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Sri Lanka Sustainable Energy Authority

Job Survey and Skills Analysis for the Renewable Energy Sector

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List of acronyms

ADB	Asian Development Bank
AI	Artificial intelligence
AIUDP	Anuradhapura Integrated Urban Development Project
AMC	Annual maintenance contract
BET	Bachelor of Engineering Technology
BEV	Battery-powered electric vehicle
BOI	Board of Investment
BSc	Bachelor of Science
BTech	Bachelor of Technology
CBSL	Central Bank of Sri Lanka
CBT	Competency-based training
CCC	Ceylon Chamber of Commerce
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CECB	Central Engineering Consultancy Bureau
CEYPETCO	Ceylon Petroleum Corporation
CGTTI	Ceylon German Technical Training Institute
CPD	Continuous professional development
CSO	Civil society organization
DMT	Department of Motor Traffic
E2W	Electric two-wheeler
E3W	Electric three-wheeler
EDB	Export Development Board
EE	Energy efficiency
EFI	Electronic fuel injection
EIA	Environmental impact assessment
ESD	Education for Sustainable Development
ESS	Energy storage system
EV	Electric vehicle
FRED	Federation of Renewable Energy Developers of Sri Lanka
GGGI	Global Green Growth Institute
GoSL	Government of Sri Lanka
HNDA	Higher National Diploma in Accounting
HNDM	Higher National Diploma in Management
HVAC	Heating, ventilating, and air conditioning
ICE	Internal combustion engine
ICEV	Internal combustion engine vehicle
ICT	Information and communications technology
IDB	Industrial Development Board
IEC	International Electrotechnical Commission
IESL	Institute of Engineers, Sri Lanka
IMC	Inter-Ministerial Committee
IOT	Internet of things
IPHT	Institute of Post-Harvest Technology
IPPs	Independent Power Producers
ISSC	Industry Sector Skills Councils
KII	Key informant interview
KOICA	Korea International Cooperation Agency
KPI	Key performance indicator
LCC	Lanka Coal Company
LECO	Lanka Electricity Company
LTS	Long-term strategy
MAP	Medium-term action plan
MIMO	Multi-input multi-output
MSME	Micro, small, and medium Enterprises
NAITA	National Apprentice and Industrial Training Authority
NAP	National Adaptation Plan
NCS	National Competency Standards
NDCs	Nationally Determined Contributions
NEP&S	National Energy Policy and Strategies of Sri Lanka
NERDC	National Engineering Research and Development Centre
NGO	Non-governmental organization
NIBM	National Institute of Business Management

NITAC	National Industry Training Advisory Committee
NSBM	National School of Business Management
NSF	National Science Foundation
NVQ	National Vocational Qualification
NVQF	National Vocational Qualifications Framework
PHEV	Plug-in hybrid electric vehicle
PUCSL	Public Utilities Commission of Sri Lanka
PV	Photovoltaic
R&D	Research and development
RE	Renewable energy
RET	Renewable energy technologies
RPL	Recognition of prior learning
SD	Sustainable development
SDGs	Sustainable Development Goals
SLAAS	Sri Lanka Association for the Advancement of Science
SLAEB	Sri Lanka Atomic Energy Board
SLEMA	Sri Lanka Energy Managers Association
SLGTI	Sri Lanka German Technical Institute
SLIATE	Sri Lanka Institute of Advanced Technological Education
SLIIT	Sri Lanka Institute of Information Technology
SLQF	Sri Lanka Qualifications Framework
SLSEA	Sri Lanka Sustainable Energy Authority
SLSI	Sri Lanka Standards Institute
SPPs	Small Power Producers
TEC	Technical Evaluation Committee
TNA	Technology Needs Assessment
ToT	Training of Trainers
TVEC	Tertiary and Vocational Education Commission
TVET	Technical and vocational education and training
UAM	Udyog Aadhaar Memorandum
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIVOTEC	University of Vocational Technology
VTA	Vocational Training Authority
VTC	Vocational Training Centre
WAsP	Wind resource assessment practitioner

1. Introduction

The socio-economic development of Sri Lanka during the past decades is strongly coupled with the progression of the energy sector and achieving 100% access to grid electricity. However, the energy sector's development is increasingly threatened by its heavy dependence on imported fossil fuels and adverse environmental impacts at the local, national, and global level, which in turn creates challenges in many other areas of socio-economic development. To address this, Sri Lanka has placed an emphasis on harnessing indigenous renewable energy (RE) resources while acknowledging the need for demand-side management through enhancing energy efficiency (EE), as reflected in the national commitment to the Paris Agreement on climate change as well as the 2030 Agenda for Sustainable Development.

Sri Lanka aims to significantly reduce greenhouse gas (GHG) emissions from key sectors including power (electricity generation), transport, industry, waste, forestry, and agriculture to achieve net-zero carbon by 2050, with specific emphasis on electricity generation through REs where a mid-term target of 70% by 2030 was set in the updated Nationally Determined Contributions (NDCs) submitted under the Paris Agreement. A just transition to clean RE and EE at an accelerated pace is necessary to achieve these targets, for which a strong enabling environment supported by adequate finance, technology, and human capacities are essential.

Strengthening green skill development and technical and vocational education is vital for an energy transition which will lead to the creation and sustaining of employment options. This research aims to identify the short- and medium-term job and skill demands for Sri Lanka's energy transition as well as requirements for the institutional and enabling environment to facilitate development of these skills. Furthermore, it will focus on youth as a key stakeholder group that should be equipped with the necessary skills to contribute to a just transition in the energy sector and a climate-friendly transformation of Sri Lanka's economy. The research also aims to identify and incorporate gender considerations and other cross-cutting challenges for a just energy transition.

Overall, the research aims to answer the following guiding questions:

1. Who are the key stakeholders, policies, and regulations for an effective and sustainable RE transition in Sri Lanka?
2. What are key aspects to be considered for a RE transition in Sri Lanka?
3. What are good practices of other regional South Asian countries and potential lessons for Sri Lanka regarding energy-related skill development?
4. What skills will be needed in the short- (3 years) and medium-term (5-10 years) for a RE energy transition?
5. How can TVET offers be (re)oriented towards future demand in light of government policies, strategies, and commitments?
6. What will be the nature of job demand and job profiles in the short- (3 years) and medium-term (5-10) for a just energy transition?
7. What are recommendations for short- and medium-term measures and courses to satisfy the identified demand?

2. Methodology

To achieve the main objectives of this research, the following methodological framework has been used to obtain and analyze data through a process with multi-stakeholder involvement:

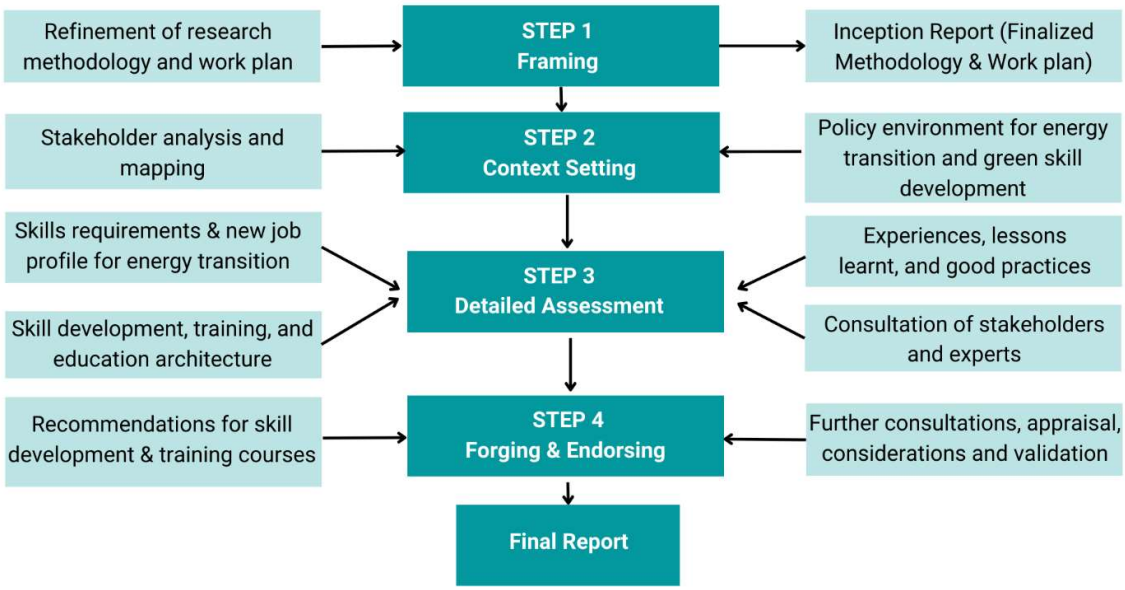

Figure 1: Overarching methodological framework of the research

In particular, the development of courses for skill development related to RE needs to be based on a more comprehensive process of curriculum development framed around a set of prescribed competencies covering cognitive, functional, and attitudinal aspects that are essential for an effective, efficient, and just energy transition.

2.1. Research activities

Under this overarching framework outlined in Figure 1, the following research activities were conducted according to a workplan that was agreed-upon between SLYCAN Trust and GIZ:

- **Desk research:** Initial desk research was carried out to identify key stakeholders and obtain detailed public domain information on these actors, relevant policies, and regulations as well as existing and future plans.
- **Structured questionnaire-based survey:** Structured questionnaires were developed for the identified stakeholder groups to obtain the detailed information on areas such as existing and future plans as well as their alignment with the requirements for a RE transition, human resource development, and related stakeholder expectations. The information received was tabulated and analysed to obtain relevant information such as future job demand, current TVET opportunities, and needs and gaps to adjust courses and curriculums.
- **Key informant interviews (KIIs):** Key informant interviews were carried out physically and virtually to cover in-depth details on the information received from the structured survey.
- **Stakeholder consultations and workshops:** Several workshops with key stakeholders and a larger stakeholder consultation were conducted to verify, validate, and expand upon the information obtained through the desk research, survey, and KIIs. The meetings also served

as focus group discussions where actors were able to provide additional inputs and feedback on draft versions of the study.

The following activities and events were conducted as part of this research in the period between May 2022 and February 2023:

Table 1: Research activities conducted 2022-2023

Category	Timeframe	Activities	Stakeholders engaged
Desk research	May-Jul 2022	Literature survey	-
	May-Aug 2022	Policy and legal analysis	-
Survey and KIIs	May-Sep 2022	Policymakers and regulatory bodies	80
		Education and training service providers	
		Energy sector stakeholders	
		Development agencies and civil society	
		Research organizations and academia	
Events and other activities	21.06.2022	Launch workshop	29
	16.08.2022	Inception workshop	9
	20.09.2022	First mid-term workshop	12
	20.10.2022	Second mid-term workshop	8
	06.12.2022	TVET stakeholder consultation	33
	24.02.2023	Validation meeting with GIZ, SLSEA and TVEC	13

A full list of engaged stakeholders through the survey, KIIs, and the consultation can be found in Annex I: Full list of engaged stakeholders.

3. The enabling environment for TVET and a just energy transition

3.1. Sri Lanka's renewable energy sector

Sri Lanka's energy sector is characterized by the utilization of both indigenous RE resources and imported fossil fuels for the generation of thermal energy and electricity to fulfil demand in the domestic, commercial, industrial, and transport sectors. RE resources harnessed at commercial level include biomass, hydro, solar, and wind, while fossil fuels comprise petroleum and coal.

Traditionally, the country's main sources of energy supply were renewables, namely biomass (for thermal energy applications) and large hydro (for electricity generation), in addition to the use of petroleum fuel for transport. However, the relatively high share of RE in the country's primary energy portfolio has been progressively reduced, as the majority of hydropower potential has already been harnessed and fossil fuels have increasingly been used to meet the growing demand for all forms of energy.[1] The main electricity generation plants are operated by the government-owned Ceylon Electricity Board (CEB) while private sector organizations supply electricity to the CEB for resale, for example, the Independent Power Producers (IPPs) using petroleum and the Small Power Producers (SPPs) producing power using renewable technologies.

Sri Lanka's primary energy supply has increased from 369 PJ in the year 2000 (50.7% biomass, 41.5% petroleum, 7.7% large hydro, 0.1% new RE) to 509 PJ in the year 2019 (33.2% biomass, 43.9% petroleum, 11.5% coal, 7.5% large hydro, 3.9% new RE), as illustrated in Figure 2.[2] Salient features here include the decline of conventional biomass, increased use of petroleum oil, entrance of coal into the energy sector as a key source of electricity generation, and the emergence of new RE (small hydro, solar, wind, and modern biomass).

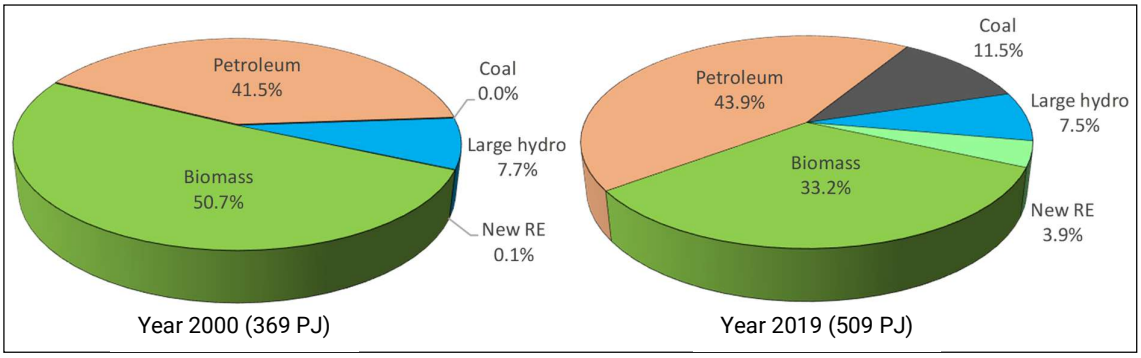

Figure 2: Evolution of energy supply sources in Sri Lanka

The progression of new RE could be primarily attributed to the establishment of the Sri Lanka Sustainable Energy Authority (SLSEA) in 2007 as well as subsequent regulatory interventions together with the provision of facilitation and guidance for project development. Figure 3 presents the capacity addition and number of SPPs. Further to SPPs, a significant contribution for new RE sector has emerged with the accelerated development of solar PV rooftop systems and the launch

[1] (Government of Sri Lanka, 2019)
[2] (SLSEA, 2021)

of the national development programme "Battle for Solar Energy." By July 2022, there are 45,456 systems installed in domestic, commercial, and industrial establishments with a total capacity of 652 MW. There are about 470 local private sector companies employing 8,000 staff in the business, signifying the broader socio-economic benefits of this sector.[3]

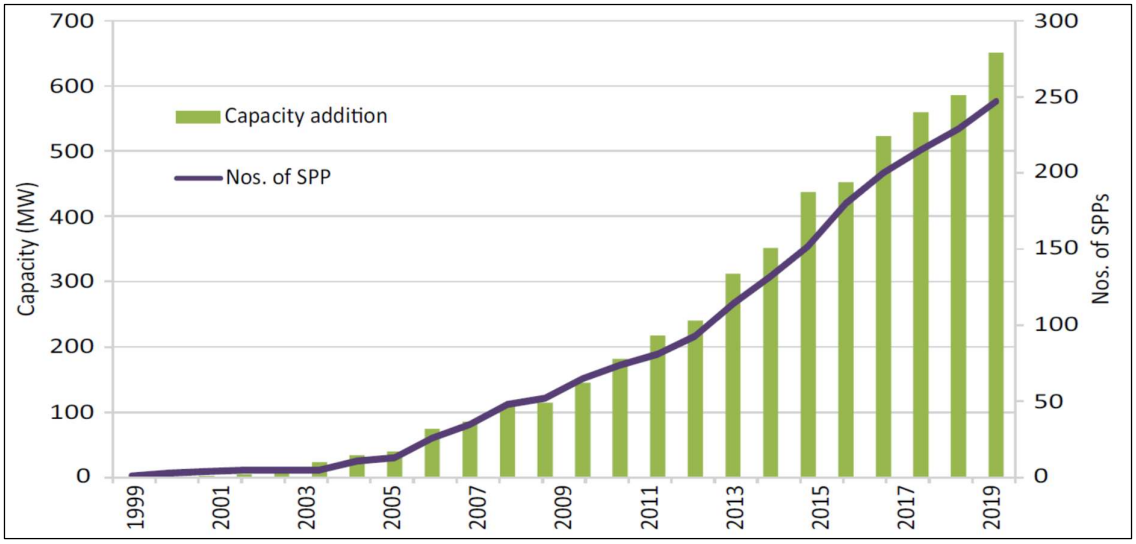

Figure 3: Cumulative capacity additions of new RE and number of SPPs

Key end-use energy sectors include households, commercial, industry, and transport. Sectoral energy demand has increased from 302.5 PJ in 2000 (23.2% industry, 23.4% transport, 53.4% household, commercial, and others) to 395.6 PJ in 2019 (28.2% industry, 35.2% transport, 36.6% household, commercial, and others).[4] Annual average energy demand growth during this period has been about 1.4% while the transport sector saw a growth rate of 3.6%. This indicates the importance of this sector, particularly due to its impact on the economy with the steady increase of petroleum products importation. Presently, the transport sector does not use renewables as an energy source, except for the very limited usage of electric vehicles (EVs) of about 8,200 (5,000 cars and 3,100 two-wheelers) with an RE component through grid electricity as well as solar PV charging at individual user level. In the domestic, commercial, and industrial sectors, the major component of thermal energy is generated through conventional biomass, which can be considered a RE source except for cases with unsustainable extractions.

The Government of Sri Lanka (GoSL) has recognized the important role of the energy sector for national socio-economic development as well as its contributions to collective global actions under processes related to climate change as well as sustainable development (SD). To this end, efforts for development and deployment of REs are emphasised in several national policies and action plans, including the recently updated Nationally Determined Contributions (NDCs) of Sri Lanka, through which the country has pledged to achieve a 70% RE target in grid electricity by 2030 and a net-zero carbon energy sector by 2050. Among examples of efforts to work towards these goals are the initiatives for an accelerated development of RE, primarily through the installation of solar and wind with a total installed capacity of about 1,000 MW in 2022 to 8,775 MW by 2030,[5] which requires a compound annual average growth rate of over 30% during the next eight years.

[3] (SLSEA, 2022)
[4] (SLSEA, 2021)
[5] (SLSEA, 2022)

Though the estimated solar and wind energy potentials in the country far exceed these requirements (26,639 MW potential for ground-mounted solar PV, 2,415 MW for floating solar, 9,910 MW for onshore wind, and 92,000 MW for offshore wind),[6] upscaling renewables requires a transformational change in the energy sector that is currently shaped by a fossil-fuel dominant economy, as presented briefly in the following section.

3.2. Key needs for Sri Lanka's energy transition

Although significant progress is evident, including 100% access to grid electricity, Sri Lanka's energy sector faces many challenges in contributing to socio-economic development in the country, which is essentially linked to global commitments such as the 2030 Agenda for SD and the Paris Agreement on Climate Change. In particular, future development pathways that focus on replacement of fossil fuels with RE resources demand for significant systemic and structural changes in the energy sector.

Although the country is blessed with ample amount of diverse RE sources (mainly solar, wind, hydro, and biomass), the level of RE deployment required to achieve sector targets is prohibitively challenging, even with the availability of commercialised technologies (particularly solar PV and wind, which are expected to contribute to the major share towards reaching the target). Gaps and needs that must be addressed to overcome these challenges could be identified under a number of broader categories, including policies and regulations, institutions and governance, economy and finance, research and technology, and data and information.

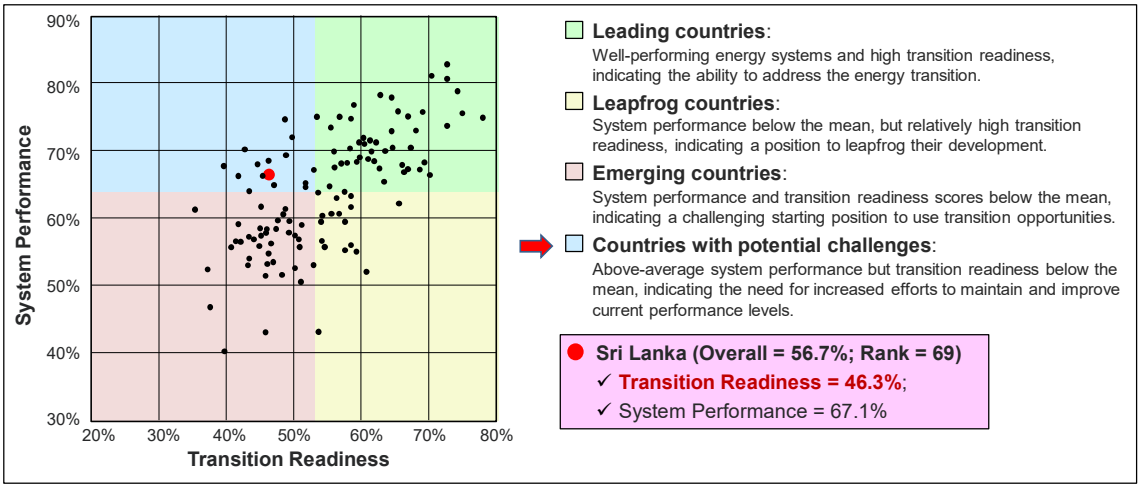

Figure 4: Energy Transition Index 2021 performance of Sri Lanka

In fact, some global indicators, such as the Energy Transition Index 2021 of the World Economic Forum[7] and the Global Entrepreneurship Index,[8] signify the lack of a country's capacity for technology transfer and adoption in the RE sector. For example, Figure 4 presents the Energy Transition Index performance of Sri Lanka in comparison with other countries. This appraisal is based on a set of indices under two main criteria, namely system performance and transition readiness. In the overall assessment, though the system performance of Sri Lanka is graded at a

[6] (SLSEA, 2021)
[7] (World Economic Forum, 2021)
[8] (GEDI, 2019)

higher level, the country's transition readiness is below the mean, indicating the need for increased efforts to maintain and improve current performance levels.

Further, more in-depth appraisals of Sri Lanka's transition readiness under the Energy Transition Index 2021 indicate gaps in several areas, as illustrated in Figure 5 (with vertical bars showing the global averages). Sub-indices in transition readiness, in general, show lower performances than those in system performance, with the lowest score for human capital and consumer participation (28.16%), followed by institutions and governance (33.05%). This signifies a need for awareness creation, knowledge transfer, and skill development to support the country's energy transition.

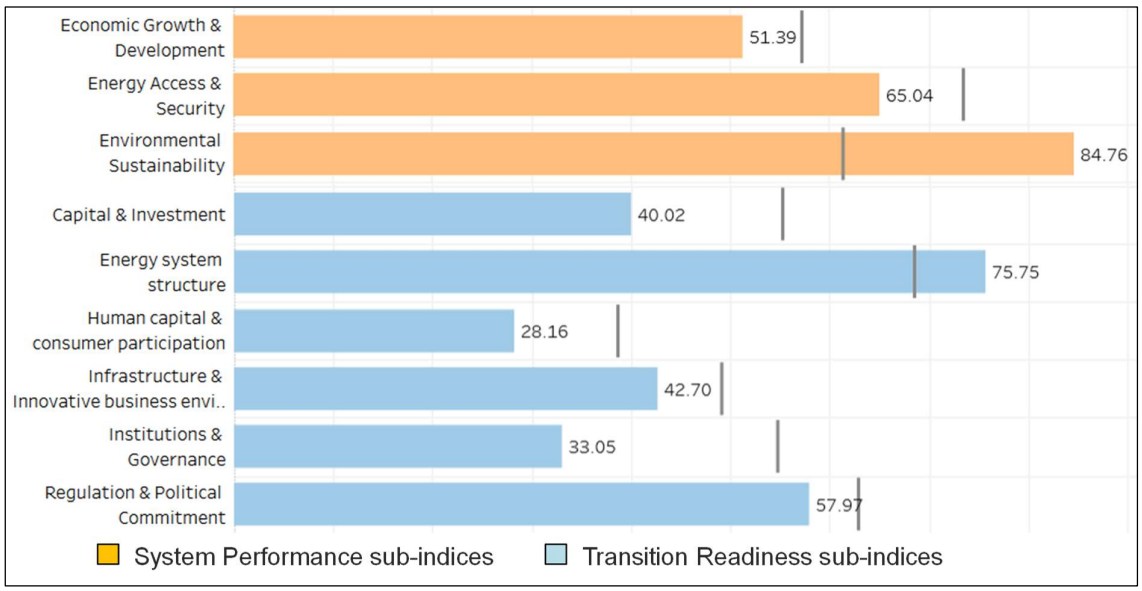

Figure 5: Energy Transition Index 2021 performance of Sri Lanka under different sub-indices

The anticipated energy transition fundamentally dependents on three main aspects: competent actors, learning organizations, and knowledgeable people. Therefore, education in a broader context is essential for creating a conducive environment for a successful energy transition. In the local context, though competencies related to knowledge are demonstrated, those related to skills are perceived to have deficiencies. The next section of this report is devoted to present an overview of technical and vocational education and training (TVET) in relation to the overall education system in Sri Lanka.

3.3. TVET education in Sri Lanka

Sri Lanka has achieved significant progress in education compared to many other developing countries, as signified by basic education indicators. The base for this is the government policy of providing free education from the primary stage to the first degree level of university education. At present, education is compulsory up to 14 years. Those who successfully complete the GCE-A/L are eligible to join universities or tertiary institutes for higher education, while those who leave schools have opportunities in vocational training. Accordingly, the different stages of education can be classified as follows:[9]

[9] (Sugathapala & Visvanathan, 2017)

- Early childhood care and education
- General education (school education)
- Tertiary and university education
- Technical and vocational education

The general organization structure of the education system in Sri Lanka is presented in Figure 6 below:

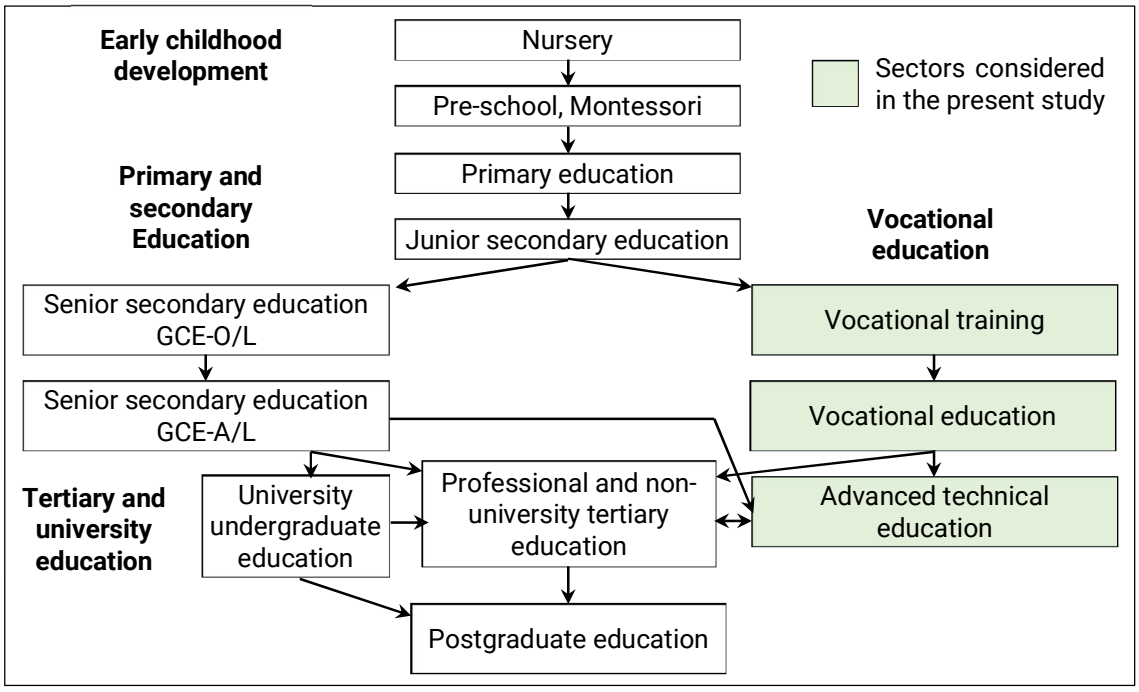

Figure 6: Organization structure of Sri Lanka's education system

The schools administered by the Ministry of Education of the central government are designated as national schools while schools administered by the provincial councils are designated as provincial schools. At the higher education level, the University Grants Commission, under the Minister of Higher Education, is the primary university administrator responsible for allocating funds, maintaining academic standards, and regulating university admissions. The number of degree-awarding institutes includes 23 universities and 28 institutes. This ministry also oversees number of technical and vocational degree and higher diploma awarding institutes. In the technical education and skill development, institutes or training colleges are overseen by several institutions under the Ministry of Skills Development, Employment, and Labour Relations. The Department of Technical Education and Training, the Vocational Training Authority, and the Tertiary and Vocational Education Commission are among the institutions under this ministry. More details of the vocational and technical education with levels of qualifications and qualification upgrading pathways are presented in the following sub-section.

3.3.1. Vocational and technical education

Vocational and technical education in Sri Lanka commenced with the establishment of the Government Technical College in 1893 in Maradana, which had the initial objective of training the blue-collar personnel performing manual labour to run the railways and tea factories. This sector of education in Sri Lanka was neglected for many years, having many institutions involved. However, there have been several initiatives and sectoral changes in the recent past to improve this situation. There is a much improved overall institutional structure, governance management,

particularly with the introduction of the National Vocational Qualifications Framework (NVQF). The NVQF consists of seven levels of instruction in three categories of professions at certificate, diploma, and degree levels, as presented in Table 2 below.[10]

Table 2: NVQ structure in Sri Lanka

NVQ Level	Qualification awarded	Level descriptor
NVQ 1	National Certificate	Level 1 recognizes entry-level skills.
NVQ 2–NVQ 4	National Certificate	Levels 2, 3, and 4 recognize increasing levels of competencies. Level 4 is at full craftsmanship.
NVQ 5–NVQ 6	National Certificate / National Diploma	Levels 5 and 6 certificates recognize the increasing levels of competencies of technicians including supervision and process management at narrow aspects of competencies with higher depth of knowledge of a specific field of work or study. Level 5 and 6 diplomas recognize increasing levels of competencies of technicians including supervision and process management in a wider range of concepts of a particular sector.
NVQ 7	Degree	Level 7 recognizes vocational and technological competencies at Bachelor's degree level.

NVQF facilitates trainees to join and leave the system at different stages with qualifications at different levels. Vertical upward progression through the system is straightforward. Lateral entry into the system is allowed at certain levels for those who have work experience in an appropriate field and are assessed to have recognized prior learning. The following figure illustrates the pathways for qualification upgrading:[11]

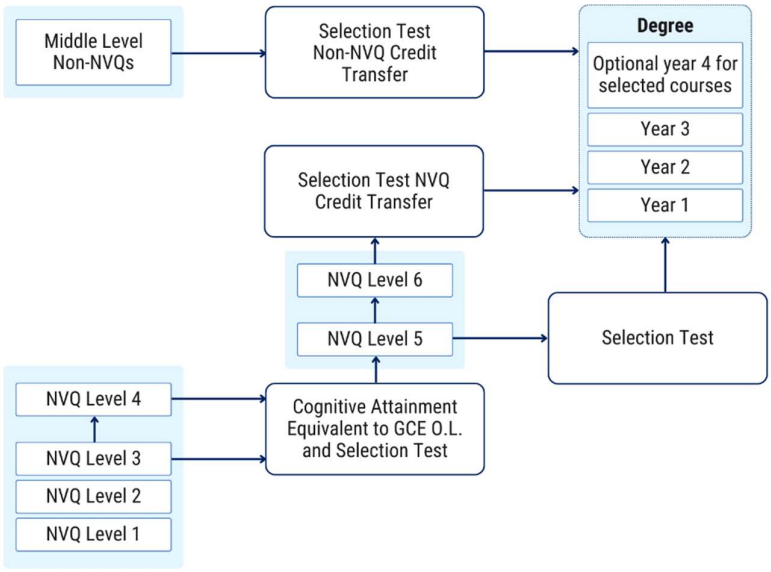

Figure 7: Pathways for qualifications upgrading in NVQF

The Ministry of Higher Education has developed the Sri Lanka Qualifications Framework (SLQF) to address the need for a comprehensive, nationally consistent, and flexible framework for all

[10] (TVEC, 2021)
[11] (TVEC, 2021)

qualifications in post-secondary education and training. The SLQF applies to all public and private sector higher education institutions and comprises twelve levels, with the first two levels (1-2) being senior secondary level education qualifications and the next four levels (3-6) undergraduate qualifications. The other six levels (7-12) are postgraduate qualifications. SLQF is comparable with NVQF in technical and vocational education, as shown in Table 3.[12]

Table 3: Comparability of SLQF and NVQF levels

SLQF level	Qualification awarded	Comparable NVQ level
12	Doctor of Philosophy/Doctor of Science/etc.	-
11	Master of Philosophy	-
10	Masters with coursework and research component	-
9	Masters with coursework	-
8	Postgraduate diploma	-
7	Postgraduate certificate	-
6	Bachelor (Hons)	-
5	Bachelor	7
4	Higher diploma	6
3	Diploma	5
2	Advanced certificate (GCE A/L or equivalent)	4
1	Certificate (GCE O/L or equivalent)	2/3

The SLQF developed for the tertiary/university education sector integrates the NVQF (which was developed for the technical/vocational education sector) and identifies flexible pathways to assist lateral mobility between the two sectors by providing basis for recognizing prior learning and credit transfer. Further, as all engineering faculties in the country offer technical diploma and certificate courses at different levels and fields, the inclusion of technical and vocational qualification levels within SLQF in addition to the undergraduate and postgraduate degree programmes ensure the clarity of different qualifications.

Although the institutional mechanism and infrastructure facilities for delivery of technical and vocational education are in place, there are issues on effective delivery, mainly due to lack of properly trained staff in the relevant trade fields and exposure to new and emerging subject areas such as RE. Therefore, the incorporation of RE-related topics into the curriculum is still not evident. However, this situation is improving, and major curriculum revisions are being introduced, especially at higher diploma and degree levels. For example, the University of Vocational Technology (UNIVOTEC) and technology faculties of several government universities offer Bachelor of Technology (BTech) degrees in several fields of specializations.

However, RE education and training at technical levels are not yet adequate to cater for the competencies demanded by the energy transition, particularly for the upscaling of REs, which are characterized by new and emerging processes, technologies, and management systems. Thus, a comprehensive strategy is required to formulate an education and training roadmap and programme of activities for the TVET sector, as well as to develop competencies and skills for workforce reorientation and enhanced human and institutional capacities.

3.4. Key institutions and stakeholders

[12] (Government of Sri Lanka, 2015)

The following five main stakeholder groups were identified as the most relevant for energy sector TVET and an effective, sustainable, and just energy transition in Sri Lanka:

Table 4: Key stakeholder groups for energy sector TVET in Sri Lanka

Stakeholder group	Breakdown
Policymakers and regulatory bodies	▪ Ministries and key departments for education and energy *Ministry in charge of Technical Education, Ministry of Labour, DTET*
	▪ Regulatory bodies *SLSEA, PUCSL, VTA, TVEC*
	▪ Other relevant government institutions
Education and training service providers	▪ Public and private sector institutions *SLSEA, TVEC, GLIDE (Pvt) Ltd., David Pieris Motor (Pvt) Ltd., NCPC, ETMA Campus, DTET, VTA, Lalith Athulathmudali Vocational Training Centre, NERDC, SLEMA, NCPC*
	▪ Education specialists, curriculum developers, delivery actors/lecturers *Government and private sector universities, CGTTI, SLGTI, Jaffna College of Technology, Rec Solar (Pvt) Ltd., UNIVOTEC, NERDC*
Energy sector	▪ Public and private sector institutions *PUCSL, CEB, SLAEB, LTL Holdings, David Pieris Motor (Pvt) Ltd., Industrial Services Bureau*
	▪ Energy producers, energy equipment and service providers *Central Engineering Consultancy Bureau (CECB), SEWIN Exergy Solutions (Pvt) Ltd., Eco Steam (Pvt) Ltd., Enricher Holdings, Access Solar, Hayleys Fentons, Windforce PLC, Vidullanka PLC, Thrithva Energy (Pvt) Ltd., GLIDE (Pvt) Ltd., ECOsolarrays, Rec Solar (Pvt) Ltd., Super Net Technology (Pvt) Ltd., REM Solar, Smart Solar Energy and Electricals, Melwire Rolling (Pvt) Ltd., Ceynshango Lanka Renewable Provider (Pvt) Ltd., Forbes Marshall Lanka (Pvt) Ltd.*
	▪ Sector experts and professionals *Individual experts and consultants, SLEMA, Rec Solar (Pvt) Ltd., CodeGen Sustainable Solutions (Pvt) Ltd., NCPC, NERDC*
Development agencies and civil society	▪ UN entities
	▪ Multi- and bi-lateral development partners *GIZ, USAID Sri Lanka Energy Program/Chemonics International*
	▪ NGOs and civil society organizations
Research organizations and academia	▪ Research organizations *NERDC, SLEMA, NCPC, NSF*
	▪ Academia *Government and private sector universities (such as Open University of Sri Lanka, UNIVOTEC, University of Moratuwa, University of Peradeniya, University of Ruhuna, University of Kelaniya, Rajarata University of Sri Lanka, Sabaragamuwa University of Sri Lanka, Kotelawala Defense University, SLIIT, and NSBM Green University)*

The institutions and institutional arrangements presented above signify the involvement of a wide range of agencies, both government and other, in the energy and TVET sector. Both of these sectors have clear mandates that cover all key aspects from strategic level interventions (policy-making, legislation, and planning) to the operational level (implementation and monitoring).

- **Energy sector:** In case of the energy sector, ministries (including state ministries) in charge of the subjects of power and energy, together with their line agencies, are responsible for developing policies, regulations, and strategies, covering both fossil fuels and RE resources, assisted by other ministries in charge of related areas such as environment, infrastructure

development, financing, land resources, and water. More details of the policy and regulatory landscape are presented in the next section. At operational level, a sound institutional arrangement is perceived as well, with PUCSL as the sector regulator with a strong mandate and involvement in the electricity sector in particular. Though a monopoly, CEB has been successful in implementing power generation (together with the private sector), transmission (sole authority), and distribution (together with LECO) projects to cater of the electricity demand of the entire country through a single national grid. Renewable energy development and deployment are well-covered by the mandates of SLSEA, where project approval is done through formal involvement of all relevant government entities ad authorities, including local government, signifying a sound engagement of stakeholder institutions.

- **TVET sector:** In case of the TVET sector, there is a well-structured hierarchical system as well, with standards, curriculum development, quality assurance, characterized by a multitude of agencies including training providers of public and private sectors. Presently, the Ministry of Education and its State Ministry take the responsibility of policy formulation, planning, quality assurance, coordination, and the development of tertiary and vocational education. Yet, governance (and financing) in the TVET sector suffers from a number of factors, including limited involvement of the private sector in skills development; limited flexibility for public institutions to revise and update standards, curricula, and training courses; shortage of qualified instructors, especially those with industry experience; inadequate responsiveness to labour market demands; and negative perception of TVET (including views that training is associated with manual labour and that TVET programmes do not provide upward social and educational mobility).[13]

However, interactions between the energy and TVET sectors are limited, which has led to gaps in the development of competencies for technical staff for the national energy transition. The present training programmes and curricula, in general, do not adequately respond to the emerging labour market demand in the energy sector, and therefore, more effective communication between the two sector is required with necessary reforms in institutional coordination mechanisms.

It is also important to look at related sectors and institutional structures that will govern the process of a just energy transition, such as those related to social protection, youth, and women. In particular, gender-responsive processes and training opportunities are vital, as the participation of women in areas related to RE is currently limited in terms of numbers and participation in technical roles. For example, in the solar energy sector, the majority of field work is carried out by men, and women are often relegated to marketing or sales roles in solar service provider companies. Providing training and capacity-building opportunities o women, particularly those in rural areas, could therefore add great value and allow them to engage in the RE transition either independently on the household level or through formal employment and workforce participation.

One example of an existing programme is the "Rivi balayata liya saviya" programme (Strengthening women through solar power) conducted by SLSEA, which aims to address knowledge gaps in solar PV installations of employees of solar service provider companies. It includes a mix of site visits, practical sessions, and on-site installations delivered through experts in the sector and aims specifically to empower the women workforce.[14]

The following figure visualizes the key entities and institutions that were mapped as some of the most critical actors for TVET and energy transition in Sri Lanka:

[13] (UNEVOC & UNESCO, 2018)
[14] Information shared by SLSEA.

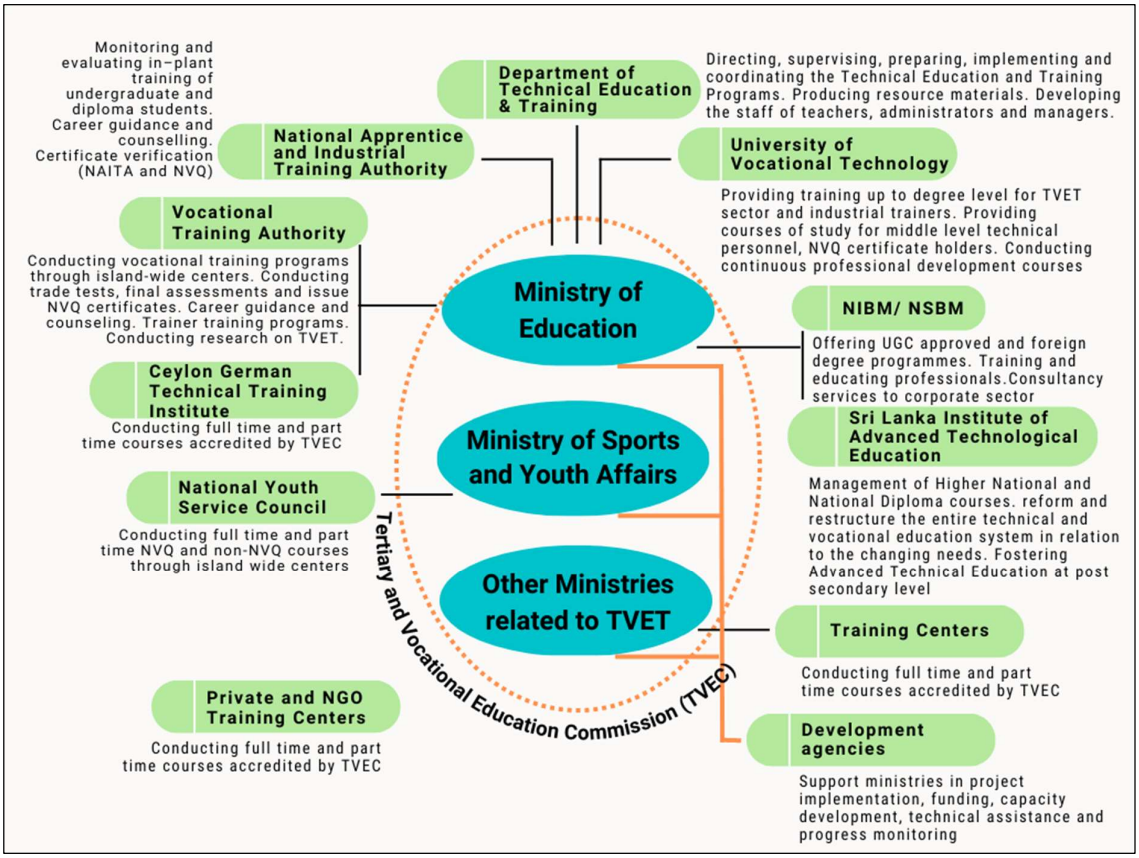

Figure 8: Institutional framework of Sri Lanka's TVET sector

3.5. Policy and regulatory landscape

The above-mentioned stakeholders operate within a complex enabling environment that includes laws and regulations, policies, strategies, and plans that guide overall national development, the functioning of the energy and education sectors, and the implementation of TVET in Sri Lanka.

The following section provides an overview of the policy and regulatory landscape as well as concrete implementation measures related to a RE transition and TVET that have already been implemented or are currently in the process of implementation.

3.5.1. Laws, policies, strategies, and cabinet decisions

Table 5 below presents an overview of relevant laws, policies, and strategies on TVET in Sri Lanka. Key acts and policies in this regard include the Tertiary and Vocational Education Act, the Tertiary and Vocational Education Policy, the National Science, Technology, and Innovation Policy, and the National Vocational Qualifications Framework of Sri Lanka and Operations Manual.

Table 5: Key legislation, policies, and strategies for TVET in Sri Lanka

Law/policy/strategy	Description
Tertiary and Vocational Education Act No. 20 of 1990	▪ Establishes the Tertiary and Vocational Education Commission and the National Apprentice and Industrial Training Authority, including their objectives, powers, mandate, and organizational structure.

	▪ Contains provisions for the registration of institutions, courses, examinations, awarding of degrees, qualifications of trainees, nature of training, and formulation of National Trade Tests.
Science and Technology Development Act No. 11 of 1994	▪ Establishes the National Science and Technology Commission, the National Science Foundation, the Council for Information Technology, the Industrial Technology Institute, and the Arthur C. Clarke Institute for Modern Technologies, including their objectives, powers, mandate, and organizational structure.
Sri Lanka Institute of Advanced Technological Education Act No. 29 of 1995 (amended 2006)	▪ Establishes the Sri Lanka Institute of Advanced Technical Education, including its objectives, powers, mandate, and organizational structure.
University of Vocational Technology Act No. 31 of 2008	▪ Establishes the University of Vocational Technology, including its objectives, powers, mandate, and organizational structure.
TVET Policy No. 80 of 2008 National Strategy on TVET Provision for Vulnerable People in Sri Lanka Strategies and Action Plans 2010	▪ Contains provisions for promoting training for vulnerable people and providing financial assistance to training institutions that deliver training for vulnerable people.
Sri Lanka Energy Sector Development Plan for a Knowledge-Based Economy 2015-2025	▪ Aims to facilitate the formulation of an Integrated National Energy Policy and a cleaner future through green energy. ▪ Contains provisions related to conservation and efficient use of energy, investments into energy infrastructure, innovative financing for a diverse energy sector, and investment in R&D.
Tertiary and Vocational Education Policy 2016	▪ Aims to identify training needs based on labour market analysis through the establishment of a Labour Market Advisory and Coordinating Committee. ▪ Contains provisions related to TVET teacher and trainer training and selection processes, annual training targets, mitigation of dropout rate, reduction of unemployment of TVET dropouts, and TVET delivery process.
Implementation Strategies of National Research and Development Framework (2016-2020)	▪ Under focus area 6 (energy), contains provisions on development and training related to RE technologies, including biomass, biofuels, solar air heaters, solar dryers, and biomass dryers. ▪ Aims to research development of technologies for biogas generation from biodegradable waste and adaptation of already developed technologies; assess indigenous energy resources; develop policy interventions for a RE roadmap with long-term targets and criteria and indicators for application of RET; and develop RET for electricity generation, including local design and manufacture of small hydro, wind turbine blades, solar PV, biomass systems (including gasifiers and microturbines), waste-to-energy, and other system components including inverters.

	▪ Establishes standards, testing protocols, facilities, and MRV systems for RE systems including low-head SHP, solar PV, wind turbines, and biomass power. ▪ Contains provisions to support innovation-driven start-ups and spinoff companies and conduct competitions on innovative processes and technologies.
Ceylon German Technical Training Institute Act No. 15 Of 2017	▪ Establishes the Ceylon German Technical Training Institute, including its objectives, powers, mandate, and organizational structure.
National Science and Technology Policy 2008 National Science, Technology, and Innovation Policy Draft 2018	▪ Aims to ensure opportunities for all segments of the population for vocational and tertiary education in science and technology and strengthen TVET. ▪ Contains provisions to provide TVET programmes in the relevant languages and enhance financial assistance schemes specifically for economically disadvantaged students in post-secondary education, including vocational training.
National Education Commission National Policy on Technical and Vocational Education 2018	▪ Contains provisions related to optimal utilization of physical, financial, and human resources for TVET, rationalisation of training programmes at regional level to minimise overlaps, and interrelation among industry, employers, employees, general education, higher education, and TVET. ▪ Outlines recruitment and career progression of TVET academic and administrative staff. ▪ Contains provisions to ensure access to TVET for vulnerable and disadvantaged people as well as career guidance.
National Vocational Qualification Circulars (2018-2022) ▪ *NVQ Circular 01 and 03/2022* ▪ *NVQ Circular 02/2022, 01/2021 and 01/2019* ▪ *NVQ Circular 02/2021* ▪ *NVQ Circular 03/2021* ▪ *NVQ Circular 04/2021* ▪ *NVQ Circular 04/2021, 02/2019 and 06/2019* ▪ *NVQ Circular 01/2020* ▪ *NVQ Circular 01/2018*	▪ Awarding of NVQ level 6 equivalence status for the Higher National Diploma in Management (HNDM) and Higher National Diploma in Accounting (HNDA) courses conducted by Sri Lanka Institute of Advanced Technological Education (SLIATE) ▪ Mature candidates' route to award NVQ Level 5 equivalent qualification for ▪ Craftsmen/Trainers with long years of experience (Teaching/training industry) ▪ Implementing e-Recognition of Prior Learning (RPL) System ▪ Equivalence of Advanced Diploma in ▪ Manufacturing Management conducted by National Institute of Business Management (NIBM) program into NVQ level 5 ▪ Compulsory training for teachers/instructors as a requirement of course accreditation ▪ Mapping/evaluation of non-NVQ qualifications to NVQ qualifications at Levels 5 and 6 ▪ Reasonable adjustments in NVQ assessment for candidates with disabilities. ▪ Assessment/Examination Procedure
National Energy Policy and Strategies of Sri Lanka	▪ Aims to assure energy security, provide access to energy services at optimum cost, improve EE and energy conservation, enhance national energy self-reliance, environmental protection, and share of RE, and provide opportunities for innovation and entrepreneurship.

National Education Policy Framework 2020-2030	▪ Contains provisions related to resourceful career guidance and counselling programmes for prospective trainees for TVET programmes; financial and logistical support; inclusiveness; promotion of female participation; recognition of pre- vocational achievements and qualifications earned from general education as entry qualifications; and enhancement of social image of TVET institutions. ▪ Contains provisions to review and revise the National Vocational Qualification Framework; enhance CBT curricula development; and work with industry on the design, development, and delivery of TVET. ▪ Aims to rationalize and strengthen the TVET centre network and review and expand apprenticeship training programmes, including through public-private training centre partnerships, pre-employment training for youth, livelihood training skills, and promotion of entrepreneurship. ▪ Contains provisions related to quality assurance in design, development, delivery, and assessment of TVET programmes and the review of human resource development, management, and capacity-building systems. ▪ Aims to ensure provision of adequate funding for TVET institutions and to empower TVET regulatory agencies and institutions with legislative enactments which are reviewed and updated periodically.
National Vocational Qualifications Framework of Sri Lanka and Operations Manual 2021	▪ Establishes National Competency Standards and contains provisions related to policy development and planning, certification, accreditation, CBT, assessment, awarding of NVQs, and National Competency Standards for 2030, particularly NVQ 5 and NVQ 6.
TVEC Corporate Plan 2022-2026	▪ Contains provisions related to the TVET system, the role of stakeholders, annual implementation plan, a national strategy to develop the TVET sector, and implementation goals for the TVEC.
TVEC Citizens'/Clients' Charter 2022	▪ Contains provisions related to the commitments and obligations of TVEC, issuing and attestation of NVQ certificates, endorsing National Competency Standards, registration of training institutions, accreditation of courses, quality management at TVET institutions, preparation and publication of Labour Market Information bulletin, and a TVET guide with course information.

In addition to the laws, policies, strategies, and plans listed above, there are also several recent cabinet decisions that pertain directly to TVET and/or the energy sector in Sri Lanka, as well as relevant projects and initiatives, which can be found in Annex II: Cabinet decisions on TVET and Annex III: List of relevant projects and initiatives in Sri Lanka, respectively.

3.5.2. Policy and regulatory environment for EVs

Further to the brief information provided on EVs under the national strategies and policies presented in the table above, this section is devoted to providing more details on the policy and regulatory environment for electric mobility in Sri Lanka and the key programmes initiated recently.

During the several years, the government has taken policy interventions related to electric mobility in general, and EVs (road) in particular. In fact, due to tax and import duty concessions introduced since 2010, EVs and hybrid vehicles have taken a notable space in the active fleet. Although there has been remarkable market penetration of hybrid vehicles, EVs still accounts for less than 1% as of 2022 while hybrid cars account for 25% of the registered cars. Although EVs received a better preferential taxation, the market peaked around 2015 and then rapidly declined (see Figure 9).[15] Presently, there are about 8,200 EVs, which include about 5,000 electric cars and 3.000 electric two-wheelers (E2Ws). The number of electric three-wheelers (E3Ws) registered in the country is insignificant (about 35) due to the low level of technology commercialization. However, technological developments are being made by private sector for converting internal combustion engine (ICE) three-wheelers and two-wheelers to electric, as well as new E3W/E2W designs due to the high market share.

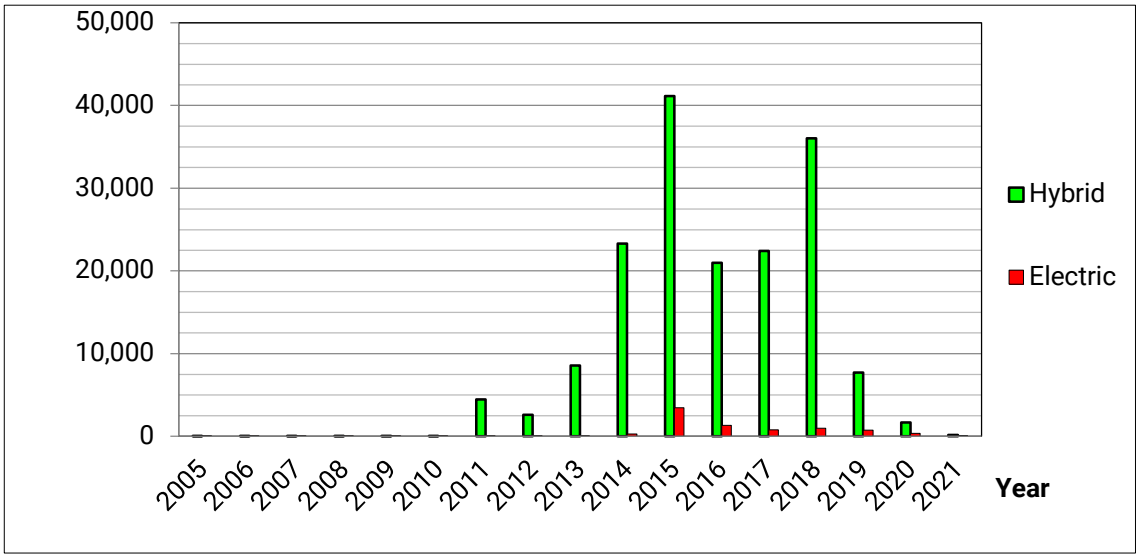

Figure 9: Number of first registration of EVs and hybrid vehicles

There are about 60 fast charging stations in Sri Lanka, mostly in Colombo and in a few other major cities. Seven of these are operated by the CEB and others are operated by private sector organizations. The two government entities, CEB and SLSEA are planning to install about 15 charging stations. However, there are no plans from the private sector to expand the network due to the lack of new EVs and the unviability of the existing fleet. Many previously functioning charging stations have either shut down or are functioning at a loss currently. Nevertheless, some local developers of charging stations have started exporting their products to neighbouring countries, having markets with more commercial potential.

As shown in Figure 9 above, the present situation of Sri Lanka's EV market remains unsatisfactory, and growth is stagnant or even retracted. There are several barriers that continue to hinder EV uptake despite the initial supportive incentives. The investment in charging infrastructure too has not grown and has become a retardant to the growth of EV segments. One of the key barriers for the deployment of EVs could be attributed to the lack of coherent policy and regulatory framework and coordination amongst policy makers in electric-mobility sector, which increases the policy

[15] Department of Motor Traffic (2022). Internal records (Unpublished data), May 2022.

risks of the investors and financing entities. The country currently lacks a specific policy framework or strategy for EVs.

The key government entities related to electric mobility include the Ministry of Transport, the Ministry of Environment, the Ministry of Power and Energy, the Department of Motor Traffic (DMT), the Central Environmental Authority (CEA), SLSEA, CEB, and PUCSL, among others. In the past, there were no formal coordination mechanism between these entities. The Minister of Environment has recently appointed an Inter-Ministerial Committee (IMC) for the promotion of EVs in Sri Lanka through cabinet paper 21/1182/321/010 approved by the Cabinet of Ministers on July 20, 2021. The IMC comprises representatives from the ministries of Environment, Power, Energy, Transport, Industry and Finance to develop a strategy for EV adoption and promotion. This committee was empowered to develop a strategic plan with the assistance of a Technical Evaluation Committee (TEC). Although this IMC has been dissolved, a three-year project under the GEF7 grant titled "Sustainable and Efficient Electric Mobility System in Sri Lanka" has been launched, with effect from the year 2023, which includes series of activities to address the policy and institutional gaps. In particular, the first component of the project will result in the government adopting a long-term strategy (LTS) and medium-term action plan (MAP) for e-mobility and operationalizing an institutional coordination framework to implement the LTS and MAP as well as steer e-mobility investments.

In November 2019, the Asia LEDS Partnership in coordination with the Ministry of Transport and with the support from the Swiss Agency for Development and Cooperation published a study report titled "Framework for Developing an Electric Mobility Policy, Sri Lanka." The tentative roadmap proposed in the study is as follows:

- Stage 1: Awareness generation (creating awareness related to EVs among citizens and other stakeholders)
- Stage 2: Capacity-building (consultations, discussions, and workshops for stakeholders for capacity building and suggestions, low-cost training programs for EV repairs for improving employment opportunities)
- Stage 3: Promotion of EVs (tax incentives and other incentives to promote EVs)
- Stage 4: Pilot projects and scaling up (initiation of pilot projects and gradual scaling up of the project to help in receiving concurrence from stakeholders of other areas in the city)
- Stage 5: Analysis and documentation (development and documentation of learnings, success and failure)
- Stage 6: Policy and regulatory framework (required to have a legal backing for promoting electric mobility)

The following table presents the recent electric mobility projects initiated in the country:

Table 6: Recent electric mobility projects in Sri Lanka

Project	Institution	Status
Introduction of 50 electric busses	Sri Lanka Transport Board (SLTB)	The electric bus programme initiated with the involvement of the Ministry of Transport in the 2018 budget has been aborted due to very high initial costs / lack of financial resources. The Ministry has now prioritized importation of luxury ICE buses over EVs.
Establishment of public EV charging stations	CEB and LECO	At least 25 new public EV charging stations with DC rapid charging capability will be established at strategic locations by the CEB and LECO by 2020. Presently, the number of charging stations operated by CEB is seven, with five more stations

		planned to be installed. More recently, SLSEA has developed a plan to introduce ten charging stations powered by solar PV. This project is still in the planning stage.
Conversion of two-stroke three-wheelers to electric	Ministry of Environment	This initiative did not move ahead due to several factors raised by several government authorities involved. The concerns were that two-stroke three-wheelers are too old and will become obsolete quickly; that the conversion cost will be considerably higher than the value of the vehicle itself; that the chassis of the vehicle is too old and not strong enough to accommodate the modifications required in conversion; and that this does not align with the government's long-term vision of phasing out two-stroke three-wheelers.
Feasibility assessment for sustainable transportation solutions	Global Green Growth Institute (GGGI)	GGGI will aid in assessing financially and technologically feasible sustainable transportation solutions including electric buses and develop an inclusive electric mobility strategy and investment plan for selected secondary cities. GGGI will work on five selected corridors in Colombo for this purpose.
Anuradhapura Integrated Urban Development Project (AIUDP) 2017-2023 GEF7 electric mobility project 2023-2025	Urban Development Authority and French Agency for Development	This project is jointly funded by the GoSL and a loan facility from the French Government to improve Anuradhapura city as a provincial capital that sustains tourism, commercial and residential activities. One objective of the project is improving urban mobility, including access, circulation, and traffic management. The GEF7-electric mobility project will build on this initiative to integrate EVs in the objective 2. There will be 10 EV charging stations (solar PV integrated), 40 E2Ws, 100 E3Ws, and 140 e-bikes,
Conversion of ICE 3Ws to electric	UNDP	UNDP in collaboration with Ministry of Environment has launched a pilot project to convert 300 ICE 3Ws to E3Ws, the selection of technology supplier is in progress and the selection is to be completed within January 2023.

In addition to above, there are number of private sector agencies, with the assistance of development partners, involved with development of E2Ws and E3Ws, including conversions, as listed below:

- SL Mobility: Engaged in producing/converting E2Ws and E3Ws and charging infrastructure.
- Codegen/Vega Innovation: Engaged in producing/converting E2Ws and E3Ws and charging infrastructure.
- Nevorp Motors: Provide EV battery management and recycling options.
- David Pieris Motor Company: Imports E3Ws.
- LAUGFS Holdings Limited: Engaged in testing of new/conversion of E2Ws and E3Ws.
- GOEV: Provides EV battery management and recycling options.
- ThermalR Industries: Engaged in producing E2Ws and conversion of E3Ws.

Very recently, the Ministry of Transport has taken initiative to finalize the draft National Transport Policy by incorporating policy elements related to EVs and hybrid vehicles, which will be presented

to the stakeholder agencies to get their views/comments and consent by mid-January 2023 and planned to submit to get the approval from Cabinet of Ministers at the end of January 2023.

3.6. Key elements for a RE transition

The following elements that could facilitate Sri Lanka's transition towards RE are compiled from the inputs received during the survey, KIIs, and consultations. They have been clustered into six areas:

- Policies and regulations
- Institutions and governance
- Economy and finance
- Research and technology
- Data and information
- Other

Aspects that directly relate to TVET and competency development in the context of the energy transition are marked in green; however, there are other aspects that could potentially contribute to the enabling environment or otherwise be indirectly relevant to TVET, such as private sector engagement or public awareness creation.

3.6.1. Policies and regulations

Table 7: Policy and regulatory aspects for a just transition

Aspect	Elements
Private sector engagement	▪ Facilitating private sector engagement in the energy transition, particularly for large-scale deployment of RE and RETs.
	▪ Developing new policies and business models to match customer and market requirements.
	▪ Removing barriers for entering solar energy and other RE investment projects and scaling up existing projects.
	▪ Ensuring competitive performance of public sector in project implementation and facilitating public-private partnerships.
	▪ Strengthening linkages between private and public sector through exchange of information and enhanced coordination.
Policy coherence	▪ Resolving inconsistencies in development plans of related institutions, including those indicated in the National Energy Policy and Strategies (NEP&S).
	▪ Integrating RE aspects and electrical engineering into other related policies and supplementary planning (e.g., the National Building Code).
	▪ Reviewing and updating outdated laws and regulations.
	▪ Setting specific targets for an energy transition in the NEP&S.
	▪ Identifying and addressing gaps and challenges in implementation the Long-Term Generation Expansion Plan, mainly due to ad-hoc decision-making.
Mandates and responsibilities	▪ Adequately implementing powers and duties given in the relevant Acts and enforcing existing regulations.
	▪ Transforming energy systems and the energy sector to become more decentralized.

Stakeholder engagement	▪ Expanding stakeholder engagement throughout all stages of planning and policy processes, particularly in strategizing, planning, and design of RE projects.
	▪ Utilizing comprehensive approaches from the policy level to engage all parties and stakeholders for a just energy transition.

3.6.2. Institutions and governance

Table 8: Institutional and governance aspects for a just transition

Aspect	Elements
Project implementation	▪ More private sector participation in wind and solar power projects and parks.
	▪ Identifying the applicability of the single-buyer model to the proposed business models.
	▪ Closing gaps in resource allocation process in RE sector projects that exist due to the conventional "first-come-first-serve" approach.
	▪ Streamlining project approval processes and allocating available government lands with wind or solar resources considering the available grid capacity.
	▪ Preventing undue monopolies and ensuring fair competition in RE development.
	▪ Shifting from demand-based transformer setup to a mixed approach of setting up transformers based on demand as well as the resource base.
Regulatory and policy environment	▪ Resolving inconsistencies in development plans of related institutions and those indicated in the NEP&S.
	▪ Improving enforcement and execution of institutional mandates, particularly of SLSEA.
	▪ De-bundling CEB to make it accountable for its operational performance and transparency in governance.
	▪ Enforcing the Electricity Act with separate licensees in transmission, generation, and distribution instead of considering CEB as the sole authority.
	▪ De-politicising PUCSL to make it a true regulator.
	▪ Strengthening regulations to make the utility sector more regulative, cost effective, and profit driven.
Stakeholder engagement	▪ Enhancing coordination among government institutions involved in the energy sector.
	▪ Improving coordination among decision-makers (ministries and other relevant institutions) linked with SDGs and NDCs.
	▪ Recognising and considering the broader sustainability aspects of RE in planning by CEB.
	▪ Improving mutual understanding among all stakeholders to support the anticipated energy transition as well as RE development and deployment.
	▪ Strengthening vertical and horizontal integration among all relevant stakeholders, including government institutions, private sector, academia, education providers, and civil society.
Other	▪ Investing in more pragmatic RE planning and resource allocation.
	▪ Synchronising RE development with energy efficiency.

	▪ Providing certificates to sustainable fuel and firewood suppliers.
	▪ Enhancing capacities in the management levels of government entities in RE sector

3.6.3. Economy and finance

Table 9: Economic and financial aspects for a just transition

Aspect	Elements
Private sector and public-private partnerships	▪ Involving private sector in mobilising funding and investment.
	▪ Enhancing awareness of finance personnel's in RE and just transition.
	▪ Promoting micro-financing schemes for RET deployment in MSMEs.
	▪ Utilising economy of scale to access global clean energy financing.
	▪ Building partnerships and collaborations with regional and international entities to support investment flows.
	▪ Facilitating foreign direct investment to cover the high upfront capital investments required for large-scale RE deployment.
Taxes and enabling environment	▪ Instituting tax relief for RE-related products, machinery, and components.
	▪ Prioritising provision of foreign exchange for importation of RE equipment.
	▪ Allocating finance for grid infrastructure strengthening and upgrading.
	▪ Conducing an annual review of feed-in-tariffs to adjust to the prevailing USD rates and Colombo Price Index as well as plant capacity factor.
Public benefit	▪ Educating financial institutes on how to collaborate with loans and opportunities available with international finance providers.
	▪ Ensuring the benefits of REs flow to the public/society (the owner of the resource) with appropriate feed-in tariff schemes.
	▪ Providing low-interest loans for financially capable small enterprises and domestic users to use off-grid solar systems.
	▪ Developing a feed-in-tariff system for RE projects with capacity of less than 10 MW.
Other	▪ Promoting innovative business models and market structures.
	▪ Investing in energy saving projects to cover costs based on savings on energy expenditure.

3.6.4. Research and technology

Table 10: Research and technology aspects for a just transition

Aspect	Elements
Process-related	▪ Enhancing research on optimising the utilization of RE sources.
	▪ Developing grid infrastructure for RE integration.
	▪ Strengthening R&D related to multiple portfolios of energy, covering sustainability dimensions, localization, benefits to

	rural communities, and emphasis on technology solutions for MSMEs.
Technology-related	▪ Conducting more R&D on the application level (applied research).
	▪ Conducting research on exotic technologies such as wave energy, hydrogen energy, energy storage, and smart grids.
	▪ Facilitating greater exposure to state-of-the-art technologies from developed economies to address potential challenges for large-scale deployment of anticipated RE targets.
	▪ Recognising RE technologies and resources as a public good
	▪ Promoting collaborations with regional and global research institutes.
	▪ Strengthening domestic research efforts on RETs, particularly solar and biomass technologies.
	▪ Strengthening coordination between energy agencies such as CEB, SLSEA, and educational/training institutes

3.6.5. Data and information

Table 11: Data and information aspects for a just transition

Aspect	Elements
Public awareness	▪ Enhancing public awareness on the advantages of RE and limitations for exploitation.
	▪ Ensuring public support for accelerated RE deployment.
	▪ Increasing awareness of consumers about energy transition through mass media, awareness sessions etc.
Data collection and use	▪ Using relevant data and information for fact-based decision-making to develop targets related to the RE transition.
	▪ Collecting high-quality and reliable data on RE resources that is refined and segregated to cover all aspects of the supply and demand side for planning purposes.
Access to information	▪ Enhancing access to information on RE resources and technologies.
	▪ Improving transparency and public availability of utility data.
	▪ Providing capacity-building and awareness creation of women energy users on EE, RE, and available sources of support and information.
	▪ Enhancing flexibility in intellectual property rights for technology transfer, adoption, and local value addition.
Other	▪ Identifying customers' demand and requirements.
	▪ Strengthening emphasis on non-electricity sectors of energy, such as thermal and transport.
	▪ Encouraging off-grid solar systems to small enterprises and domestic users.
	▪ Exposing professionals to available strategies and models.

3.6.6. Other

Table 12: Other key aspects for a just transition

Aspect	Elements
Other	▪ Building a pool of qualified human resources for the RE transition on both the implementation and the management side.

	▪ Mainstreaming RE- and EE-related basic knowledge and skills into education curricula.
	▪ Ensuring female participation and providing gender-responsive TVET opportunities.
	▪ Creating more additional and extracurricular means of engagement with RETs, such as clubs, associations, job fairs, and youth programmes.

3.7. Regional experiences

Providing demand-driven and quality-assured TVET is necessary to ensure the creation of flexible pathways for learners, meet skill requirements in the labour market and address the aspirations of youth. Countries in the South Asian region have made progress in strengthening TVET students' linkages to the world of work, improving the recognition of formal TVET qualifications, and developing pathways to further education, employment, and self-employment for TVET graduates. Existing institutional mechanisms, policies, and regulatory framework as well as collaborative initiatives can be studied to identify good practices and lessons learned for Sri Lanka's TVET sector and the RE transition.

Throughout the region, there are ongoing projects aiming to strengthen TVET policy frameworks; enhance mobility and harmonization between TVET and higher education (for example, through establishment of a skill university or through regional cooperation); upgrade teacher qualifications; render skills programmes more responsive to local labour market demand; expand job-relevant training opportunities for basic- to mid-level skills linked with job placements through industry partnerships; modernize TVET institutions to boost employability of youth; mainstream RET into training courses; enhance capacities of women and promote involvement of women in the energy sector; and improve equitable access to market-relevant training programmes and TVET sector service delivery.

From different countries, lessons can be learned for trends and good practices. These include the following:

- Alignment between economic growth and national development visions, labour market trends and demands, and international and regional standards through promotion of research activities and thorough labour market analysis. (Green Skill Development Programme in India)
- Initiation of TVET education programmes in mainstream schools starting from primary school and including school electives as well as avenues for equivalency or credit transfer between academic scores and national certification systems; establishment of new RE-related certificates and curricula and recognition of these qualifications by government agencies and private sector job providers. (Vocational Pathway Concept in Nepal)
- Restructuring of TVET with demand-driven curriculums and hands-on training or workplace exposure through exchange visits, peer-to-peer learning, mentoring, backstopping, job fairs, and other programmes set up in partnership between TVET institutions and job providers. (PPP programmes in Nepal)
- Developing and refining competency standards and curriculums based on skills analysis in urban and rural areas and in consultation with service providers and users as well as training providers and industry representatives. (TVET Reform Project in Bangladesh; Development of a Curriculum process in Nepal)
- Linking TVET and entrepreneurship/SME/start-up development through establishment of seed funding programmes, investment platforms, exchange between entrepreneurs and students, incubators, accelerators, launchpads, runways, regulatory sandboxes, and other systems that facilitate RE entrepreneurship and business development among TVET students

and graduates, as well as post-training support such as continued mentorship, trainee business planning, and establishment of credit and market linkages. (Skill up! Project in Nepal, Green Skill Development Programme in India)

- Accessibility to training opportunities through targeted programmes for women, youth, and those from rural or underprivileged communities, including stipends, financial support, and mentoring. (Skill up! Project in Nepal)
- Capacity development of training providers and institutions and establishment of employment sector councils and multi-stakeholder expert committees. (Skill Council for Green Jobs in India)

4. Skills and competencies for a renewable energy transition

4.1. Required competencies and skills

Competency is the application of knowledge, skills, attitudes, and values relative to an industry standard of performance. The concept of competency focuses on what is expected of an employee in the workplace, rather than on the learning process, and embodies the ability to transfer and apply knowledge, skills, attitudes, and values to different situations and environments.

Therefore, a competency-based training (CBT) places emphasis on what a person can do in the workplace because of completing a programme of training. Conventionally, the competencies are identified for a specific education or training programme, course, or discipline as well as subject modules therein as the basis of developing and delivering the curricula to shape students for certain employments. However, individuals need to draw on a wide range of competencies to adapt to a world characterised by transformations, complexities, and interdependencies.

Furthermore, competencies are not just a way to adapt individuals to these changing circumstances but also to assist them in shaping others, including institutions and society. Although the competencies explored in this study are largely related to those of individuals, it is fundamental that the sum of individual competencies should contribute to shape institutional competencies, and ultimately to achieve shared goals of the societies at local, national, and global levels.[16] Thus, the competencies related to a particular training programme/course could be established by two perspectives at two levels:

- **Core competencies** in generic forms that describe the essential knowledge, skills, attitudes, and values necessary for the practice of specific discipline in the professional, educational, and other life contexts. These competencies exceed the typical boundaries of a specific training programme. A comprehensive approach to such competency framework is provided by the concept of Education for Sustainable Development (ESD), a mandate of the United Nations Educational, Scientific, and Cultural Organization;[17]
- **Specific or key competencies** are related to a particular training programme and are thematically defined and narrower in scope than core competencies, but still aligned and bound together in an integrated approach.[18] These are defined within more formal structure of a specific education or training programme/course for a targeted level of qualification (such as NVQ). These are also governed by accreditation requirement prescribed by professional bodies of a particular training programme under formal education settings (for example, the Dublin Accord, which is an agreement for the international recognition of engineering technician qualifications).

These two perspectives are further elaborated in the following sections, as they provide the foundation for the development or adaptation of TVET programmes as well as curriculum development in the country.

[16] (OECD, 2005)
[17] (UNESCO, 2017)
[18] (KMK & BMZ, 2016)

4.1.1. Core competencies

A set of core competencies for the overarching competency framework of a technical education programme is identified, aligned with the ESD Competency Framework, as presented in Table 13:

Table 13: Core competencies for the implementation of RE projects

Competency area	Associated competencies
Cognitive competencies *(knowledge)*	▪ Information competency: The ability to access and understand data and information on topics related to RE sources and RETs.
	▪ Systems thinking competency: The abilities to recognize and understand relationships between components in a RE system.
	▪ Critical thinking competency: The ability to understand the performance of RE systems in relation to environmental, economic, social, and technological factors in varying circumstances.
Functional competencies *(skills and know-how)*	▪ Anticipatory competency: The abilities to understand, evaluate and perform installation and operationalisation of RE systems.
	▪ Strategic competency: The ability to ensure and enhance the performance of a RE system through collective actions in a multidisciplinary team by considering local circumstances.
	▪ Integrated problem-solving competency: The overarching ability identify and rectifies a performance deterioration and failure of RE systems or subsystems and components with a utilization of instruments and software tools where relevant.
Attitudinal competencies *(behavioural and values)*	▪ Normative competency: The abilities to understand and reflect on the norms, behaviours and values related to the roles and responsibilities of the employment.
	▪ Collaboration competency: The abilities to learn from others; to understand and respect the needs and to facilitate collaborative and participatory approach in operationalizing RE systems.
	▪ Self-awareness competency: The ability to continually evaluate and self-motivate for one's career progression in realising the responsibility towards the betterment of the local community and society as whole.

Note that the core competencies listed in Table 13 are in a generic form and serve as a guide. They need to be further developed and specified for a particular training programme, course, discipline, subject area, or level in accordance with the applicable competency standards, as detailed in the next section. For example, a training course on solar PV for mid-level technicians could include related specific technological aspects and systems features in generic RE resources, technologies, or systems.

As there are a range of RE resources, technologies, and systems relevant to the country, there are diverse skill and competency development programmes (existing and proposed). Thus, the above generic core competency framework is used in the present study to obtain the feedback from the actors in the sector. However, when administering the questionnaires and interview questions, relevant RE resources, technologies, and disciplines are considered, and the feedback is recorded accordingly.

4.1.2. Specific competencies

The fundamental basis for the development of specific competencies is provided by the National Competency Standards which define the competencies required for effective performance in a particular industry sector or in an occupation. An occupation is a collection of job functions (termed as competency units) that could be performed by a single person. In the case of development of curricula for National Certificate levels (NVQ 1 to 4) or National Diploma levels (NVQ 5 and 6) competency units specified in the Competency Standards are transformed into Module Aim/s and Learning Outcome/s. In fact, the NVQF described in Section 3.3 is based on the National Competency Standards, which include relevant specific technical and employability competencies anticipated from individuals upon successful completion of a given training programme or course. These standards are industry-determined specifications of performance that set out the knowledge, skills, attitudes, and values required to operate effectively in a specific industry or profession.

The important features of the National Competency Standards and their applications:[19]

- Focus on what is expected from an employee in the workplace rather than on the learning process;
- Stress upon the ability of individuals to transfer and apply skills, knowledge and attitudes to new situations and environments;
- Are concerned with what individuals are able to do and the ability to carry out a task within a given range of context;
- Package into qualifications corresponding to existing jobs and occupations in the industry sectors; and
- Include the qualifications corresponding to specific levels in the NVQF.

As per the National Competency Standards, the combination of units for an industry sector or occupation must cover the following five components of competency:

- **Task handling:** The requirement to perform individual tasks to the required performance standards and output standards;
- **Task management:** The process of managing a task through its life cycle, including planning, testing, tracking and reporting. Effective task management includes managing all aspects of a task, including its status, priority, time, human and financial resources assignments, recurrences, notifications and so on;
- **Problem solving and contingency management:** The capacity for flexibility in varying responses and attitudes to meet the needs of different situations and ability to respond to unexpected situations;
- **Job-, role-, and work environment-handling:** The requirement to deal with responsibilities and expectations of the work environment including interacting appropriately with others in the workplace; and
- **Transfers skills:** Competencies in the performance of a particular job which can be used in the performance of another job. The capacity for flexibility and the ability to respond to meet the needs of different work contexts.

[19] (TVEC, 2009)

4.2. National Competency Standards

Competency standards shall be developed for industry sectors and occupations identified through an analysis of relevant labour market sources and other information. The main steps of the development of National Competency Standards (NCS) are as follows:[20]

Table 14: Main steps for National Competency Standard development

Step	Description
1	Industry sectors or occupations for competency standards development shall be identified based on the industry requirements and government policies.
2	Approval for the identified industry sectors or occupations shall be obtained from the relevant Committee established by the TVEC (National Competency Standards Development Monitoring Committee).
3	Identified industry sectors or occupations shall be forwarded to NAITA/UNIVOTEC or other relevant organisation which has good industry linkages and capacity for development of competency standards and curricula.
4	The assigned organisation shall select 6-12 resource persons to develop the competency standards. At least two thirds of the members of the competency standard development committee shall be current industry practitioners. Priority should be given to the representatives from relevant bodies. Thereafter, 6-12 resource persons shall be selected to develop the curriculum. At least two thirds of the members of the curriculum development committee shall be relevant academic staff.
5	The development group shall conduct a functional and/or occupational analysis as well as a "functional map" or "competency profile," which shall be developed thereafter.
6	The functional map/competency profile, unit titles, and unit descriptors are submitted to the committee with TVET experts appointed by the TVEC for consideration and feedback during the development process.
7	The development group prepares the draft competency standard and curriculum.
8	The competency standard and curriculum shall be sent for industry comments from stakeholders such as industry bodies.
9	The Qualification Packaging Committee appointed by the TVEC reviews the proposed qualification packages in keeping with the packaging policy.
10	The draft Standard and curriculum shall be forwarded to the NAITA together with the functional map/competency profile for validation.
11	Once the National Industry Training Advisory Committee (NITAC) has validated the National Competency Standard and curriculum and qualification packages, the competency standard together with the functional map/competency profile shall be submitted to the TVEC for endorsement.
12	The TVEC shall endorse the competency standard or return it to NAITA for review, with reasons for not endorsing the competency standard.
13	The Competency Standard and curriculum shall be sent for wide industry comments from stakeholders such as industry bodies, trade unions, technical experts, and practitioners, and also shall be made available for public review and comments after the endorsement.

It is expected that with the completion of the activities of the present project, a formal process presented above could be initiated for the development of competency standards and curriculums of specific training programmes and courses covering the RE sector in the country.

[20] (TVEC, 2009)

Furthermore, the establishment of specific competencies of a training programme should also consider accreditation requirements prescribed by relevant professional bodies. For example, the Dublin Accord defines Professional Competency Profiles (see Table 15) for engineering technicians required to meet the minimum standard of competence a person must demonstrate that they are able to practice competently in their practice area to the standard expected of a reasonable engineering technician. The extent to which the person can perform each of the following elements in their practice area must be considered in assessing whether or not they meet the overall standard.[21]

Table 15: Professional Competency Profiles of engineering technicians

Competency category	Competency profile
1. Comprehend and apply universal knowledge	▪ Comprehend and apply knowledge embodied in standardised practices.
2. Comprehend and apply local knowledge	▪ Comprehend and apply knowledge embodied in standardised practices specific to the relevant jurisdiction.
3. Problem analysis	▪ Identify, state, and analyse well-defined problems.
4. Design and development of solutions	▪ Design or develop solutions to well-defined problems.
5. Evaluation	▪ Evaluate the outcomes and impacts of well-defined activities.
6. Protection of society	▪ Recognise the reasonably foreseeable social, cultural, and environmental effects of well-defined activities generally, and have regard to the need for sustainability; use engineering technical expertise to prevent dangers to the public.
7. Legal and regulatory	▪ Meet all legal and regulatory requirements and protect public health and safety during activities.
8. Ethics	▪ Conduct activities ethically.
9. Manage engineering activities	▪ Manage part or all of one or more well-defined activities.
10. Communication	▪ Communicate clearly with others during activities.
11. Lifelong learning	▪ Undertake CPD activities sufficient to maintain and extend competence.
12. Judgement	▪ Choose and apply appropriate technical expertise. Exercise sound judgement during well-defined activities.
13. Responsibility for decisions	▪ Be responsible for making decisions on part or all of one or more well-defined activities.

The information provided above in this section highlights the basis and process of developing key competencies related to any technical education or training programme or course. As required by the National Competency Standards, competencies should comply with industry-determined specifications of performance and the consultation of key stakeholders and experts (both energy sector and technical education sector) is an essential requirement to establish the required competencies and identify the gaps therein. The next section is devoted to presenting an analysis of these aspects based on the feedback of the stakeholders and desk research findings.

[21] (IESL, 2014)

4.3. Competencies and curriculum development

As briefed in Section 4.1.2, the competency framework provides the basis for curriculum development as well as the preparation of teaching, learning, and assessment materials and training plans. The distinctly different features of courses and institutions demand specific attributes in the curriculum in each training programme. In the comprehensiveness and completeness of the nation-wide RE training programmes, it is important to establish thematic areas and subject topics underpinning the just energy transition in the country. Such an overall training programme is essentially guided by the core competency framework proposed in this study.

Furthermore, in line with the core competencies, programme outcomes should describe what trainees will know and be able to do when they complete a training programme. Note that the programmes outcomes are different from competencies that they describe performances that require one to integrate and apply one's learning. The core competencies, programmes outcomes, and thematic areas or subject topics should be refined and tailored to suit each of the specific training programme/course or module.

Accordingly, the following requirements are established as guiding principles in developing course-specific RE training programmes and related curriculums:

- The specific course should demonstrate its contribution to overall technical training on just energy transition as well as the connectivity of their concepts and activities;
- The sector/subject-specific competencies (SCs) should be established, aligning with the core competencies;
- The sector/subject-specific learning outcomes should be established, aligning with the programme outcomes; and
- The sector-relevant subject topics should be identified under relevant thematic areas and subject topics.

Figure 10 below illustrates this approach as a framework for the development of specific training programmes within the overall technical training on RE systems.

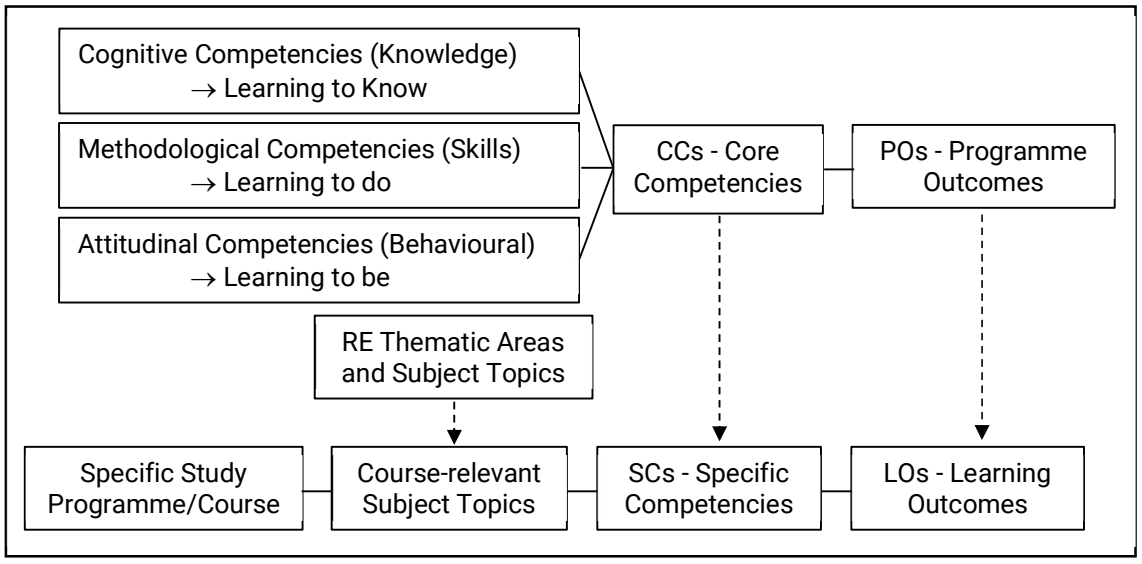

Figure 10: Overall framework of curriculum development for a RE training programme

5. Existing TVET opportunities for renewable energy

As shown in Figure 11 below, Sri Lanka currently only has a limited number of TVET opportunities for RE. The majority of dedicated training programmes, modules, and certificate courses is focused on solar PV systems (ground, floating, and/or rooftop), while most TVET opportunities that incorporate RE-related elements have a general focus on different kinds of RE. There are almost no available structured TVET offerings for small and mini hydro power, biomass, biogas, and wind energy. As the Three Lanka project offers a large amount of 20 courses which are not currently operational, these have not been included in the overview figure to avoid distortion.

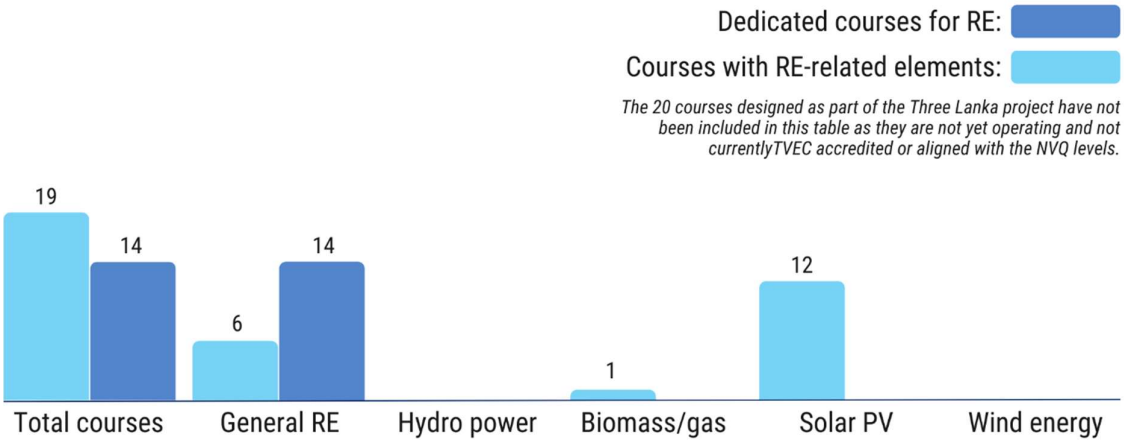

Figure 11: Overview of TVET opportunities for RE

5.1. Training programmes, modules, and certificate courses

Table 16 below provides an overview of existing training programmes, modules, and certificates related to RE in Sri Lanka. For higher education opportunities (SLQF 6 and up and UGC-accredited) related to RE, please see Annex IV: Higher education opportunities related to RE.

Table 16: Overview of existing training programmes, modules, and certificates

Qualification/course	Curriculum contents	Learning outcomes
National Apprentice and Industrial Training Authority (NAITA)		
Solar PV Systems Technician (NVQ 3-4) *Entry: the candidate should have been found competent in "basic competencies to work" or may concurrently apply for basic competencies to work and this qualification* *829 hours with practical and theory sessions*	▪ Solar PV systems (site assessment, installation, commissioning, operation and maintenance, small-scale solar PV, workplace communication, occupational literacy and numeracy, teamwork, occupational health and safety)	▪ Understanding of basics of solar energy and its applications ▪ Ability to perform a site assessment based on resource availability and customer requirements ▪ Ability to install simple wiring circuits and use low-voltage electrical testing equipment ▪ Understanding of different types of solar

		PV system components, their integration, and their installation ▪ Ability to design a small-scale solar PV system ▪ Ability to perform testing and commissioning of solar PV systems under the supervision ▪ Ability to install and carry out operation and maintenance of solar PV systems ▪ Ability to communicate ideas and information at the workplace effectively and contribute to work in a team environment ▪ Understanding of workplace health and safety ▪ Understanding and application of environmental aspects
Sri Lanka Sustainable Energy Authority (SLSEA)		
Training Programme for Solar Power Systems Technicians (NVQ 4) *Entry: minimum of GCE A/L or equivalent qualification or should be a technical staff having five years' experience and aged below 35 years*	▪ Solar PV systems (site assessment, installation, commissioning, operation and maintenance, small-scale solar PV, workplace communication, occupational literacy and numeracy, teamwork, occupational health and safety)	▪ Refreshed knowledge of electronic engineering and electronics fundamentals ▪ Understanding of principles of energy conservation, auditing, and management ▪ Understanding of basics of solar panel systems and components of PV systems ▪ Knowledge on PV mounting structures for ground and rooftop solar ▪ Ability to install solar PV systems and connect them to the CEB grid ▪ Insight into installation procedure of rooftop solar PV ▪ Ability to identify and avoid common issues ▪ Knowledge on quality control and SLSI standards ▪ Knowledge on workplace safety and health in solar installation
Solar PV Technician Training (NVQ 4) *Entry: same as above*	▪ Solar energy (basics, solar plants and products, site assessment and evaluation, system designing, on- and off-grid plant installation, mounting and roof structures, SLSI and IEC standards, solar and electrical safety, solar resources and development in Sri Lanka, global trends in solar projects)	
Training of Trainers Workshop for Solar PV Rooftop Installations for Women Employees of Sri Lanka Armed Forces	▪ RE in Sri Lanka (regulatory and policy framework, current trends and schemes, electronics and electricals, demand and tariff, energy conservation	

Entry: not specified, ToT not regularly offered *25 hours*	and management, solar resources, grid connection, solar panels and grid tie inverters, system design, civil and mechanical works, SLSI standards, connected PV power systems, occupational health and safety, solar energy service providers, commissioning, common issues)	
College of Technology under Department of Technical Education and Training (DTET)		
National Diploma in Technology and Education (Electrical Technology) (NVQ 5) *Entry: Pass G.C.E Advanced Level in science or technology stream or NVQ Level 4 certificate in the electrical field with six months bridging programme, if relevant*	▪ Electronics (Sequential logic systems, opto-electronic devices, photo diodes solar cells, photo detectors, LED light emitting materials, electronic circuits design using relevant software)	▪ Information not available
Solar PV Systems Technician *Entry: the candidate should have been found competent in "basic competencies to work" or may concurrently apply for basic competencies to work and this qualification.*	▪ Solar PV systems (basics of solar energy, electrical and electronic principles, basics of civil and mechanical engineering, basics of solar PV systems, site assessment, electrical installation, components of a solar PV system, arranging small-scale solar PV systems, grid connection requirements in connecting solar PV systems, installation methods, testing and commissioning, operation and maintenance, service and maintenance, workplace communication skills and teamwork, workshop calculation and science, occupational health and safety, environmental aspects)	▪ Information not available
NCECP Industrial Electrician (NVQ 4)	▪ Power generation	▪ Information not available
National Cleaner Production Centre (NCPC)		
Training programme on Energy Management for	▪ Energy and environment RETs	▪ Understanding of energy management and efficient energy use

Energy Managers (not TVEC-accredited) *Entry: individuals willing to apply for Energy Manager accreditation from SLSEA* *6 days (24 hours total)*	▪ Electricity generation, flow, and load management ▪ Energy conservation and saving ▪ Energy codes and standards ▪ Energy efficient steam generation and distribution ▪ Monitoring, evaluation, and reporting	▪ Ability to create a culture of EE within an organization or workplace
National Engineering Research and Development Centre (NERDC)		
Industrial training courses *Entry: no specific requirement listed* *2 days*	▪ Biogas digesters (construction, operations, maintenance)	▪ Information not available
Sri Lanka German Training Institute / Ceylon German Technical Training Institute		
Training in RE Systems *Entry: interested individuals or groups* *150 hours*	▪ RE systems project-based learning (installation, commission, test, service, repair, fault diagnosis for solar, wind, backup and standby systems, convertors, invertors, power supplies, control and monitoring systems) ▪ Electrical power generation (sea, wind, and solar PV)	▪ Theoretical knowledge in and understanding of RE ▪ Ability to operate, maintain, and repair hydraulic, pneumatic, electrical, and electronic systems ▪ Ability to identify, create, assemble, and install parts and sub-systems ▪ Ability to programme, test, and diagnose plants and equipment in a multidisciplinary environment ▪ Workshop ethics and team work skills
Applied research project Entry: internal students		
Sri Lanka Institute of Advanced Technological Education		
Higher National Diploma in Engineering – Building Services (NVQ 6) *Entry: should have passed combined mathematics, physics, and chemistry in G.C.E. Advanced Level examination in one sitting, simple pass for English subject in Ordinary Level (O/L), pass in the General Papers compulsory for the applicants qualified in the GCE (A/L) new syllabus* *2,179 hours*	▪ EE in buildings ▪ RET for buildings	▪ Information not available
Higher National Diploma in Engineering – Electrical Engineering (NVQ 6)	▪ Heavy current and power application of electricity, generation transmission, distribution, and utilization	▪ Information not available

Entry: same as above	▪ Design and installation of power electronics ▪ Electricity supply, electrical mechanics, utilization of electrical energy, microprocessor-based systems	
Tertiary and Vocational Education Commission (TVEC)		
Solar Power Photovoltaic Installer (NVQ 3) *Conducted by NAITA*	▪ PV systems (site assessment, installing of PV systems, commissioning, performing operations and maintenance of solar PV, arranging small-scale solar PV, workplace communication and interpersonal relations, occupational literacy and numeracy, teamwork, occupational health and safety)	▪ Understanding of basics of solar energy and its applications ▪ Ability to perform a site assessment based on resource availability and customer requirements ▪ Ability to install simple wiring circuits and use low-voltage electrical testing equipment ▪ Understanding of different types of solar PV system components, their integration, and their installation ▪ Ability to design a small-scale solar PV system ▪ Ability to perform testing and commissioning of solar PV systems under the supervision ▪ Ability to install and carry out operation and maintenance of solar PV systems ▪ Ability to communicate ideas and information at the workplace effectively and contribute to work in a team environment ▪ Understanding of workplace health and safety ▪ Understanding and application of environmental aspects
Solar Power Photovoltaic Technician (NVQ 4) *Conducted by NAITA*	▪ PV systems (site assessment, installing of PV systems, commissioning, performing operations and maintenance of solar PV, arranging small-scale solar PV, workplace communication and interpersonal relations, occupational literacy and numeracy, teamwork, occupational health and safety)	
Renewable Energy Technology (NVQ 5) *Conducted by NAITA* *1,500 hours*	▪ RE systems (introduction, occupational health and safety, general workshop practices, mathematics for RET, physics for RE systems, basic computer applications, electrical measurements and instruments, electrical	▪ Understanding of RE systems and environmental sustainability ▪ Knowledge of workplace health and safety ▪ Ability to carry out basic woodwork, metal work,

	technology, batteries, managing workspace information and communication, engineering drawing, applied electronics, electrical machines, electrical installation, solar technology, pico hydro systems, small-scale wind power systems)	plumbing, and welding required in RE systems ▪ Ability to analyze and troubleshoot RE systems and components ▪ Ability to apply basic computer applications relevant to RE ▪ Understanding of measuring instruments and procedures ▪ Knowledge of basic AC and DC circuits in RE systems ▪ Ability to select, install, and maintain battery backups and generators for RE systems ▪ Knowledge of workplace information management ▪ Ability to draw and present information through engineering drawings as per the standards ▪ Ability to design basic electronic circuits for RE applications ▪ Ability select sites, assess potential, design, and install RE systems, including solar PV and thermal systems, pico hydro, and small-scale wind ▪ Ability to effectively communicate, plan, and schedule work
Renewable Energy Technology (NVQ 6) *Conducted by NAITA* *3,000 hours*	▪ RET (mathematics for RET, fluid mechanisms, industrial electronics, electrical technology, electrical machines, problem-solving and decision-making, teamwork and leadership, construction technology for RE systems, electrical installation, solar technology, micro hydro, hybrid energy systems, workplace learning culture)	▪ Knowledge of fundamentals of advanced mathematics applications and fluid mechanics for RET ▪ Ability to design, assemble, and troubleshoot basic electronic systems in RE applications ▪ Ability to apply knowledge of advanced AC and DC systems,

		generators, and transformers ▪ Ability to install and control electrical machines in RE systems ▪ Ability to apply basic computer applications for RE systems ▪ Ability to work as part of a team or lead and facilitate work teams ▪ Ability to apply knowledge of construction technology in RE systems ▪ Ability to design, install, and maintain protection, electrical panel boards, grid connections, basic electronic circuits, solar systems, water pumping systems, micro hydro, and hybrid energy systems ▪ Ability to draw and present information through engineering drawings ▪ Understanding of occupational health and safety ▪ Understanding of the concept of learning culture
Automobile Technician (covers EV hybrid)	▪ Workplace practices (workplace communication, interpersonal relations, teamwork, occupational health and safety, occupational literacy and numeracy, workspace calculation and science) ▪ Automobile technology (maintaining and replacing storage batteries, repairing and maintaining conventional starting, charging, and ignition systems, lighting, wiper, horn, automotive batteries, motor generators and transformers, starting and charging systems)	▪ Information not available

University of Vocational Technology (UNIVOTEC)		
BTech in Mechatronics Technology (NVQ 7) *Entry: NVQ level 5 in the relevant technology area (mechatronics, electrical, electronics, mechanical, production, automobile, bio-medical) or HNDE, NDT, NDES, NDET or equivalent qualification in a relevant technology area or any other qualification accepted by TVEC as equivalent to NVQ level 5 or 6* *3 years*	▪ Energy management (energy scenario & types of energy sources, energy management, energy conservation in electrical systems and thermal systems, energy economics and accounting) ▪ Environmental management and cleaner production (fundamental of sustainable consumption and production, sustainable consumption theory and application, tools to practice sustainable consumption, holistic waste management and global agenda) ▪ RE (4th-year module introduced in 2022)	▪ Information not available
BTech in Manufacturing Technology (NVQ 7) *Entry: same as above* *3 years*	▪ Energy management (energy scenario and types of energy sources, energy management, energy conservation in electrical systems and thermal systems, energy economics and accounting) ▪ Environmental management and cleaner production (fundamental of sustainable consumption and production, sustainable consumption theory and application, tools to practice sustainable consumption, holistic waste management and global agenda)	▪ Information not available
BTech in Building Services Technology (NVQ 7) *Entry: same as above* *3 years*	▪ Building environment and systems (human comfort, construction technology, building services drawing, architectural aspects, lighting, ancillary systems, acoustics, piped services, energy management in buildings)	▪ Information not available

	▪ Electrical technology ▪ Industrial economics and management	
VTA Vocational Training Centres		
Certificate for Solar PV Technician (NVQ 3) *Entry: the candidate should have been found competent in "basic competencies to work" or may concurrently apply for basic competencies to work and this qualification* *6 months*	▪ Solar PV systems (basics of solar energy, electrical and electronic principles, basics of civil and mechanical engineering, basics of solar PV systems, site assessment, electrical installation, components of a solar PV system, arranging small-scale solar PV systems, grid connection requirements in connecting solar PV systems, installation methods, testing and commissioning, operation and maintenance, service and maintenance, workplace communication skills and teamwork, workshop calculation and science, occupational health and safety, environmental aspects)	▪ Information not available
ETMA Campus (Engineering Technology Master in Automation)		
Online Solar Training Course *Entry: no specific requirement listed* *14 days (140 hours total)*	▪ Introduction to solar power systems (fundamentals of conversion, solar cell, solar power system, types of solar power systems, solar thermal, solar PV) ▪ Solar PV system types (on-grid/off-grid/hybrid systems, requirements and space, solar panel types, panel structure, specification, connections of panels) ▪ Required components (mounting structure, combiner and distribution box, charge controller, inverter and types, battery, maintenance, cables) ▪ Components selection (load calculation, connection, solar system design, return on	▪ Understanding of fundamentals of conversion and components of solar cells, solar thermal, and solar PV systems ▪ Knowledge of different types of PV systems (such as OFF/ON/hybrid) and types of solar panels ▪ Knowledge of components required for a solar PV system ▪ Ability to select components and design a solar system connection ▪ Understanding of return on investment, maintenance, and maintenance contracts ▪ Knowledge of marketing, dealership options, digital marketing, and

	investment, maintenance of system, AMC) ▪ General (UAM registration, MSME registration, dealership, marketing analysis, digital marketing lead generation)	registration processes for UAM and MSME
Glide Energy		
Energy Manager Training Programme *Entry: individuals looking to be accredited as Energy Managers* *9 days (24 hours total)*	▪ RETs, energy and environment ▪ Building energy measurement and energy audits ▪ Electric motors and variable speed drives ▪ Electrical load management ▪ Air conditioning and ventilation ▪ Energy conservation in air conditioning, lighting, steam, and heat ▪ Pumps, fans, and compressors ▪ Furnaces and dryer operations and energy conservation ▪ Energy and financial reporting, energy audits ▪ Energy labelling and standards ▪ Management for sustainable development	▪ Ability to identify, plan, and implement changes to reach organizational energy goals ▪ Functions as a prerequisite to obtaining Energy Manager accreditation from SLSEA
Lalith Athulathmudali Vocational Training Centre		
National Certificate in Solar PV Systems Technician (NVQ 3/to be started in 2023) *Entry: minimum G.C.E. Ordinary Level qualified* *6 months*	▪ Solar PV systems (basics of solar energy, electrical and electronic principles, basics of civil and mechanical engineering, basics of solar PV systems, site assessment, electrical installation, components of a solar PV system, arranging small-scale solar PV systems, grid connection requirements in connecting solar PV systems, installation methods, testing and commissioning, operation and maintenance, service and maintenance,	▪ Competencies related to solar energy basics, installation, system components, and grid connection ▪ Understanding of workplace communication, team work, and occupational health and safety

	workplace communication skills and teamwork, workshop calculation and science, occupational health and safety, environmental aspects)	
Nikini Learning		
Online Solar PV Installation Course (currently on hold) *Entry: exposure to basic knowledge in electrical and mechanical fundamentals*	▪ Solar PV systems (overview, solar PV installation in Sri Lanka, relevant authorities and best practice codes, PV module types, inverter, cabling, wiring, connection systems, earthing, roof types, types of shading, documentation overview, customer consultations, commissioning, common problems, industry best practices, maintenance and troubleshooting, warranty and insurance, good/bad practices)	▪ Information not available
Nuwan Madanayake Auto Hybrid Training Academy (Pvt) Ltd.		
Hybrid Technology Course (not TVEC-accredited) *Entry: no specific requirement listed*	▪ EFI engine management systems ▪ Scan tools ▪ Hybrid systems (Toyota and Honda hybrid systems, hybrid transaxle, high voltage systems, inverter, converter, brake systems, high voltage safety)	▪ Information not available
EV/PHEV Technology Course (not TVEC-accredited) *Entry: no specific requirement listed*	▪ EVs (overview of EVs, BEV technology, EV battery, power distribution modules, transmission)	▪ Information not available
School of Engineering – ESOFT Metro Campus		
BEng (Hons) in Electrical and Electronic Engineering (not conducted at NVQ level) *Entry: BTEC HND/HNDE/NDT/NDES/City & Guilds Advanced Diploma (IVQ L5) in the relevant field with minimum credit pass for English in G.C.E. Ordinary Level* *12 months (weekend course)*	▪ Electrical systems design and installation (design, installation, maintenance) ▪ Instrumentation, control, and group project ▪ RE systems and energy management (local, regional, and global trends in electrical and electronic engineering)	▪ Information not available
Sri Jinarathana Vocational Technical Training Center		

Solar PV Training (not conducted at NVQ level) *Entry: interested individuals*	▪ Hands-on experience on solar PV installation, commissioning, operations, and maintenance	▪ Information not available
Sri Lanka Energy Managers Association (SLEMA)		
Energy Auditor Training Course (not TVEC-accredited) *Entry: individuals willing to apply for Energy Manager accreditation from SLSEA*	▪ Energy management in industries, buildings, and energy utilities	▪ Information not available
Other seminars, workshops, and trainings *Entry: interested individuals*	▪ RE ▪ Energy planning and management, EE ▪ Energy and environment	▪ Information not available
Three Lanka Project		
20 certificate courses offered (under development, not TVEC-accredited) *Entry: no specific requirement listed*	▪ RE system installation and commissioning procedures ▪ Industrial safety standards for RET ▪ Installation of PV systems ▪ Operation and maintenance of solar PV plants ▪ Solar thermal/pumping systems ▪ Installation, operation, and maintenance of energy storage systems ▪ Installation of rooftop solar PV systems ▪ Installation, operation, and maintenance of biogas/biomass heat and power plants ▪ Wind turbine installation, commissioning, monitoring, and maintenance ▪ Small hydro power plant installation, commissioning, and maintenance ▪ RE entrepreneurship ▪ RE systems design, installation, and commissioning ▪ Design of hybrid RE systems ▪ RE and green buildings	▪ Understanding of climate change, SDGs, current energy scenarios, policies, tariff structures, and future trends related to RE in Sri Lanka ▪ Knowledge of operating principles of RETs ▪ Ability to estimate energy production from RETs ▪ Understanding of RE entrepreneurship ▪ Ability to formulate risk mitigation plans, strategies, and business plans for RE entrepreneurs ▪ Ability to write energy policy documents

	▪ Operation and maintenance of PV systems ▪ Design, installation, and maintenance of energy storage technologies ▪ RE policies in developing countries ▪ Performance evaluation of RE systems ▪ EIAs of RE projects ▪ Technical and financial feasibility studies for RE projects	

5.2. Additional activities and offers

In addition to the TVET training curricula, modules, and programmes listed above, several institutions also offer additional or extracurricular activities related to RE, including the following:

Institution	Qualification/course
University of Ruhuna	▪ Webinars and workshops ▪ Field visits ▪ Initiate societies such as the Green Technology Society ▪ Public awareness programmes ▪ Final year research
Rajarata University of Sri Lanka	▪ Final year undergraduate projects (rechargeable batteries and solar cells) ▪ Collaborative research with the National Institute of Fundamental Studies
General Sir John Kotelawala Defence University	▪ Industrial field visits to power plants ▪ Final year undergraduate projects (bio gas, wave energy, increasing efficiency of solar panels by introducing concentrated solar panels)
Sabaragamuwa University of Sri Lanka	▪ Field visits to solar and hydro power plants ▪ Industrial training - 6 months (hydro power plants) ▪ Guest lectures and workshops on RE
Sri Lanka Institute of Information Technology	▪ Partner in THREE Lanka Project (certificate programmes of 10 ECTS for technicians with knowledge competency, capacity enhancement encompassing, and technical, entrepreneurial, installation, verification of performance)
University of Kelaniya	▪ Center of Sustainable Studies ▪ Green clubs at each faculty ▪ Field visits for net energy zero buildings ▪ Students' initiatives on RE and waste recycling
Vocational Training Authority	▪ Student admission and job fair
University of Peradeniya	▪ Final year undergraduate projects ▪ Partner of THREE Lanka Project
Lalith Athulathmudali Vocational Training Centre	▪ Ongoing discussions with institutions to conduct hands-on training modules based on RE

University of Moratuwa	▪ CPD programmes such as short courses and workshops on solar energy ▪ Research degrees focusing on RE related topics
NSBM	▪ Conducted the first ever research conference with the theme "SDGs" on November 25th, 2022 (ICOBI 2022) ▪ A RE club was established under the Engineering Students' Association which focuses on opportunities from the industry research related to RE ▪ The green task force is a club for students to work together on green-themed projects
UNIVOTEC	▪ Projects related to RET (such as solar panel-cleaning robots) are promoted ▪ For the energy management module in sixth semester, undergraduates are supposed to do a mini project on "energy review" and introducing energy-saving practices
SLSEA	▪ SLSEA is a partner of THREE Lanka Project ▪ SLSEA operates the solar power park of Baruthankanda, Hambantota, which allows visitors to experience the operation of a solar power plant ▪ SLSEA operates the Indurana Village Hydro Power Plant, which has a training centre on its premises ▪ SLSEA provides training opportunities to university interns ▪ SLSEA hosted the Vidulka exhibition and National Energy Symposium from 2007-2019 ▪ SLSEA officers participate in knowledge-sharing workshops island-wide on request ▪ "Rivi balayata liya saviya" programme for strengthening women through solar power and training on rooftop installation
GLIDE Pvt Ltd	▪ Conduct webinars on RE-related topics ▪ Offer solar consultancy service where client is educated on making informed decisions when choosing solar contractor as per requirement
CGTTI	▪ Has a makerspace to conduct projects ▪ Willing to conduct full-time RE courses
SLGTI	▪ Offers basic training to students from Level 4 Electrician and Level 5 Mechatronics on RE
NCPC	▪ Conducting technology fairs to bridge the gap between suppliers and potential clients (not on a regular basis)

5.3. Geographic overview

The following figure shows the availability of TVET trainings and programmes related to RE across Sri Lanka. As evidenced in the map, the vast majority of available TVET opportunities is concentrated in Colombo district, which has more RE-related courses on offer than all other districts combined. Colombo district harbours 56% of all RE-related courses counted in this study and 40% of the ones that are TVEC-accredited or -registered. It also has by far the highest number of TVET institutions overall and with RE-related courses.

Galle, Anuradhapura, Badulla, Jaffna, and Kandy provide the next highest number of TVET opportunities but lag far behind Colombo in terms, together accounting for less than half of Colombo's overall number.

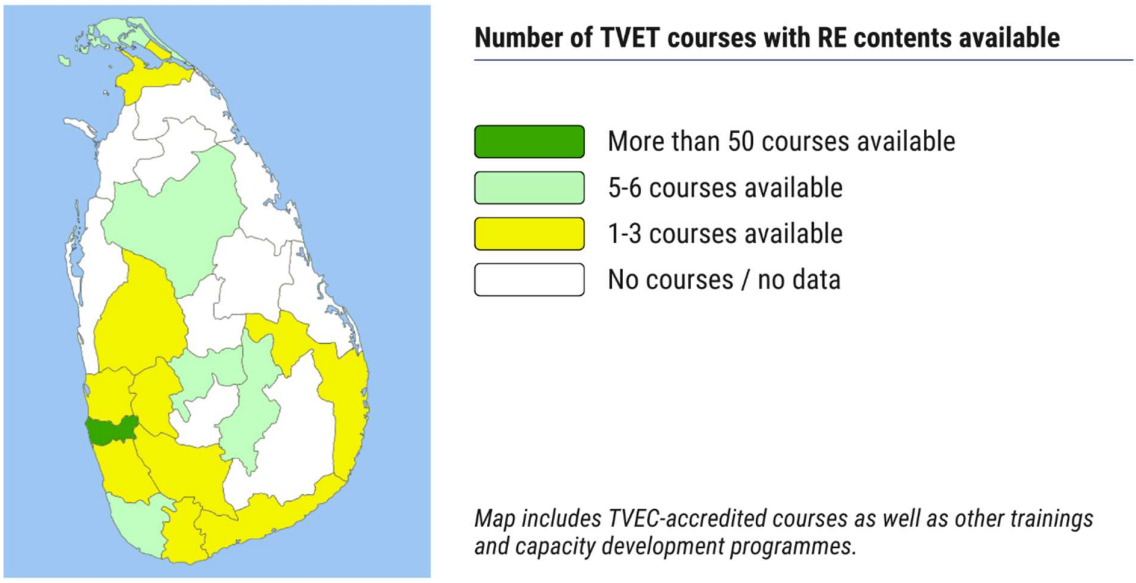

Figure 12: Map of RE-related TVET courses in Sri Lanka by district

Based on this data, further research could be conducted to identify provisions and districts with high RE development potential and/or planned RE development and triangulate this with existing TVET opportunities related to the relevant RE resources, highlighting a need to expand training and education options in certain districts to build a local pool of human resources.

6. Future job demand and profiles for a renewable energy transition

The research has identified the nature of job demand and job profiles in the short- (up to 3 years) and medium-term (up to 10 years) based on the identified competency and skill requirements. This can mean new occupation profiles, but also additional skills and competencies required for energy transition in existing trades and training courses. As elaborated in Section 4.1.2, it will be important to develop Professional Competency Profiles in line with the National Competency Standards to contribute to guiding TVET and facilitating a more effective, and successful energy transition in the country.

6.1. Identified job demand

Based on national plans and commitments for the future development of the RE sector, Sri Lanka intends to add a total RE capacity of 2,060 MW in the short term (2023-2025) and 7,190 MW in the medium term (2023-2030), an overall increase of more than 900% compared to the current capacity of 780 MW. Most of this addition will consist of solar PV and on-shore wind energy in the short term as well as solar PV and on- and offshore wind energy in the medium term, with smaller additions of hydro and biomass energy.

Extrapolating from the current employment numbers per MW of installed capacity, an overall demand of approximately 1,650 technicians (NVQ 3 and 4) and 1,100 technical assistants (NVQ 1 and 2) in the short term and 5,300 technicians and 2,900 technical assistants in the medium term (cumulative) can be projected. The job demand in the short term is particularly high for solar technicians and technical assistants, while highest demand in the medium term is for wind (on- and offshore) technicians as well as solar technicians and technical assistants.

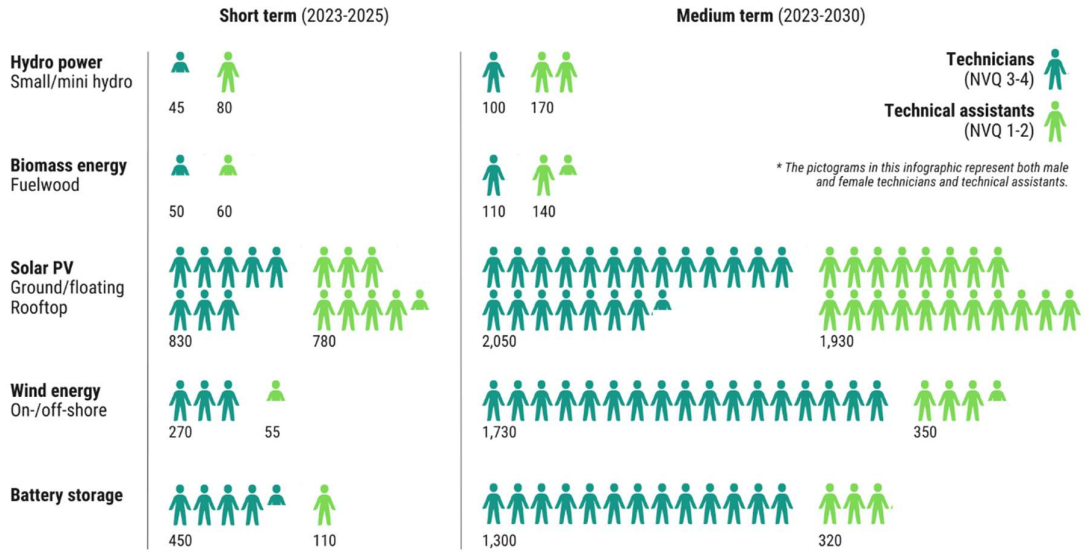

Figure 13: Short- and medium-term job demand[22]

[22] See Annex V: Calculation of projection of job demand for full calculation of this projection.

It is important to note that this job demand for technical staff mainly covers installation and operation of grid-connected RE power plants for electricity generation, while additional employment generation for technical staff could come from manufacturing of RE plants, systems, sub-systems, and components. Furthermore, the technical staff under the two categories given above (technicians and technical assistants) may require different types and levels of competencies relevant to each RE resource and RET, which need to be considered when designing educational and training programmes. NVQ 5 and 6 level staff are likely to be needed in smaller numbers, in practice, NVQ 4 level staff also sometimes gets promoted to NVQ 5 level staff to take over the role of engineers or plant managers. There might also be demand in other areas of RE which are not yet included in the national plans at commercial scale, such as geothermal and wave energy, green hydrogen, and supporting elements like battery storage development.

6.2. Competency requirements and future job profiles

Based on desk research and inputs received from the surveyed stakeholders, anticipatory competency has been identified as the highest priority in the short term, followed by information competency, systems thinking competency, and integrated problem-solving competency. In the medium term, information competency, anticipatory competency, and strategic competency take on the highest priority, followed by systems thinking competency and integrated problem-solving competency.

Table 17: Priority competencies for future job profiles

Competency area	Associated competencies	Short term	Medium term
Cognitive competencies *(knowledge)*	Information competency		
	Systems thinking competency		
	Critical thinking competency		
Functional competencies *(skills and know-how)*	Anticipatory competency		
	Strategic competency		
	Integrated problem-solving competency		
Attitudinal competencies *(behavioural and values)*	Normative competency		
	Collaboration competency		
	Self-awareness competency		

Low priority | *Medium priority* | *High priority*

In addition to these general competencies, there is also a set of job roles, specialized competencies, and skills required for a workforce that can enable a successful RE transition in Sri Lanka in the short and medium term. The skill and competency requirements in the energy sector are appraised based on the overarching core competency framework presented in Table 13, with the information collected from stakeholder consultations and literature on similar studies. Skill and competency requirements are identified under two timeframes, namely short-term (up to 3 years) and medium-term (up to 10 years). The number of responses in each area of competency is given within simple brackets ():

Table 18: Future job and competency requirements

Energy source	Job roles	Competencies
Hydro power	Short term ▪ *Assistant electricians* ▪ *Civil engineers* ▪ *Construction site supervisors* ▪ *Electrical technicians*	Short term ▪ Information competency: Assessment of RE potential and RE sites (4); data

	▪ *Electricians* ▪ *Electricity transmission experts* ▪ *Environmental officers* ▪ *Hydraulic technicians* ▪ *Hydro turbine designers* ▪ *Penstock fabricators* ▪ *Quantity surveying assistants* ▪ *Resource assessors* ▪ *RET technicians* ▪ *Survey field assistants* ▪ *Surveyors* ▪ *Welders* ▪ *Welders for hydro turbines*	collection and data monitoring (4); GIS mapping (2) ▪ Systems thinking competency: Development of pilot-scale models for energy storage (5); skills related to business, administration, supervision, and project engineering (4) ▪ Critical thinking competency: Financial skills for budgeting, allocation, transactions (6); procurement (1) ▪ Anticipatory competency: Grid infrastructure development, management, operations, and maintenance (14); battery technology (6); design and manufacturing of hydro power plants including turbine and penstock (5); troubleshooting for system repair, machinery, and component installation of RET (4)
	Medium term ▪ *Civil engineers/technologists* ▪ *Electrical engineers*	Medium term ▪ Systems thinking competency: Conceptual skills (9); project implementation and management (7), upscaling of RE projects (3) ▪ Critical thinking competency: Knowledge of international bidding processes (2); supply chain management (2); energy demand prediction (2) ▪ Anticipatory competency: Energy storage technology (12)
Biomass energy	Short term ▪ *Biogas operators* ▪ *Cookstove manufacturers* ▪ *Environmental officers* ▪ *Experts in gasifier technology* ▪ *Fuel/firewood suppliers* ▪ *Laboratory assistants* ▪ *Maintenance staff* ▪ *RET technicians* ▪ *Skilled pottery makers* ▪ *Skilled practitioners for biomass and biogas in MSMEs*	Short term ▪ Information competency: Data collection and data monitoring (4) ▪ Systems thinking competency: Development of pilot-scale models for mini-grids and energy storage (5); skills related to business, administration, supervision, and project engineering (4); energy auditing (2) ▪ Critical thinking competency: Financial skills for budgeting, allocation, transactions (6); procurement (1) ▪ Anticipatory competency: Operation and maintenance of

		biomass and biogas technology (11); battery technology (6); troubleshooting for system repair, machinery, and component installation of RET (4)
	Medium term ▪ *Biogas and biomass equipment manufacturers* ▪ *Skilled masonry, metal, and fibre workers*	Medium term ▪ Systems thinking competency: Conceptual skills (9); project implementation and management (7) ▪ Critical thinking competency: Knowledge of international bidding processes (2); supply chain management (2); energy demand prediction (2) ▪ Anticipatory competency: Energy storage technology (12); design, operation, and maintenance of biomass and biogas technology (7); waste-to-energy power generation (3); smart grid technology (3); equipment selection (1) ▪ Strategic competency: Business model development, marketing, and promotion (5) ▪ Integrated problem-solving competency: Quality controlling, assurance, standards, and certifications (5)
Solar PV	Short term ▪ *Assistant electricians* ▪ *Civil engineers* ▪ *Construction site supervisors* ▪ *Electrical technicians* ▪ *Electricians* ▪ *Electricity transmission experts* ▪ *Laboratory assistants* ▪ *Laboratory technicians* ▪ *PV tracker mounting technicians* ▪ *Resource assessors* ▪ *RET technicians* ▪ *Surveyors* ▪ *Survey field assistants*	Short term ▪ Information competency: Assessment of RE potential and RE sites (4); data collection and data monitoring (4); GIS mapping (2) ▪ Systems thinking competency: Development of pilot-scale models for solar, mini-grids, and energy storage (5); skills related to business, administration, supervision, and project engineering (4); energy auditing (2) ▪ Critical thinking competency: Financial skills for budgeting, allocation, transactions (6); management of solar farms (2); procurement (1) ▪ Anticipatory competency: Installation, operation, and maintenance of ground,

		mounted, and floating solar PV systems and technologies (31); grid infrastructure development, management, operations, and maintenance (14); controller systems, harmonic checking, and hybrid inverters (14); battery technology (6); design, operation, and maintenance of solar thermal systems (5); troubleshooting for system repair, machinery, and component installation of RET (4) ▪ Integrated problem-solving competency: EE, energy conservation, and management (5)
	Medium term ▪ *Cell engineers* ▪ *Certified resource assessment practitioners* ▪ *Electrical technicians* ▪ *Electricians* ▪ *Quality controllers/assessors* ▪ *RET technicians* ▪ *Solar PV equipment manufacturers*	Medium term ▪ Systems thinking competency: Conceptual skills (9); project implementation and management (7), upscaling of RE projects (3) ▪ Critical thinking competency: Knowledge of international bidding processes (2); supply chain management (2); energy demand prediction (2) ▪ Anticipatory competency: Energy storage technology (12); production and manufacturing of solar panels and tiles (6); smart grid technology (3); solar panel recycling (1); wireless system monitoring techniques (1); equipment selection (1) ▪ Strategic competency: Business model development, marketing, and promotion (5) ▪ Integrated problem-solving competency: Quality controlling, assurance, standards, and certifications (5); design and manufacturing of solar-powered charging stations (2)
Wind energy	Short term ▪ *Assistant electricians* ▪ *Civil engineers* ▪ *Construction site supervisors* ▪ *Electrical technicians* ▪ *Electricians*	Short term ▪ Information competency: Assessment of RE potential and RE sites (4); data collection and data monitoring (4); GIS mapping (2)

	▪ *Electricity transmission experts* ▪ *Environmental officers* ▪ *Laboratory assistants* ▪ *Laboratory technicians* ▪ *Quantity surveying assistants* ▪ *Resource assessors* ▪ *RET technicians* ▪ *Survey field assistants* ▪ *Surveyors*	▪ Systems thinking competency: Development of pilot-scale models for wind and energy storage (5); skills related to business, administration, supervision, and project engineering (4); energy auditing (2) ▪ Critical thinking competency: Financial skills for budgeting, allocation, transactions (6); procurement (1) ▪ Anticipatory competency: Installation, operation, and maintenance of wind turbines (7); battery technology (6); troubleshooting for system repair, machinery, and component installation of RET (4) ▪ Integrated problem-solving competency: EE, energy conservation, and management (5)
	Medium term ▪ *Certified resource assessment practitioners* ▪ *Repairing technicians* ▪ *Wind turbine blade technicians* ▪ *Wind turbine erectors and de-erectors*	Medium term ▪ Systems thinking competency: Conceptual skills (9); project implementation and management (7), upscaling of RE projects (3) ▪ Critical thinking competency: Knowledge of international bidding processes (2); supply chain management (2); energy demand prediction (2) ▪ Anticipatory competency: Energy storage technology (12); production and manufacturing of solar panels and tiles (6); wireless system monitoring techniques (1); equipment selection (1) ▪ Integrated problem-solving competency: Quality controlling, assurance, standards, and certifications (5)
General	Short term ▪ *Energy auditors* ▪ *Experts in sustainable architecture and services*	Short term ▪ Systems thinking competency: Development of pilot-scale models for wave energy (5) ▪ Anticipatory competency: Grid infrastructure development, management, operations, and

		maintenance (14); EV technology (3) ▪ Strategic competency: Building simulation software and energy consumption calculation (5) ▪ Integrated problem-solving competency: EE, energy conservation, and management (5); green building concepts (5); industrial automation (3) ▪ Normative competency: Professional training qualifications (7)
	Medium term ▪ *Experts on integrated management and development of RE plans* ▪ *Project managers* ▪ *Project officers* ▪ *Trainers on emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)*	Medium term ▪ Information competency: Resource assessment, identification, extraction, and development of wave energy and geothermal energy (10) ▪ Anticipatory competency: Design and manufacturing of EVs (8); hydrogen energy technologies (4) ▪ Strategic competency: Strategizing and higher-level planning and management (16); business model development, marketing, and promotion (5) ▪ Integrated problem-solving competency: Integrated energy transition planning (3) ▪ Collaboration competency: Management of cross-disciplinary teams (2) ▪ Self-awareness-competency: Social skills (8)

6.3. Closing gaps and enhancing existing TVET curricula

It is apparent that the main competency and skill requirements identified through the research are linked to the installation, commissioning, operation, monitoring, and maintenance of RE plants (mainly solar, biomass/biogas, wind, and hydro) and related systems such as energy storage, grid infrastructure, system control. Both cognitive and functional competencies in these areas are not adequate for technical staff to contribute to the upscaling of RE systems, as stipulated in national policies and targets.

Further, non-technical competencies, particularly attitudinal, have received less emphasis, which reflects a challenge as well. Limited availability of training programmes on RE offered in the TVET sector is another challenge for the prompt introduction of new and emerging topics. It is observed that the National Competency Standards for RE- related education and training are yet to be developed to cover all essential aspects related to energy transition in the country. Further, there

is a lack of trained staff for RE education and training within TVET sector institutions, emphasizing the need for developing and implementing training of trainer (ToT) programmes too, to support the effective delivery of RE training programmes/ courses.

Regarding the development of hands-on skillsets related to RE, there are significant gaps and related human resource shortages for grid-integrated solar PV, rooftop solar PV, off-grid solar PV, solar thermal/pumping, biogas/biomass heat and power plants, and small hydro power. These are currently only addressed by the regulator SLSEA and by the Three Lanka project, which is ongoing and does not yet offer the TVET courses in development.

The training and capacity building at technical level take place at all the level of formal and non-formal levels of education, Here the formal (or basic) education/training refers to that takes place in education and training institutions, is recognized by relevant national authorities and leads to certificates, diplomas and other qualifications. Further, formal education modes also could include the structured continuous professional development (CPD) programmes offered by education and training institutions. The non-formal education or training usually takes place in the workplace such as on-the-job and in-service or community-based settings, which is also structured according to educational and training arrangements, but more flexible. In addition, more informal forms of education also occur through interests and activities of individuals, including learning from experience. Though the primary the competency building occurs through the formal programmes implemented by dedicated institutions in the TVET sector, universities and tertiary education institutes too offer technical level short courses, workshops, and seminars CPD at certificate level to diplomas. The appraisal of the training programmes/ curricula performed in the present study covers those offered by dedicated TVET institutes and the related programmes offered by other institutes (including universities).

It is apparent from the different TVET programmes and curricula offered by various institutions reviewed in the present study, the thematic areas and subject topics of importance for a RE transition are hardly covered. Though very limited, the primary attempt to address this gap seems to be focused on introducing specific training modules and programmes. One exception is the CBT curriculum for RET developed by TVEC with the consent of UNIVOTC and validated by NAITA. This is developed based on National Competency Standards, which specifies the skills required by the industry at middle management level, leading to award of NVQ Level 5 and 6 National Diplomas under the NVQ Framework (see Section 3.3.1). This curriculum is treated as the national curriculum that facilitates the teaching and learning process in CBT mode. Another relevant training programme that based on National Competency Standards and CBT is the training curriculum for Solar PV Systems Technician, leading to award of National Certificate at NVQ Level and 4. More detailed appraisals of these two training curricula are presented in the section 7.2 as case examples.

Another area of deficiency in the present approaches for competency-building of technical staff for a RE transition is the failure to explore the opportunities in integrating (or introducing) related topics to existing modules, which is more effective in realizing the objective. As the topics related to RE system, for example, are wide-ranging and multi-disciplinary, it is fundamental that the concepts can be promptly linked to existing modules, and therefore it is rational and effective to introduce into the existing curricula without major changes. The other important aspect that is largely missing is the specific competencies for just energy transition. It is important to recognize that the topic of just energy transition is enmeshed with the broader context of sustainability, which emphasises the need for the appraisal of technologies through sustainability lens (involving social and environment criteria in addition to economic). Accordingly, a comprehensive training plan at national level should be developed to identify a sound curriculum framework, thematic areas and subject/lesion topics, learning or programme outcomes, and specific competencies to guide the training providers in TVET sector to develop and deliver programmes.

In order to support the implementation of national level training plan proposed above, it is vital to have human resources (trainers). Thus, formulation and implementation of ToT programmes too should be an integral part of the plan. As the topics of importance in just energy transition are relatively novel, ToT programmes should be assisted with a resource pack for the trainers providing all the teaching materials, including complementary reading materials, assignments, sample questions, and case studies.

7. Re-orienting TVET for Sri Lanka's energy transition

Based in the findings presented in chapter 6, a set of specific competencies could be established in accordance with the overall competency framework (Table 13), the National Competency Standards (Section 3.3) and professional competency profiles (Table 15). These specific competencies should align with core competencies, incorporate considerations related to gender, and relate to different RE resources, technologies, processes, systems, and sub-systems.

7.1. Adapting existing curricula

The following table provides proposed curriculum contents and competencies to be added for adjusting the existing TVET offerings and addressing identified gaps and needs. However, many courses do not present their intended learning outcomes in a structured way or in the form of competencies, rendering it difficult to provide detailed recommendations beyond the general competency requirements identified through the research. Two examples of courses with more information present are analysed as case studies in section 7.2 below and can serve as a template to conduct a more detailed analysis of other TVET programmes and modules in collaboration with the relevant training providers.

Table 19: Proposed adaptations to existing curricula

Qualification/course	Curriculum contents to add	Competencies to add
National Apprentice and Industrial Training Authority (NAITA)		
Solar PV Systems Technician (NVQ 3-4)	▪ Solar resource assessment ▪ Electricity transmission ▪ PV tracker mounting ▪ Basics of civil engineering and construction	▪ Critical thinking competency (scaling up RE projects) ▪ Anticipatory competency (troubleshooting for system repair; knowledge of production and manufacture of solar panels; battery technology, hybrid inverters) ▪ Integrated problem-solving competency (energy system efficiency) ▪ Normative competency (conceptual skills)
Sri Lanka Sustainable Energy Authority (SLSEA)		
Training Programme for Solar Power Systems Technicians (NVQ 4)	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission ▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing	▪ Information competency (data collection and data monitoring) ▪ Systems thinking competency (development of pilot-scale models for solar; conceptual skills)

	▪ Grid infrastructure	▪ Critical thinking competency (management of solar farms; procurement; energy demand prediction) ▪ Anticipatory competency (grid infrastructure development, management, operations, and maintenance; controller systems, harmonic checking, and hybrid inverters; battery and energy storage technology; production and manufacturing of solar panels and tiles; smart grid technology; solar panel recycling; wireless system monitoring techniques) ▪ Integrated problem-solving competency (EE, energy conservation, and management; design and manufacturing of solar-powered charging stations)
Solar PV Technician Training (NVQ 4)	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission ▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing	
Training of Trainers Workshop for Solar PV Rooftop Installations for Women Employees of Sri Lanka Armed Forces	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission ▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing ▪ PV tracker mounting	
College of Technology under Department of Technical Education and Training (DTET)		
National Diploma in Technology and Education (Electrical Technology) (NVQ 5)	▪ Basics of RE and RETs ▪ Grid infrastructure ▪ EE and energy management	▪ Information competency (resource assessment, identification, extraction, and development of RE and RETs) ▪ Anticipatory competency (grid infrastructure development, management, operations, and maintenance) ▪ Strategic competency (strategizing and higher-level planning and management; business model development, marketing, and promotion) ▪ Integrated problem-solving competency (EE, energy conservation, and management; integrated

		energy transition planning) ▪ Self-awareness-competency (social skills)
Solar PV Systems Technician	▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing	▪ Information competency (data collection and data monitoring) ▪ Systems thinking competency (development of pilot-scale models for solar; conceptual skills) ▪ Critical thinking competency (management of solar farms; procurement; energy demand prediction) ▪ Anticipatory competency (production and manufacturing of solar panels and tiles; smart grid technology; solar panel recycling; wireless system monitoring techniques)
National Cleaner Production Centre (NCPC)		
Training programme on Energy Management for Energy Managers (not TVEC-accredited)	▪ Energy auditing ▪ Integrated management and development of RE plans ▪ Emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)	▪ Strategic competency (building simulation software and energy consumption calculation; strategizing and higher-level planning and management; business model development, marketing, and promotion) ▪ Integrated problem-solving competency (EE, energy conservation, and management; green building concepts; integrated energy transition planning) ▪ Normative competency (professional training qualifications) ▪ Collaboration competency (management of cross-disciplinary teams)

		▪ Self-awareness-competency (social skills)
National Engineering Research and Development Centre (NERDC)		
Industrial training courses	▪ Cookstove manufacturing ▪ Gasifier technology ▪ Biomass and biogas in MSMEs	▪ Anticipatory competency (operation and maintenance of biomass and biogas technology; troubleshooting for system repair, machinery, and component installation of RET) ▪ Anticipatory competency (design, operation, and maintenance of biomass and biogas technology; equipment selection) ▪ Strategic competency (business model development, marketing, and promotion) ▪ Integrated problem-solving competency: (standards, and certifications (5)
Sri Lanka German Training Institute / Ceylon German Technical Training Institute		
Training in RE Systems Applied research project	▪ RE resource assessment ▪ Battery and energy storage technology ▪ Integrated RE systems ▪ Planning and project management	▪ Information competency (assessment of RE potential and RE sites; data collection and data monitoring; GIS mapping) ▪ Systems thinking competency (development of pilot-scale models; skills related to business, administration, supervision, and project engineering; conceptual skills; project implementation and management; upscaling of RE projects) ▪ Critical thinking competency (supply chain management; energy demand prediction) ▪ Anticipatory competency (grid infrastructure development, management,

		operations, and maintenance; battery technology; troubleshooting for system repair, machinery, and component installation of RET)
Sri Lanka Institute of Advanced Technological Education		
Higher National Diploma in Engineering – Building Services (NVQ 6)	▪ Sustainable architecture and services ▪ Integrated management and development of RE plans ▪ Grid- and off-grid integration	▪ Strategic competency (building simulation software and energy consumption calculation) ▪ Integrated problem-solving competency (green building concepts)
Higher National Diploma in Engineering – Electrical Engineering (NVQ 6)	▪ Heavy current and power application of electricity, generation transmission, distribution, and utilization ▪ Design and installation of power electronics ▪ Electricity supply, electrical mechanics, utilization of electrical energy, microprocessor-based systems	▪ Information not available
Tertiary and Vocational Education Commission (TVEC)		
Solar Power Photovoltaic Installer (NVQ 3) Solar Power Photovoltaic Technician (NVQ 4)	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission ▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing ▪ Grid infrastructure	▪ Information competency (data collection and data monitoring) ▪ Systems thinking competency (development of pilot-scale models for solar; conceptual skills) ▪ Critical thinking competency (management of solar farms; procurement; energy demand prediction) ▪ Anticipatory competency (grid infrastructure development, management, operations, and maintenance; controller systems, harmonic checking, and hybrid inverters; battery and energy storage

		technology; production and manufacturing of solar panels and tiles; smart grid technology; solar panel recycling; wireless system monitoring techniques) ▪ Integrated problem-solving competency (EE, energy conservation, and management; design and manufacturing of solar-powered charging stations)
Renewable Energy Technology (NVQ 5) Renewable Energy Technology (NVQ 6)	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission ▪ Batteries and energy storage ▪ Integrated management and development of RE plans ▪ Emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)	▪ Information competency (data collection and data monitoring; GIS mapping) ▪ Systems thinking competency (skills related to business, administration, supervision, and project engineering; conceptual skills; project implementation and management; upscaling of RE projects) ▪ Critical thinking competency (energy demand prediction) ▪ Anticipatory competency (grid infrastructure development, management, operations, and maintenance; battery and energy storage technology)
Automobile Technician (covers EV hybrid)	▪ Charging stations ▪ Basics of RE sources and RETs	▪ Systems thinking competency (conceptual skills; project implementation and management) ▪ Anticipatory competency (battery and energy storage technology; troubleshooting for system repair and component installation; EV technology; design and manufacturing of EVs)
University of Vocational Technology (UNIVOTEC)		

BTech in Mechatronics Technology (NVQ 7) BTech in Manufacturing Technology (NVQ 7) BTech in Building Services Technology (NVQ 7)	▪ Energy auditing ▪ Integrated management and development of RE plans ▪ Emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)	▪ Strategic competency (building simulation software and energy consumption calculation; strategizing and higher-level planning and management; business model development, marketing, and promotion) ▪ Integrated problem-solving competency (EE, energy conservation, and management; green building concepts; integrated energy transition planning) ▪ Normative competency (professional training qualifications) ▪ Collaboration competency (management of cross-disciplinary teams) ▪ Self-awareness-competency (social skills)
VTA Vocational Training Centres		
Certificate for Solar PV Technician (NVQ 3)	▪ Electricity transmission ▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing ▪ Grid infrastructure	▪ Information competency (data collection and data monitoring) ▪ Systems thinking competency (development of pilot-scale models for solar; conceptual skills) ▪ Critical thinking competency (management of solar farms; procurement; energy demand prediction) ▪ Anticipatory competency (grid infrastructure development, management, operations, and maintenance; controller systems, harmonic checking, and hybrid inverters; battery and energy storage technology; production and manufacturing of

		solar panels and tiles; smart grid technology; solar panel recycling; wireless system monitoring techniques) ▪ Integrated problem-solving competency (EE, energy conservation, and management; design and manufacturing of solar-powered charging stations)
ETMA Campus (Engineering Technology Master in Automation)		
Online Solar Training Course	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission ▪ Batteries and energy storage ▪ Cell engineering and solar PV equipment manufacturing ▪ Grid infrastructure	▪ Information competency (data collection and data monitoring) ▪ Systems thinking competency (development of pilot-scale models for solar; conceptual skills) ▪ Anticipatory competency (battery and energy storage technology; production and manufacturing of solar panels and tiles; smart grid technology; solar panel recycling; wireless system monitoring techniques) ▪ Integrated problem-solving competency (EE, energy conservation, and management; design and manufacturing of solar-powered charging stations) ▪ Collaboration competency: Management of cross-disciplinary teams (2) ▪ Self-awareness-competency: Social skills (8)
Glide Energy		
Energy Manager Training Programme	▪ Energy auditing ▪ Integrated management and development of RE plans ▪ Emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)	▪ Strategic competency (building simulation software and energy consumption calculation; strategizing and higher-level planning and management; business model

		development, marketing, and promotion) ▪ Integrated problem-solving competency (EE, energy conservation, and management; green building concepts; integrated energy transition planning) ▪ Normative competency (professional training qualifications) ▪ Collaboration competency (management of cross-disciplinary teams) ▪ Self-awareness-competency (social skills)
Nuwan Madanayake Auto Hybrid Training Academy (Pvt) Ltd.		
Hybrid Technology Course (not TVEC-accredited) EV/PHEV Technology Course (not TVEC-accredited)	▪ Charging stations ▪ Basics of RE sources and RETs	▪ Systems thinking competency (conceptual skills; project implementation and management) ▪ Critical thinking competency (financial skills for budgeting, allocation, transactions; procurement) ▪ Anticipatory competency (battery and energy storage technology; troubleshooting for system repair and component installation; EV technology; design and manufacturing of EVs) ▪ Strategic competency (business model development, marketing, and promotion) ▪ Integrated problem-solving competency (design and manufacturing of solar-powered charging stations)
School of Engineering – ESOFT Metro Campus		
BEng (Hons) in Electrical and Electronic Engineering (not conducted at NVQ level)	▪ Basics of civil engineering and construction site supervision ▪ Electricity transmission	▪ Information competency (data collection and data monitoring; GIS mapping)

	▪ Batteries and energy storage ▪ Integrated management and development of RE plans ▪ Emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)	▪ Systems thinking competency (skills related to business, administration, supervision, and project engineering; conceptual skills; project implementation and management; upscaling of RE projects) ▪ Critical thinking competency (energy demand prediction) ▪ Anticipatory competency (grid infrastructure development, management, operations, and maintenance; battery and energy storage technology)
Sri Lanka Energy Managers Association (SLEMA)		
Energy Auditor Training Course (not TVEC-accredited)	▪ Integrated management and development of RE plans ▪ Emerging technologies (green hydrogen, energy storage, smart grids, other ICT applications)	▪ Strategic competency (building simulation software and energy consumption calculation; strategizing and higher-level planning and management; business model development, marketing, and promotion) ▪ Integrated problem-solving competency (EE, energy conservation, and management; green building concepts; integrated energy transition planning) ▪ Normative competency (professional training qualifications) ▪ Collaboration competency (management of cross-disciplinary teams) ▪ Self-awareness-competency (social skills)

In addition to these specific recommendations, several general recommendations were also identified by the stakeholders and can be found in Annex VI: Recommendations for other short- and medium-term measures.

7.2. Case examples for detailed curriculum adjustment

This section provides two examples of performing an in-depth analysis of selected RE related technical training curricula, with particular emphasis on the ways to improve further to cater for the future employment demand in the anticipated clean energy transition in the country.

7.2.1. Case example 1: National Diploma Courses in RET (NVQ 5/6)

The CBT curriculum for RET developed by TVEC with the consent of UNIVOTC and validated by NAITA is the most comprehensive curriculum in the TVET sector to cater for the technical training in RETs and produce technicians with NVQ 5 and 6 levels. This curriculum was developed following the steps given in the development of National Competency Standards (see Table 14) and provides information on the following aspects:

- Conditions to be fulfilled by training providers in order to award diplomas at NVQ 5 and 6 levels;
- List of modules under two categories as technical (26 modules) and employability (6 modules);
- Module structure (code, title, type, and notional hours under three components as lectures/tutorials, practical/design/site visits, and self-study);
- Mapping of competency units and curriculum modules;
- Module descriptors (title, code, type, related competency units, pre-requisites, module aim/s, learning outcomes, learning content, practical, resources, prescribed text/references, teaching/learning activities, assessment and weighting, duration)

Therefore, the curriculum of this programme offers a sound framework for training providers to develop and implement courses on RETs targeting the award of diploma for the sector technical staff.

Note that core competencies for the training course and specific competencies related to a particular module are not listed in this format of curriculum framework to identify gaps, particularly with respect to the proposed competency framework presented in this study. However, the aims and learning outcomes of each module are defined based on competency units specified in the Competency Standards, it is possible to recognize related competencies in general. An elementary-level comparison indicates gaps that could be considered for minor or major revisions within competency units in the subsequent periodic review of the National Competency Standards as stipulated in the Operational Manual of the NVQ Framework of Sri Lanka. Following table presents the key areas for improvements in the competency units, which should eventually reflect through the content and delivery across all the modules in the curriculum.

Table 20: Areas for improvement of the competency units

Core Competency	Suggested aspects to be covered in the NCS competency units
Information competency	Acquisition and management of data and information related to RE sources, technologies, systems, and sub-systems.
Systems thinking competency	Interactions and interdependence of sub-systems and components in RE plants.
Critical thinking competency	Appraisal of RE systems, technologies, and their operations in relation to environmental, economic, social criteria and indicators.
Anticipatory competency	Use of standards and best practices to ensure optimum operation of RE systems and technologies.
Strategic competency	Incorporation of innovative concepts and procedures to enhance the performance of RE systems and technologies continuously.

Integrated problem-solving competency	Use of appropriate instrumentations, tools, software and methodologies for predictive and preventive maintenance in order to identify and rectify system and component failures.
Normative competency	Ensure the compliance with the legal, regulatory safety requirements (personal and machinery) requirements, as reflected through personal and professional behaviours and values.
Collaboration competency	Contribute to, and gained from, knowledge management in RE system operation with effective collaborations and participations.
Self-awareness competency	Explore continually the career progression through full commitment to the employment and learning through experience.

More significant gaps in the curriculum of the RET course reside within the content. Firstly, the scope of RE resources covered in the curriculum is not broad enough to capture the anticipated RE technology development in the country. The emphasis is primary, if not entirely, given to electricity generation, undermining the vital role of thermal energy services in the sector. The emphasis given to solar PV is understandable, but clean energy transition is determined through much broader resources and technologies. Accordingly, the following table presents the gaps in the curriculum in relation to the content and coverage, which need to be addressed.

Table 21: Areas for improvement of the course content

Thematic areas or topics	Coverage and content (gaps and suggestions for improvement)
Thermal energy services of RET	Very limited coverage. RETs for thermal energy applications should be included. In line with this, fundamental core module on Thermodynamics (covering fuels and combustion) too needs to be incorporated.
Biomass energy	Biomass resources (which is the main source of energy in the country) and technologies are not covered. These technologies should be related to the key processes such as beneficiation, densification, thermo-chemical conversion, biological conversion etc. and main thermal applications such as steam generation, water boiling, heating, air drying, and de-hydration.
Solar energy	Solar thermal energy is not covered. Solar water heaters and air driers should be covered.
Wind energy	Wind energy is only limited to small-scale wind power, which is now obsolete application in Sri Lanka. The more important topics of grid-connected on-shore and offshore wind turbines and wind farms should be covered.
Hydro power	The topics covered are related to pico and micro hydro only, which are very rare. The most important application is grid connected mini hydro that should be included.
Other RE resources	Though not presently harnessed, geothermal and ocean energy could contribute to the clean energy transition in the country. Thus, at least basic introduction to these resources and technologies should be incorporated.
Other technologies	There are new and emerging RE related technologies, such as energy storage, green hydrogen, or smart grids that need to be presented briefly in the curriculum.
Other topics	In the context of clean energy development, there are other topics of importance for any educational/training programmes, such as: ▪ Energy and environment including GHG emissions and climate change ▪ Waste management (particularly related to end-of-life fate of RE plants, batteries etc.) ▪ SD and SDGs

	▪ Just transition and social inclusion in the energy sector.

The list of topics given above does not mean that new modules are required to enhance the curriculum. In general, most of the topics can be incorporated into the existing modules. Further, some areas can be developed as a module, but more logical way to include them is to offer optional and elective modules than compulsory ones. In fact, another deficiency of the present curricula is that all the modules are compulsory, thus inflexible. Therefore, it is better to introduce revisions in the curriculum to have optional and elective modules for the participants to choose appropriately.

7.2.2. Case Example 2: National Certificate Courses in Solar PV Systems (NVQ 3/4)

This training programme to is developed based on National Competency Standards and CBT, which leads to award of National Certificate at NVQ Level 3 (in the occupation of Solar PV Systems Installer) and NVQ Level 4 (in the occupation of Solar PV Systems Technician). As with the RET diploma course presented above, there is a sound curriculum framework, with more details on competency units and competencies, allowing for a more detailed analysis. The content of the curriculum covers the following:

- **Competency standard:**
  List of competency units (11 units for both NVQ 3 and 4)
  Qualification packaging (7 units for NVQ 3 and 10 units for NVQ 4)
  Occupational definition
  Description of competency units
- **CBT curriculum:**
  List of modules (17 modules: 13 core modules and 4 basic modules)
  Competency profile (4 competency areas and 18 competencies)
  Programme structure
  Mapping sheet
  Description of modules (title, code, type, duration, learning outcomes, learning content theory and practical, teaching/learning activities, and forms of assessment)

This curriculum presents a list of competencies, which can be mapped against the core competency areas established in the present study to identify gaps. The results are presented in the following table:

Table 22: Mapping of competencies against core competencies

Core competency	Related competencies in the curriculum
Information competency	A1. Collect site information A2. Understand working environment A3. Outline list of materials and list of services B8. Communicate to relevant parties
Systems thinking competency	B1. Fix civil and mechanical components B2. Mount solar modules B3. Fix electrical components and inverters B4. Integrate energy storage systems (off grid and hybrid) B5. Fix safety and protection components;
Critical thinking competency	No specific competency
Anticipatory competency	B6. Follow grid code, standards, and regulations
Strategic competency	No specific competency
Integrated problem-solving competency	C1. Identify test points, tools and equipment C2. Conduct civil & mechanical tests C3. Conduct electrical tests C4. Conduct system verification

	D1. Conduct preventive maintenance D2. Conduct troubleshooting D3. Conduct civil and mechanical repairs
Normative competency	B7. Establish safety, productivity and compliance
Collaboration competency	No specific competency
Self-awareness competency	No specific competency

The above mapping indicates that the competencies listed in the curriculum of National Certificate Courses in Solar PV Systems (NVQ 3/4) cover the core competency areas established in the present study. However, there are four core competencies where there are specific competencies identified in the course. Yet, contents of some modules in the curriculum signify that there are competencies (beyond those listed) that could be effectively developed through the delivery of the module. Accordingly, more comprehensive assessment is required to identify the major gaps in relation to the competencies and corresponding remedial measures to improve the certificate course.

In relation to the content, no significant gap is noticed, but the challenge would lie with the effective delivery of the course with limited resources in the technical education sector. It is important to recognize here that the above certificate course is targeted for the application of solar PV technology for grid electricity generation. However, similar courses for other resources and technologies (wind, biomass, hydro, solar thermal) are not available, which may hinder the progression of RET education and training, particularly to cater for the just energy transition. Under these circumstances, more effective way of incorporating required competencies in the technical education sector would be to incorporate relevant topics and lessons into existing (related) modules.

8. Conclusions

The present socio-economic crises in Sri Lanka emphasise the need for re-shaping the energy sector through systemic changes in the policy and governance environment, while large scale deployment of cleaner energy sources, particularly REs, such as solar, wind, small hydro, and biomass/biogas.

Key takeaways

1. TVET opportunities for the RE sector in Sri Lanka are currently limited and either focused on solar PV or RE in general.

33 TVET courses

2. The existing TVET offerings are also limited in their scope, their geographic availability, their incorporation of non-technical competencies, and integration with existing modules, courses, and educational frameworks.

3. Sri Lanka will need a large and skilled workforce to achieve its national commitments, including at least 1,650 technicians and 1,100 technical assistants in the short as well as 5,300 technicians and 2,900 technical assistants in the medium term. Several key competencies and job roles can be identified for this workforce.

Technicians (NVQ 3-4) **1,650 | 5,300**

Tech. assistants (NVQ 1-2) **1,100 | 2,900**

4. Key competencies include anticipatory competency in the short term and information competency, anticipatory competency, and strategic competency in the medium term.

5. Amending curriculum content and adding specific competencies into existing TVET courses could contribute to closing the existing gaps and training more qualified personnel. More courses and trainers are needed as well.

Figure 14: Key takeaways

To achieve a successful RE transition in Sri Lanka, several gaps and challenges must be overcome. One of the key challenges is the lack of competencies of the technical level staff to support the just energy transition that demands for a set of new and varying skills. In fact, the preparedness of the TVET sector for competency building on technical staff is fundamental for a just energy transition in Sri Lanka. The energy sector and TVET sector in the country, in general, are well established, with strong policy, regulatory and institutional environment. However, there is a lack of connectivity between the two sectors, which has led to inadequate responsiveness to labour market demand as reflected in the curricula of the present training programmes. This strongly points to the need to establish more formal and effective coordination between the energy and TVET sector institutions.

The following key recommendations have been identified by the stakeholders and experts to facilitate Sri Lanka's RE transition through an enhanced TVET sector:

Table 23: Overview of key recommendations

Area	Recommendation
Policies and regulations	▪ Formulate and implement a national training strategy and implementation plan for the competency development of technical staff, building on a sound curriculum framework covering all levels and sectors of TVET (cognitive, functional, and attitudinal areas that could lead to adequate number of

	competent staff, who will also be capable of building institutional competencies).
	▪ Develop the above-mentioned training plan with carefully designed common core competencies and programme outcomes as well as a comprehensive list of thematic areas and subject topics, through which the specific training programmes for selected target groups could be developed.
	▪ Enhance standardization of TVET related to RE and award certifications in line with global requirements to strengthen competitiveness of local labour with foreign labour; this can also apply for Sri Lankans going abroad to earn foreign remittances with relevant skills on RE development.
Institutions and governance	▪ Create an industry-level forum with education providers for matchmaking between supply and demand side on energy-sector TVET, potentially building on the existing private sector engagement platform under the Ministry of Energy.
	▪ Create a multi-stakeholder skills council for the energy sector in Sri Lanka to fill the trainer gap with industry experts and professionals.
	▪ Strengthen industry involvement in curriculum development for TVET on RE.
	▪ Establish a holistic dialogue format between the private sector, education providers, and other stakeholders (finance, technology).
	▪ Strengthen vertical and horizontal integration among all relevant stakeholders, including government institutions, private sector, academia, education providers, and civil society.
Economy and finance	▪ Promote innovation for entrepreneurship and self-employment to train job creators, not just job seekers; for example, by developing enterprise-related modules and incorporating them as optional content into RE courses, or through low-interest loan programmes and self-employment promotion initiatives.
	▪ Conduct entrepreneurship trainings at the DS level for people entering universities.
Research and technology	▪ Facilitate innovative training approaches that continuously reflect innovation and technical advances in curriculum development.
	▪ Provide capacity-building and awareness creation of women energy users on EE, RE, and available sources of support and information.
Data and information	▪ Expose professionals to available strategies and models.
	▪ Promote on-site and in-company training on RE to keep pace with innovations and developments in the industry.
Other	▪ Design ToT programmes with appropriate resource packs for trainers to promptly develop relevant training topics, modules, and programmes in specific areas.
	▪ Build capacities of career guidance officers and centres on RE and relevant current and projected developments in the job market.
	▪ Build a pool of qualified human resources for the RE transition on both the implementation and the management side.
	▪ Mainstream RE- and EE-related basic knowledge and skills into education curricula.

	▪ Ensure female participation and provide gender-responsive TVET opportunities.
	▪ Create more additional and extracurricular means of engagement with RETs, such as clubs, associations, job fairs, and youth programmes.

In the short-term, competency requirements include competencies related to assessments of RE potential and identification of RE sites (information competency) as well as RE systems operation, maintenance, and repair (anticipatory competency). In the mid-term, key competencies include those related to mobilizing finance for RE, for example through bidding processes (critical thinking competency) as well as producing and scaling up RE projects, for example wind turbine erection, design of biogas or biomass, or manufacturing of solar panels and e-vehicles (anticipatory competency).

Other important competencies in the mid-term include strategy competency (for example, building simulation software to calculate building energy consumption), integrated problem-solving competency (for example, identifying and addressing energy system inefficiencies), normative competency (for example, conceptual skills), and self-awareness competency (for example, social skills and project coordination).

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10. Annexures

The following annexures contain additional relevant information related to the activities conducted as part of this study, the methodology, and thematic areas connected to, but beyond the specific scope of this study.

Annex I: Full list of engaged stakeholders

Survey and KIIs

Entity	Contact person	Designation
Policymakers and regulatory bodies		
SLSEA	Eng. Ravini Karunarathne	Assistant Director (National Projects)
	Eng. Poornima Kalhari	Assistant Director (Solar Resource Assessment)
	Eng. Chamila Jayasekara	Director (R&D)
PUCSL	Mr. Gamini Herath	Deputy Director General
CEB	Mr. Ronald Comester	Deputy General Manager (Research and Development)
TVEC	Dr. K. K. Lalithadheera	Director General
Ministry of Labour	Mrs. K. D. R. Olga	Additional Secretary
Ministry of Technology, Research and Atomic Energy	Himali W. K. Athauda	Assistant Director
Education and training service providers		
CGTTI	Mr. Namal Nishantha Edirisinghe Kodithuwakku	Lecturer
SLGTI	Mr. A. B. Alfred	Registrar
Jaffna College of Technology	Mr. A. B. Alfred	Visiting Lecturer
UNIVOTEC	Eng. J.K. Kanthi	Senior Lecturer, Electrical and Electronics
Energy sector		
SLAEB	Mr. Malinda Ranaweera	Scientific Officer, International Cooperation Division
SLSEA	Mr. Chamila Jayasekara	Director (R&D)
SLEMA	Mr. Chamila Jayasekara	President
SEWIN Exergy Solutions (Pvt) Ltd.	Eng. Ranjith Padmasiri	Managing Director
Eco Steem (Pvt) Ltd.	Balachandran Ramesh	CEO
Enricher Holdings	Pasindu Weerasooriya	Technical Officer
Central Engineering Consultancy Bureau	Eng. Sameera Shaman	Electrical Engineer
Access Solar	Sujeewa Fernando	Manager Energy Management
Hayleys Fentons	Tuan Anosh Ismail	Project Engineer
Windforce PLC	Eng. Chamika Perera	Chief Development Officer
	Mr. Sanjaya Navarathne	General Manager (Solar Power)
	Eng. Chamira Buddhika	Engineer

	Mr. Prasanna Dissanayake	General Manager (Hydro)
Vidullanka PLC	Mr. Chanaka Dehikumbura	Mechanical Engineer
	Mr. Asanka Kumarasiri	Manager – Precontracts
LTL Holdings	M. K. D. U. Dharmasena	Electrical Superintendent
	M. G. H. J. Rajeewa	Electrical Superintendent
	Lahiru Weerakoon	Electrical Superintendent
	Layan Anushka Gunasekara	Electrical Superintendent
	H. P. R. M. Hewawasam	Electrical Superintendent
	S. D. Liyanage	Electrical Superintendent
	R. M. C. M. Jayasinghe	Electrical Superintendent
	U. P. Mahagamage	Assistant Engineer
	Sameera Marapperum	Electrical Superintendent
	Mr. Thisara	Electrical Engineer
	Ms. Udari	Management trainee
	Mr. Janitha Jayasinghe	Electrical Engineer
	Mr. Chathura	Electrical Engineer
Eco Tech Base	Rohitha Ananda	Energy Expert
	Lalith Aruna	Technical Officer
Simple Engineering	Ajith Kumara	Engineer
	Lankajith Ruwan Pathirana	Technical Officer
GLIDE (Pvt) Ltd.	Mr. Peter Rezel	Managing Director
	Thejan Wickremasurendra	Associate Engineer
ECOsolarrays	Sandun Lakshan	Business Development Manager
Independent Consultant	Eng Gamini Senanayake	N/A
Rec Solar (Pvt) Ltd.	Mr. Amila Pathirana	Country Manager
Super Net Technology (Pvt) Ltd.	Mr. T. K. U. Perera	Project Engineer
	Mr. Ruwan Kumara	Installer
David Pieris Motor (Pvt) Ltd.	Mr. P. H. Kaushan	Technical Officer
REM Solar	Mr. Dhanapala	Assistant Engineer
	Ms. Madhushika Senevirathne	Technical Officer
Industrial Services Bureau	Mr. Thilanka Alwis	Consultant-Engineer
Smart Solar Energy and Electricals	Mr. A. D. R. M. G. Rajapakshe	Managing Director
	Mr. J. L. R. Mahindasiri	Engineer
Melwire Rolling (Pvt) Ltd.	Mr. Janaka Rukmal	Senior Electrical Engineer
	Mr. A. Abishake	Head of Operations
Ceylon Sons Power (Pvt) Ltd.	Mr. A. Anushka Dilruksha	Managing Director
	Mr. W. Shevon Hirushka	Team Leader
Digital Sales (Pvt) Ltd.	Mr. Srimal Wijeythunga	Managing Director
	Mr. Nirusha Fernando	Director
Ceynshango Lanka Renewable Provide (Pvt) Ltd.	Mr. Nimal Weerathunge	Vice Chairman/Managing Director
CodeGen Sustainable Solutions (Pvt) Ltd.	Mr. Heshan Karunarathna	Director
	Dr. Gamini Piyadasa	Consultant
	Mr. Amila Perera	Head of Division

	Ms. Kavindya Baddegama	Senior Product Coordinator
Idel Tiles – E-bike	Christo Dabare	Managing Director
IDEA (GTE) Ltd.	Dumindu Herath	Consultant
DIMO	Mr. Nalaka Kularathne	Deputy General Manager
	Mr. Sanura Gunasekara	Manager
	Mr. Vibhanu Arachchige	Senior Manager
Development agencies and civil society		
SLEMA	Mr. Namiz Musafer	Country Manager – Sri Lanka
	Mr. Chamila Jayasekara	President
USAID/Chemonics	Mr. Nadeera Wijesinghe	Technical Lead
NCPC	Eng. Samantha Kumarasena	Chief Executive Officer
Forbes Marshall Lanka (Pvt) Ltd.	Mr. Dilan Priyanath	Application Engineer
Research organizations and academia		
NSF	Dr. J. G. Shantha Siri	Head, International Affairs Division/Principal Scientific Officer
NERDC	Eng. Ananda Namal	Director General
Open University of Sri Lanka	Dr. I. U. Atthanayake	Head, Mechanical Engineering
Open University of Sri Lanka	K. U. C. Perera	Senior Lecturer

TVET stakeholder consultation, 06.12.2022

Entity	Contact person	Designation
Policymakers and regulatory bodies		
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Vocational Training Authority of Sri Lanka	Mr. A. P. Jagath Nishantha	Assistant Director
	Mr. P. N. Ranaweera	Assistant Director
	Mr. S. L. S. P. Karunasiri	Technical Officer
Tertiary and Vocational Education Commission	Mr. T. Senthuran	Director, Planning and Research Division
Education and training service providers		
CGTTI	Mr. Namal Nishantha Edirisinghe Kodithuwakku	Lecturer
SLGTI	Mr. P. Jathursan	Staff, Electrical and Electronics Technology Department
UNIVOTEC	Eng. J. K. Kanthi	Senior Lecturer, Electrical and Electronics
Dept. of Technical Education and Training	Mr. S. C. Jagath	Director General
	Mr. H. R. A. P. Gunathilake	Instructor
Lalith Athulathmudali Vocational Training Centre	Mr. Niroshan Aponsu	Academic Coordinator
ETMA Campus	Eng. E. T. M. Rijad	Founder and Managing Director
Energy sector		
GLIDE (Pvt) Ltd.	Thejan Wickremasurendra	Associate Engineer
Development agencies and civil society		
NCPC	Mr. M.M. Munsif	Energy Engineer

Research organizations and academia		
NERDC	Dr. Jayathu G. Samarawickrama	Director General
University of Moratuwa	Dr. Hirushie Karunathilake	Senior Lecturer
Open University of Sri Lanka	Dr. Iresha Attanayake	Head, Department of Mechanical Engineering
University of Peradeniya	Prof. S. D. G. S. P. Gunawardane	Professor, Mechanical Engineering
University of Ruhuna	Eng. Mr. H. V. H. H. Senavirathna	Lecturer (Probationary)
University of Kelaniya	Dr. Pradeep Samarasekara	Senior Lecturer
Rajarata University of Sri Lanka	Dr. Chaturanga Thotawatthage	Senior Lecturer
Sabaragamuwa University of Sri Lanka	Mr. H. V. V. Priyadarshana	Lecturer
Kotelawala Defense University	Mr. F. B. Y. Randana De Silva	Lecturer
Sri Lanka Institute of Information Technology (SLIIT)	Prof. R. A. Attalage	Dean, Faculty of Graduate Studies
	Prof. Migara Liyanage	Head, Department of Mechanical Engineering
NSBM Green University	Ms. Kaumadee Samarakoon	Head, Department of Electrical, Electronic and Systems Engineering

Annex II: Cabinet decisions on TVET

In addition to the laws, policies, strategies, and plans listed in section 3.5, there are also several recent cabinet decisions that pertain directly to TVET and/or the energy sector in Sri Lanka:

Table 24: Cabinet decisions on TVET (2020 onward)

Cabinet decision	Description
Cabinet Decision (2022-08-15) Entering into a Memorandum of Understanding on Cooperation in the Fields of Science, Technology and Innovation between the GoSL and the Government of Nepal	Proposal approved for Memorandum of Understanding on Cooperation in the Fields of Science, Technology and Innovation between the GoSL and the Government of Nepal which was initiated by the then Ministry of Skills Development, Vocational Education, Research and Innovation.
Cabinet Decision (2022-08-08) Entering into a Memorandum of Understanding on Academic Cooperation between the International Centre for Higher Education Innovation and the Ministry of Education of the GoSL	The International Centre for Higher Education Innovation functioning under the auspices of UNESCO has agreed to provide online training to enhance the capacity of staff of the Technical and Vocational Education and Training Institutes of the Public sector.
Cabinet Decision (2021-11-29) Capacity Building Project for Construction Courses at Technical Colleges and Colleges of Technology in Sri Lanka	In view of providing a high quality technical and vocational education and training to meet the labour market demand in the field of construction, the Korea International Cooperation Agency (KOICA) has agreed to award a grant of USD 4 million to implement a project to upgrade training courses in the construction field at selected Colleges of

	Technology and Technical Colleges. The proposal made by the Minister of Education to implement the proposed project during the period from the year 2021 to the year 2024 and to sign an Agreement with the KOICA to obtain the respective Grant for the purpose, was approved by the Cabinet.
Cabinet Decision (2021-08-09) Entering into a Memorandum of Understanding between the Open University of Sri Lanka and the University of Essex, the United Kingdom	Accordingly, the proposal made by the Minister of Education to sign the said Memorandum between two parties, for the objectives of obtaining opportunities to enter into the University of Essex for students who have qualified after completing the relevant courses at the Open University of Sri Lanka, implementing collaborative research projects on mutual consent and organizing student, faculty and staff exchange programmes, was approved by the Cabinet.
Cabinet Decision (2021-08-02) Commencing a national broadcasting channel for primary, secondary, higher education and tertiary education	The joint proposal made by the Minister of Education and the Minister of Mass Media to utilize one of the channels of the Sri Lanka Broadcasting Corporation covering the entire country so as to commence a broadcasting channel dedicated for education, was approved by the Cabinet.
Cabinet Decision (2021-07-19) Vesting the Government owned lands used by the Open University of Sri Lanka, with the said University	The proposal made by the Minister of Education to vest seventeen Government-owned land plots where Regional Centres and Study Centres are located, with the Open University of Sri Lanka as per the provisions of the State Lands Ordinance enabling to further improve the adequate physical facilities of the said Centres, was approved by the Cabinet.
Cabinet Decision (2021-05-24) Entering into a Memorandum of Understanding between the Open University of Sri Lanka and the Korea National Open University, South Korea	Cabinet approval to the proposal made by the Minister of Education to sign an MoU to develop collaboration in the fields of open and distance education, capacity building, ICT applications, use of laboratory services, research and publications and staff exchange programmes.
Cabinet Decision (2021-05-03) Entering into a Memorandum of Understanding between the Open University of Sri Lanka and the Graduate School of Environmental and Life Science, Okayama University, Japan	Cabinet approved the proposal made by the Minister of Education to enter the Memorandum in view of promoting the activities of organizing student, faculty and staff exchange programmes, collaborative research, instructional and cultural programmes and exchanging research information.
Cabinet Decision (2021-03-01) Vesting of the land and buildings owned by the National Housing Development Authority located at Thammannagama, Anamaduwa with the Ceylon German Technical Training Institute	The Ceylon German Technical Training Institute (CGTTI) requested the land and its buildings to establish its Anamaduwa Regional Centre. Accordingly, the proposal made by the Minister of Education to transfer the said land and buildings back to the Government and to vest the same with the CGTTI on a free grant, was approved by the Cabinet.
Cabinet Decisions (2021-02-22) Intent of Cooperation between COMSATS University Islamabad, Pakistan and Industrial Technology Institute	Proposal was approved for Cooperation on Education and Research to be signed between the COMSATS University Islamabad of Pakistan and the Industrial Technology Institute of Sri Lanka.

Memorandum of Understanding between the International Centre for Chemical and Biological Sciences, University of Karachi of Pakistan and Industrial Technology Institute	Proposal made by Minister of Technology to enter a Memorandum of Understanding on Education and Research between the International Centre for Chemical and Biological Sciences, University of Karachi of Pakistan and the Industrial Technology Institute was approved by the cabinet
Cabinet Decisions (2020-07-08) Construction of a Hostel, Workshop, and a Canteen for the University of Vocational Technology, Ratmalana	The Cabinet granted approval for the construction of three separate buildings for a hostel, workshop, and canteen for UNIVOTEC in Ratmalana under an estimated cost of LKR 927.34 million.

Annex III: List of relevant projects and initiatives in Sri Lanka

In addition to the policies and regulations, there are also a number of programmes and initiatives by different actors—including government entities, development partners, universities, and UN agencies—to further Sri Lanka's RE transition and relevant TVET development.

Table 25: Project related to energy transition (2010 onwards)

Institution	Project Status
Development projects	
Government of Sri Lanka	Long Term Generation Expansion Plan 2022-2041 and 2023-2042, CEB *CEB regularly produces generation expansion plans for 20 years which include results of generation expansion planning studies carried out by CEB, information on existing generation systems, generation planning methodology, system demand forecasts, investment requirement and implementation plans, and contingency analysis.*
	"Energy Empowered Nation" – The ten-year development plan, Ministry of Power and Energy *Practical workplan up to 2025 formulated with contribution of the private sector and focused on eight thrust areas that have direct impact on the energy sector.*
	Battle for Solar Energy, Ministry of Power and State Ministry of Solar, Wind, and Hydro Power Generations Projects Development in collaboration with SLSEA, CEB, and LECO *Community-based power generation project titled "Soorya Bala Sangramaya" (Battle for Solar Energy) to promote small solar power plants on the rooftops of households, religious places, hotels, commercial establishments, and industries; expected to add 1,000 MW of solar electricity to the national grid by 2025 and 1,500 MW by 2030 through this intervention. (Progress)*
	Renewable Energy Resource Development Plan 2021-2026, SLSEA *Plan for mapping and harnessing RE resources and RE park development for the period 2021-2026.*
Asian Development Bank	Power Sector Development Program (2002-2010)
	Clean Energy and Access Improvement Project (2010-2017)
	Sustainable Power Sector Support Project (2011-2017)
	Clean Energy and Network Efficiency Improvement Project (2013-2020)
	Green Power Development and Energy Efficiency Improvement Investment Program 2015 and 2017 onwards
	Wind Power Generation Project Feasibility study (2016-2021)
	Rooftop Solar Power Generation Project 2016-2017 and 2018-2022
	Supporting Electricity Supply Reliability Improvement (2017-2023)
	Power System Reliability Strengthening Project (2017 onwards)
	Wind Power Generation Project (2018 onwards)

	South Asia Subregional Economic Cooperation Regional Energy Cooperation (2018 onwards)
	Promoting Increased Renewable Energy Deployment, Energy Efficiency, and Power System Resilience (Proposed)
	Power System Reliability Strengthening Project (Proposed)
UNDP	Biomass Energy Production (2012-2019)
	Energy Generation NAMA (March 2015 - January 2020)
	Biomass Energy 2022 – Phase 2 (2018-2022)
	Biogas and Solar Trilateral Cooperation - Transitioning to Sustainable Energy Uses in the Agro-Industry in China (2019- 2023)
USAID	USAID 5-year, USD 19 million Sri Lanka Energy Project (2021)
	Partnership with David Pieris Motor Company to Boost Electric Mobility in Sri Lanka (2022)
	Partnership with VEGA to Promote Green Energy and EVs in Sri Lanka (2022)
World Bank	Renewable Energy for Rural Economic Development Project (2002-2011)
R&D, capacity-building, awareness creation, promotion work	
Government of Sri Lanka	Presidential Environment Awards 2016 / 2018 / 2019 / 2022, CEA
	CEB study on integrating RE to national grid 2018-2028, CEB *Includes RE generation projects (mini hydro, solar, wind) as one of the categories for applications for awards.*
	Developed Technologies at NERDC, *Green Building Council of Sri Lanka*
	e-Swabhimani 2019, ICTA
	Technology Park and Engineering Museum, NERDC
	Vidulka Exhibition, Ministry of Power and SLSEA *Annual exhibition organised to showcase novel inventions in the power and energy sector and educate the public.*
	Energy Media Awards, SLSEA
	National Energy Symposium (2013-2019), SLSEA
	Sanraksha Newsletter (2019 onwards)
	Sri Lanka National Energy Efficiency Awards, SLSEA
Development partners and others	Building the Capacity of the Sustainable Energy Authority, ADB (2008-2011)
	Smart Grid Capacity Development, ADB (2011-2018)
	South Asia Regional Workshop on Competitive Electricity Markets, USAID (2014)
	South Asia Energy Regional Consultations and Competitive Tendering Workshop, USA Commercial Law Development Program (2016)
	Rooftop Solar Power Generation Project 2016-2017 and 2018-2022, ADB
	Improving Institutional Capacity on Preparing Energy Efficiency Investments, ADB (2016-2021)
	Project for Capacity Development on the Power Sector Master Plan Implementation Program, Japan International Cooperation Agency (2019-2023)
	Deploying Solar Systems at Scale, ADB (2019 onwards)
Universities	Biogas Production Centre operated by Center for Sustainability Solutions, University of Kelaniya
	Pilot scale biogas project - General Sir John Kotelawala Defence University
Guidelines, regulations, and standards	
Government of Sri Lanka	Energy Efficiency Labelling Scheme, SLSI and SLSEA Energy Efficiency Building Code of Sri Lanka 2021, SLSEA
	Green Environment Rating System and Rating System for Sustainable Cities, Green Building Council Sri Lanka
	Sri Lankan Grid Code – Special requirement for wind turbine driven generators

	Guideline for Sustainable Energy Residences in Sri Lanka by SLSEA
	PUCSL regulations for electric vehicle charging stations
	Measurement, Reporting and Verification (MRV) – Biogas digester programme, Climate Change Secretariat
	Sri Lanka Standard Code of Practice, Specification, General Requirements, Particular Requirements related to on-grid and off-grid PV power systems
	Guidelines on rooftop solar PV installation for solar service providers, PUCSL Guidelines on rooftop solar PV installation for utility providers, PUCSL
	CEB Manual for Interconnection of Micro Scale Renewable Energy-Based Power Generating Facilities at Low Voltage Consumer Feeders of National Grid
Green Skills Development Programs	
International Labour Organization	Green Jobs in Asia - Sri Lanka (2010-2012)
	National Green Jobs Conference (2011)
	"Green Light for Green Jobs" – Employers Symposium (2011)
	Value Chain Development in Solid Waste Management Stakeholder Consultation and Validation Workshop (2011)

Annex IV: Higher education opportunities related to RE

Institution	Qualification/course	Curriculum
University of Colombo	BTech Eng. (Hons)in Instrumentation and Automation (SLQF 6) *Entry: at least S grades in engineering technology, science for technology, and one subject among economics, geography, home economics, English, communication and media studies, information and communication technology, art, business studies, agricultural science, accountancy, or mathematics in G.C.E. Advanced Level examination*	▪ Non-conventional energy sources and their applications
University of Jaffna	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical and Electronics Engineering *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ Electric power (energy conversion, alternative energy systems, measurement of power and energy, three phase systems, transformers, transmission systems and lines, admittance model and network calculations) ▪ (E) Electric generation from RE sources (solar, hydro, wind, wave and tidal, grid interconnections, institutional and economic factors) ▪ (E) Distribution automation and smart grid (power system basics, unbalanced operation of power system, power system measurements, communication

		for applications, control of distribution, demand response)
University of Kelaniya	BTech Eng. (Hons) (SLQF 6) *Entry: at least S grades in engineering technology, science for technology, and one subject among economics, geography, home economics, English, communication and media studies, information and communication technology, art, business studies, agricultural science, accountancy, or mathematics in G.C.E. Advanced Level examination*	▪ Sustainable technology systems ▪ Conventional and alternative energy resources
	BET (Hons) in Sustainable Energy *Entry: At least "S" grades for engineering technology, science for technology, and for third subject from among economics, geography, home economics, English, communication and media studies, information and communication technology, art, business studies, agriculture science, accountancy, or mathematics*	▪ Project development in sustainable energy ▪ Hydrology ▪ Energy storage ▪ Water and wastewater ▪ Soil and solid waste ▪ Air pollution ▪ Monitoring and assessment ▪ Sustainable facility management
	Short-term courses	▪ Sustainable energy
University of Moratuwa	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Chemical and Process Engineering *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ Waste-to-energy (concepts, resource identification and assessment, waste conversion pathways, waste-to-energy technologies) ▪ Biofuels and biorefineries (feedstock, biorefinery processes, biofuels, techno-economic analysis, technology selection, design and simulation of modular process systems) ▪ RE (wind, hydro, solar, biomass, micropower design and optimization) ▪ Energy storage systems (thermal, electrochemical, chemical, mechanical, electrical, system integration)
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical Engineering *Entry: same as above*	▪ Power systems (generation, transmission, distribution, power flow) ▪ Control systems (modelling, feedback control systems, root locus, frequency response, MIMO systems, digital control, recent trends in control systems) ▪ RE and environment (environmental impacts by energy, status of RE development, design of small hydro, solar PV, wind, and biomass power plants,

		energy storage including pumped hydro and battery technologies) ▪ (E) Microgrids (distributed generation, microgrid architecture, battery energy storage, solar PV, microgrid design and protection) ▪ (E) Energy systems (energy source costs and limitations, conversion processes, energy policy and planning, energy conservation and EE, environmental impacts of energy)
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electronic and Telecommunication Engineering *Entry: same as above*	▪ (E) Advanced power electronic design (converter dynamics and control, PV energy conversion systems, multiport converters)
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Materials Science and Engineering *Entry: same as above*	▪ (E) Energy materials (materials for energy harvesting, storage, and transmission)
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Mechanical Engineering *Entry: same as above*	▪ (E) Energy systems engineering (energy supply and demand scenarios, hydro, solar, wind, biomass, other alternative energy sources and technologies, environmental, economic, and social impacts)
	MEng (SLQF 10)/PG Diploma (SLQF 8) in Energy Technology *Entry: BSc Eng. from University of Moratuwa in Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Materials Science and Engineering or any other engineering degree of at least four years duration from a recognised University in a relevant field or any recognized category of membership of a recognized Professional Institute*	▪ Energy engineering ▪ RE (biomass, wind, solar, hydro, modern energy, technologies to reduce environmental degradation while improving energy security) ▪ Waste heat recovery technologies ▪ Energy conservation and management (energy auditing, energy conservation and management) ▪ Design of energy systems and energy economics ▪ Building energy (air conditioning, lighting, thermal comfort, heat transfer, EE) ▪ Energy and environment (adverse impacts, technical and non-technical mitigation options)
	MSc in Building Services Engineering	▪ Not available.
	Joint MSc in Energy for Circular Economy (offered by UoM, UoR, UoP, and OUSL under Europe Sri Lanka Capacity-Building in Energies Circular Economy Project funded	▪ Not available.

	by ERASMUS) – Online Delivery (SLQF 10)	
Open University of Sri Lanka	BTech (Hons) in Mechanical Engineering and Mechatronics Engineering (SLQF 6/NVQ 7) *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination or Advanced Certificate in Science with courses in the disciplines of mathematics, physics, and chemistry offered by the OUSL or a minimum of three credit passes for mathematics, physics, and chemistry in Cambridge/Edexcel Advanced Level examination or an equivalent or higher qualification*	▪ Renewable sources of energy (biomass, geothermal, solar, wind, hydro, tidal and wave) ▪ Sustainable transportation (planned) ▪ Net-zero energy building (planned)
	Master of Energy Management (SLQF 9) *Entry: A Bachelor Eng. (Hons) in the specializations of Mechanical, Mechatronics, Electrical, or Chemical Engineering of at least 120 SLQF credits obtained from a recognized university or a Bachelor Eng. of at least 120 SLQF credits obtained from a recognized university in any other specialization and one year of post-qualifying experience in the relevant field or a BSc of at least 90 SLQF credits with physics and mathematics as subjects obtained from a recognized university, and two years of post-qualifying experience*	▪ Energy and environment ▪ Thermal energy utilities ▪ Electrical energy utilities ▪ HVAC and building lighting ▪ RETs ▪ Energy policy and planning ▪ Energy management and auditing ▪ Combined energy systems for efficient energy use ▪ Planning and implementation of energy projects ▪ Financial management ▪ Human resources for energy sector
University of Peradeniya	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical and Electronics Engineering *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ Power and energy (three phase systems, measurement of power/energy, tariff and demand side management, RE) ▪ (E) Modern power systems (coordinated operation of power system, optimization, HVDC transmission, flexible ac transmission, reactive power compensation, power quality, harmonics and filters, smart grid and metering, computer-based project)
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Mechanical Engineering *Entry: same as above*	▪ Control systems (fossil fuels, nuclear energy, RE including hydro, solar, wind, marine, biomass, geothermal, hydrogen,

		batteries and ESS, EE, energy management and auditing, field visits) ▪ (E) Energy systems design
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Chemical and Process Engineering *Entry: same as above*	▪ (E) Energy technology for the process industry (review of combustion, fossil fuels, renewable and alternative energy sources, biomass, energy conservation, pollution formation and control) ▪ (E) Alternative energy systems, policies, and economics (energy security, alternative energy sources, energy conversion, electrochemical methods, energy economics ▪ (E) Microgrids (distributed generation, microgrid architecture, battery energy storage, solar PV, microgrid design and protection) ▪ (E) Energy systems (energy source costs and limitations, conversion processes, energy policy and planning, energy conservation and EE, environmental impacts of energy)
	MEng/MSc (SLQF 9/10) and PGDip (SLQF 8) programmes	▪ Environmental pollution control ▪ Sustainable built environment ▪ Building services engineering
	Expert Course on Wave Energy *Entry: anyone who wishes to gain a deeper understanding of the challenges and opportunities in the wave energy industry (up to three days duration) or wishes to actively contribute to wave energy as a technology or project developer (up to five days duration)*	▪ Wave energy (modelling and representation of the wave climate, fundamental of wave energy converters, physics of ocean waves, introduction to wave energy, economics of wave energy converters, calculating annual energy production, basic modelling and hydrodynamics of wave energy converters, wave energy converter design, techno-economic optimisation of wave energy converters, wave energy converter power-take off and control systems, wave-tank demonstration, physical modelling of wave energy converters, design and modelling of wave farms, wave-to-wire modelling of wave energy converters, future of wave energy, advanced modelling of wave energy converters, mooring design for wave energy converters)
Rajarata University of Sri Lanka	BSc/BSc (Hons) in Applied Science (SLQF 6) *Entry: at least S grades in combined mathematics or higher mathematics, chemistry, or physics, and one subject from agricultural science, higher mathematics, mathematics, combined*	▪ Energy resources (overview, batteries and fuel cells, solar energy, physics of semiconductor solar cells, nuclear energy, hydro, wind, tidal, EE)

	mathematics, chemistry, physics, or information and communication technology in G.C.E. Advanced Level examination	
University of Ruhuna	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical and Information Engineering *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ (E) RE (introduction to RE, solar energy, micro-hydro energy systems, wind energy, fuel cell, biomass energy) ▪ (E) Photonic devices (coupling of waves and modes, optical couplers, electro-optic devices, magneto-optic devices, acousto-optic devices) ▪ (E) Smart grid
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Mechanical and Manufacturing Engineering *Entry: same as above*	▪ (E) Energy technology (introduction to energy technologies, non-renewable energy sources, overview of RET, biomass, solar, wind, hydro, wave energy, ocean thermal energy conversion, geothermal energy, environmental impacts, application of energy technologies in Sri Lanka) ▪ (E) Energy management (introduction to energy management, energy conversion in boiler and steam systems, waste heat recovery methods, process integration for pinch technology, total energy schemes, energy management systems, energy auditing)
	Bachelor of the Engineering Technology (Hons) (SLQF 6) *Entry: at least S grades in engineering technology, science for technology, and one subject among economics, geography, home economics, English, communication and media studies, information and communication technology, art, business studies, agricultural science, accountancy, or mathematics in G.C.E. Advanced Level examination*	▪ Electro-mechanical instrumentations and process control (electrical and mechanical engineering technology, solar technology, biomass, wave energy, opportunities in RE, guidance to the energy sector during the training period)
	BSc (Hons) in Green Technology (SLQF 6) *Entry: at least S grades in biology, chemistry, and one subject among physics, agriculture, and soft technologies in G.C.E. Advanced Level examination. At least C grade for English in G.C.E Ordinary Level examination*	▪ RE I (concept of energy, units and measurement, types of energy, energy and power, energy demand, history of fossil fuels, sources of energy, Solar, wind, biomass, animal, human) ▪ RE II (energy in water, power contained in static and flowing water, components in a hydropower system, energy assessment, site assessment, configuration, sizing, installation and maintenance issues of a micro hydropower system, economic

		evaluation, tidal waves energy, nuclear energy, fuel cells and hybrid technologies) ▪ Biomass energy technology (biomass classification, production techniques, harvesting, processing for rural use, energy efficiency biomass burner, gasifier and its process, producer gas, bio-ethanol production, bio-diesel production, electricity generation from biomass)
Sabaragamuwa University of Sri Lanka	BTech (Hons) in Biosystems Technology (SLQF 6) *Entry: at least S grades in biosystem technology, science for technology, and one subject among economics, geography, home economics, English, communication and media studies, information and communication technology, art, business studies, agricultural studies, accountancy, or mathematics in G.C.E. Advanced Level examination*	▪ RE systems (terminology, energy demand in Sri Lanka and global, biomass and bioenergy, nuclear and hydrogen fuel cells, wind, solar, hydro, geothermal)
	BTech Eng. (Hons) degree (SLQF 6) *Entry: same as above*	▪ Building services (operation and maintenance, smart buildings) ▪ Industrial installations (electrical systems, heating systems, compressed air systems, energy management in industry, industrial communication system, industrial waste management)
University of Sri Jayewardenepura	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Mechanical Engineering *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ (E) Energy performance in buildings ▪ (E) Green engineering and environmental compliance
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical and Electronic Engineering *Entry: same as above*	▪ (E) Energy studies (introduction, energy consumption and demand, energy conversion processes, energy policy, energy planning and management, energy economics, environmental concerns)
Uwa Wellassa University	BTech in Material Science and Technology *Entry: at least S grades in engineering technology, science for technology, and one subject among economics, geography, home economics, English, communication and media studies, information and*	▪ Green technology

	communication technology, art, business studies, agricultural science, accountancy, or mathematics in G.C.E. Advanced Level examination	
	BTech in Food Engineering and Bioprocess Technology *Entry: same as above*	▪ Biomass conversion and biofuels
	BTech in Mechatronics *Entry: same as above*	▪ Energy technology
Wayamba University	BTech Eng. (Hons) in Electrotechnology (SLQF 6) *Entry: at least S grades in engineering technology, science for technology, and one subject among economics, geography, home economics, English, communication and media studies, information and communication technology, art, business studies, agricultural science, accountancy, or mathematics in G.C.E. Advanced Level examination*	▪ Emerging vehicle technology
NSBM Green University	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical and Electronic Engineering (UGC approved) *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E.*	▪ RE and RET (introduction to energy sources, introduction to RE, environmental and techno-economic impact assessment and of RE systems and conventional fuel systems, energy storage, design and suggest RE/hybrid energy systems)
	BSc in Mechatronic Engineering	▪ RETs
	Degrees in Engineering, Science Business, or Computing	▪ Introduction to sustainability development
General Sir John Kotelawala Defence University	BSc Eng. (Hons) in Electrical and Electronics Engineering (SLQF 6) *Entry: followed maths stream (combined maths, physics, chemistry) and obtained a minimum of two credit passes and one simple pass in G.C.E. Advanced Level examination or a minimum of two very good passes and one credit pass at the Cambridge or Edexcel Advanced Level examination*	▪ Energy studies and environment ▪ RE systems
	BSc Eng. (Hons) in Mechanical Engineering (SLQF 6)	▪ Energy technology and environment ▪ (E) Energy conservation

	Entry: same as above	▪ Sustainable engineering (energy technology and sustainability) ▪ Building energy
Sri Lanka Technological Campus	BSc Eng. (Hons) in Electronics and Telecommunication (SLQF 6) *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ (E) RE systems
	BSc Eng. (Hons) in Electronics and Power Systems (SLQF 6) *Entry: same as above*	▪ RE systems
	BTech (Hons) in Environmental Technology (SLQF 6) *Entry: at least S grades in approved subjects in technology, physical science, biological science, or ICT stream in G.C.E. Advanced Level examination*	▪ Energy and environment ▪ (E) RE systems
Sri Lanka Institute of Information Technology (SLIIT)	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Electrical and Electronic Engineering *Entry: at least S grades in chemistry, combined maths, and physics in G.C.E. Advanced Level examination*	▪ (E) RE systems
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Mechanical Engineering *Entry: same as above*	▪ Sustainable engineering ▪ (E) Energy technology and sustainability ▪ (E) Energy conservation and management
	BSc Eng. (SLQF 5)/BSc (Hons) Eng. (SLQF 6) in Mechanical Engineering (Mechatronics) *Entry: same as above*	▪ (E) Energy technology and sustainability

(E) Elective course/module

Annex V: Calculation of projection of job demand

To accurately match competency requirements with future employment opportunities, it would be important to conduct more comprehensive additional research and quantify the need for different qualifications and job profiles based on analysis of national plans and commitments, market predictions, supply and value chain actors, and technology development and manufacturing outside the country. However, the present technical level job profile of the RE industry in the country, regional and international literature on job market in the RE value chain, together with the RE development plan of the sector could be used to have a basic quantification of technical level employment opportunities in short and medium terms, as presented in this section. Here, the assessment is done for the RE based grid electricity generation till 2030, as the government has

set clear target through the updated NDCs submitted in September 2021, the overall target pledged in the NDCs is 70% RE contribution in grid electricity by 2030.

As most of the RE resources and technologies targeted are already in operation in the country, the employment opportunities for technical level staff already generated could be used for the estimation of new jobs that will be generated for the RE development in years to come. Further, the expansion of the RE sector could provide opportunities for further value addition within the country than those at present, that could create further job opportunities. Such additional opportunities could be identified through the information related to whole value chain of the RE industry. Presently, the commercialized RE resources and technologies in the country could be identified as small hydro (mini-hydro of capacity less than 10 MW, up to about 100 kW), onshore wind farms, ground mounted solar PV and roof-top solar PV and biomass (fuelwood, agro-residues and waste). Number of plants and total installed capacities are presented in the following table:

Table 26: Grid-connected RE plants in operation by end-2020

RE resource/technology category		Number of plants	Total capacity (MW)
Small hydro	Mini hydro	206	402.9
Biomass	Fuelwood (dendro)	8	30.5
	Agro-waste/biogas	4	13.1
	MSW	1	10.0
Solar PV	Ground-mounted	32	75.4
Wind	On-shore	18	248.5
	Total	269	780.4

In addition to above, by the end-of 2020, there were 30.139 solar PV rooftop systems with total installed capacity of 33.75 MW. The subsequent development of the RE industry is mainly through the installation of solar rooftop systems, which has reached 700 MW (47,000 plants) by July 2022. Fuelwood (dendro) refers to the biomass-based electricity generation through sustainable plantation and supply of fuelwood. The values given in the study for the employment of technical staff also includes those involved with the fuelwood plantation and processing (chipping and drying), thus relatively higher than other RE resources per MW of installed capacity.

The details of the technical level staff employed in the operational RE plants will provide a basis for a basic estimation of future job opportunities associated with anticipate energy transition. Accordingly, feedback was obtained from three leading RE developers in the country, summary of which is presented in the following table:

Table 27: Employment of technical staff in RE plants

RE resource/technology category		Total capacity (MW)	Details of Technical Staff
Small hydro	Mini hydro	34.65	16 engineers/plant managers 13 technicians 25 plant operators
Biomass	Fuelwood (dendro)	3.3	12 engineers/plant managers 8 technicians 10 plant operators
Solar PV	Ground-mounted	41.0	6 engineers/plant managers 19 technicians 12 plant operators
	Rooftop	17.36	3 engineers/plant managers 4 technicians 8 plant assistants
Wind	On-shore	70	7 engineers/plant managers

			36 technicians 6 plant assistants

Note: Technicians are at NVQ Level 3 & 4; Plant operators/assistants are at NVQ Level 1 & 2, in general.

Technically qualified staff with NVQ Level 5 and 6 are also often recruited as assistant engineers and subsequently promoted to engineering level with experiences or acquiring of further qualifications. These employments are listed under engineers/plant managers category in the table.

Further to above, the records of SLSEA provide details on technical level staff employed in solar rooftop system providers. The overall data of the leading 150 companies is presented in the following table:

Table 28: Employment of technical staff in solar PV rooftop system providers

No of companies	Number of plants	Total capacity (MW)	Total no of technical staff
150	28,573	474.98	1,113

Based on the above data, following approximations are used to estimate the employment potentials for technical level staff in the RE sector.

Table 29: Employment of technical staff in RE plants per MW of installed capacity

RE resource/technology category		Employment per MW	
		Technicians (NVQ 3 & 4)	Technical assistants (NVQ 1 & 2)
Small hydro	Mini hydro	0.4	0.7
Biomass	Fuelwood (dendro)	2.4	3.0
Solar PV	Ground-mounted	0.5	0.3
	Rooftop	0.9	1.4
Wind	On-shore	0.5	0.1
Geothermal		0.3	0.1
Ocean		0.5	0.1
Battery storage		0.64	0.16

In case of battery storage, the employment generation is reported as in the range 6-10 jobs/MW of storage. In this, major component lies with raw material extractions and manufacture, and also the end-of-life recycling. In Sri Lanka, all these stages of value chain are not in place. Thus, the number presented above assumes that 15% employments are related to operation and maintenance of battery storage system.

The future development of RE sector is primarily governed by the government pledge of 70% RE in grid-electricity generation by 2030, SLSEA, as the mandated agency, has performed a preliminary assessment to identify the resource-wise capacity addition in each resource/technology category, as presented in the following table by 2025 (short-term) and 2030 (mid-term).

Table 30: Short and medium term RE development plan towards 70% RE target by 2030

RE resource/technology category		Total capacity addition (MW)	
		Short term (2023-2025)	Medium term (2023-2030)
Small hydro	Mini hydro	115	245
Biomass	Fuelwood (dendro)	20	45
Solar PV	Ground	655	1,725
	Rooftop	330	815
	Floating	400	900

Wind	On-shore	540	1,460
	Off-shore	0	2,000
Geothermal		0	30
Wave energy		0	10
Battery storage		700	2,000
	Total	2,760	9,230

The potential employment generation per MW of installed capacity presented earlier could be used to estimate the total job opportunities for technical staff by 2025 and 2030. The results are presented in the following table. As the data on employment opportunities for off-shore wind and floating solar is not available, the relevant data for onshore wind and ground-mounted solar is used in these estimates.

Table 31: Short and medium term RE development plan towards 70% RE target by 2030

RE resource/technology category		Number of Technical Staff			
		Technicians (NVQ Level 3 & 4)		Technical assistants (NVQ Level 1 & 2)	
		Short term (2023-2025)	Medium term (2023-2030)	Short term (2023-2025)	Medium term (2023-2030)
Small hydro	Mini hydro	46	98	81	172
Biomass	Fuelwood (dendro)	48	108	60	135
Solar PV	Ground/Floating	528	1,313	317	788
	Rooftop	297	734	462	1,141
Wind	On-shore/Off-shore	270	1,730	54	346
Geothermal		0	9	0	3
Wave energy		0	5	0	1
Battery storage		448	1,280	112	320
	Total	1,637	5,276	1,085	2,905
	Annual average	546	660	362	363

Above estimations show that the yearly demand for technicians for the RE sector development during the next three years (2023-2025) would be about 546 and that of technical assistants would be 362. In the medium term (2023-2030), the corresponding figures are about 546 technicians and 363 technical assistants per year during the eight-year period.

The job demand for technical staff estimated in the study mainly covers installation and operation of grid-connected RE power plants for electricity generation (except for the case of biomass that include fuelwood plantation and preparation), while additional employment generation for technical staff could come from other stages of the value chain, particularly manufacturing of RE plants, systems, sub-systems, and components. The percentage of employment generation in each stage of the value chain varies across different RETs, for example, a majority of jobs in the biomass industry is attributed to fuel production and processing as well as in operation and maintenance, while in the rest of the RE industry, it is manufacturing and construction/installation. On average, around 25% of the employments are in the operation and maintenance. Thus, the employment generation for technical staff in the other stages of value chain will be significant and the rightful benefit of harnessing RE resources lies on the level of local value addition and manufacture.

Further, the technical staff presented under two categories (viz technicians and technical assistants) may require different types and level of competencies relevant to each resource/technology, which need to be taken into account when designing educational and training programme.

Annex VI: Recommendations for other short- and medium-term measures

Key entry points and recommendations for enhancement of existing TVET programmes based on the requirements and gaps identified above, with special focus on industry demand and practical training components in industry/private sector:

- Educate technical staff to provide engineering services and troubleshooting.
- Arrange technical colleges to conduct trainings on youth sector in the context of RE (e.g., SLGTTI training courses expansion to RE).
- Train energy auditors in the context of RE (practical sessions in calculations, designing, and installation such as pilot projects).
- Establish specific focal division in harnessing the competencies to support the energy transition.
- Support and collaborate with relevant entities at regional and global level for sharing of knowledge, best practices, tools, methodologies, and resources.
- Allocate sufficient funds and resources to TVET institutes to expand the curriculum and upscale existing resources and laboratories.
- Establish a pilot-scale fully RE-based mini grid to understand how it operates and its local application.
- Conduct TVET institutional-wise short courses on energy efficiency and biogas technology on a regular basis (e.g., every 6 months).
- Promote energy modesty and behavioural adaptation towards energy demand management.
- Improve technology and science streams of A/L students towards energy management and RE.
- Enhance and develop first degree level education programmes for RE, including separate bachelor degree courses.

In consideration of the demand for competent technical workforce with new set of skills in the RE sector, characterized by new and emerging processes, technologies, and management systems, to cater for the anticipated just energy transition that would be emerged with national priorities and targets (such as 70% RE in grid electricity by 2030 and net zero carbon by 2050), it is recommended to formulate a comprehensive national level training strategy and implementation plan for the TVET sector. This plan should be implemented under a sound framework encompassing prospect for right governance, while facilitating effective coordination, collaboration and engagement of the key government institutions and other stakeholders, with a process of continuous improvements through lateral inputs from local and international expertise and experiences.

This could be effectively realized by having two main levels of organisational decisions and processes viz. hierarchical model of policy planning, policy implementation and monitoring framework at strategic level, and implementation framework for specific technical qualifications levels (such as certificate, diploma, high diploma) and training institutions at functional and operational level. It is important to highlight at this juncture that it is crucial for the TVET sector agencies work closely with energy sector agencies to comprehend the competency requirements and market demand for different functional areas/technologies of the energy sector.

The plan should also be based on a sound curriculum framework with identified core competencies and programme outcomes that facilitates the training institutions and the programme developers and deliverers in the TVET sector to establish specific competencies and learning outcomes for particular training course of a selected target group and area of training (thematic area and related subject topics and lessons). In order to obtain the recognition from the TVET sector authorities for the curricula, it is recommended to take initiatives, on a priority basis, to follow the formal process presented in Section 4.1.3 for the National Competency Standard

Development defined in the National Vocational Qualifications Framework of Sri Lanka. In relation to receive international level recognition for the courses, it is further recommended to comply with the Dublin Accord (Engineering Technicians) accreditation requirements.

Once the formal recognition is obtained for the competency standards and curricula, it is essential that the required resources be in place to deliver the training programmes. Accordingly, another vital intervention is to develop and implement ToT programmes, furnished with a resource pack for the trainers providing all the teaching materials, including complementary reading materials, assignments, sample questions, and case studies. The development and delivery of ToT programmes should explore the opportunities for accessing international expertise and other supports to ensure the relevance and quality of the training programmes. This will also provide opportunities to establish formal partnerships with international institutions in the TVET sector, while benchmarking with globally recognized institutions and programmes.

As the proposed training programmes for the development of competent workforce for just energy transition are to be introduced to the already established TVET sector in the country, another area of importance is to establish a sound guidance framework for different pathways for the integrating to the exiting certificate and diploma courses or introducing as new courses. In case of existing courses, fundamentally this could be realized as a combination of the three approaches, namely (i) different topics related just energy transition are taught in relevant subjects of the existing curricula; (ii) integrated into the curricula as a specific subject; (iii) taught as a cross-cutting interdisciplinary theme and incorporated into similar courses across TVET entities. This should be done in consideration of the particular characters of a given TVET sector institutions and their scope of training provided.

Further to the above overall recommendations, a series of additional recommendations for short- and mid-term measures and courses have been identified from the stakeholder input and desk research conducted as part of this research, which are presented under the next two sub-sections.

Short-term recommendations (up to 3 years)

Table 32: Short-term recommendations

Aspect	Recommendations
Capacity-building and training	▪ Provide trainings for skill enhancement related to biomass/biogas targeting MSMEs
	▪ Develop and conduct training programmes for specific areas and technologies to the staff of implementation agencies
	▪ Use ongoing mass-scale RE projects as training places for technical staff with lack of competencies and hands on experience in RE technologies
	▪ Provide institutional/company-wise foreign training opportunities (e.g., Global Wind Organization) for the technical staff
	▪ Provide trainings for skill enhancement related to biomass/biogas targeting MSMEs
	▪ Set up a fully-pledge training centre
	▪ Involving military staff to trainings on sustainable energy related activities
	▪ Promote NVQ level 4, 5, and 6 education
Policies and regulations	▪ Incorporate RE experts into national-level discussions on upgrading existing TVET curricula to support energy transition

	▪ Revise the tariff on mini hydro, solar, biomass, and mini hydro to attract more entrepreneurs to the sector that can facilitate more HR and to provide trainings to existing workforce
	▪ Regulations to have minimum skill level people and upgrade the standard of the certification criteria or a star rating or a grading rate to the solar service providers
Institutions and governance	▪ Establish a central body equipped with competent staff (Engineering. Economics, Finance, Social, Environment) to drive the 70% RE target (somewhat similar to Mahaweli Development Authority)
	▪ Establish partnerships between TVET institutes, power-related companies, and implementation agencies
Economy and finance	▪ Expand and upgrade existing projects to allocate more staff and to provide training facilities
Research and technology	▪ Build a resource pool through which expertise knowledge/personnel can be sought to support conduct capacity building programmes/courses
Data and information	▪ Develop and conduct specific awareness creation and education programmes for technical staff on RE technologies (such as solar PV and wind)
	▪ Maintain up-to-date track records of the solar service providers in terms of their staff, on-going projects, completed projects etc.
	▪ Implement a management information system to match job opportunities and job seekers
Other	▪ Ensure inclusive processes and provide equitable access to RE-related TVET training to women, including through targeted programmes and specific opportunities

Medium-term recommendations (up 10 years)

Table 33: Medium-term recommendations

Aspect	Recommendations
Capacity-building and training	▪ Provide licences and professional development opportunities for NVQ level 4-6 employees
	▪ Initiate capacity-building, education, and training programmes on other RE sources such as ocean energy (wave, ocean thermal), and geothermal
Policies and regulations	▪ Formulate and operationalize a comprehensive strategic plan and roadmap for capacity-building for energy transition (particularly RE deployment), with clearly defined responsible agencies, targets, KPIs, and time-bound milestones for progress monitoring
	▪ Formulate an implementation action plan at institutional level (short-, medium-, and long-term), aligned with the above strategic plan and roadmap
Research and technology	▪ Explore other RE sources such as ocean energy (wave, ocean thermal) or geothermal with appropriate awareness, education, and training programmes
Other	▪ Allocate more responsibilities on NVQ level 4-6 professions below the chartered engineering level to provide job satisfaction and incorporate them into approval and certification processes (for smaller-scale projects such as 3-phase 30A and below, 5 KW or less)