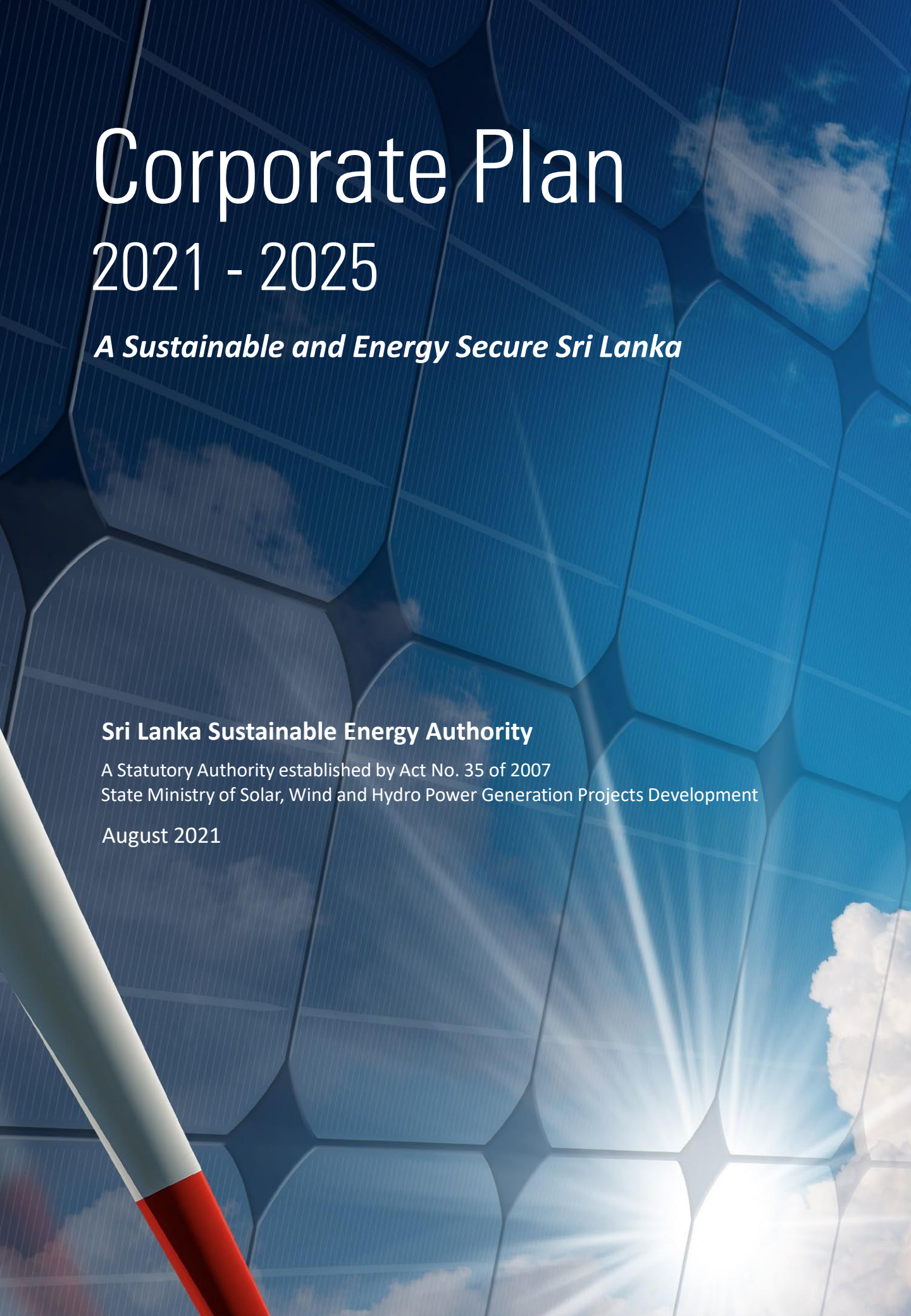
Corporate Plan
2021 - 2025

A Sustainable and Energy Secure Sri Lanka

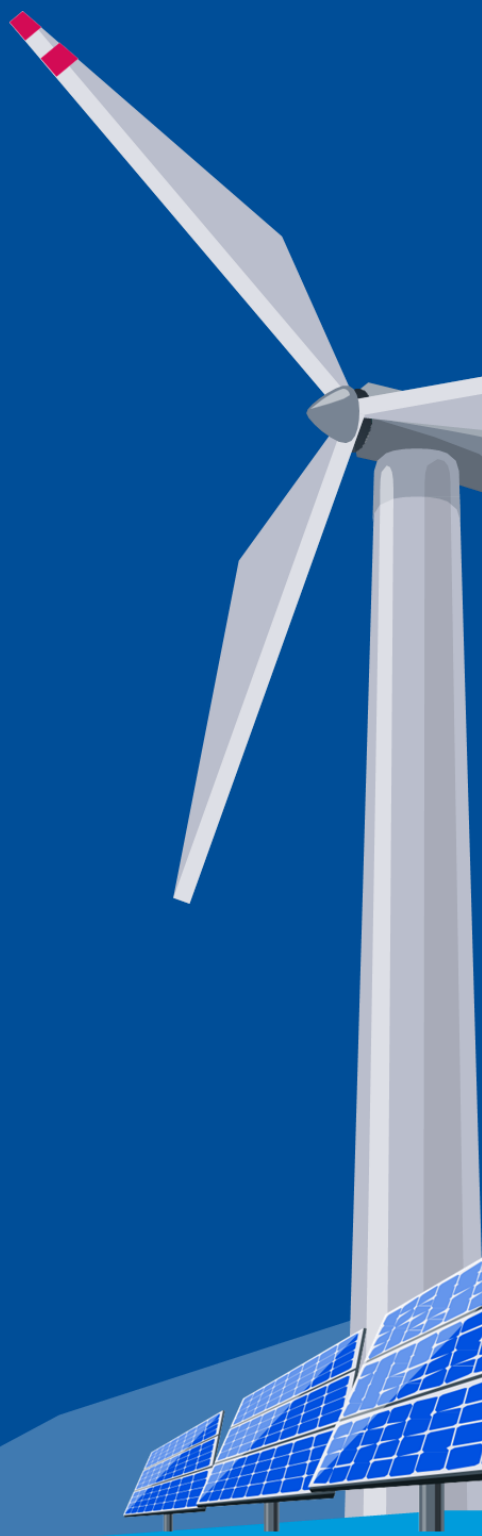


Sri Lanka Sustainable Energy Authority

A Statutory Authority established by Act No. 35 of 2007
State Ministry of Solar, Wind and Hydro Power Generation Projects Development

August 2021

Contents



Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
AI	Artificial intelligence
CEB	Ceylon Electricity Board
DC	Direct Current
DSM	Demand Side Management
EaaS	Energy as a Service
EMS	Electronic Message System
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GEF	Global Environment Facility
GHG	Greenhouse Gas
GoSL	Government of Sri Lanka
GW	Gigawatt
GWh	Gigawatt-hours
IEA	International Energy Agency
IT	Information Technology
ICT	Information and Communication Technology
IRENA	International Renewable Energy Agency
kV	Kilovolt
LECO	Lanka Electricity Company (Pvt) Ltd
MW	Megawatt
NDCs	Nationally Determined Contributions
P2P	Peer to Peer
PUCSL	Public Utilities Commission of Sri Lanka
PV	Photovoltaics
R & D	Research and Development
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
SLSEA	Sri Lanka Sustainable Energy Authority
SLSI	Sri Lanka Standards Institution
TWh	Terawatt-hours
UK	United Kingdom
UNDP	United Nations Development program
UNFCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollar
VRE	Variable Renewable Energy

Chapter 1

Introduction

This chapter includes an introduction to the background of SLSEA and the purpose of the Corporate Plan

Energy is one of the key aspects in the entire socio-economic development process of a country. Measures in line with the development of the energy sector will be very important and critical in diverse dimensions. In this context, sustainable energy development has become a priority in Sri Lanka. After experiencing the world energy crisis in the 1970s, the attention of different nations was drawn towards energy conservation. Sri Lanka took the energy conservation initiatives in the 1980s, where the establishment of the Energy Conservation Fund under the Ministry of Power and Energy was an important milestone. With the expansion of electrification in the country, the electricity needs could not be met only through hydro power, and the thermal power share in the energy mix was increased gradually. In this background, Sri Lanka had to face challenges in meeting the electricity demand of the country amidst the fluctuation of fuel oil prices at international level. The importance of energy security was identified by the Government, and thereby sustainable energy development was mainstreamed in the country. This background led to the establishment of a focal entity for sustainable energy development. Thus, the Energy Conservation Fund was elevated to the Sri Lanka Sustainable Energy Authority (SLSEA) as the focal national entity for sustainable energy development, on 1st October 2007, with four objects, namely: Renewable Energy, Energy Management, Policy Development and Fund Management enacted by the Sri Lanka Sustainable Energy Authority Act, No. 35 of 2007.

Innovative solutions to decarbonize the global energy sector require combining various policy instruments across the whole technology lifecycle, from R&D to market scale-up, as well as the development of new smart technologies, information technology, new types of financial and market instruments, business models and the engagement of new actors across the energy systems. Further, the attention of different nations with reference to the promotion of renewable energy and energy conservation is significantly improving. Nationally Determined Contributions (NDCs) to Greenhouse Gas (GHG) emission reduction efforts have been ratified to the United Nations Framework Convention on Climate Change (UNFCCC), where the NDC targets have been declared for the period 2020-2030. National Energy Policy & Strategies of Sri Lanka 2019 specifically recognizes the importance of sustainable energy development programs. Apart from the specific necessities coming under the energy sector, the Government of Sri Lanka (GoSL) is committed to align the development programs in the country to the United Nations Sustainable Development Goals (SDGs). Above all, the Government has established a target of **realizing 70% of the electricity generation in the country through renewable energy by 2030**. The programmes will lay the foundation towards that.

The Corporate Plan of the Sri Lanka Sustainable Energy Authority sets the direction to make a smooth transition from conventional, non-renewable energy sources to sustainable energy sources across industries and households in Sri Lanka. The Corporate Plan has been developed taking into consideration these national and international sustainable energy development initiatives and the “Vistas of Prosperity and Splendor” for the period 2021-2025. The key purposes of developing the Corporate Plan for the Sri Lanka Sustainable Energy Authority for the five-year period commencing from the year 2021 to 2025 are to create awareness among investor groups, higher authorities and the general public on the services and direction of the SLSEA while also hoping to attract both foreign and local donors/ investors to financially support the implementation and completion of the strategies to achieve the Vision, Mission and Strategic Objectives of SLSEA.

Chapter 2

History and Flashback of Achievements

This chapter includes the history of SLSEA along with the key milestones achieved by SLSEA over the years

2. History and Flashback of Activities

2.1 History and Key Milestones

2007

- Establishment of SLSEA

2010

- Launched Vidulka Exhibition + Symposium + National Energy Efficiency Awards
- First mandatory energy labelled product – Compact Fluorescent Lamp
- Launched the net-metering scheme for rooftop power generation

2011

- School Energy Clubs were introduced
- Energised first grid connected solar power plant of 1.237 MW in Hambantota

2014

- Published Solar Resource Atlas of Sri Lanka

2015

- Reached 10% share of electricity generation from new renewable energy realising the policy goal

2016

- Soorya Bala Sangramaya program launched for solar rooftop power generation, enhancing the net-metering scheme

2017

- Establishment of a Presidential Task Force on Operation DSM with 10 thrust programs

2018

- Reached the 100 MW target set for solar rooftops under the Soorya Bala Sangramaya program
- Completed the highly satisfactory Sustainable Biomass Energy Project supported by UNDP/FAO/GEF

2.2 Flashback of Achievements

2.2.1 Renewable Energy

SLSEA being a new organization handling a vast area of subjects, where the subject itself is emerging, has taken many key initiatives in the national sustainable energy development journey of Sri Lanka. A key highlight is giving a profound initiative to the renewable energy development program. Renewable energy project development was initiated through the introduction of a feed-in tariff scheme suitable for the development of the renewable energy industry which was designed also considering the tariff setting methodologies practiced in many other countries. The feed-in tariffs introduced in the inception were attractive enough to budding entrepreneurs of the country to join a novel venture with a substantial amount of technological involvement. This specially paved the way for a good industry in hydro power development.

Since it was difficult to meet the cost involved in biomass power plants, the initial biomass power plants were given a top-up tariff, whereby the implementation of biomass power plants was made possible.

Despite the good potential available in solar power, there was a requirement to make the initial intervention by the Government, and SLSEA took the forefront in implementing a 1.3 MW solar power plant in Hambantota using grant financial assistance from the Government of Korea and the Government of Japan. The introduction of net-metering, is yet another good intervention of SLSEA, where it was also given a paradigm shift through the Soorya Bala Sangramaya (Battle for solar power). More than 300 local companies have ventured in this, and it has led to creating jobs for Engineers and Technicians as well as for other skilled and unskilled personnel.

Wind is a highly potential resource in the country, and immediately after inception, SLSEA took measures to carry out wind resource measurement, country wide. This has supported the initiation of large wind power projects.

By now, SLSEA has compiled resource maps and resource inventory pertinent to the four major renewable energy resources – wind, solar, biomass and hydro.

Renewable energy development shifted to competitive bidding since of late, and SLSEA has shown an active involvement in preliminary project development activities through the Energy Park concept.

2.2.2 Energy Conservation and Management

Giving leadership for energy conservation and management has also been a key area of intervention. The introduction of energy efficient appliances through the energy labeling scheme, the introduction of energy efficient building infrastructure through the code of practice for energy efficient buildings, enhancement of energy efficiency improvement activities in establishments through Energy Managers, Energy Auditors and Energy Service Companies, energy consumption benchmarking are some of the key interventions in the area of energy efficiency improvement. SLSEA has also taken initiatives to nationally recognize the establishments successfully involved in energy efficiency improvement activities through the Sri Lanka national energy efficiency award.

National level interventions for energy conservation have been done by way of the Operation Demand Side Management program, where the activities were implemented under the guidance of a Presidential Task Force and a National Steering Committee.

2.2.3 Energy Education

SLSEA has also vividly focused on energy education as an important element in energy conservation, where many programs have been introduced from the level of elementary school to higher studies. Exhibitions and other social movements have been used for enhancing energy consciousness of the entire society. One of the major achievements is SLSEA being able to provide input to the curricular of Science subject from grade 6 to grade 11, in collaboration with the Ministry of Education.

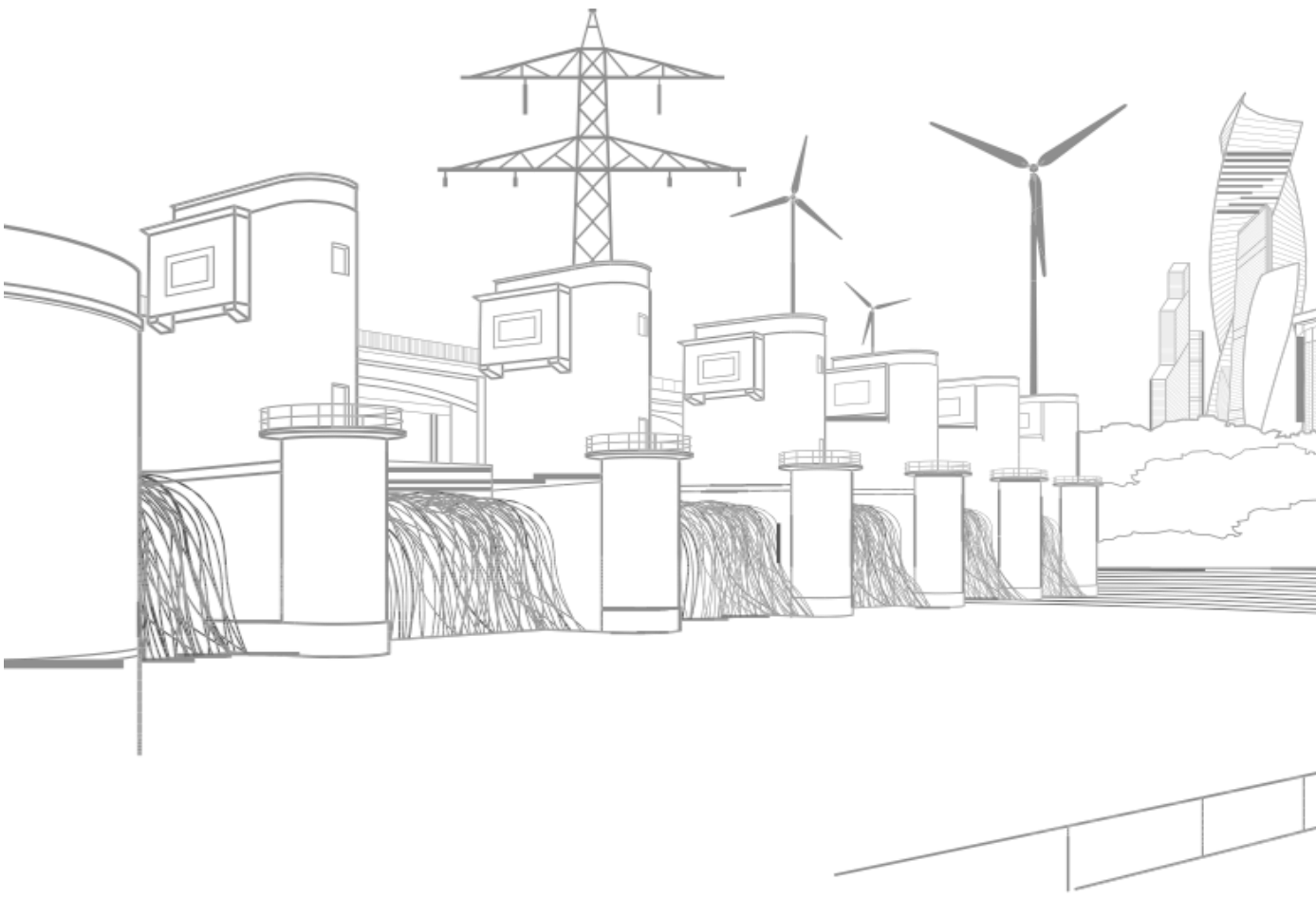
2.2.4 R & D Interventions

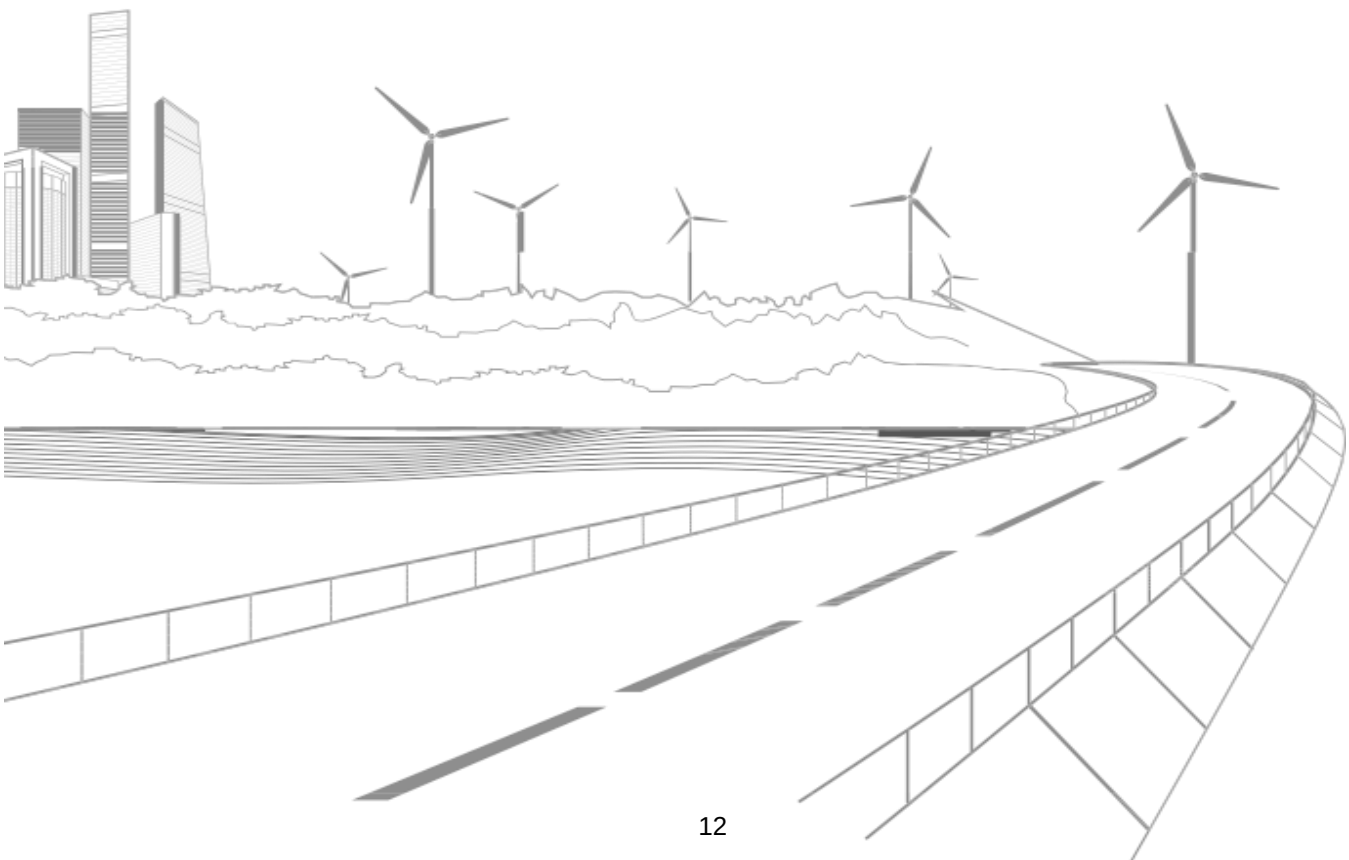
The importance of R&D and innovation has also been particularly focused, and SLSEA makes a platform for energy researchers to take their energy research outcomes to the

policy makers and other important stakeholders through the Sri Lanka National Energy Symposium. Collaboration has been made with universities and the National Engineering Research and Development Center to resolve key technical issues related to renewable energy development and energy efficiency improvement and conservation. Good relationships have also been made with international donor agencies and international universities and research institutions.

2.2.5 CSR Activities

SLSEA has carried out multiple mini-projects to uplift the quality of life of the rural community and ensure accessibility to energy requirements. In addition, several initiatives are taken to empower women in the rural community by opening up job opportunities. Further, several initiatives have been taken to support the rural economy of the country.





Chapter 3

Enablers and Constraints

This chapter includes Enablers and Constraints for SLSEA

3.1 Enablers

A. Human Resources

- The employees of SLSEA which is the biggest asset of the Authority, is a mixture of multi-disciplinary professionals, intellectuals and support staff, who are dedicated, committed, competent with good attitudes and motivation and have a vast knowledge in the power and energy sector. Starting from the Board of Management to the operational staff, all posses the required experience and skills to understand and respond to the country's requirement of renewable energy and energy management. In addition to knowledge, they are all open minded in embracing new technologies and innovation and have a positive attitude in striving to bring about an energy secure Sri Lanka.
- Technology literacy of the staff with the breakthrough innovation and evolutionary or revolutionary waves. SLSEA and its staff are vigilant, observant on advancements in technology and adopt or adapt as appropriate.

B. Financial Background and Donor/investor Confidence, Financial Stability and Sources of Income

- SLSEA has different financial in-flow avenues such as the central government allocations through the treasury, service fees, grants and own income generation from running power plants and professional services. Further, SLSEA is provisioned for additional revenue from Cess, but is not operational currently.
- Along with its contribution to sustainability, renewable energy aids economic development in numerous ways. Through harnessing renewable energy, externalities from carbon can be mitigated and the use of these resources will create additional local jobs.
- The recent financial statements of SLSEA indicate that the authority has a strong financial position which serves as a contributing factor to expand as an organization in the power and energy sector and execute its vision and mission.

B.1 Donor and Investor Confidence

- Sustainable energy investments bring about great returns to investors. This has caught the attention of many investors who are willing to contribute towards the projects conducted on sustainable energy development by SLSEA. Close collaboration with international agencies such as ADB, UNDP, World Bank, EU, JICA and KOICA have been supportive in monetary terms.
- Further, new funding channels for the developments such as green bonds and environmental benign technologies are also on the rise giving sustainable energy investors the benefit of utilizing whichever channel that suits best.

C. Contribution to the Economy and Energy Sector

- The Sri Lanka Sustainable Energy Authority, enacted by the Sri Lanka Sustainable Energy Authority Act No. 35 of 2007, is the main and only institution responsible for renewable energy and Energy Management in Sri Lanka. Therefore, the authority has the benefit of excelling in the power and energy sector and to be the apex body of sustainable energy in Sri Lanka.
- Sustainable energy is a measure important at national level; embracing sustainable energy can bring about major economic benefits, thus the Government of Sri Lanka is also highly interested and committed to sustainable energy interventions.

D. Climate Change and Sustainable Development

- SLSEA plays the role of a trend-setter and environmental custodian in Climate Change Mitigation, Adaptation and implementation of SDG 07 to ensure all citizens of Sri Lanka have access to affordable, reliable, sustainable and modern energy.
- SLSEA's scope is in line with global trends. The authority is positioned well among leading institutions to guide other institutions from different disciplines which are also in or related to the power and energy sector.
- Since renewable energy is a popular subject across the world, SLSEA also plays a prominent role in the global context, and that in return, has brought recognition to both the institute and its staff resulting from their best recorded performance in the sector.

E. Legal Standing and Powers Vested by the Act

- The Sri Lanka Sustainable Energy Authority Act No. 35 of 2007 enacted by the parliament has vested power to SLSEA in terms of regulation, land acquisition and investigation which is required in implementing sustainable energy initiatives. Further, the authority is given the required power to set benchmarks in terms of energy usage, produce energy labels together with SLSI, etc.

- The Act also mandates the process of recognizing, registering, appointing and training Energy Auditors, Energy Managers and Energy Service Providers with the required skills and knowledge to conduct and support the initiatives of SLSEA.
- The Sri Lanka Sustainable Energy Authority Act gives the power to make recommendations in energy policy formulation. Further, to review and engage in energy policy propagation, advocacy and influence.

F. Close Collaboration with the Expert Community

- Maintaining strong relationships with other key players in the power and energy sector such as CEB, PUCSL and LECO who have stronger stake in different related aspects to obtain an optimum outcome for the country as a whole. From the international perspective IEA, IRENA and the SAARC Energy Centre could also be considered.

3.2 Constraints

A. Technological Advancements and R&D

- SLSEA is unable to adapt fast enough to changing technologies due to the lack of resources. This includes both the hardware (equipment) and software (packages, tools, techniques). Further, although there is an in-house (or potential to hire) capacities to develop applications (Apps), the availability and pouring of so many Apps among the populace makes it hard to penetrate into the right people and to have a positive impact on the energy sector. SLSEA has to depend on supporting agencies for this to a certain extent.
- SLSEA must rely on third parties for research and development, laboratory testing, technical support, transportation, etc. at times, due to these facilities not being sufficiently available in-house or as no adequate resources are available to carry out the same. This would lead to SLSEA incurring an added cost to carry out the mentioned facilities through third parties. Further, SLSEA has limited control over it and must abide with the timing, rules and standards of third-party organizations.

B. Implications of Covid 19 Pandemic and the Need for Economic Recovery

- Devastation to the national economy by the Covid 19 pandemic has necessitated a rapid development trajectory. Under such circumstances, the country can find it hard to wait for long turnaround renewable energy projects which are site specific. SLSEA has to work with donors, funding agencies and investors who are willing to take the initial challenge for longer term sustainability and sustained returns.
- The investments into the renewable energy and energy management interventions have become scarce due to lower overall economic performance at all micro, meso and macro scales. However, such interventions may reap better returns on investments in the medium to long term tenures with the economic recovery.

C. Relationship with Key Stakeholders

- SLSEA has to work with many other agencies to obtain clearances and facilitate renewable energy investments, who have different mandates and priorities. A considerable coordination and follow-up is necessary to obtain relevant data and information.
- Being an organization under the central government and its office situated at a centralized location (Colombo), it becomes difficult for SLSEA to have a wide outreach to the provinces, districts, divisions and villages. Working in partnerships and collaboration with the Provincial Councils, District Secretariats, Divisional Secretariats, Local Government Authorities and Developmental Agencies with presence in the areas of SLSEA's interests are used to some extent. To obtain an optimum outcome for the country, the Ministries responsible for these institutions have to create a conducive environment to reach synergy.

D. Human Resource

- A major constraint SLSEA is facing is the limited number of current staff within the organization to conduct a vast number of projects. Recruiting new employees with the required skill and knowledge and retaining them is a difficult task for SLSEA due to the limited fringe benefits and low remuneration.

E. General

- In comparison to the global status of the energy transition, Sri Lanka is lagging behind due to the considerable amount of time and effort taken to implement a proposed project with lengthy statutory procedures.
- SLSEA is a treasury dependent organization and operated mostly with the funds allocated by the government. Therefore, limited finances are a major constraint to pursue the initiatives of the Sri Lanka Sustainable Energy Authority.
- The general public, certain industries and commercial organizations lack awareness of the presence and purpose of SLSEA and its initiatives towards embracing renewable energy. This may be because the priority given for sustainable energy activities is inconsistent. Further, less actions have been taken to initiate the required technological advancements to embrace the innovations related to sustainable energy.

Chapter 4

Global Trends

Moving into renewable energy resources and energy management in relation to the supply of energy and power generation provides many benefits to a country's economy which has led many countries to adapt to the transition from conventional energy to sustainable energy. This change goes hand in hand with many technological advancements, financial support and policy changes that have brought about global sustainable energy trends. In order to succeed in the future, it is vital for a nation to adapt to the trends.

Please refer Annexure 02 for a detailed description of the global trends identified below:

01

Energy Transition

Refers to the global energy sector's shift from fossil-based systems of energy production and consumption including oil, natural gas and coal, to renewable energy sources such as wind, biomass, solar, etc. The increasing penetration of renewable energy into the energy supply mix, the onset of electrification and improvements in energy storage are all key drivers of the energy transition.

02

Mini Grids

Mini-grids are integrated energy infrastructure that combines loads and renewable energy resources and that are designed to be able to operate on a self-sustainable basis.

03

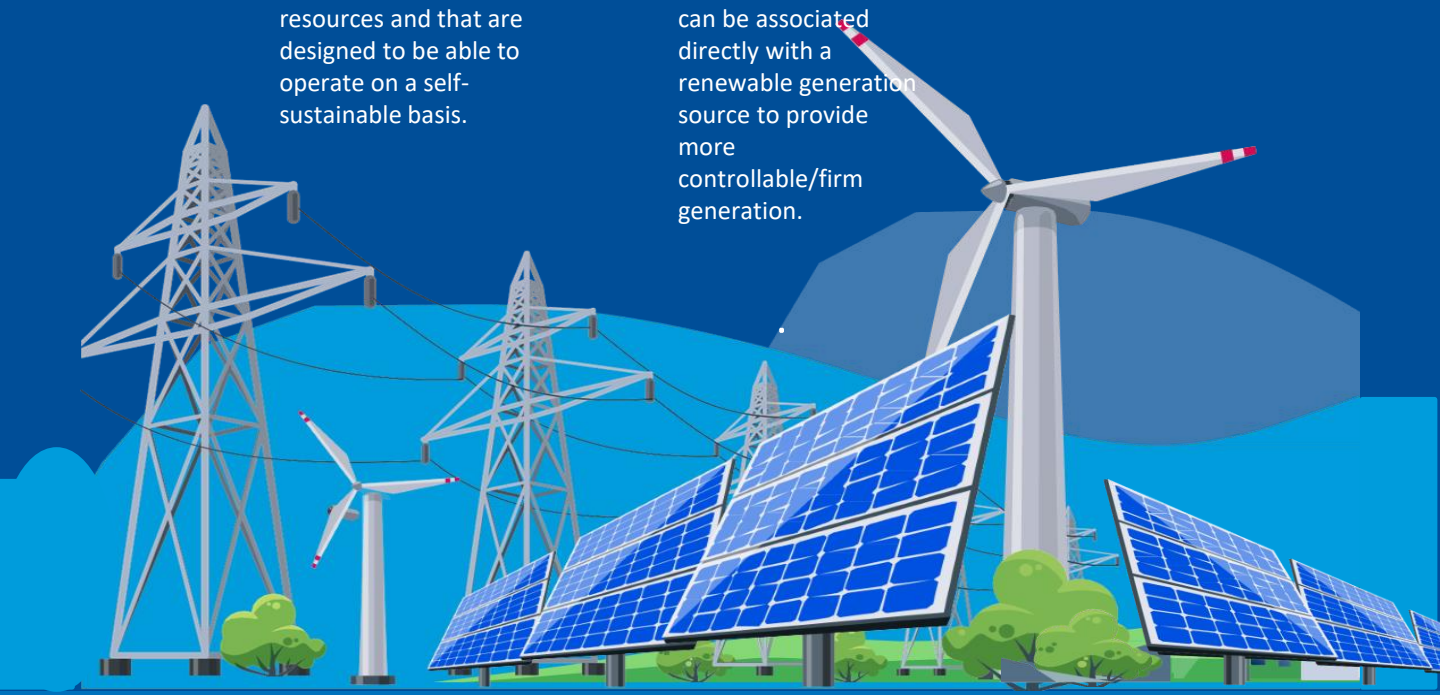
Utility Scale Batteries

Utility-scale batteries are used mainly to provide grid support functions, but also can be associated directly with a renewable generation source to provide more controllable/firm generation.

04

Super Grids

DC super grids have the potential to transmit electricity over long distances in a more efficient manner than AC systems. Coupling renewable energy generation and power load centers across long distances with fewer line losses reduces the cost of electricity transport from remotely located renewable sources to distant consumers.



Please refer Annexure 02 for a detailed description of the global trends.

05 Behind the Meter Batteries

Behind-the-meter storage is located at or close to the site of energy usage, and downstream from the connection point between the utility and the customer. It is usually applied in homes and workplaces.

06 Renewable Power to Heat

Renewable power-to-heat is the use of renewable power to generate useful heat energy for buildings or industrial processes. For example: via heat pumps or electric boilers.

07 Peer to Peer Electric Trading

They create an online marketplace for energy where consumers and distributed energy suppliers make peer-to-peer transactions. The primary objective of a P2P market is to provide a transparent and trusted mechanism for prosumers to fairly balance their preferences and requirements.

08 Power Wheeling

In electric power transmission, wheeling is the transportation of electric energy (megawatt-hours) from within an electrical grid to an electrical load outside the grid boundaries.

09 Aggregators

An aggregator can operate many distributed renewable energy sources together, creating a sizeable capacity similar to that of a conventional generator/virtual power plant.

10 Cross-border Energy Transfers

Sharing of cross-border infrastructure, establishing regional power producers, and enhancing competition across regional markets.

11 ICT

Enables real-time communication through the Internet, among devices in electricity demand centres and across the grid. The combination of AI and big data could help integrate VRE in the power system.

12 Home/ Building/ Industrial EMS

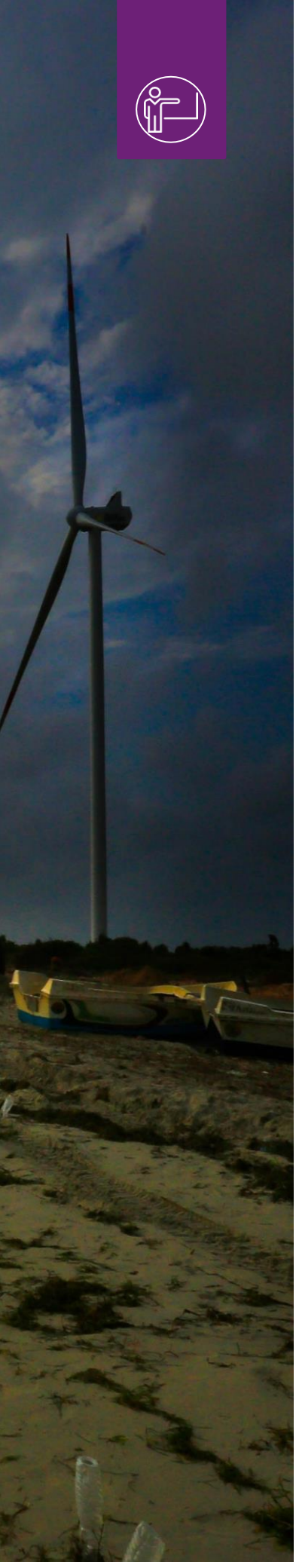
A growing sector in the modern era of the smart grid and smart homes. Home EMS can provide value to the homeowner and the utility by saving money and energy.
A sophisticated method to monitor and control a building's/industrial energy needs. This system can control and monitor a large variety of other aspects of the building regardless of whether it is residential or commercial.

Please refer Annexure 02 for a detailed description of the global trends.

Chapter 5

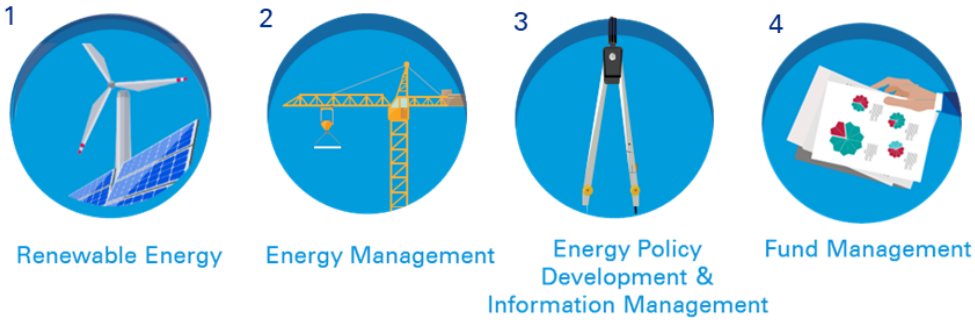
Corporate Framework

This chapter includes SLSEA's Objects, Core Values, Vision, Mission and Goals towards 2025



5.1 Objects

SLSEA is entrusted with a broad scope of implementing national level sustainable energy programs in Sri Lanka. Under this broad scope, SLSEA's primary objects are prescribed in the Sri Lanka Sustainable Energy Authority Act No. 35 of 2007, as follows:



1. Renewable Energy Development:

Identify, assess and develop renewable energy resources with a view to enhance energy security and thereby derive economic and social benefits to the country.

2. Energy Efficiency Improvement and Conservation:

Identify, promote, facilitate, implement and manage energy efficiency improvement and energy conservation programs for use of energy in domestic, commercial, agricultural, transport, industrial and any other relevant sector.

3. Energy Policy Development and Information Management:

Promote security, reliability and cost effectiveness of energy delivery to the country, by policy development and analysis and related information management.

4. Fund Management:

Ensure that adequate funds are available for the Authority to implement its objects, consistent with minimum economic cost of energy and energy security for the nation.

5.2 Core Values

The Core Values of SLSEA:

1. **Sustainability –** Be a socially, economically and environmentally sustainable and conscious Authority, which places emphasis on long term gains for generations to come.
2. **Public Focus –** Aim to support the growth of the country while contributing towards the national responsibility. Provide awareness and knowledge sharing to the broader community and support to uplift the local economy.
3. **Integrity -** Act in a reliable, ethical assuring the best interest of the Authority, its stakeholders and professional manner the society at large.
4. **Continuous Improvement –** Drive growth through the continuous improvement of processes, people and resources and adding value to them. Always monitor the Authority's growth for potential areas of improvement, while being innovative and achieving benefits to the nation.

5.3 Vision Statement

"A Sustainable and Energy Secure Sri Lanka"

5.4 Mission Statement

"To establish sustainable energy value chains by providing leadership to renewable energy, energy management and journey towards energy sustainability; through facilitation, regulation and knowledge management, paving the way for energy transition of the country, lowering the impact on the national economy and reducing the burden on the planet."

5.5 Goals

Goals provide direction on what action SLSEA would need to take in order to succeed in its Vision and Mission. These would go on to form the strategic objectives, strategies and activities.

1. Increase the renewable energy share in the primary energy supply
2. Reduce energy waste across all sectors by energy efficiency improvement and conservation
3. Create an environment conducive for a robust pipeline of sustainable energy programs to make those a strength to the economy
4. Contribute to reduce GHG emissions from energy sector
5. Create a policy framework to provide a fertile soil for sustainable energy programs
6. Transform the society to an energy-conscious society

Chapter 6

Strategic Objectives

This chapter includes the Strategic Objectives identified for SLSEA for the period from 2021 to 2025

6. Strategic Objectives

Strategic objectives will further aid SLSEA in achieving its goals by providing direction on how the Authority's vision would be achieved.

01

Making Renewable Energy a Major Share in Power Generation

02

Realizing 1,000 MW Capacity in Rooftop Solar PV Systems

03

Realizing an Electricity Saving of 1,500 GWh

04

Ensuring Efficient and Effective Thermal Energy Systems

05

Ensuring Efficient and Effective Energy Utilization in the Transportation Sector

06

Ensuring Effective Fund Management

07

Enhancing Energy Knowledge, Awareness and Consciousness

08

Creating a Conducive Environment for Sustainable Energy Implementation

Chapter 7

Strategies, Activities and Investment Details

This chapter includes SLSEA's Strategies and Activities in-line with the Strategic Objectives together with the investment requirement for each activity from SLSEA and other investors, respectively.

Disclaimer: The financial details included herein are geared to obtain general information in connection to the implementation of prospective activities and the investments to be incurred by external parties in the implementation of programmes. The details are included based on the information currently available, and therefore the financial information provide indicative information for taking policy decisions, but not the precise figures that will be required at the implementation of projects. At the project development stages under each programme, analysis will be done using updated information, whereby more precise financial information will be available.

Strategic Objective 1 : Making Renewable Energy a Major Share in Power Generation

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
1.1 Carry out renewable energy resource assessments	• Biomass resource assessment	10	-
	• Wind resource assessment	210	-
	• Solar resource assessment	90	-
	• Hydro resource assessment	5	-
	• Marine renewable energy resource assessment	20	-
	• Off-shore wind resource assessment	120	-
	• Geothermal resource assessment	95	-
Total Estimated Investment for the Strategy		**550**	**-**
1.2 Prepare and update the Renewable Energy Resource Development Plan	• Prepare the initial renewable energy development plan based on resource assessment	5	-
	• Carry out a detailed identification of sites		-
	• Carry out prioritization of sites		-
	• Update the Renewable Energy Development Plan		-
Total Estimated Investment for the Strategy		**5**	**-**
1.3 Declare renewable energy development areas	• Take actions to declare development areas in Sri Lanka for renewable energy	1	-
Total Estimated Investment for the Strategy		**1**	**-**

Strategic Objective 1 : Making Renewable Energy a Major Share in Power Generation

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
1.4 Develop and implement renewable energy parks	• Conduct pre-feasibilities and project feasibilities	420	-
	• Obtain environmental and other clearances	420	-
	• Vesting and acquisition of lands	5	-
	• Carry out transmission infrastructure development initiatives	-	80,000
	• Facilitation work for energy park development	-	288,000
	• Carry out/ monitor environmental/ social and infrastructure related implementation	20	14,400
	• Formulate new financing structures (green bonds)	5	-
Total Estimated Investment for the Strategy		**870**	**382,400**
1.5 Carry out renewable energy project approval and facilitation process	• Establish a smoothened renewable energy project development and approval process	1.5	-
	• Establish an institutional coordination mechanism	2	-
	• Monitor projects at implementation and post-implementation stages	6	-
Total Estimated Investment for the Strategy		**9.5**	**-**

Strategic Objective 1 : Making Renewable Energy a Major Share in Power Generation

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
1.6 Overcome constraints in absorbing renewable energy-based electricity to the grid	• Introduce energy storage for firming outputs from renewable energy power plants (Utility Scale Batteries)	95	845
	• Introduce technical improvements in the electricity grid to facilitate renewable energy absorption	7	-
Total Estimated Investment for the Strategy		**102**	**845**
1.7 Introduce effective forecasting technologies for wind, solar and rainfall	• Carry out renewable energy resource forecasting on a regular basis	5	-
Total Estimated Investment for the Strategy		**5**	**-**
1.8 Carry out R&D and pilot projects in different renewable energy sources and technologies	• Carry out R&D and pilot projects in renewable energy	40	40
	• Catalyse energy research through National Energy Symposium	6	-
	• Disseminate R&D findings for scaling up and scaling out	4	-
Total Estimated Investment for the Strategy		**50**	**40**

Strategic Objective 1 : Making Renewable Energy a Major Share in Power Generation

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
1.9 Carry out capacity building in different aspects of renewable energy	• Carry out training programs on renewable energy for target audiences	15	10
Total Estimated Investment for the Strategy		**15**	**10**
1.10 Off-grid electrification	• Pilot off-grid electrification in areas with remote chances to have access to the national grid	9	9
Total Estimated Investment for the Strategy		**9**	**9**

Strategic Objective 2 : Realizing 1,000 MW Capacity in Rooftop Solar PV Systems

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
2.1 Carry out quality assurance of rooftop solar PV systems through appropriate mechanisms	• Introduce quality assurance systems for solar PV systems and their installations	4	-
	• Renewal of registration of solar PV service providers based on performance	2.5	-
Total Estimated Investment for the Strategy		**6.5**	**-**
2.2 Introduce finance facilitation for encouraging rooftop solar PV systems	• Introduce soft financing schemes	1	20,000
	• Facilitate roof leasing	0.5	192
Total Estimated Investment for the Strategy		**1.5**	**20,192**
2.3 Overcome adverse impacts on the electricity distribution system from rooftop solar PV systems	• Introduce technical improvements in distribution system and grid integration	5	-
	• Introduce battery storage for firming electricity at distribution level	20	-
Total Estimated Investment for the Strategy		**25**	**-**
2.4 Develop the capacity of energy service providers and technicians	• Carry out capacity building programs for energy service providers and technicians	15	10
Total Estimated Investment for the Strategy		**15**	**10**

Strategic Objective 3 : Realizing an Electricity Saving of 1,500 GWh

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
3.1 Take measures to enhance energy utilization efficiency in building infrastructure	• Implement the energy efficiency building code on a mandatory basis	10	2,700
	• Introduce tax concessions for energy efficient building construction	1	-
	• Introduce a differential taxation system on energy efficiency for commercial buildings	1	-
	• Introduce energy efficiency guidelines for residential buildings	6	250
Total Estimated Investment for the Strategy		**18**	**2,950**
3.2 Take measures to enhance energy utilization efficiency in establishments	• Implement the Energy Manager program	2	-
	• Establish energy usage benchmark	18	15
	• Conduct energy audits and implementation of energy audit recommendations	1.5	2.5
	• Provide advisory services and implementation assistance for energy efficiency improvement programs	20	12
	• Audit high energy consuming state institutions	1.5	750
	• Popularise ISO 50001	1.5	0.5
Total Estimated Investment for the Strategy		**44.5**	**780**

Strategic Objective 3 : Realizing an Electricity Saving of 1,500 GWh

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
3.3 Take measures to popularize energy efficient appliances	• Introduce minimum energy performance standards and energy labeling	140	150
	• Intervene for implementing green procurement processes	2	2
Total Estimated Investment for the Strategy		**142**	**152**
3.4 Intervene to popularize energy efficient technologies in electrical systems	• Carry out R&D and pilot projects on energy efficiency improvements in electrical systems	10	30
Total Estimated Investment for the Strategy		**10**	**30**
3.5 Give priority and recognition for energy efficiency and conservation	• Conduct national level interventions in energy efficiency improvement and conservation	10	-
	• Carry out the national energy efficiency award scheme	12	2
	• Focus on energy efficiency improvement in street lighting	2	1
Total Estimated Investment for the Strategy		**24**	**3**

Strategic Objective 3 : Realizing an Electricity Saving of 1,500 GWh

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
3.6 Carry out capacity building in energy efficiency improvement	• Carry out training programs in energy efficiency improvement & conservation for Energy Auditors, Energy Managers and Energy Management Officers	12	10
Total Estimated Investment for the Strategy		**12**	**10**
3.7 Take measures for finance facilitation for energy efficiency improvement projects	• Implement Sustainable Energy Guarantee Fund	0.5	-
	• Facilitate soft loans		-
Total Estimated Investment for the Strategy		**0.5**	**-**

Strategic Objective 4 : Ensure Efficient and Effective Thermal Energy Systems

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
4.1 Promote efficient utilization of thermal energy systems in establishments	• Promote energy services companies for their involvement in thermal energy systems	2.5	1.5
Total Estimated Investment for the Strategy		**2.5**	**1.5**
4.2 Intervene in popularizing energy efficient technologies in thermal systems	• Carry out R&D and pilot projects on energy efficiency improvements in thermal systems	10	10
Total Estimated Investment for the Strategy		**10**	**10**
4.3 Support biomass related innovations and other interventions in the society	• Introduce and promote improved biomass conversion devices and biomass-based fuels	2.5	2.5
	• Encourage biomass fuel products and improved cook stoves for households providing fiscal incentives to manufacturers & distributors	2	2
	• Recommend kitchen and behavioral improvements for better air quality in households and health impact of cooks	5	-
Total Estimated Investment for the Strategy		**9.5**	**4.5**

Strategic Objective 4 : Ensure Efficient and Effective Thermal Energy Systems

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
4.4 Establish biomass as a commercial fuel by strengthening the biomass supply chain	• Establish biomass depots	10	100
	• Promote adaptation of the National Standard on Solid Biofuels and Specification for Principal Criteria and Indicators for Sustainably Produced Fuelwood - SLS 1551	15	-
	• Enhance energy plantations	50	500
Total Estimated Investment for the Strategy		**75**	**600**
4.5 Establish renewable energy based integrated energy facilities in industrial/ commercial clusters	• Introduce cogeneration/tri-generation for industrial zones	4	6,000
Total Estimated Investment for the Strategy		**4**	**6,000**
4.6 Introduce fuel switching for industrial/ commercial sectors	• Introduce fuel switching for industrial/commercial sectors	5	125
Total Estimated Investment for the Strategy		**5**	**125**

Strategic Objective 5 : Ensure Efficient and Effective Energy Utilization in the Transportation Sector

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
5.1 Explore the possibilities of utilizing new fuels (biofuels, hydrogen, etc.)	• Investigate on new fuel interventions (bio fuels, hydrogen, etc.)	5	5
Total Estimated Investment for the Strategy		**5**	**5**
5.2 Promote high efficient vehicles and electric vehicles	• Promote energy efficient/electric vehicles	2	-
	• Establish EV charging stations	2	100
Total Estimated Investment for the Strategy		**4**	**100**
5.3 Promote virtual mobility interventions	• Promote virtual offices, video/ teleconferencing and other related e-platforms including research (ecommerce, e-banking, etc.)	4	-
Total Estimated Investment for the Strategy		**4**	**-**
5.4 Promote sustainability interventions and improvements in public transport	• Promote public transport and traffic management	1	-
	• Promote sustainable townships	1	-
Total Estimated Investment for the Strategy		**2**	**-**

Strategic Objective 6 : Ensuring Effective Fund Management

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
6.1 Uplift the operation of sustainable energy related funds established under the Act	• Implement Sustainable Energy Guarantee Fund		-
	• Establish a mechanism to strengthen the flow of funds to Sustainable Energy Fund through the provisions given in the Act	1	-
	• Develop the necessary formulation to enhance the scope of utilizing Sustainable Energy Fund		-
Total Estimated Investment for the Strategy		**1**	**-**
6.2 Establish procedures to monitor projects/ programs	• Ensure continuous monitoring of timelines and budget utilizations of the projects/programs	0.5	-
Total Estimated Investment for the Strategy		**0.5**	**-**
6.3 Create avenues for investor funding opportunities	• Take measures to create awareness among donor funding agencies and other local/foreign investors on SLSEA's initiatives	1.5	-
	• Create avenues to attract investor funds to SLSEA	1	-
Total Estimated Investment for the Strategy		**2.5**	**-**
6.4 Implement finance facilitation schemes for sustainable energy development	• Conduct programs on interventions in sustainable energy finance exploration	0.5	-
Total Estimated Investment for the Strategy		**0.5**	**-**

Strategic Objective 7 : Enhancing Energy Knowledge, Awareness and Consciousness

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
7.1 Carry out energy education programs	• Conduct the school energy education program	30	-
	• Conduct Scouts' energy programs	5	-
	• Promote Montessori/pre-school programs including Ludo games and story books related to sustainable energy	6	-
	• Incorporate energy education into universities and other tertiary education institutes	5	6.2
Total Estimated Investment for the Strategy		**46**	**6.2**
7.2 Carry out outreach programs	• Promote and conduct women empowerment programs	5	-
	• Promote energy efficient cooking programs through mobile apps	2.5	-
	• Publish articles in women's and children's magazines	5	-
	• Carry out awareness creation programs for government institutions, hospitals, offices, etc.	5	-
	• Conduct technology demonstration programs	2.5	-
	• Conduct media programs (awards)	4	-
	• Engage in consumer engagement through web and social media	5	-
	• Issue sustainable energy publications	7.5	-

Strategic Objective 7 : Enhancing Energy Knowledge, Awareness and Consciousness

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
7.2 Carry out outreach programs (continued)	• Issue publications in newspapers and magazines	5	-
	• Conduct national and other exhibitions (Vidulka)	8	15
	• Introduce social media videos with sustainable energy content	6	-
Total Estimated Investment for the Strategy		**55.5**	**15**

Strategic Objective 8 : Creating a Conducive Environment for Sustainable Energy Implementation

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
8.1 Make up-to-date data and information on energy supply and consumption available	• Compile and disseminate the Sri Lanka Energy Balance publication	10	-
	• Carry out information dissemination programs	5	-
Total Estimated Investment for the Strategy		**15**	**-**
8.2 Identify policy interventions and carry out related policy dialogues	• Carry out policy analysis and provide support services to the government on sustainable energy	1	-
	• Provide input and suggest updates to the National Energy Policy	0.5	-
Total Estimated Investment for the Strategy		**1.5**	**-**
8.3 Identify necessary legal interventions and take relevant measures	• Provide input/suggestions for related laws and regulations	4	-
Total Estimated Investment for the Strategy		**4**	**-**
8.4 Make special technological interventions in collaboration with utilities	• Promote smart electricity systems and ICT interventions	2	2
	• Promote IT related infrastructure to improve data and information accuracy and visualization	40	10
Total Estimated Investment for the Strategy		**42**	**12**

Strategic Objective 8 : Creating a Conducive Environment for Sustainable Energy Implementation

Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
8.5 Intervene to enhance energy sustainability in socio-economic engagement	• Introduce sustainable value chains into different socio-economic sectors	1	-
	• Introduce energy-based livelihood options and enterprises	4	1
Total Estimated Investment for the Strategy		**5**	**1**
8.6 Take measures for wider social engagement of SLSEA	• Carry out social access enhancement programs	0.5	-
Total Estimated Investment for the Strategy		**0.5**	**-**
8.7 Enhance organizational strength of SLSEA	• Promote capacity development of SLSEA staff	3	-
	• Enhance SLSEA staff	7.5	-
	• Strengthen the self-standing status of SLSEA	0.5	-
	• Enhance operational systems and procedures of SLSEA	1	-
	• Promote the use of technologies, software and other modern resources	10	20
Total Estimated Investment for the Strategy		**22**	**20**

Strategic Objective	Strategy	Activity	SLSEA (LKRM)	Other Investors (LKRM)
Strategic Objective 8 : Creating a Conducive Environment for Sustainable Energy Implementation	8.8 Take measures to enhance the knowledge repository and dissemination systems	• Enhance knowledge management and repository systems	3	-
		• Disseminate through websites and other programs	3	-
	Total Estimated Investment for the Strategy		**6**	**-**
	8.9 Take measures to enhance stakeholder engagement and networking	• Improve stakeholder engagement and networking	4	-
		• Collaborate and partner with key stakeholders	2	-
	Total Estimated Investment for the Strategy		**6**	**-**

Chapter 8

KPIs and Modes of Verification

This chapter includes Objective wise KPIs and the Modes of Verification.

8. KPIs and Modes of Verification

Objective	KPI	Mode of Verification
01. Making renewable energy a major share in power generation	Percentage of renewable energy generation	CEB digest report
02. Realising 1,000 MW capacity in rooftop solar PV systems	Grid connected rooftop solar capacity	CEB & LECO reports
03. Realising an electricity saving of 1,500 GWh	Amount of electricity saved	SLSEA reports
04. Ensuring efficient and effective thermal energy systems	Percentage of thermal energy saved	SLSEA reports
05. Ensuring an efficient and effective energy utilization in the transportation sector	Fuel efficiency improvement in terms of distance travelled per litre of fuel input	Central Bank of Sri Lanka Annual Reports
06. Ensuring effective fund management	Percentage of the fund secured and spent against the Annual Budgets of the SLSEA (of respective years)	SLSEA's Reports (annual budgets, progress reports and financial statements)
07. Enhancing energy knowledge, awareness and consciousness	Number of personnel awareness created	SLSEA reports
08. Creating a conducive environment for sustainable energy implementation	Number of policies developed, Number of schemes	SLSEA reports, Central Bank reports

Annexures

Annexure 01 – UN Sustainable Development Goals and Targets

Annexure 02 – Global Trends

Annexure 01 – Mapping of Strategies to SDG Targets

Main Sustainable Development Goal (SDG) related to SLSEA is Goal 07.

Below identified are the targets of SDG 07

Target Number	Target Description
7.1	By 2030, ensure universal access to affordable, reliable and modern energy services
7.2	By 2030, increase substantially the share of renewable energy in the global energy mix
7.3	By 2030, double the global rate of improvement in energy efficiency
7.a	By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
7.b	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, least developed countries, small island developing states, and land-locked developing countries, in accordance with their respective programs of support

Annexure 02 – Global Trends

1. Energy Transition

Energy transition refers to the global energy sector's shift from fossil-based systems of energy production and consumption — including oil, natural gas and coal — to renewable energy sources such as wind, biomass, solar, etc. The increasing penetration of renewable energy into the energy supply mix, the onset of electrification and improvements in energy storage are all key drivers of the energy transition.

IRENA records a 10.3 per cent rise in globally installed capacity of renewable energy in the previous year. At the end of 2020, global renewable generation capacity amounted to 2,799 GW with hydropower still accounting for the largest share (1,211 GW) with solar and wind catching up fast. The two variable sources of renewables dominated capacity expansion in 2020 with 127 GW and 111 GW of new installations for solar and wind, respectively. The total renewable energy generated in the world in 2020 amounted to 2,799,094 MW.

China and the United States were the two outstanding growth markets from 2020. China, already the world's largest market for renewables added 136 GW last year with the bulk coming from 72 GW of wind and 49 GW of solar. The United States installed 29 GW of renewables last year, nearly 80 per cent more than in 2019, including 15 GW of solar and around 14 GW of wind. Africa continued to expand steadily with an increase of 2.6 GW, slightly more than in 2019, while Oceania remained the fastest growing region (+18.4%), although its share of global capacity is small and almost all expansion occurred in Australia. The shift in the renewable energy profiles in many countries was supported by the following combination of interventions:

- Use of legislation and feed-in-tariff (FiT) where available
- Tax incentives on technology imports and development
- Advancement in commercial-scale technology
- Newer forms of commercial structuring and funding avenues, such as green bond financing

Annexure 02 – Global Trends

Highlights by Renewable Energy Technology

- Wind energy: Wind expansion almost doubled in 2020 compared to 2019 (111 GW compared to 58 GW last year). China added 72 GW of new capacity, followed by the United States (14 GW). Ten other countries increased wind capacity by more than 1 GW in 2020. Offshore wind increased to reach around 5% of total wind capacity in 2020.
- Solar energy: Total solar capacity has now reached about the same level as wind capacity owing largely to the expansion in Asia (78 GW) in 2020. Major capacity increases in China (49 GW) and Vietnam (11 GW). Japan also added over 5 GW and India and the Republic of Korea both expanded solar capacity by more than 4 GW. The United States added 15 GW.
- Bioenergy: Net capacity expansion fell by half in 2020 (2.5 GW compared to 6.4 GW in 2019). Bioenergy capacity in China expanded by over 2 GW. Europe the only other region with significant expansion in 2020, adding 1.2 GW of bioenergy capacity, similar to 2019.
- Geothermal energy: Very little capacity added in 2020. Turkey increased capacity by 99 MW and small expansions occurred in New Zealand, the United States and Italy.
- Off-grid electricity: Off-grid capacity grew by 365 MW in 2020 (2%) to reach 10.6 GW. Solar expanded by 250 MW to reach 4.3 GW and hydro remained almost unchanged at about 1.8 GW.
- Hydropower: Growth in hydro recovered in 2020, with the commissioning of several large projects delayed in 2019. China added 12 GW of capacity, followed by Turkey with 2.5 GW.

2. Mini-Grids

Mini-grids are integrated energy infrastructures that combine loads and renewable energy resources and are designed to be able to operate on a self-sustainable basis. Renewable generation, intelligent switching and protection, a controller and energy storage typically form the backbone of a mini-grid. When connected to the main grid, mini-grids can be a source of flexibility, providing frequency response, reduced grid congestion and load management. Direct current (DC) mini-grids are emerging as a solution to increase efficiency in the grid.

Drawback - The integrated control of alternating current (AC) and DC hybrid grids is a challenge that has not been tested much yet.

Ongoing Developments:

- 12,000 MW of mini-grids worldwide
- Key regions where grid-connected mini-grids are being developed: Australia, Netherlands and the US.

Annexure 02 – Global Trends

Electric Vehicle Smart Charging

Smart charging of EVs adapt the charging cycle to events in the power system, enabling the vehicles to be integrated into the power system in a grid and in a user-friendly way. Smart charging of EVs (charging following renewable energy generation profiles) can help mitigate the curtailment of renewables, while avoiding the addition of extra load to peak demand and additional infrastructure costs. Vehicle-to-grid (V2G) technologies could bring even greater flexibility in the system by supplying power back to the grid when needed. The potential for smart charging to adapt the charging time depends strongly on the kinds of vehicles, the charging location, and the power and speed of the charging equipment. In an extreme case, autonomous electric collective taxis might fast-charge at 150 kW to 500 kW for 10 minutes several times a day, with practically no flexibility during daytime but only during the night.

Ongoing Developments:

- 4 million EVs on the street in 2017, with 40% of them in China (BNEF, 2018)
- 57% compound annual growth rate of sales over the last six years
- Largest markets for EVs: China, Germany, Norway, UK and the US
- Share of total electricity demand if all light-duty vehicles were electric, in 2016: 24% in US; 10-15% in Europe, with impact on peak demand, if not smartly charged.

3. Utility Scale Batteries

Utility-scale batteries are used mainly to provide grid support functions, but also can be associated directly with a renewable generation source to provide more controllable/firm generation.

4. Super Grids

DC super grids have the potential to transmit electricity over long distances in a more efficient manner than AC systems. Coupling renewable energy generation and power load centers across long distances with fewer line losses reduces the cost of electricity transport from remotely located renewable sources to distant consumers.

Ongoing Developments:

- Key regions where super grids are being developed: Europe, India, Bangladesh, Nepal, Bhutan, North Asia (China, Japan, the Russian Federation, the Republic of Korea and Mongolia).
- Average costs for developing DC 500 kilovolt (kV) transmission lines: approximately USD 570,000 per kilometer.

Drawbacks - Disposing of a battery may cause serious damage to the environment due to the high pollution.

Annexure 02 – Global Trends

Ongoing Developments:

- Global installed capacity of large-scale battery storage systems: 10 gigawatt-hours (GWh) in mid-2017
- Key countries where large-scale batteries are used: Australia, China, Germany, Italy, Japan, the Republic of Korea, UK and the US.
- Most established large-scale battery storage technology: Lithium-ion batteries constitute more than 90% of the current total installed capacity for large-scale battery storage.
- Transmission system operators in UK (National Grid) and Netherlands (TenneT) also have contracted large-scale batteries for balancing services.

5. Behind the Meter Batteries

Behind-the-meter storage is located at or close to the site of energy usage, and downstream from the connection point between the utility and the customer. It is usually applied in homes and workplaces.

Contribution to VRE Integration:

- Enables the effective integration of local renewable energy generation, to unlock the benefits of distributed generation
- Smoothens the peak load profile
- Facilitates demand-response services and participates in the ancillary service market, providing flexibility to the system
- Cuts the cost of distributed renewables by maximizing self-consumption

Ongoing Developments:

- Key regions where small batteries are used (2017): Germany, Italy, UK, Australia, Japan, Netherlands and China
- Germany: 100,000 batteries installed (August 2018), 60% of the new rooftop PV systems equipped with batteries
- South Australia's government launched a program in October 2018 to install 40,000 household batteries (Skyes, 2018)

6. Renewable Power to Heat

Renewable power-to-heat is the use of renewable power to generate useful heat energy for buildings or industrial processes, for example via heat pumps or electric boilers.

Power-to-heat could:

- Store energy on a large-scale through thermal storage
- Reduce the curtailment of renewable energy by transforming it into heat: a fuel to help decarbonize other energy sectors
- Enable demand-side management with heat pumps, which are more energy efficient than other forms of heating

Annexure 02 – Global Trends

Ongoing Developments:

- Cost of heat production with heat pumps: EUR 0.06- 0.12 per kWh, which is less than half the cost of heat production with natural gas condensing boilers.
- Heat pumps installed in EU-21 (2017): 10.5 million units; with a storage capacity of 368 GW and contributing to116 TWh of renewable energy (EHPA, 2018).
- Key regions where power-to-heat systems have been implemented (2017): Europe (primarily Denmark, Sweden, Germany, UK, Switzerland), US, China and Canada.

7. Peer to Peer Electric Trading

Platform business models are sometimes referred to as the "Uber or Airbnb of energy". They create an online marketplace for energy where consumers and distributed energy suppliers make peer-to-peer transactions. The primary objective of a P2P market is to provide a transparent and trusted mechanism for prosumers to fairly balance their preferences and requirements. P2P trading encourages more renewable energy distributed generation installations and increased local use of energy resources. But the regulatory treatment, for example for grid usage charges, still requires strong evolution before large-scale implementation of P2P trading would be likely to provide strong benefits to consumers.

Ongoing Developments:

Countries where projects are in place:
- Bangladesh (SOLShare)
- Germany (Lumenaza, sonnenCommunity)
- Netherlands (Vandebron, Powerpeers)
- UK (Piclo – Open Utility)
- US (TransActive Grid)

8. Power Wheeling

In electric power transmission, wheeling is the transportation of electric energy (megawatt-hours) from within an electrical grid to an electrical load outside the grid boundaries.
The two types of wheeling are:
1) a wheel-through, where the electrical power generation and the load are both outside the boundaries of the transmission system, and
2) a wheel-out, where the generation resource is inside the boundaries of the transmission system, but the load is outside.

Wheeling often refers to the scheduling of the energy transfer from one Balancing Authority (Balancing Authority, Tie Facility and Interconnection) to another. Since the wheeling of electric energy requires use of a transmission system, there is often an associated fee which goes to the transmission owners. In a simpler sense, it refers to the process of transmission of electricity through the transmission lines.

Annexure 02 – Global Trends

Ongoing Developments:

- Many countries such as the United States, Germany, Japan and the Philippines use power wheeling in their energy sector reform towards renewable energy (JICA, 2016).

9. Aggregators

An aggregator can operate many distributed renewable energy sources together, creating a sizeable capacity similar to that of a conventional generator (also called a "virtual power plant"). As such, aggregators can then sell electricity or ancillary services in the wholesale market, or in the system operator's ancillary services procurement. An aggregator enables smoother integration of distributed energy resources into the power system, by allowing them to provide energy to the wholesale market and ancillary services to the grid operator. Thus, it contributes to the system's flexibility.

Ongoing Developments:

- Countries with an established regulatory framework for aggregators: Australia, Belgium, France, Germany, Netherlands, UK and US
- Number of aggregators in the UK: 19 (National Grid ESO, 2018)
- Installed capacity of aggregators in the UK: approximately 10 GW

10. Cross-border Energy Transfers

In South Asia, the existing cross-border electricity trade between India and its neighbors namely Bhutan, Bangladesh and Nepal, provides a foundation for furthering this cooperation at the regional level. The existing electricity trade agreements are bilateral in nature and have benefited the participating nations**.** Currently, there are ongoing discussions on sea links between India and Sri Lanka.

Regional electricity cooperation may include the sharing of cross-border infrastructure, establishing regional power producers and enhancing competition across regional markets. This would require, among others, investment in new border interconnections and the development of harmonized codes, policies and regulations for the overall growth of the power sector. Given the significant potential of hydro-electricity generation in South Asia it is expected that this would play a major role in any future strategy for regional power sector cooperation.

Annexure 02 – Global Trends

11. Digital Transformation of the Energy Sector

11.1 Internet of Things (IoT)

The IoT enables real-time communication through the Internet, among devices in electricity demand centres (homes, commercial and industry facilities) and across the grid, facilitating information gathering and exchange.

The IoT, together with optimisation algorithms, could:

- Increase system flexibility by enabling remotely managed and/or rapid automatic changes in distributed resources and demand.
- Improved renewable energy forecasting and trading, decreasing uncertainty.

Ongoing Developments:

- By 2025, 75 billion devices are expected to be connected worldwide, compared to 15 billion in 2015 (Statista, 2018)
- Many companies, consortiums, foundations and groups are working on IoT technologies at different levels: app layer, data layer, connectivity layer and device layer
- All Nordic countries are moving towards the implementation of data hubs for electricity meter data and market processes. Transmission system operators in Denmark, Finland, Norway and Sweden are responsible for introducing a data hub for each of the electricity retail markets (NordREG, 2018).

11.2 Artificial Intelligence and Big Data

The combination of big data with artificial intelligence (AI) has emerged as one of the most important developments in several fields. Although many AI technologies existed for several decades, only now are they able to take advantage of sufficiently sized datasets, providing meaningful learning and results for energy market applications.

This combination could help integrate VRE in the power system by:

- Increasing the accuracy of renewable energy
- Generation forecasting
- Improving the operation of the system and better management of the distributed sources
- Improving asset management through remote monitoring, analysis and maintenance optimization

Ongoing Developments:

- Key regions where AI is implemented in energy applications: US and Europe (France, Germany, Spain, UK, etc.).

Annexure 02 – Global Trends

12. Energy Management

The global energy management system market was valued at USD 8. 48 billion in 2019, and it is forecasted to reach a value of USD 17. 38 billion by 2025, reflecting a CAGR of 16. 2% during the period, 2020 – 2025 (Energy Management Systems Market - Growth, Trends, Forecasts (2020 - 2025).

13. Home EMS

Home energy management systems (HEMS) are a growing sector in the modern era of the smart grid and smart homes. HEMS can provide value to the homeowner and the utility by saving money and energy by providing a mixture of control, scheduling and user information. It can monitor the energy consumption of the home residents to help them adapt their energy usage behavior based on the feedback they receive from the system and can support utility demand-response (DR) programs and reduce peak demand. The system can receive DR signals from the utility and create schedules based on the signals, the system goals, and the homeowner's priorities.

- One of the requirements of HEMS is to improve the energy consumption in homes and buildings which require specific capabilities
- The system should be capable of communicating with the various home devices for monitoring and control
- The system should also be capable of external communication with the local utility for receiving DR signals
- The system needs some intelligence to be able to analyze data such as energy consumption and provide feedback to homeowners
- It should also create schedules based on energy consumption behavior, system goals, users' priorities and utility DR signals
- Due to the nature of the HEMS capabilities and communications in a building or residence, cybersecurity must also be a capability

13.1 Building Energy Management Systems (BEMS)

A building energy management system (BEMS) is a sophisticated method to monitor and control the building's energy needs. This system can control and monitor a large variety of other aspects of the building regardless of whether it is residential or commercial. Examples of these functions are heating, ventilation and air conditioning (HVAC), lighting or security measures. BEMS technology can be applied in both residential and commercial buildings.

BEMS differs from other control systems due to the characteristic of communication: information of the processes and functions of the building can be received and controlled at a central, single operating unit. Therefore, decisions can be made based on the information received. This is a critical aspect of a BEMS as it allows for optimization of the system.

Annexure 02 – Global Trends

13.2 Industrial Energy Management System (IEMS)

The Global Industrial Energy Management Systems (IEMS) market is estimated to reach $36. 3 Billion by 2027. Amid the COVID-19 crisis, the global market for Industrial Energy Management Systems (IEMS) is estimated at US$25.

Ongoing Developments:

The Industrial Energy Management Systems (IEMS) market in the US is estimated at US$7.6 Billion in the year 2020. China, the world`s second largest economy, is forecast to reach a projected market size of US$6.4 Billion by the year 2027 trailing a CAGR of 4.7% over the analysis period of the year commencing 2020 to 2027. Among the other noteworthy geographic markets are Japan and Canada, each forecast to grow at 5% and 4% respectively over the 2020-2027 period. Within Europe, Germany is forecast to grow at approximately 4.1% CAGR.

Annexure 02 – Global Trends

Renewable Energy Trends in other Countries

Denmark

VRE Penetration	Challenges
More than 40% since 2014, reaching 53% in 2017 (IEEFA, 2018), with most of it coming from wind energy. Target: 100% renewables in the energy sector by 2050, with 50% wind electricity.	Balancing supply and demand, ensuring that sufficient baseload power is available when there is no wind. Keeping wind power valuable during high wind production, as currently large wind power quantities are sold at low or negative prices (Zaman, 2018).

Republic of Ireland and Northern Ireland

VRE Penetration	Challenges
VRE accounted for 29.7% of the electricity demand in 2017, with wind providing the vast majority (26.4%). In January 2015 Ireland experienced a maximum instantaneous wind penetration of 66.2%. Target: 40% renewable energy penetration by 2020, mostly from wind.	Limited interconnections make the system almost like an isolated grid. Wind power is curtailed to maintain system stability, due to maximum non-synchronous penetration levels and other grid constraints. Curtailment reached 4% of total wind generation in 2017.

California

VRE Penetration	Challenges
Almost 20% of the generation mix was from wind and solar in 2017 (CEC, 2018). There is a large share of distributed renewable resources in the grid, with 5 900 megawatts (MW) of rooftop solar PV capacity. Target: 33% renewable energy generation by 2020, 50% by 2026 and 60% by 2030 (Roberts, 2018).	Oversupply of renewables and congestion in the grid, leading to curtailment. Steep morning and evening ramps created by the increasing distributed solar generation.

Annexure 02 – Global Trends

India – Tamil Nadu

VRE Penetration	Challenges
14% of wind and solar generation in 2016-2017, from 32% of the total installed capacity. Target: 17.5% wind and solar share to be reached between 2021 and 2022; 21% by 2027 (CEA, 2018).	Insufficient grid capacity in South India to export wind power has resulted in curtailment. Further, the increase in frequency fluctuations.

South Australia

VRE Penetration	Challenges
In 2017 48.4% of power generation came from wind and solar sources, with wind accounting for 39.2% and rooftop solar for 9.2%. More than 30% of households have a PV system installed, for a total of 781 MW. Target: 50% renewables in the generation mix by 2020, 75% by 2025 (Morton, 2018).	Synchronous power generation provides adequate levels of system reliability and inertia, required to secure a power system. In 2016 South Australia experienced an extreme weather event where a windstorm knocked down part of the grid, triggering a cascading event and a major blackout.

Uruguay

VRE Penetration	Challenges
In 2017 48.4% of power generation came from 28% wind and solar generation. Together with hydropower and biomass, total renewable generation accounted for 98%. Target: • Flexible hydropower generation • Complementary generation profiles for hydropower and wind.	With a steep, eight-fold jump in wind generation from 2013 to 2014, Uruguay's main challenge was to maintain the reliability of the system, given the increased variability in the short term. A big challenge is VRE curtailment, because biomass runs as baseload throughout the year and wind penetration exceeds minimum demand. The excess generation could be exported through the 2.57 GW interconnection with Argentina and Brazil; however, no active cross-border market is in place with neighboring countries.

Annexure 02 – Global Trends

Australia – King Island

VRE Penetration	Challenges
65% wind penetration; 100% instantaneous share of VRE was reached in 2013. High imported diesel fuel costs led to the installation of three 250 kilowatt (kW) wind turbines in 1998, followed by two 850 kW wind turbines in 2013 and 3 MW / 1.6 MWh of battery storage (Zaman, 2018). Target: A 100% renewable energy grid.	Maintain the reliability of intermittent renewable sources in a small system with no interconnections.

Germany

VRE Penetration	Challenges
Variable wind and solar generation was 25% in 2017. Total renewable energy generation (hydropower, wind, solar and biomass) was up 15% year-on-year to 210 terawatt-hours (TWh), or 38.2% of the 2017 total (Fraunhofer ISE, 2018). Target: 65% renewables in electricity by 2030	A key challenge is wind curtailment to maintain grid stability and to solve the bottlenecks in the transmission grid. Curtailment is especially high in the north, where most of the wind plants are located, mostly because of the grid congestion between the north and south. Renewable energy generators are compensated for lost revenue during most curtailments. Network operators are required to redispatch the power plants in the south and increase their output to meet the increased power demand, while the interconnection with the north remains congested. Additional operating costs caused by the re-dispatching are subject to financial compensations, which make the procedure very costly for the system. In 2017, Germany had a record 144 hours of day-ahead negative wholesale electricity prices.

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