a century and is largely associated with the power generation of colonial-era large-scale tea plantations. Since then, until the 1960s, the limited hydro capacity steadily expanded until the expansion of the power grid to provide power. CEB 's assistance to the development of the Mini hydropower sector was given in the 1990s with the necessary assistance to the private sector, which involved training & capacity building, pre-feasibility studies, and resource assessments. Beginning in 1997, the process for the purchasing of electricity from Small Power Producers (SPPs) by the CEB was regularized by the publication of the Uniform Power Purchase Agreement (SPPA), which included a scheme to measure the purchase price based on the concept of avoided costs. Further, 2006 National Energy Policy established fuel diversification and energy security in electricity generation as a strategic target and as part of this strategy the development of renewable energy projects was established. In view of

the above, the implementation of a three-tier tariff was introduced instead of the avoided cost-based tariff with effect from 2008. Both large-scale hydropower generation facilities will remain under government control for the near future, and the private sector will be responsible for the construction of small hydropower plants. Currently the technology specific cost reflective tariff introduced in 2012 is in force.

The geo-climatic condition in Sri Lanka is favorable for the mini hydro development and several past studies have assessed the potential for the development of mini-hydro resources. A comprehensive study was conducted as part of the hydropower portion of the Ministry of Irrigation and Water Resources' Dam Safety and Water Resources Planning (DSWRP) project, focusing on the country's 13 river basins, and the study concluded that the country's total Minihydro capacity is 873MW.

The total grid-connected Mini hydro capacity at the end of 2018 is 393.5 MW, comprising 368.5 MW built by the private sector and 25 MW under the multi-development project Moragahakanda Kaluganga Development by the relevant Ministry of Mahaweli Development and Environment with the Mahaweli Authority of Sri Lanka.

Minihydro capacity is expected to grow moderately over the next twenty years in the long-term generation expansion plan, as most of the attractive resources and sites have already been established.

7.1 List of Mini Hydro projects undertaken by Listed Power Companies in Sri Lanka

TABLE 05:LIST OF MINI HYDRO PROJECTS UNDERTAKEN BY LISTED POWER COMPANIES

Power Project	Ownership	Generation Capacity	Location	River Catchment	Plant Factor	Commissioning Year
Bambarabatuoya MHPP	Vidullanka PLC	3.2 Mw	Rathnapura	Kalu Ganga, Bambarabatuoya	44%	1-Jun-2001
Rideepana MHPP	Vidullanka PLC	1.75 Mw	Badulla	Badulu Oya	4%	15-May-2015
Lower Kothmale MHPP	Vidullanka PLC	4 MW	Kotmale, Nuwara-Eliya	Kothmale Oya	37%	25-Jun-2014
Madugeta MHPP	Vidullanka PLC	2.5 MW	Neluwa, Galle	Gin Gange	46%	1-Nov-2013
Wembiyagoda MHPP	Vidullanka PLC	1.3 MW	Kalawana, Ratnapura	Koswathu Ganga	40%	19-Mar-2013
Ganthuna MHPP	Vidullanka PLC	1.2 MW	Ganthuna, Aranayake, Kegalle	Gurugodaya	38%	26-Mar-2010
Ethamala Ella	Vidullanka PLC	2 MW	Matara	Nilwala Ganga	44%	30-Sep- 2016
Batatotha MHPP	Vidullanka PLC	2.0 MW	Kuruwita, Ratnapura	Kuru Ganga	58%	6-Mar-2007
Udawela MHPP	Vidullanka PLC	1.4MW	Badulla	Badulu Oya	45%	29-Dec-2017
Upper agra oya hydropower project	Resus Energy PLC	2.6 MW	Lindula, Thalawakele	Agra Oya	39%	01-Feb-2006
Giddawa hydropower project	Resus Energy PLC	2.0 MW	Giddawa, Teldeniya	Huluganga	45%	01-Oct-2008
Upper magal ganga hydropower project	Resus Energy PLC	2.4 MW	Dikellakanda. Maliboda	Magal Ganga	40%	01-Sep-2011
Gomale oya hydropower project	Resus Energy PLC	1.4 MW	Magala, Maliboda	Gomale Oya	30%	01-Aug-2016
Moragaha oya hydropower project	Resus Energy PLC	1.5 MW	Panvila, Kandy	Moragaha Oya	35%	01-Mar-2017

Ranawala oya hydropower project	**Resus Energy PLC**	**1.2 MW**	**Maliboda, Deraniyagala**	**Ranwala Oya**	**37%**	**29-Nov-2018**
Upper hulu ganga hydropower project	Resus Energy PLC	1.9 MW	Panwila, Kandy	Hulu Ganga	35%	25-July-2019
Rathganga MHP	Panasian Power PLC	3 Mw	Ratthurugala, Ratnapura	Rathganga	45%	2004
Manelwala MHP	Panasian Power PLC		Walapane,Nuwara Eliya	Kurundu Oya	38%	2008
Padiyapelella MHP	Panasian Power PLC	3.5 Mw	Padiyapelella, Nuwara Eliya	Beliul Oya	43%	2017
Erathna mhpp	Vallibel Power Erathna PLC	9.9 MW	Kuruwita, Rathnapura	Kuru Ganga	N/A	2004
Denawaka ganga mhpp	Vallibel Power Erathna PLC	7.2 MW	Malwala, Rathnapura	Denawaka Ganga	N/A	2012
Kiriwaneliya mhpp	Vallibel Power Erathna PLC	4.65 MW	Norton Bridge, Nuwara Eliya	Maskeli Oya	N/A	2011
Ginigathhena	Laugfs Power PLC	0.7 MW	Ginigathhena	N/A	N/A	2017
Ranmudu Oya Phase 1	Laugfs Power PLC	0.5 MW	Balangoda	N/A	N/A	2017
Ranmudu Oya Phase 3	Laugfs Power PLC	0.55 MW	Balangoda	N/A	N/A	2017
Belihul oya	LVL Energy Fund PLC	2.2 MW	Balangoda	Horton Plains	47%	May 2002
Assupini ella	LVL Energy Fund PLC	4.0 MW	Gampola and Mawanella	Maha Oya	47%.	November 2005
Kadawala	LVL Energy Fund PLC	6 MW	Watawala and Kadawala	N/A	25%	March 2008
Neluwa	LVL Energy Fund PLC	2.2 MW	border of Galle and Kalutara	Gin Ganga	33%	January 2008
Theberton	LVL Energy Fund PLC	1.3 MW	Kiriwaneliya	N/A	41%	September 2015
Campion	LVL Energy Fund PLC	1.2 MW	Bogawantalawa	Kehelgamuwa Oya	45%.	May 2017
Bambarapana	LVL Energy Fund PLC	2.5 MW	Bambarapana, Badulla	Uma Oya	41%.	February 2018

7.2 Small Hydro Power Developers Association (SHPDA)

The Small Hydro Power Developers Association (SHPDA), representing the major local power generators of renewable energy in Sri Lanka, seeks to jointly work with relevant state authorities to formulate and implement appropriate national renewable energy policies. SHPDA members currently supply approximately 10% of the nation's demand, saving millions of dollars in foreign exchange to the country annually. Moreover, small hydropower projects, while being environmentally friendly, have stimulated tangible economic progress among rural Sri Lankan communities. Table 06 includes the members of Small Hydro Power Developers Association.

TABLE 06: MEMBERS OF SMALL HYDROPOWER DEVELOPERS ASSOCIATION

	Company	Installed capacity in mini hydro projects
1	Access Energy (Pvt.) Ltd.	N/A
2	Eco Power (Pvt.) Ltd.	58.2 Mw
3	Recogen Haycarb (Pvt.) Ltd.	N/A
4	Hydrodynamics (Pvt.) Ltd.	N/A
5	Saman Jala Viduli Co. (Pvt.) Ltd. (Formerly known as Hydro Tech Lanka Dickoya)	N/A
6	Zyrex Power (Pvt.) Ltd.	N/A
7	Elpitiya Plantations	4.46 Mw
8	Lotus Hydro Power Plc. (Formerly known as Hydro Power Free Lanka / Browns Hydro Power Plc.)	4.9 Mw
9	Natural Power (Pvt.) Ltd.	N/A
10	Dunsinane Power Co. (Pvt.) Ltd.	N/A
11	Midland Energy (Pvt.) Ltd.	N/A
12	Vallibel Power Erathna Plc.	21.85 Mw
13	Serendib Energy (Pvt.) Ltd.	N/A
14	Weswin Power (Pvt.) Ltd.	N/A
15	Agraoya Hydro Power (Pvt.) Ltd.	N/A
16	Santak Power (Pvt.) Ltd.	N/A
17	Energy Reclamation (Pvt.) Ltd.	N/A
18	Hydro Trust Lanka (Pvt.) Ltd.	4 MW
19	WKV Hydrotechnics (Pvt) Ltd.	43.4 Mw
20	Samangiri Hydro Electrical Co. Pvt	N/A
21	Hynford Water Power (Pvt.) Ltd.	N/A
22	Resus Energy Plc. (Formerly known as Hemas Power Plc.)	13 MW
23	Falcon Valley Hydro	N/A
24	Bogo Power (Pvt.) Ltd.	N/A
25	Vidullanka Plc	32.35 Mw
26	Mark Hydro (Pvt.) Ltd / Mark Marine Services Pvt. Ltd.	N/A
27	Royali Power (Pvt.) Ltd.	N/A
28	Branford Hydro Power (Pvt.) Ltd.	N/A

29	Hayleys Power Ltd. (Formerly known as Hayleys Industrial Solutions)	9.5 MW
30	Panasian Power Plc.	8.9 Mw
31	Waltrim Hydropower (Private) Ltd. Formerly known as Sunshine Power (Pvt.) Ltd.	6.6 MW
32	Terraqua International (Pvt.) Ltd.	N/A
33	Sujalashakthi (Pvt.) Ltd.	N/A
34	Wellawaya Hydro Power Pvt. Ltd.	N/A
35	Castle Power House (Pvt.) Ltd.	11.85 Mw
36	Energy Generators (Pvt.) Ltd.	N/A
37	Laugfs Power Ltd.	1.75 Mw
38	Ceylex Engineering Pvt. Ltd. (LTL Power)	7.5 MW
39	Magalganga Power (Pvt.) Ltd.	N/A
40	Bhoruka Power Lanka (Pvt.) Ltd.	N/A
41	Hiran Power (Pvt.) Ltd.	N/A
42	Nilwala Vidulibala Company (Pvt.) Ltd.	N/A
43	Eskey Power Generators Pvt. Ltd.	N/A
44	Fair Energy Developers Pvt. Ltd.	N/A
45	Campion Hydro Pvt. Ltd.	N/A
46	Escas Owala Pvt. Ltd.	N/A
47	Mossiville Hydro Power Pvt. Ltd.	N/A
48	Aqua Power Pvt. Ltd.	N/A
49	Meunex Nahawathura Hydro Power Pvt Ltd.	N/A
50	Hydro Jet Power Pvt. Ltd.	N/A

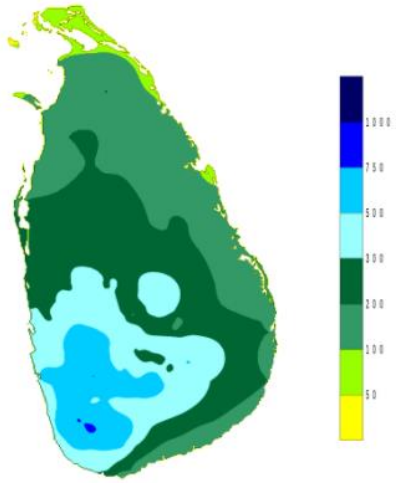
7.3 Cyclin impact on the hydro power projects

Although an assessment of a project's technological viability would be straight forward, the climate conditions could be highly complicated.

The climate of Sri Lanka is marked by the southwest monsoon and northeast monsoon. The Climate experienced during the 12 months period in Sri Lanka can be characterized in to 4 climate seasons as follows.

1. First Inter-monsoon Period (March to April)

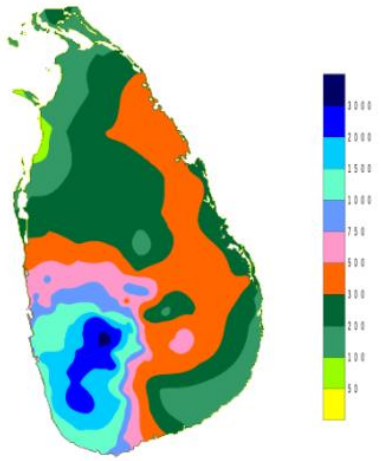
Arm and uncomfortable conditions, with thunderstorm-type rain, particularly during the afternoon or evening, are the typical weather conditions during this season. The distribution of rainfall during this period shows that the entire South-western sector at the hill country receiving 250 mm of rainfall, with localized area on the South-western slopes experiencing rainfall in excess of 700 mm (Keragala 771 mm). Over most parts of the island, the amount of rainfall various between 100 and 250 mm, the notable exception being the Northern Jaffna Peninsula (Jaffna-78 mm, Elephant pass- 83 mm).



Source: http://www.meteo.gov.lk/

2. Southwest Monsoon Period (May to September)

Windy weather during this monsoon eases off the warmth that prevailed during the 1st Inter monsoon season. Southwest monsoon rains are experienced at any time of the day and night, sometimes intermittently mainly in the Southwestern part of the country. Amount of rainfall during this season varies from about 100 mm to over 3000 mm. The highest rainfall received in the mid-elevations of the western slopes (Ginigathhena- 3267 mm, Watawala- 3252 mm, Norton- 3121 mm). Rainfall decreases rapidly from these maximum regions towards the higher elevation, and in Nuwara-eliya, it drops to 853 mm. The variation towards the Southwestern coastal area is less rapid, with the Southwestern coastal belt experiencing between 1000 mm to 1600 mm of rain during this 5-month long period. Lowest figures are recorded from Northern and Southeastern regions.

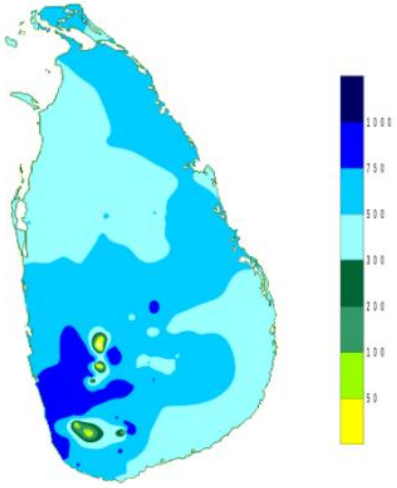


Source: http://www.meteo.gov.lk/

3. Second Inter-monsoon Period (October to November)

The thunderstorm-type of rain, particularly during the afternoon or evening, is the typical climate during this season. But unlike in the Inter-monsoon season, the influence of weather system like depression and cyclones in the Bay of Bengal is common during the second Intermonsoon season. Under such conditions, the whole country experiences strong winds with wide spread rain, sometimes leading to floods and landslides. The second Intermonsoon period of October – November is the period with the most evenly balanced distribution of rainfall over Sri Lanka. Almost the entire island receives in excess of 400 mm of rain during this season, with the Southwestern slopes receiving

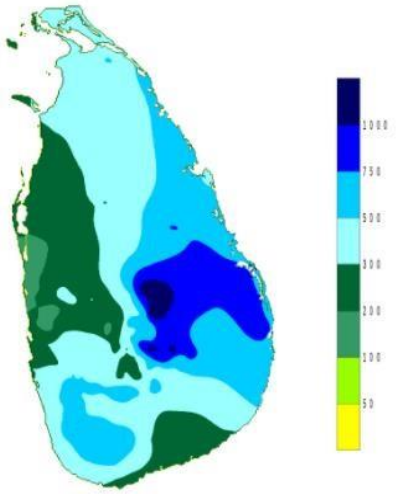
higher rainfall in the range 750 mm to 1200 mm (Weweltalawa Estate in Yatiyantota recording 1219 mm)



Source: http://www.meteo.gov.lk/

4. North-East Monsoon Period (December to February)

The dry and cold wind blowing from the Indian land-mass will establish a comparatively cool, but dry weather over many parts making the surrounding pleasant and comfortable weather except for some rather cold morning hours. Cloud-free skies provide days full of sunshine and pleasant and cool night. During this period, the highest rainfall figures are recorded in the North, Eastern slopes of the hill country and the Eastern slopes of the Knuckles/Rangala range. The maximum rainfall is experience at Kobonella estate (1281 mm), and the minimum is in the Western coastal area around Puttalam (Chilaw-177 mm) during this period.

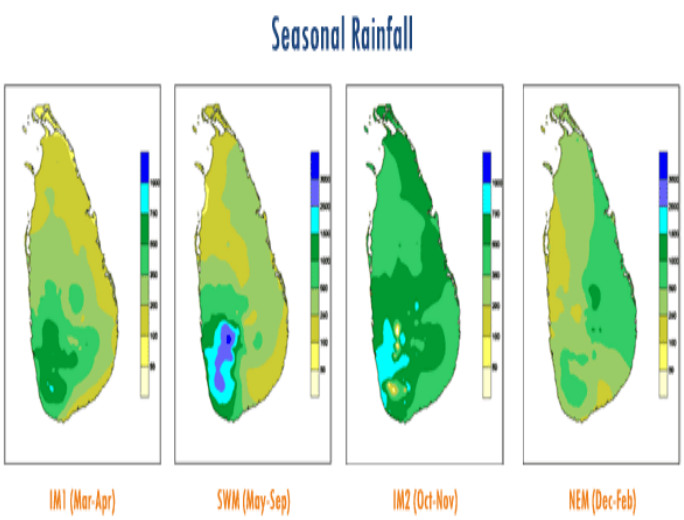


Source: http://www.meteo.gov.lk/

Seasonal Rainfall

The rainfall pattern is influenced by the monsoon winds of the Indian Ocean and Bay of Bengal and is marked by four seasons. The first is from mid-May to October, when winds originate in the southwest, bringing moisture from the Indian Ocean. When these winds encounter the slopes of the Central Highlands, they unload heavy rains on the mountain slopes and the southwestern sector of the island. Some of the windward slopes receive up to 250 centimeters of rain per month, but the leeward slopes in the east and northeast receive little rain. The second season occurs in October and November, the inter-monsoonal months. During this season, periodic

squalls occur and sometimes tropical cyclones bring overcast skies and rains to the southwest, northeast, and eastern parts of the island. During the third season, December to March, monsoon winds come from the northeast, bringing moisture from the Bay of Bengal. The northeastern slopes of the mountains may be inundated with up to 125 centimeters of rain during these months. Another inter-monsoonal period occurs from March until mid-May, with light, variable winds and evening thundershowers.



Source: http://www.meteo.gov.lk/

7.4 Approval Process of a mini-hydro Project

Obtaining recognition and approval of a mini-hydro power project requires lengthy inspections as outlined below, and going through loads of red tape. Whenever a developer finds a potential site for a hydropower project, they must examine the feasibility and apply an application for construction to the sustainable energy Authority (SEA), which would grant a provisional approval (PA). With the PA, the developer will now be applying for a CEB Letter of Intent and Central Environmental Authority (CEA) environmental approval.

The CEA will refer the application to another authority serving as Agency for Project Approval (PAA). The PAA sets in scope meetings and government agencies from which the developer needs to seek project approval, which will include no objections from the Grama Sevaka and Divisional Secretary calling public meetings. PAA will also provide Terms of Reference (TOR) for an initial report on environmental assessments (IEER).

The developer shall submit the IEER to PAA along with other approvals to be reviewed by the Technical Assessment Committee (TEC) appointed by PAA.

Environmental clearance for the Energy Permit (EP) shall be given to CEA if approved.

The developer is required to begin physical construction at the proposed site upon receipt of EP. The developer would submit Public Utility application from the Public Utilities Commission of Sri Lanka (PUCSL) for Energy License and apply for signing a Power Purchase Agreement with the CEB.

7.5 Factors to consider by an investor who is looking to have exposure to the mini hydro sector

If an investor is going to purchase an already established plant, the historical generation of the plant or the plant factors need to be considered.

Once the technical feasibility of undertaking the project is done, marginal cost and benefit analysis needs to be performed. If only marginal cost of generating 1 Mw is less than the additional revenue it generates, the project is feasible. Most of the locations of the projects are inaccessible and developers need to create roads or upgrade existing footpaths to allow vehicles and equipment for construction. Power generators are very heavy and the operation of the plant requires daily access after completion, therefore proper roads are required.

8. Wind Projects in the Industry

More than a century ago, wind turbines first appeared. In the 1830s, after the invention of the electric motor, engineers began trying to harness wind energy to generate electricity. Wind power generation took place in the United Kingdom and the United States in 1887 and 1888, but in Denmark, where horizontal-axis wind turbines were built in 1891 and a 22.8-metre wind turbine began operation in 1897, modern wind power is considered to have been first developed.

Using the kinetic energy created by air in motion, wind is used to produce electricity. Using wind turbines or wind energy conversion devices, this is converted into electrical energy. Wind first hits a turbine’s blades, causing them to rotate and turn the turbine connected to them. This converts kinetic energy into rotational energy by rotating a shaft connected to a generator and, by electromagnetism generating electrical energy.

Depending on the size of the turbine and the length of its blades, the amount of power which can be harnessed from the wind is determined. The output is proportional to the rotor's dimensions and to the wind speed cube. In principle, as wind speed doubles, the capacity for wind power increases by a factor of eight.

Wind-turbine capacity has increased over time. Typical turbines had a nominal capacity of 0.05 megawatts (MW) and a 15-metre rotor diameter in 1985.

The turbine potential of today's latest wind power projects is around 2 MW onshore and 3-5 MW offshore. Commercially available wind turbines with rotor diameters of up to 164 meters have achieved a capacity of 8 MW. In iron smelting

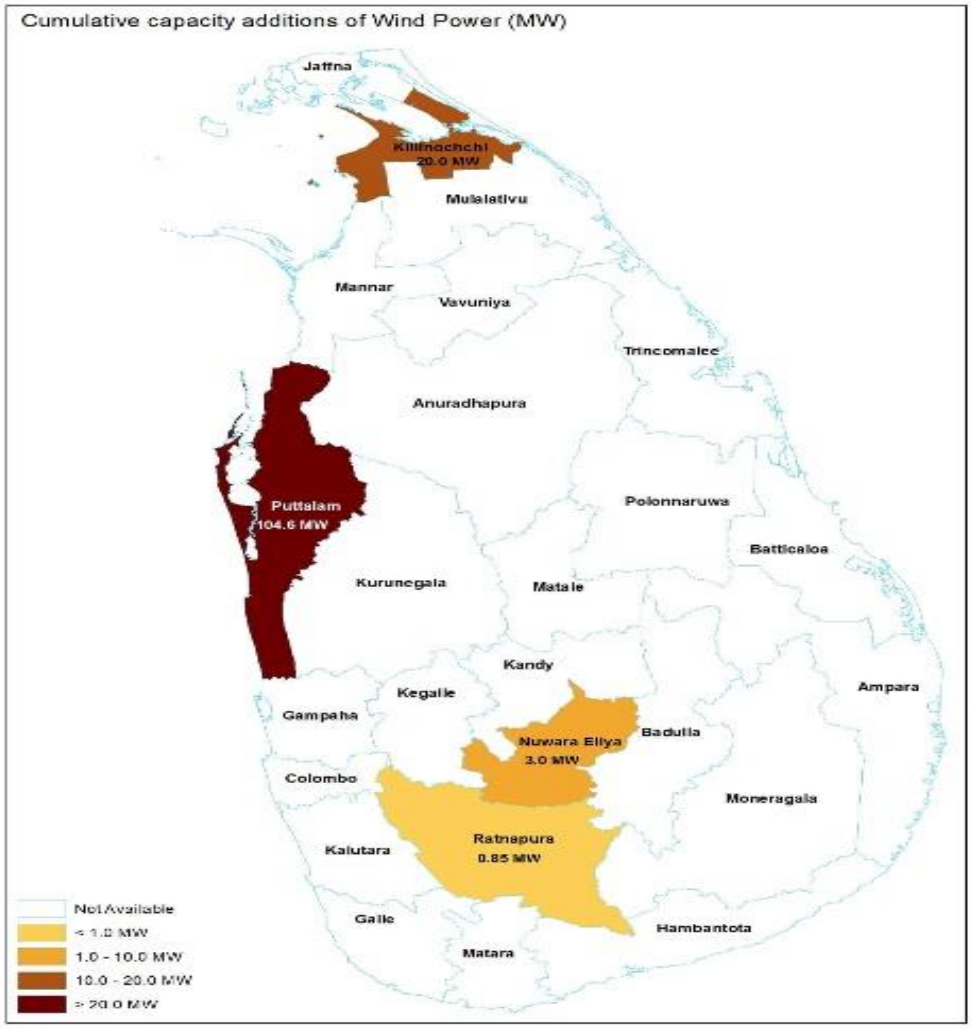
fucentury B.C., Sri Lanka is the country which first used wind for industrial use.

The National Renewable Energy Laboratory (NREL) of the USA developed the All Island Wind Energy Resource Atlas of Sri Lanka in 2003, suggesting nearly 5,000 km2 of windy areas with good-to-excellent potential for wind resources in Sri Lanka. Of the total windy area, approximately 4,100 km2 is on land and about 700 km2 is in lagoons. The windy land represents about 6 percent of Sri Lanka's total land area (65,600 km2). Using a conservative estimate of 5 MW per km2, nearly 20,000 MW of potential installed capacity could be provided by this windy property. The total theoretical wind capacity rises to approximately 24,000 MW if the windy lagoons are included.

Sri Lanka is blessed with quality wind energy primarily in the coastal region of the northwest, the northern and central highlands. There is a slightly higher potential for wind power in areas exposed to the southwestern monsoon. For different factors, such as overlapping land uses, accessibility and environmentally sensitive issues, only a fraction of the overall available capacity is economically exploitable. The Ceylon Electricity Board has established these possible exploitable wind resources and, along with the expansion of transmission networks, has prioritized their growth activities. Harnessing the exploitable wind power potential is then subjected to various technical constraints such as power systems stability, power system operation, seasonality and variability. This technical potential is defined by the renewable energy grid integration study conducted by the Ceylon Electricity Board.

In the next 20-year period, Mannar and Northern areas will be focused for wind power development at large scale and the Puttalam, Eastern and central highland areas are will contribute to small to medium scale wind power resource development. Sri Lanka Sustainable Energy Authority has identified resource locations for large scale wind power development in Mannar, Jaffna peninsula, Kokilai and Puttalam areas. There is both public and private participation in the production of these tools, and competitive pricing strategies are increasingly being sought in the production of these power projects at present.

FIGURE 17 : CUMALATIVE CAPACITY ADDITION OF WIND POWER



Source: www.energy.gov.lk

TABLE 07 : WIND RESOURCE REGIMES AND EXPECTED ANNUAL CAPACITY FACTORS

Wind Regime	Annual Capacity Factor(%)
Northern	34.1
Mannar	36.7
Puttalam	32.1
Eastern	27.3
Central Highland	19.1

Source: Generation Expansion Plan 2019

TABLE 08: CEB OWNED WIND POWER STATIONS

Power Station	Capacity (in MW)	Year of Commissioning
Mampur	10.000	May,2010
Seguwanthivu	10.000	May,2010
Vidatamuna	10.000	July,2010
Willpita	0.150	Oct,2010
Nirmalapura	10.000	Oct, & Jul,2012
Uppu Daluwa	10.000	July,2012
Madurankuliya	10.000	July,2012
Ambewaka-Ace Wind	3.000	Aug,2012
Total Wind	73.040	As at Dec,.2012

Source : Powermin.gov.lk

Wind power plants with a total capacity of 210 MW will be added in 2020, 2022 and 2023. Other wind power plants will be added giving priority to the areas with high wind energy resource potential identified in the RE resource inventory. A pilot project on offshore wind energy will be connected to the national grid in 2025.

TABLE 09 : WIND POWER CAPACITY ADDITION

	Capacity (MW)		
	Offshore	Onshore	Total
2019	-	20 (Chinaka -10 MW x2 Nos.)	95
2020	-	100 (Mannar-100 MW)	100
2021	-	**50** (10 MW X 5Nos. - Trincomalee, Monaragala, Kilinochchi…)	**400**
2022	-	290 Pooneryn 240 MW Mannar 50 MW	290
2023	-	**160 MW** (Mannar 60 MW, Mannar mainland 100 MW)	**160**
2024	-	50 (Kokilai - 50 MW)	50
2025	5	130 (Puttalam - 100 MW, Jaffna - 30 MW)	135
Total	5	800	805

Source: Renewable Energy Development Plan Phase I

9. Solar Power Projects in the Industry

Solar power generation has come a long way from its inception and is now becoming a very competitive renewable energy source. Solar power can be generated using many methods and the most common and environmentally friendly alternative is photovoltaic (PV) panels.

Both rooftops and solar farms will install PV panels. Solar farms are desirable choices for countries with large open land areas, such as the Middle East, Australia and North America. But it isn't a feasible choice for an island nation and a biodiversity hotspot like Sri Lanka with restricted land resources. Rooftop solar systems, on the other hand, reuse existing government rooftops and private office buildings, factories, and residential houses. They have no negative environmental consequences, can be easily installed in a very short time. Excess power from on rooftop solar panels can be fed back to the national grid. Rooftop solar projects also provide the benefit of being able to install grid off in rural areas, as seen in countries such as Bangladesh, making solar rooftop projects more appropriate for Sri Lanka.

While the government of Sri Lanka has not been able to promote solar rooftop projects until recently, several private companies have successfully carried out their own projects in their factories and office buildings. At their fabric park in Thulhiriya, MAS Holdings has completed a 1 MW solar rooftop project. With a 1.3 MW rooftop solar project to power the famous HNB buildings of Colombo, 249 HNB customer centers throughout the island and seven solar-only branches, Hatton National Bank followed up.

9.1 Solar Power Projects Undertaken by CEB

TABLE 10: CEB OWNED SOLAR POWER STATIONS

Power Station	Capacity (in MW)	Year of Commissioning
Battaramulla	0.018	Jan,2002
Gannoruwa-2	0.500	April,2011
Thiruppane	0.123	July,2011
Gannoruwa-1	0.737	Aug.,2011
Total Solar	1.378	As at Dec,.2012

Source: Powermin.gov.lk

9.2 Solar Power Plants Capacity Additions

According to Renewable Energy Development Plan Phase I 2019-2025, 25 projects of 1 MW X 60 Nos.solar power tender were added in 2019, and the balance will be added in 2020. Projects under 1 MW X 90 Nos. solar power tender will be added in 2020, 2021 and 2022. Further, the already tendered 10 MW projects of Valachchanai and Vaunathivu will be added in 2020. Apart from these, a total capacity of 360 MW will be added from 2021 to 2025 from this type of projects other than solar parks. Monaragala, Pooneryn, Polonnaruwa and Mahiyanganaya have been identified for establishing solar parks.

Out of these, 100 MW from Monaragala and 130 MW from Pooneryn will be added by 2021. 100 MW each will be added from Polonnaruwa, Monaragala and Mahiyanganaya in the period 2023-2025. Apart from these, Maduru Oya floating solar project will be added in 2021. Solar roof top systems will be added through the Soorya Bala Sangramaya project.

TABLE 11 : SOLAR POWER CAPACITY ADDITION

	Capacity (MW)			
	Large	Rooftop	Floating	Total
2019	25 (1 MW x 25 Nos.)	70	-	95
2020	129 (Valachchenei - 10 MW, Vaunathivu – 10 MW, Pooneryn – 80 MW, 1 MW X 29 Nos.)	30	-	159
2021	270 (Monaragala – 100 MW, Pooneryn – 50 MW, 1 MW X 50 Nos., 70 MW from other projects)	30	100	400

2022	**90** (1 MW x 20 Nos., 70 MW from other projects)	**26**	**15**	**31**
2023	180 MW (Monaragala – 100 MW, 80 MW from other projects)	25	15	220
2024	170 MW (Polonnaruwa – 100 MW, 70 MW from other projects)	40	50	265
2025	170 MW (Mahiyanganaya – 100 MW, 70 MW from other projects)	104	20	294
Total	1034	330	200	1564

Source: Renewable Energy Development Plan Phase I

9.3 Development of Rooftop Solar Power

Roof top solar systems are beginning to play a prominent role in providing electricity consumers with energy needs and it is an efficient type of embedded generation located at the end user.

With the availability of rooftop spaces, rooftop solar PV installations can significantly reduce land use and environmental issues, especially in urban and suburban areas. Several schemes are introduced around the world to create an enabling environment for photovoltaic penetration on small scale and top roof.

In Sri Lanka, in 2010, the Ministry of Power and Renewable Energy, Ceylon Electricity Boards (CEB) and Lanka Electric Company (LECO) launched the 'Energy Banking Facility' for such micro-scale generating facilities, generally known as the 'Network Energy Metering Facility' for electricity consumers. This scheme requires any user of electricity to engage as a producer in the production of electricity from a source of renewable energy for their own use and in the export of any surplus energy. The installed capacity of the generating facility shall not surpass the customer's contractual requirement. Consumers are not charged for energy exports, but are compensated (in kWh) for consuming the same amount of energy over subsequent billing periods. No financial compensation is paid out for the consumer's surplus energy exported. Taking into account the difference between the import and the export of energy, the electricity bill is prepared. At present, under a net metering scheme amounting to 106 MW of solar power, the country has around 14,700 such installations.

In order to further improve the renewable energy portfolio in Sri Lanka's electricity generation market, the Government of Sri Lanka (GOSL) initiated an accelerated solar growth program in 2016 to promote the country's top roof solar installations. The goal of the above program is to achieve an installed roof top solar power of up to 200MW by 2020.

To endorse the clean energy promotional campaign of the GOSL, the Net Metering Concept was further strengthened by the implementation of two other schemes. The concept of "net accounting" is the second scheme introduced. It is an enhancement of the current new metering system where customers are charged for the energy exported with a tariff of two levels for 20-year duration. The plant's generating capacity is limited to the consumer's contract demand and this scheme is limited only to the production of solar power. Solar PV installations are restricted to roof top style installations for the above three schemes and must be connected to the low voltage distribution network. The total installed capacity of solar PV rooftop systems under Net Accounting and Net Plus has currently reached 63 MW, taking the country's total solar PV rooftop capacity to 169 MW. These three schemes turn the position of the conventional user of electricity into a consumer and a producer.

10. Thermal Projects in the Industry

In early stages the electricity demand of the country was mainly supplied by hydro generation and the contribution from thermal generation was minimal.

With the time, thermal generation has become prominent. At present, thermal generation share is much higher than that of hydro.

The existing generating system in the country has approximately 4,046 MW of installed capacity by 2019 including non-dispatchable plants of capacity 610 MW owned by private sector developers. The majority of dispatchable capacity is owned by CEB (i.e. about 84% of the total dispatchable capacity), which includes 1,398.85 MW of hydro and 1,504 MW of thermal generation capacity. Balance dispatchable capacity, which is totally thermal plants, is owned by Independent Power Producers (IPPs).

10.1 The Capacity Breakdown of the Sectors and the Sources of Generating Thermal Power

TABLE 12 :OWNERSHIP & SOURCES OF THERMAL POWER PROJECTS

Ownership & Sources	Generation (GWh)	No. of Plants	Percentage of Total
CEB:	1,504	8	79.24%
Thermal (Oil)	604	7	40.16%
Thermal (Coal)	900	1	59.84%
PPP:	394	3	20.75%
Thermal (Oil)	394	3	20.75%

Source: Statistical Digest 2018

CEB

The CEB owned capacity made up of Lakvijaya Coal power plant of 900MW, Kelanitissa Gas Turbines of 195MW, Kelanitissa Combined Cycle plant of 165MW, Sapugaskanda Diesel power plants of 160MW, Uthuru Janani diesel power plant of

24 MW and Barge Mounted Plant of 64MW. The Lakvijaya Coal plant 900MW funded by EXIM Bank China commissioned in 2011 (Phase I) and 2014 (Phase II) was the latest thermal power plant addition to the CEB system.

For planning purposes, retirement dates of CEB owned existing thermal power plants are considered as indicated in table 13.

TABLE 13 :RETIREMENT DATES OF CEB OWNED EXISTING THERMAL POWER PLANTS

CEB Power Plants	Year
1.KPS Frame5 GTs all units	2023
2.KPS GT7*	2023
3.Sapugaskanda PS A (4 Units)	2024
4.Sapugaskanda PS B (4 Units) **(4 Units)**	2023 2026
5.Barge Mounted Power Plant	2025
6.Kelanithissa Combined Cycle	2033

Source: Generation Expansion Plan 2019

*Provision of further extension beyond 2023 will be further studied.

As a CEB owned committed power plant, only 130 MW Gas Turbine Power Plant at Kelanitissa is proposed to be commissioned by 2021. Capacity and energy details of the existing and committed thermal plants are shown in Table 14 and technical parameters and cost details of the existing thermal generation plants are summarized in Table 15.

TABLE 14 :DETAILS OF EXISTING AND COMMITTED POWER PLANTS

Plant Name	No of Units x Name Plate Capacity (MW)	No of Units x Capacity used for Studies (MW)	Annual Max. Energy (GWh)	Commissioning
Puttalam Coal Power Plant **Lakvijaya CPP**	3 x 300	3 x 270	5355	2011 & 2014
Puttalam Coal Total	900	810	5355	
Kelanitissa Power Station **Gas turbine (Small GTs)** **Gas turbine (GT 7)**	4 x 20 1 x 115	4 x 17 1 x 115	382 703	Dec 81, Mar 82, Apr 82, Aug 97
Combined Cycle (JBIC)	**1x 165**	**1 x 161**	**1196**	**Aug 2002**
Kelanitissa Total	360	344	2281	
Sapugaskanda Power Station **Diesel** **Diesel (Ext.)**	4 x 20 8 x 10	4 x 17 8 x 9	493 481	May 84, May 84, Sep 84, Oct 84 4 Units Sept 97 4 Units Oct 99
Sapugaskanda Total	160	140	974	
Other Thermal Power Plants **Uthuru Janani** **Barge Mounted Plant**	3 x 8.9 4 x 16	3 x 8.9 4 x 15.6	184 515	Jan 2013 Acquired in 2015
Existing Total Thermal	1510.7	1383.1	9309	
Committed **Kelanitissa Gas**	3 x 45	130		2021
Committed Total Thermal	135			

Source: Generation Expansion Plan 2019

TABLE 15:TECHNICAL PARAMETERS AND COST DETAILS OF EXISTING CEB OWNED THERMAL Plants

		Kelanitissa			Sapugaskanda		Lakvijaya Coal		Other
Name of Plant	Units	GT(Old)	GT(New)	Comb. Cycle (JBIC)	Diesel (Station A)	Diesel (Ext) (Station B)	Coal (Phase I & II)	Uthuru Janani	Barge Mounted Plant
Basic Data									
Engine Type		GE FRAME 5	FIAT (TG 50 D5)	VEGA 109E ALSTHOM	PIELSTIC PC-42	MAN B&W L58/64	-	Wartsila 20V32	Mitsui MAN B&W 12K50MC-S
Input Parameters for Studies									
Number of Units		4	1	1	4	8	3	3	4
Unit Capacity	MW	17	115	161	17	9	270	8.93	15.6
Minimum operating level	MW	17	80	100	17	9	162	8.93	15.6
Calorific Value of the fuel	kCal/kg	10500	10500	10880	10300	10300	6300	10300	10300
Heat Rate at Min. Load	kCal/kWh	4294	3542	2127	2303	2185	Unit 1-2767 Unit 2-2691 Unit 3-2615	2164	2226
Incremental Heat Rate	kCal/kWh	0	2337	1359	0	0	Unit 1-2172 Unit 2-2331 Unit 3-2330	0	0

Heat Rate at Full Load	**kCal/kWh**	**4294**	**3175**	**1837**	**2303**	**2185**	**Unit 1-2529 Unit 2-2547 Unit 3-2501**	**2164**	**2226**
Fuel Cost	USCts/GCal	5168	5168	5295	4274	4274	1680	4274	4274
Full Load Efficiency	%	20	27	47	37	39	Unit 1-31 Unit 2-32 Unit 3-33	40	39
Forced Outage Rate	%	29	19	8	8	17	12	15	2
Scheduled Maintenance	Days/Year	35	52	27	38	28	52	32	24
Fixed O&M Cost	$/kW month	3.04	0.17	1.87	8.47	7.76	1.09	1.75	0.92
Variable O&M Cost	$/MWh	0.64	5.04	2.72	5.75	1.70	3.90	8.35	6.21

Source: Generation Expansion Plan-2019

IPP

Apart from the thermal generating capacity owned by CEB, Independent Power Producers have commissioned diesel power plants and combined cycle power plants given in Table 16.

TABLE 16: EXISTING AND COMMITTED IPP THERMAL PLANTS

Plant Name	Name Plate Cap. (MW)	Cap. Used for studies	Min.Generated Ann. Energy	Commissioning	Contract Period (Yrs)
Independent Power Producers					
Sojitz Kelanitissa (Pvt.) Ltd	163	163	-	GT-March 2003 ST-October 2003	20
ACE Power Embilipitiya Ltd+	100	99.5	697	2005 April	10
West Coast (Pvt) Ltd.	300	270	-	2010 May	25
Existing Total IPP	563	532.5			
Committed					
Reciprocating Engine Power Plants at the Grid Substations of Habarana,Moneragala, Horana and Pallekelle	4 x 24	4 x 24		2021	
NG fired Combined Cycle Power Plant	300	287		2022	
Committed Total IPP	396	383	-		

Source: Generation Expansion Plan-2019

10.2 Thermal Plant Specific Cost Comparison

The specific costs of the selected candidate plants for different plant factors are tabulated in the Table 9.5. These basic costs have extracted from the screening curve approach that takes into account the cost of capital expenditure, the cost of service and maintenance, the cost of fuel and the economic life of an alternative generation. It shows how various technologies work on different factors in the factory. Accordingly, at low plant factor operation, Peak Load Power plants are cost-effective, whereas base load plants such as Coal and Nuclear are desirable alternatives for greater plant factor operations. However, the size of the generation units is taken into account in real simulations and will have a direct impact on the final selection of the factory.

TABLE 11: SPECIFIC COST OF CANDIDATE THERMAL PLANTS IN USCts/kWh (LKR/kWh)

Plant \ Plant Factor	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
45MW Gas Turbine Natural Gas	22.23 (40.04)	16.85 (30.34)	15.05 (27.11)	14.16 (25.50)	13.62 (24.53)	13.26 (23.88)	13.00 (23.42)	12.81 (23.07)
300MW Combined Cycle Plant Auto Diesel	21.99 (36.91)	15.80 (28.45)	13.73 (24.73)	12.70 (22.87)	12.08 (21.76)	11.67 (21.02)	11.37 (20.48)	11.15 (20.09)
150MW Combined Cycle Plant Natural Gas	20.43 (36.79)	13.90 (25.04)	11.73 (21.12)	10.64 (19.16)	9.99 (17.98)	9.55 (17.20)	9.24 (16.64)	9.01 (16.22)
300MW Combined Cycle Plant Natural Gas	19.45 (35.03)	13.46 (24.24)	11.46 (20.64)	10.46 (18.84)	9.86 (17.76)	9.46 (17.04)	9.17 (16.52)	8.96 (16.14)
600MW Combined Cycle Plant Natural Gas	17.40 (31.34)	12.41 (22.35)	10.75 (19.36)	9.92 (17.86)	9.42 (16.96)	9.08 (16.36)	8.85 (15.93)	8.67 (15.61)
300MW High Efficient Coal Plant	32.32 (58.20)	18.30 (32.95)	13.62 (24.53)	11.29 (20.33)	9.88 (17.80)	8.95 (16.12)	8.28 (14.91)	7.78 (14.01)
600MW Super Critical Coal Plant	34.21 (61.61)	19.11 (34.42)	14.08 (25.36)	11.56 (20.82)	10.05 (18.11)	9.05 (16.29)	8.33 (15.00)	7.79 (14.03)
600MW Nuclear Plant	65.26 (117.53)	32.93 (59.31)	22.15 (39.90)	16.77 (30.19)	13.53 (24.37)	11.38 (20.49)	9.84 (17.72)	8.68 (15.64)
15MW Reciprocating Engines	26.22 (47.23)	18.15 (32.70)	15.47 (27.85)	14.12 (25.43)	13.31 (23.98)	12.78 (23.01)	12.39 (23.32)	12.10 (21.80)

Source: Generation Expansion Plan-2019

Note: 1US$=LKR 180.10

11. Listed Power Generation Companies

11.1 Vidullanka PLC (VLL)

Total Capacity	36.25 Mw
Inception	1997
Energy Source	hydro , solar and bio mass
Market Capitalization (as at 15th Oct.)	Rs. 4,942,934,243.50

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
6.14	6.71	7.29	7.87	8.44

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.2 Resus Energy PLC (HPWR)

Total Capacity	N/A
Started Year	2003
Energy Source	Hydro,Solar Power
Market Capitalization (as at 15th Oct.)	Rs. 2,227,493,729.00

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
22.85	23.89	24.93	25.97	27.01

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.3 Vallibel Power Erathna PLC (VPEL)

Total Capacity	21.85 Mw
Started Year	2001
Energy Source	Hydro
Market Capitalization (as at 15th Oct.)	Rs. 5,976,877,848.00

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
12.07	12.73	13.39	14.06	14.72

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.4 Panasian Power PLC (PAP)

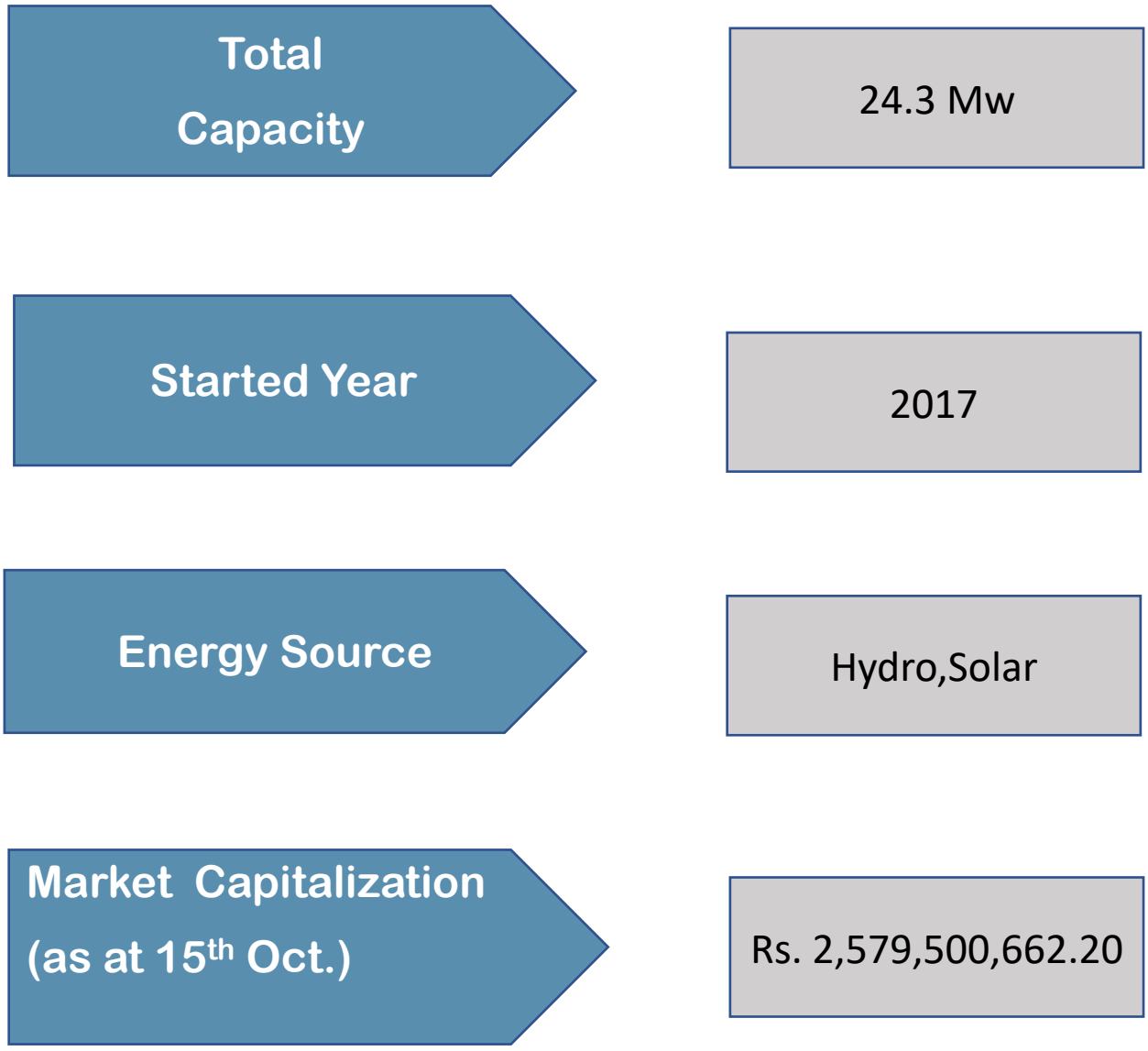
Total Capacity	19.8 Mw
Started Year	2002
Energy Source	Hydro,Solar
Market Capitalization (as at 15th Oct.)	Rs. 2,500,000,000.00

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
3.54	3.74	3.93	4.19	4.46

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.5 Laugfs Power PLC (LPL)



Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
5.35	5.72	6.08	6.44	6.79

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.6 Laugfs Power PLC (LPL.X)

Total Capacity	24.3 Mw
Started Year	2017
Energy Source	Hydro,Solar
Market Capitalization (as at 15th Oct.)	Rs. 338,000,000.00

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
4.41	4.72	5.02	5.31	5.60

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.7 LVL Energy Fund PLC (LVEF)

Total Capacity	139.1 Mw
Started Year	2006
Energy Source	Hydro, Wind, Thermal Power
Market Capitalization (as at 15th Oct.)	Rs. 5,648,097,734.90

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
4.73	5.04	5.34	5.65	5.95

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

11.8 Lotus Hydro Power PLC (HPFL)

Total Capacity	4.9 Mw
Started Year	2000
Energy Source	Hydro
Market Capitalization (as at 15th Oct.)	Rs. 894,522,518.40

Based on relative valuation, following target share prices for the forecasted years have been extracted.

2021	2022	2023	2024	2025
11.19	11.94	12.70	13.45	14.20

*These are the median values obtained from the estimated target prices based on Price / EPS, Price / EBITDA, Price / Sales and EV / Sales.

12. Conclusion

In conclusion of the report, we would like to highlight few important findings derived through this research.

Since Sri Lanka is a developing nation, Sri Lanka's power demand continues to increase with the numerous developments within the nation. To meet year-on-year rise in electricity, Sri Lanka needs to look beyond publicly funded projects and encourage increased private sector participation. At the same time, the clean energy market should be involved, as it has now moved to renewable energy all over the world. Due to the fact that we are highly reliant on hydropower generation in the current generation system, we have to rely on expensive oil production during adverse monsoon seasons, resulting in high costs of power generation.

With widespread adoption of renewable energy and related technologies boding well for a sustainable future, Sri Lankan renewable energy market has begun to grow in encouraging ways. Solar PV and wind power are rapidly the cheapest source of electricity in many markets around the world as well as in Sri Lanka.

Therefore, it is crucial for both private sector participants and investors to move into the renewable energy sector.

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