Study on Skills Gaps and Local Labour Market Needs for Renewable Energy (RE) / Energy Efficiency (EE) in Bangladesh

To:

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn

By:

Renewables Academy (RENAC) AG
Schönhauser Allee 10-11
10119 Berlin - Germany

Tel: +49-30-58 708 70 – 00
Fax: +49-30-52 689 58 – 99
E-mail: breid@renac.de

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Acronyms and Abbreviations

BACI	Bangladesh Association of Construction Industry
BSMA	Bangladesh Steel Manufacturers Association
DOE	Department of Environment
DTE	Directorate of Technical Education
O&M	Operations and Maintenance
RAJUK	Rajdhani Unnayan Kartripakkha
RAPSS	Remote Area Power Supply System
ADB	Asian Development Bank
AFD	French Development Agency
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BBDF	Bangladesh Biogas Development Foundation
BBDF	Bangladesh Biogas Development Foundation
BCSI	Bangladesh Cement & Steel Industry
BERC	Bangladesh Energy Regulatory Commission
BES	Biogas Energy System
BESS	Battery Energy Storage Systems
BGMEA	Bangladesh Garment Manufacturers and Exporters Association
BIPPA	Bangladesh Independent Power Producers' Association
BMZ	German Federal Ministry for Economic Cooperation and Development
BNBC	Bangladesh National Building Code
BNCB	Bangladesh National Curriculum and Textbook Board
BPDB	Bangladesh Power Development Board
BRAMA	Bangladesh Refrigeration Air Condition Merchant Association
BREEAM	Building Research Establishment's Environmental Assessment Method
BRTA	Bangladesh Road Transport Authority
BSTI	Bangladesh Standardization and Testing Institute
BTEB	Bangladesh Technical Education Board
BTMA	Bangladesh Textile Mills Association
CACS	Competency Assessment and Certification System
CBT	Competency-Based Training
ccGAP	Climate Change and Gender Action Plan
CISC	Construction Industry Skills Council
CMP	Conservation Master Plan
CNC	Computer Numerical Control Operator
DC	Designated Consumer
DMS	Distribution Management System
DPDC	Dhaka Power Distribution Company
DSHE	Directorate of Secondary and Higher Education
EDGE	Excellence in Design for Greater Efficiencies
EE	Energy Efficiency
EE&C	The Energy Efficiency & Conservation
EE&CMP	Energy Efficiency and Conservation Master Plan
EECPFP	Energy Efficiency & Conservation Promotion Financing Project
EF	Employment factor
EHS	Environmental Health and Safety
EV	Electric Vehicles
FTE	Employment factor refers to the number of full-time equivalents
GB	Green Building
GDP	Gross domestic Product
GHG	Greenhouse Gas

GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GOB	Government of Bangladesh
HSE	Health, safety, and Environment
HVAC	Heating, Ventilation, and Air Conditioning
IDCOL	Infrastructure Development Company Ltd
IEPMP	The Integrated Energy and Power Master Plan
IFC	International Finance Corporation
IIDFC	Industrial and Infrastructure Development Finance Company Limited
ILO	International Labour Organisation
IRENA	International Renewable Energy Agency
JDC	Junior Dakhil Certificate
JSC	Junior School Certificate
KIIs	Key Informant Interviews
LEED	Leadership in Energy and Environmental Design
MOE	Ministry of Education
MOI	Ministry of Industry
MRG	Ready-made garments sector
MW	Megawatts
NDC	Nationally Determined Contribution
NDC	Nationally Determined Contributions
NESCO	Northern Electricity Supply PLC
NREL	National Renewable Energy Laboratory
NSDA	National Skills Development Authority
NTVQF	National Technical Vocational Qualifications Framework
PETA	Power and Energy Training Academy
PGCB	Power Grid Company of Bangladesh Ltd
PGCB	Power Grid Company of Bangladesh
PSMP	Power System Master Plan
RAC	Refrigeration and Air Conditioning
RAC	Refrigeration and Air Conditioning
RE	Renewable Energy
REB	Rural Electrification Board
RENAC	The Renewables Academy AG
RMG	Ready-made Garment
SDGS	Sustainable Development Goals
SHS	Solar Home System
SIL	Starting, Lighting, and Ignition
SIPS	Solar Irrigation Pumps
Skills4SE	Skills Development for Sustainable Energy Solutions
SME	Small and Medium Size Enterprises
SOPs	Standard Operating Procedures
TR	Tons of Refrigeration
TSR	Teacher-Student Ratio
TVET	Technical and Vocational Education and Training
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
VET	Vocational Education and Training
WZPDCL	West Zone Power Distribution Company Ltd

Executive summary

Recognizing the importance of renewable energy for sustainable development, Bangladesh has prioritized the renewable energy (RE) sector in its National Industrial Policy 2016, where it ranks 8th among the country's 24 "Priority Sectors." Bangladesh's economy relies heavily on the ready-made garments sector (RMG) and other high energy consuming industry subsectors that require an uninterrupted and increasing supply of power. However, achieving energy sustainability necessitates advancements in how energy is supplied and utilized making it crucial to reduce the energy required to provide various goods and services.

Energy efficiency and renewable energy, the two foundational elements of sustainable energy transition are facing some challenges in Bangladesh with the shortage of knowledge and skilled personnel being particularly critical. To support the alignment of skills training with market demands, this studyaims to address workforce gaps in Bangladesh's renewable energy (RE) and energy efficiency (EE) sectors. Specifically, it identifies skills requirements, quantifies labour demands, and suggests training interventions to ensure a skilled workforce for sustainable energy solutions. This study was conducted as part of the "Skills Development for Sustainable Energy Solutions" (Skills4SE) project, which is commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in Bangladesh.

The study employed a multi-faceted approach, including a desk literature review, stakeholder workshops, key informant interviews, and a survey of 150 RE/EE companies. The Employment Factor (EF) approach was used to project the number of direct jobs over the next 10 to 15 years in specific segments of the value chain across 10 selected sectors in Bangladesh - solar photovoltaic energy (large scale PV as well as distributed rooftop PV), on and off-shore wind energy, biogas, power grid expansion / smart grids, energy storage (battery energy storage systems), energy management / auditing, energy efficiency in commercial / residential buildings, energy efficiency for industrial production (RMG / textiles, fertilizers, etc.), energy efficiency in transport and energy efficiency in the refrigeration and air conditioning (RAC). Employment Factor is expressed as full-time equivalent (FTE) jobs created per unit of energy (installed or planned capacity) or investment. Based on Bangladesh's present installations, strategies and investment projections, the employment numbers were calculated and future employment forecasted.

The country mission in Dhaka, Bangladesh, from April 20-25, 2024, included workshops and Key Informant Interviews (KIIs), fully supported by GIZ. Three workshops were held with distinct groups: TVET institutions, RE companies, and EE companies. The workshops explored skills supply and demand in renewable energy (RE) and energy efficiency (EE), addressing occupational standards, training gaps, and women's inclusion.

Key findings include the need for structured training offers in solar, wind, biogas, and energy efficiency sectors, also addressing job opportunities for women. A follow-up questionnaire with 21 companies emphasized skill gaps, particularly in solar installation, CAD design, and energy management, with challenges in finding qualified staff including lack of experience, low number of applicants to job adverts, and high salary expectations. Most companies plan to invest in new RE/ EE divisions while also, focusing on skills development and facilities expansion, with an openness to internships and in-house training to meet workforce needs.

The study explores Bangladesh's demand for renewable energy (RE) and energy efficiency (EE) skills, particularly for mid- and entry-level qualifications across solar, wind, biogas, grid expansion, battery storage sectors and energy efficiency applications. Employment potential varies by technology and value chain stage, with jobs concentrated in installation, operation, and maintenance. Solar PV shows high demand in operation (56%) and other segments like procurement and installation require specialized roles like solar system designers and technicians. Biogas adds unique jobs in feedstock collection. Power grid and battery storage expansions each create varied occupational needs per sector. Occupations in wind, biogas, and grid/smart grid expansion also present diverse roles, from engineers to technicians, requiring targeted training to support sector growth effectively.

In Bangladesh, job creation potential within renewable energy (RE) and energy efficiency (EE) sectors is big along each segment of the value chain as the markets are still in an infancy state. Skilled personnel are critical across low-, mid-, and high-level roles, although this study focuses on mid- and low-level qualifications. Our analysis examines existing and future job needs along RE/EE value chains and projected workforce demands over the next 10 to 15 years through "employment factors".

Employment factors for Bangladesh indicates that rooftop solar creates 13.8 job-years per MW, with utility-scale solar at 9 job-years per MW, highlighting the scale benefits of utility projects. Wind energy which involves jobs in both onshore and off-shore projects creates 5.5 job-years per MW and 2.0 job-years per MW respectively. Power grid and battery storage expansions each create 5.5 job-years per $1 million USD invested, highlighting varied occupational needs per sector.

The report estimates the workforce needed in Bangladesh's renewable energy (RE) and energy efficiency (EE) sectors for 2024, 2030, and 2041, based on installed/ planned capacity/ investment and employment factors. These factors define the relationship between capacity (MW)/investment and job creation.

Bangladesh's power sector aims for 40 GW capacity by 2030, with 15% from clean energy, and 60 GW by 2041, with 40% from clean energy. Workforce projections for key technologies (solar PV, wind, biogas, etc.) were calculated for manufacturing, operation, and maintenance segments, considering the share of local content. For example, in distributed rooftop scale solar PV, workforce size is expected to grow from 2,570 job-years in 2024 to 9,818 job-years in 2041. On-shore wind energy will create significant jobs by 2041, while biogas energy will have a smaller workforce. The total workforce size for the 10 RE /EE sectors considered in this study of the Bangladeshi market is estimated to be 14,157 job-years in 2024, increasing to 19,702 job-years in 2030 and topping 33,130 job-years in 2041.

The skill development system is divided into five segments: public, private (subsidized), private (commercial), industry-based, and workplace training. The analysis shows that RE and EE training programs are only rarely offered by RE/ EE companies and some private organisations which will not cover the demand in skilled labour forces.

The education system in Bangladesh is structured into three levels - primary, secondary, and higher education. Secondary education is further divided into lower and upper level, encompassing three categories that include Technical and Vocational Education and Training (TVET). TVETs programs, overseen by institutions such as Directorate of Technical Education (DTE) and the Bangladesh Technical Education Board (BTEB), provide formal, informal, and non-formal training in various sectors aligned with market needs and competency standards.

The renewable energy (RE) and energy efficiency (EE) sectors lack defined occupational /competency standards and specialized training facilities. Currently, the RE sector has one competency standard on "solar electrical systems", with a corresponding course designed for TVET technician levels 1, 2 and 3 according to the National Technical Vocational Qualifications Framework. Seven additional standards proposed by the Construction Industry Skills Council (CISC), are still awaiting approval. In contrast, the EE sector does not yet have any defined occupations at the TVET level.

International best practices highlight the critical role of industry collaboration, practical training, and flexible learning in developing a skilled workforce—areas the study finds lacking in Bangladesh. The skills gap analysis points to the disconnect between existing skills sources and market needs, emphasizing the need for targeted training interventions to support Bangladesh's energy goals by 2041 by 2041.

Bangladesh has made notable progress in integrating renewable energy (RE) and energy efficiency (EE) into its energy mix. However, a considerable skills gap exists, particularly within technical vocational education and training (TVET) programs.

To support Bangladesh's renewable energy (RE) and energy efficiency (RE) transition and the projected increase to 33,130 full-time equivalent job-years by 2041, RENAC recommends the development of a comprehensive skills development roadmap. This roadmap should prioritize standardized TVET training, certification, and strong industry partnerships that align with market demands. It should focus on the existing value chain segment of each sector in Bangladesh. The trainings curriculum should develop the skills needed for various identified occupations, not just for electricians and mechanics but also for commercial jobs which are conducive for women. This approach will encourage greater female involvement in the sector, moving beyond their role as consumers.

Key actions aligned with Bangladesh's competency-based training system should focus on defining occupational and competency standards as well as developing specialized TVET curricula based on these standards. Establishing well-equipped TVET training centres for hands-on training in areas such as PV, solar thermal, biogas, and energy efficiency is crucial. Additionally, creating a pool of skilled trainers through new skill development and re-skilling programmes at vocational teachers training centres is essential to build a local trainer workforce. Integrating industry participation for practical experience will further enable Bangladesh to meet its RE/EE workforce needs and sustainability goals.

1 Introduction and context of the study

According to the International Renewable Energy Agency (IRENA), global employment in renewable energy is estimated to reach 16,7 million by 2030 and its annual review of global employment related to renewable energy shows that 13.7 million people were employed in 2022 [1]. Renewable energy (RE) which allows for the establishment of new enterprises with job creation is ranked 8th among the 24 "Priority Sectors" in Bangladesh's National Industrial Policy 2016 [2].

Bangladesh experienced more than 7% GDP growth from 2015-16 until the onset of the pandemic. Its economy heavily relies on the ready-made garments sector (RMG), other industry subsectors, and agriculture for employment. These sectors depend on the uninterrupted supply of power, making increased electricity production crucial for sustaining high GDP growth. Currently, 100% of the population have access to electricity [3]. Energy transition, including renewable energy and energy efficiency (EE), is vital to meet rising demand, but faces challenges. The German development cooperation in Bangladesh identified several key barriers to the energy transition in Bangladesh, among which the lack of knowledge and skilled staff is crucial. The technical cooperation project "Skills Development for Sustainable Energy Solutions" (Skills4SE), commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) therefore addresses these gaps by enhancing the vocational education and training offer in the areas of renewable energy and energy efficiency.

The Skills4SE project, implemented by the Deutsche Gesellschaft für Internationale Zusammenarbei (GIZ) GmbH, targets professionals, youths, and young adults to enable them to obtain essential competence and certifications for the growing demand in RE and EE sectors. It is to align education and training in EE and RE with the needs of the labour market through a study of the RE/EE market.

1.1 Study objective

The overall goal of this study was to identify skills required for Bangladesh's energy transition, make recommendations for skill development interventions, and prioritize appropriate training capacity. The specific objectives of the study were to:

1. identify the qualifications of workforce in the RE and EE sectors with respective job task profiles
2. quantify the needs on the local labour market for qualified specialists in the field of sustainable energy solutions in the short to medium term (covering the period of the next 15 years),
3. identify skills gaps among the existing workforce in RE/EE for a successful transformation of the energy sector as well as to
4. draw potential entry points for improved training offer for RE/EE in Bangladesh.

The Renewables Academy AG (RENAC) was assigned by GIZ Bangladesh to conduct the study on “Skills Gaps and Local Labour Market Needs for RE/EE in Bangladesh”. The analysis was to identify key constraints and potentials for labour market development and employment promotion for RE/EE at both national and local level. This included an analysis of the supply and demand side conditions of the labour market in RE and EE, the matching mechanisms as well as framework conditions.

The report aims to give a complete skills and employment evaluation, a better understanding of current and future training needs, and recommendations for interventions to be addressed. This will help stakeholders build a shared knowledge of skills needs in the RE and EE sectors, laying the groundwork for the formulation of a roadmap and skill development long-term strategy for sustainable energy solutions in Bangladesh.

1.2 Scope of report

This study report analyses the skills development and employment in renewable energy and energy efficiency in Bangladesh. It covers the current state of RE / EE in Bangladesh, analyses skill gaps and future demand, and recommends skills development. Based on the information sources, the study reviews national policies, strategies, and available literature, analyses existing quantitative data sources, and provide an overview of the vocational education and training structure and stakeholder landscape in renewable energy and energy efficiency. The study focuses on 10 key areas in RE and EE which are:

1. Solar photovoltaic energy (large scale PV as well as distributed rooftop PV)
2. On and off-shore wind energy
3. Biogas
4. Power grid expansion / smart grids
5. Energy storage (battery energy storage systems)
6. Energy management / auditing
7. Energy efficiency in commercial / residential buildings
8. Energy efficiency for industrial production (RMG / textiles, fertilizers, etc.)
9. Energy efficiency in transport
10. Energy efficiency in the refrigeration and air conditioning (RAC) sector

The demand side of the RE/EE market is studied with the companies providing employment opportunities to graduates while the supply side is addressed through skills development institutions and Vocational Education and Training (VET) sector that are responsible for preparing the human resources for the labour market. As important stakeholders in both sides of the employment market, sector representative and public institutions, having decisive roles both for regulating the sector and for the employment processes, were also included in the study.

The report identifies potential areas of intervention, recommend updating and developing curricula, improving certification systems, and building capacity. The accuracy of projected labour demands and key occupations depends on the employment factors.

2 Methodology

RENAC's approach in collecting primary and secondary data considered research methods, data collection tools, target groups and sampling, implementation steps and timeline. To implement the project, RENAC followed a target-oriented work plan incorporating key actors, objectives, and deliverables. RENAC analysed the situation, identified gaps between the current and desired state, and recommended capacity-building interventions. The procedure was divided into five stages:

1. Project initiation (research concept and desk study)

2. Review of existing information and materials (literature and data review)
3. Preparation of concepts, strategies, and plans (workshop and interviews)
4. Presentation of deliverables (validation workshop and present report)
5. Project feedback/reporting (reflection and evaluation)

2.1 Desk study

Desktop research was used initially to get information through review of existing documents, website, etc. A review of policies, academic literature, and relevant reports from stakeholders fostered the research by establishing a solid background and benchmarks regarding employment levels and employment factors in various subsectors, where available, or in the RE/EE sector as a whole. The focus was to get an overview of the current status of the targeted sectors and its outlook, what targets are in place, which institutional framework, certification to perform job, how they are certified, etc.

2.2 Country visit with stakeholder workshop and Key informant Interviews (KIIs)

RENAC paid a country visit using workshops and Key Informant Interviews (KIIs) to complement data gotten through desktop research. With these methods, RENAC was able to get in-depth qualitative information, allowing for more detailed answers from stakeholders. The workshops and Key Informant Interviews (KIIs) took place from the 20th to the 25th of April 2024 in Dhaka – Bangladesh, with Dr. Ms Emilienne Tingwey and Ms Christiane Vaneker from RENAC and the national consultants Dr. Md Anisuzzaman, Mr Sajib Sen and Dr. Taskin Jamal. The mission was strongly and entirely supported by the GIZ staff. A detailed report of this mission was published before this final report.

Before the event detailed interview guidelines and possible questions to use were developed by RENAC in collaboration with GIZ/Skills4SE. The list of persons invited was established with the support of the national experts and confirmation gotten from the GIZ.

During the country visit, three separate workshops were organised for three categories of identified stakeholders, namely: TVET institutions including universities, private companies from the RE sector and private companies from the EE sector. In each of the workshops, there was the presentation of the project and input on “energy transition and skills development” received from the participants by way of group work. The groups formed were according to subsectors giving room for more in-depth discussion of skills, jobs etc of each subsection and streamlining the information gotten from a homogeneous group as oppose to a heterogeneous one.

The study team conducted key informant interviews with respondents from different stakeholders (Annex 4) and organisations to get detail information.

2.3 Questionnaires

Given the fact that not so many RE nor EE companies could be reached during the country visit, a questionnaire (Annex 2) was sent out to 150 companies identified to be active in the RE / EE sector to get complementary information. It was sent to the respondents considering them as a valued player in this industry. The questionnaire survey was conducted to identifying the pressing needs and skill gaps in the sector, enabling us to create an improved range of vocational education and training opportunities aligned with the labour market requirements. A link was shared to submit their response online.

2.4 Estimation of workforce (employment) in each sector

Based on extensive literature review and study of various reports, an estimation of jobs to be generated during the Bangladesh's energy transition in the next 10 to 15 years were estimated utilising the Employment factor (EF) approach, adopted from Rutovitz et al. (2015) [4]. This is the most widely used methodology in direct employment studies and particularly in the renewable energy sector.

The renewable energy sector employs millions of people, directly, indirectly and by induction at various points of the value chain of each technology. Direct employment is the employment coming from and directly related to renewable energy investments such as manufacturing, construction, installation, operation, maintenance, decommissioning and power transmission.

Indirect employment is employment arising in another sector that provide inputs/services which are not directly involved in the supply chain of renewable energy. Induced employment on the other hand does not have a link with the sector but create employment in other sectors due to the increase in gross domestic production, the multiplier effect (multiple linkages to other sectors), and improvement in the overall economy. The sum of direct, indirect, and induced employment effects is called the net employment effect.

Given the project's limitations and scope, and challenges of revealing indirect and induced employment, only direct employment which arises during the manufacturing, building, operation of a renewable energy power plant and transmission and storage was considered in the study. All jobs are expressed in job-years, or the total number of full-time jobs needed.

Employment factor refers to the number of full-time equivalent (FTE)[1] jobs created per unit of energy (e.g., megawatts (MW)) representing the installed capacity. It is measured in job-years/MW installed [5]. This approach is used by the International Renewable Energy Agency (IRENA) and the International Labour Organisation (ILO) in their annual "Renewable Energy and Jobs Review" publications [1]. The employment created by sectoral investments is therefore estimated by multiplying the installed capacity with employment factors. As such current employment figures could be calculated and future employment predicted based on strategies and investment projections.

2.4.1 Methodological approach to determining the employment factors

In order to identify and corroborate the employment factors for respective renewable energy, energy efficiency, energy storage, and smart grid technologies in Bangladesh, a two-step methodological approach was employed.

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[1] *The number of employees is expressed as Full Time Equivalent (FTE). FTE is the value that defines the time allocated to business activities by the labour force working in the sector in a year as person/year. One FTE can be considered as one person/year.*

1. Comprehensive review of industry publications, reports and employment studies. The review focused both on the international and national (Bangladeshi) levels, and across all focus technologies.
2. Adjustment for country- / regional-level variations in employment effects, to ensure that employment factors reflect the specific conditions of Bangladesh.

This approach was used for several important reasons:

- **Reliability.** Through drawing on a diverse range of peer-reviewed and quality industry publications, reports and employment studies, a high degree of reliability can be achieved regarding the validity and accuracy of the data.
- **Availability of time and resources**. So-called “bottom-up” studies that seek to derive employment factors through interviewing and consultations with project developers and operators are typically undertaken over a period of years and have very significant time input requirements (given the need to interview dozens, if not hundreds, of project representatives, per respective technology). The present study had a much shorter timeframe.
- **Lack of technology-specific employment factor research / published studies for Bangladesh.** Generally, most reputable research on renewable energy, energy efficiency and energy storage job creation / employment factors has tended to be concentrated in a relatively small group of countries. In particular, studies have focused mainly on the markets of the European Union (considered as a single block), the United States, Australia, and a handful of other countries. However, reputable work on this topic has yielded useful information on regional differences in workforce needs (employment factors) for energy transition technologies.
  Region-specific (and indeed country-specific) employment factor data allows the calculation of so-called “regional conversion factors” and “country conversion factors”. Such conversion factors are used to adjust employment factor data, from an international average, to yield region or country-specific employment factors. This approach is accepted as good practice in the international research context of this topic.
  The application of regional and country conversion factors was a necessary methodological step within the present study, given that no country-specific studies of employment factors for the focus technologies (and especially for less mainstream technologies (e.g., battery storage and energy efficiency at sub sectoral levels) have been undertaken and published specifically within the Bangladeshi market and sector.

As mentioned above, a comprehensive review was undertaken of all available reports and publications on employment factors and workforce needs for the respective 10 focus technologies.

The review covered the historical and recent work of key sectoral institutions (e.g., IRENA, the IEA, etc.); as well reputable research groups (e.g., the US National Renewable Energy Laboratory, NREL); and country- or regional-level programmes for energy transition and job creation (e.g., those of the European Union, the United States government). Annex 1 shows key studies and datasets from which information was drawn upon, for the respective technology categories.

2.4.2 Methodological approach to determining the workforce needed

The starting point of the study of workforce development and size is to comprehensively understand both the current status of the respective energy subsectors (i.e., in 2024), and how the sector is forecasted to develop over time (i.e., to 2030, and 2041).

To this end, a comprehensive review was undertaken of all publicly available relevant national government and institutional (official) plans and strategies for renewable energy, energy efficiency, and the broader energy transition in Bangladesh. This formed the basis for understanding how the size of each technology segment is expected and planned to develop over time.

Through basing the analysis of likely sector development (e.g., total installed capacities; total annual expected energy savings; etc.) on official national-level and technology-specific plans, the study results will have considerable reliability, and will be aligned with broader government planning for Bangladesh's energy transition.[2]

In this context, many important assumptions related to renewable energy sector expansion, and energy efficiency improvements throughout the economy of Bangladesh, in the study period (2024-2041) were based directly on data and information set out within the Integrated Energy and Power Master Plan (IEPMP) of Bangladesh [6]. The IEPMP is the foremost official power and energy sector planning document, as published by the Bangladesh Ministry of Power, Energy and Mineral Resources, in July 2023.

Nevertheless, the quality and depth of official targets and objectives for certain less established technologies (e.g., power storage systems) in Bangladesh was rather limited, compared, for example, to the situation for more established and mainstream renewable energy technologies (e.g., solar PV, wind power, etc.). In the instances where official government targets or plans for the deployment and use of certain energy technologies were not in effect in Bangladesh, the study drew on key criteria and assumptions specified by leading international energy authorities (e.g., the IEA, NREL, IRENA, etc.), and applied them to the Bangladeshi case as appropriate.

2.5 Study limitations

The study on "Skills Gaps and Local Labour Market Needs for RE/EE in Bangladesh" faced certain limitations:

1) The study could not cover all intended subsectors. The list of subsectors was limited to 10 sectors of most interest to the country.
2) Employment factor was easy to determine with RE but not with EE given that energy efficiency is not readily measured in terms of production capacity, and even in terms of energy savings is far from straight forward. More research had to be done on this.
3) An important issue to underline is the complexity in deriving assumptions on sector size (total installed capacities, etc.) for given technologies and systems in the year 2024. This present study was undertaken from January till August 2024. Two important implications arise from this:

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[2] T*his is a more solid and useful approach compared to drawing on market forecasts of industry players who often make statements regarding their strategic ambitions for developing project, but may postponed, cancelled, or even expanded.*

a. During the remaining 4 calendar months of 2024, it is entirely possible that the construction of new projects will be commenced, which would affect calculations of the construction-focused workforce, for example.

b. The issue of unavailability of official data (e.g., on total installed capacities) for the country at a technology or system level for the year 2024. Typically, such data is published with at least one calendar year of time lag (e.g., 2024 data will be published in late 2025, or 2026). In response to this situation, high-level market research was conducted to address the data.

4) This is a qualitative study where the overall insight from the sector has been collected from academics, training institutions, government, NGOs, policymakers, private sector, industry associations and development partners. The study did not gather direct insights from the consumers.

3 Country context

Bangladesh, a country located in South Asia with a total area of 147,570 square kilometres stretching along the coastline of the Bay of Bengal, shares its borders with India and Myanmar [7]. Bangladesh has eight principal administrative units (divisions) - Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, Sylhet - with the major cities being- Dhaka, Chittagong, Rajshahi and Khulna. Dhaka, the capital, is the largest.

With an estimated population of 167,184,465 in 2023, Bangladesh is one of the most densely (1140 persons per sq. km) populated countries in the world [8]. Bengali (Bangla), is its national language though English is widely spoken. Bangladesh has a strong track record of growth and development [9]. Adult literacy rate of 75.6% [10] The country had its gross domestic product[3] (GDP), reaching USD 2,688 per capita and was ranked 35 out of the 50 major world economies by GDP in 2022. Its five largest industries are jute, cotton, garments, paper and leather. Bangladesh's growth needs to be supported by energy security that can fuel its economic and social activities [11].

Figure 1: Map of Bangladesh (Source: https://www.worldometers.info/img/maps_c/BG-map.gif)

[3] The economic strength of a country is determined by its gross domestic product (GDP). This is the amount of all income generated in the country from the sale of goods and services [88].

3.1 The energy sector

Bangladesh's total sources energy supply[4] as of 2022 is made up of natural gas (52,7%), oil (26.0%), biofuels and waste (15,5%), coal (5,5%) and hydro (0,1%) and renewables which includes wind and solar (0.1%). For its domestic energy production, natural gas which is produced locally accounts for the 71% which is mostly used for electricity production [12]. Oil and LPG are imported. Biomass is also being used as a greater share of energy. A share of electricity is imported from India [13]. As of 2021, 100% electrification was achieved in Bangladesh [6].

According to IRENA, Bangladesh's electricity installed capacity keeps increasing and stands at 28,461 MW in 2023 as compared to 25,395 MW in 2022 and 23,991 MW in 2021. Its electricity generation however, dropped in 2022 to 82,191 GWh from 91,412 in 2021. As of 2023, the total grid-based installed capacity had risen to 25,480 MW from 22,420 MW in 2022 [14].

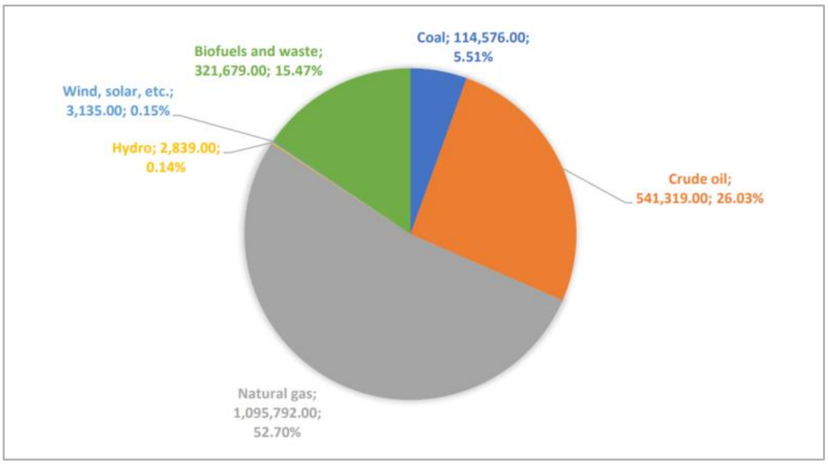

Figure 2: Composition in domestic energy production in Terajoules (TJ), Bangladesh, 2022([12])

The electricity generation in Bangladesh is dominated by fossil fuels (98% in 2022) with largest source being natural gas (52.70%). The proportion of electricity generated from renewables remains below the 5% (Figure 2) [12] .

Table 1: Electricity installed and generation capacity of Bangladesh 2018-2023 [14]

	Electricity generation (GWh)				Electricity Installed capacity (MW)			
Year	Total	Total non-renewable	Total renewable	Total renewable %	Total	Total non-renewable	Total renewable	Total renewable %
2018	75,995	74,756	1,238	1.6%	19,550	19,072	478	2.4%
2019	80,636	79,441	1,195	1.5%	21,523	21,005	518	2.4%
2020	85,208	83,964	1,245	1.5%	23,682	23,100	582	2.5%
2021	91,412	90,056	1,356	1.5%	23,991	23,247	744	3.1%
2022	82,191	80,605	1,586	1.9%	25,395	24,633	762	3.0%
2023					28,461	27,455	1,006	3.5%

[4] *Total energy supply (TES) includes all the energy produced in or imported to a country, minus that which is exported or stored [12] .*

As of 2022, the largest energy consumers in Bangladesh are the residential sector and industries followed by the commercial and public services. The least is the transport sector (0,7%) Figure 3.

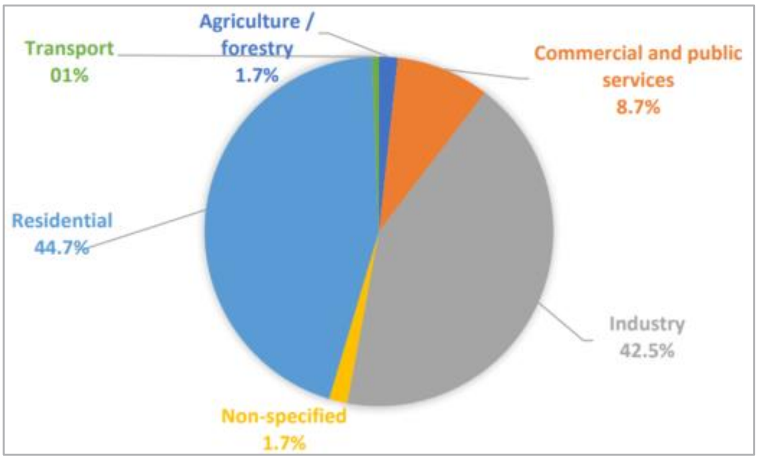

Figure 3: Electricity final consumption by sector in Bangladesh 2022 [12]

However, due to population growth, industrialization and advances in agricultural production, it is expected that the demand for electricity will continue to grow at a rate of almost 7% per annum over the next two decades. The power system master plan (PSMP) in 2018 projects that by 2025, the demand for electricity will rise to ~28 GW, requiring a net generation capacity exceeding 40 GW and around 60 GW (58,399 MW) by 2030 [10]. As of 2023, the government of Bangladesh aims to have an installed capacity of 40 GW by 2030 and 60 GW by 2041 [15]. This requires add-ons to generation capacity, transmission, and distribution systems [10].

3.2 The renewable energy sector in Bangladesh

The amount of renewable energy presently in the energy mix of Bangladesh is still low. But as of the time of writing this report, Bangladesh has ambitious renewable energy goals, aiming for 10% of its electricity to come from renewable sources by 2025, including solar, hydropower, and wind [16]. The government also aims to generate 15% of electricity from renewable sources by 2030, 40 % by 2041, and ultimately achieving 100% by 2050. As of September 2024, the total installed capacity for electricity of RE stands at 1,379.52 MW (Table 2). The major source being solar (1,085.53 MW) sub-sector [17]. Under its updated Nationally Determined Contribution (NDC) (August 2021), Bangladesh aims to reach 4.1 GW of renewable capacity by 2030, with a 2.3 GW of solar capacity [15].

Table 2: Renewable energy installed capacity in september 2024 is 1379.52 MW [17].

Technology	Off-grid (MW)	On-grid (MW)	Total (MW)	% of installed capacity
Solar photovoltaic	377.08	708.44	1,085.53	78.69
On-shore wind	2	60.9	62.9	4.56
Renewable hydropower	0	230	230	16.67
Biogas to Electricity	0.69	0	0.69	0.05
Biomass to Electricity	0.4	0	0.4	0.03
Total	**380.17**	**999.34**	**1,379.52**	

The Power System Master Plan (PSMP) 2016, total electricity demand in 2030 will be 41,890 MW. As a result, renewable energy power generation capacity will have to reach 12,567 MW [18]. However, the current installed renewable capacity reaches only meet 4,11% of its 2030 Sustainable Development Goals (SDGs)[5] goals target of 10%, requiring more effort from the country [16].

3.2.1 Solar photovoltaic sector in Bangladesh

Situated between 20°34′ and 26°38′ north latitude and 88°01′ and 92°41′ east longitude, Bangladesh possesses an ideal geographical location for effectively harnessing solar energy [19] as such it is the most promising of the available renewable energy sources.

a) Solar PV implementation status in Bangladesh

The overall landscape of the 1,085.53 MW (Table 2) installed solar energy consist of small- and large-scale solar projects. Most capacity resides in large-scale solar projects which includes solar-powered rooftops, irrigation, mini-grids, microgrids, nano-grids, and solar charging stations Table 3. The small-scale projects are solar-powered home systems, streetlights and water heaters.

- **Large-Scale Solar Projects, Solar Power Plant / Solar Park**: A total of 72 large-scale solar IPP projects with an envisaged capacity of 4,663.24 MWp have been considered by the Government of Bangladesh (GoB) as of 12 September 2024. Of these, 12 utility-scale (Table 3) on-grid solar power projects with a total capacity of 537 MWp are in operation, 09 with a total capacity of 411.9 MWp are undergoing implementation and 43 (3,514.34 MWp) are at the planning stage. Unfortunately, 8 of these 72 with a capacity of 200 MWp have been rejected from planning phase [17].
- **Rooftop Solar Projects with net metering:** The Net Metering Guidelines-2018 launched by the GoB on 28 July 2018 aimed to motivate consumers to install solar PV systems on rooftops, integrate with the main grid and thus become active prosumers. Public utilities have been mandated with capacity limits to installation under this scheme. According to SREDA, a total of 2,529 rooftop net metering systems with a total capacity of 112.29 MWp have already been approved. Of these, 2,528 (112.27 MWp) have been completed and are in operation and one with a capacity of 0.02 MWP was rejected at the planning phase.
- **Rooftop Solar Projects without net metering:** There are 256 (87.61 MWp) rooftop system with no net metering approved by the GoB. Of these, 247 (85.88 MWp) have been completed and running while 3 (0.58 MWp) are GoB still under construction, 2 (0.05 MWp) under maintenance and 1 (0.85 MWp) in the planning phase. One system is obsolete and rejected while 2 (0.25 MWp) have been rejected from planning [17].
- **Solar Irrigation Pumps (SIPs):** Following the global trend of increasing utilization of solar energy to power irrigation pumps, the Government of Bangladesh initiated various projects to promote the use of SIPs across the country. Several government organizations have acted as implementing agencies in realizing the 3,499 SIP projects with a total capacity of 60.39 MWp envisaged for the country. So far

[5] *Indicator "7.2.1: Renewable energy share in the total final energy consumption" looks to increase substantially the share of renewable energy in the global energy mix by 2030 [16].*

3,403 of a capacity of 57.61 MWp have been completed and running while 96 with a capacity of 2,776 MWp implementation is still ongoing.

Table 3: Status of solar PV in Bangladesh as of September 2024 [17]

Projects type	Systems completed and running		Implementation ongoing		Under planning		Rejected from planning phase		Under maintenance		Obsolete		Total number of systems	Total capacity (MWp)
	Number of systems	Capacity (MWp)	Number of systems	Capacity (MWp)	Number of systems	Capacity (MWp)	Number of systems	Capacity (MWp)	Number of systems	Capacity (MWp)	Number of systems	Capacity (MWp)		
Solar parks	12	537.00	9	411.90	43	3,514.34	8	200.00					72	4,663.24
Rooftop Solar Projects with net metering	2,528	112.27					1	0.02					2,529	112.29
Rooftop Solar Projects without net metering	247	85.88	3	0.58	1	0.85	2	0.25	2	0.05	1	0.00	256	87.61
Solar Irrigation	3,403	57.61	96	2.78									3,499	60.39
Solar Mini Grids	28	5.81											28	5.81
Solar Nano Grids	2	0.00											2	0.00
Solar charging stations	15	0.29											15	0.29
Solar-powered Telecom Tower	1,933	8.06											1.933	8.06
Solar Drinking Water systems	82	0.10									34	0.03	116	0.13
Solar Home System (SHS) Program	6,037,689	263.59											6,037,689	263.59
Solar Street Light	297,691	17.10											297,691	17.10
Total	**6,343,630**	**1,087.71**	**108**	**415.25**	**44**	**3,515.19**	**11**	**200.27**	**2**	**0.05**	**35**	**0.03**	**6,343,830**	**4,955.03**

- **Solar mini grids:** With a range of 100 to 650 kWp, there are 28 solar PV powered off-grid mini-grids having capacity of 5.81 MWp with diesel generators as backup as of September 2024. IDCOL operates 26 of them, while 1 is by BPDB and the other by Northern Electricity Supply PLC (NESCO) [17].
- **Solar nano grids:** With a range of below 1 kWp, there are 2 solar PV powered nano-grids having capacity of 0.001 MWp financed by the GIZ as of September 2024 [17].
- **Solar charging stations**: According to SREDA's website, 15 solar charging stations have been installed and are running with total capacity of 0.29 MWp. The stations are owned and financed by different utilities, such as, BPDB, BREB, DESCO, DPDC, DAE and WZPDCL.

- **Solar-powered telecommunication tower**: So far, a total of 1,933 solar PV-powered telecom towers have been installed in Bangladesh, which translates into a total of 8.06 MW of solar capacity [20].
- **Solar drinking water systems:** Presently, there are 2,787 solar pumps nationwide but just 116 drinking water systems with a total capacity of 0.13 MWp are operational. Of these, 34 are obsolete and 82 are completed and running [17].
- **Solar home system (SHS) program:** The SHS programme has to date, installed 6,037,689 SHSs with a capacity of 263.59 MWp in remote areas ensuring solar electricity supply to millions of people. This has been made possible by several agencies such as IDCOL, GIZ, BREB, etc [17].
- **Solar street light**: According to the website of SREDA, 297,691 solar-powered street light systems have been installed with a capacity of 17.10 MWp in the country until December 2024 [17].

Manufacturing PV components projects: In a bid to achieve self-sufficiency in PV manufacturing, IDCOL has funded two photovoltaic assembly plants with a combined capacity of 10 MW.

b) National strategies, plans, and targets for solar pv development

The government of Bangladesh has set these ambitious targets to increase the share solar PV, in the overall energy mix. The national solar energy action plan calls for around **41 GW** of solar power by 2041 [18]. Some planned projects to reach this target are:

- **Solar mini grids**: IDCOL aims to install 50 mini-grids by 2025 and plans to install 50,000 solar pumps by 2025. Currently, IDCOL has approved approximately 1,429 pumps, of which 1,186 are operational, with a total capacity of 26.59 MW.
- **Rooftop solar projects**: IDCOL's ambition includes generating 1,000 MW of electricity from rooftop solar projects. It's estimated that rooftops in the textile industry alone can produce 400 MW, while industrial and commercial rooftops combined have the potential to generate 4,000 MW [21].
- **Solar power plant/solar park**: 43 solar projects are in the planning phase.
- The utility companies have been mandated to add certain amounts of renewable component to their existing capacity, which if implemented shall account for 700 MW of solar power.
- The GoB has also received proposals for 3 large-scale solicited grid-tied solar IPP projects. All of these IPP projects are of 50 MW capacity and are to be located on land available near the 132/33 kV grid substation at Boriahat, Rangunia and Netrokona.

3.2.2 On and off-shore wind energy sector in Bangladesh

Bangladesh faces limitations in wind energy development. The average wind speed in the country is low despite its subtropical climate with occasional high wind speeds during cyclones and storms. Most on-shore locations are expected to have an annual average of around 5 m/s at a height of 50-80m [22]. While cyclone seasons bring wind gusts exceeding 35m/s, this is not suitable for power generation. However, Energy Laboratory (NREL) study estimated Bangladesh's wind energy potential to be at least 30,000 MW (Jacobson, 2018). The study identified over 20,000 km^2 of land and 5 locations with wind speeds ranging from 5.75 to 7.75m/s, suitable for generating over 30,000 MW of power. Based on this study, the government has identified potentially viable sites and established guidelines for on-shore wind power projects.

a) Wind power implementation status in Bangladesh

Bangladesh's journey with wind power began in 2005 with the constructing of a 0.9 MW plant near the Muhuri River in Feni. Three years later, another 2.0 MW plant was built on Kutubdia Island. Unfortunately, both pioneering projects are now defunct due to a lack of proper oversight and interest [23]. The country has made significant progress, launching its first commercial on-shore wind farm in May 2023 with a capacity of 60 MW [24]. Taking advantage of the naturally strong winds along Bangladesh's 724-kilometre coastline, the project utilizes the wind resource. According to SREDA (Table 4), there are 14 on-shore wind projects in Bangladesh with an envisaged capacity of 779.9 MWp as of September 2024. These range from 900 kWp to maximum of 200 MWp with some being on-grid while others are off-grid [17].

Table 4: All on-shore wind projects in Bangladesh completed or in planning as of September 2024 [17]

Location	Agency	Capacity (MWp)	Grid Connectivity	Status
Chakaria Upazila, Cox's Bazar	BPDB	60	On-Grid	Completed & running
Kutubdia Upazila, Cox's Bazar	BPDB	1	Off-Grid	Completed & defunct [23]
Kutubdia Upazila, Cox's Bazar	BPDB	1	Off-Grid	Completed & defunct [23]
Sonagazi, Feni	BPDB	0.9	On-Grid	Completed & running
Sirajganj Sadar Upazila, Sirajgonj	BPDB	2	On-Grid	Implementation ongoing
Anwara Upazila, Chittagong	EGCB	100	On-Grid	Under planning
Maheshkhali Upazila, Cox's Bazar	CPGCBL	100	On-Grid	Under planning
Assasuni Upazila, Satkhira	BPDB	100	On-Grid	Under planning
Chakaria Upazila, Cox's Bazar	BPDB	220	On-Grid	Under planning
Sonagazi, Feni	BPDB	30	On-Grid	Under planning
Mongla Upazila, Bagerhat	BPDB	55	On-Grid	Under planning
Cox's Bazar Sadar Upazila, Cox's Bazar	BPDB	50	On-Grid	Under planning
Chandpur Sadar, Chandpur	BPDB	50	On-Grid	Under planning
Kalapara Upazila, Patuakhali	RPCL	10	On-Grid	Under planning
Total		**779.9MWp**		

b) National strategies, plans, and targets for wind power development

In demonstrating Bangladesh's commitment to diversifying its energy sources and promoting sustainable development, the country aims to install 10 other plants (Table 4). These projects are at various stages of development [23].

In its updated Nationally Determined Contributions (NDC) submitted in 2021 with a target of 2030, a possible mitigation action was to have the wind power capacity of 149 MW in 2030 and 597 MW I 2041 [25].

The Integrated Energy and Power Master Plan (IEPMP) 2023 outlines an ambitious plan to establish a low-carbon economy in Bangladesh through a significant increase in the usage of clean energy sources like on-shore wind. The plan project a total of 5,000 MW of on-shore wind capacity to be installed by 2050, primarily located in the coastal areas through a phased-development plan of 800 MW within 2023-2030, 800 MW between 2031-2041 and 3,400 MW from 2042 to 2050 [26] [6].

Table 5: On-shore wind power additional capacity and required investment till 2050 [6]

	On-shore Wind	
Year	Capacity Addition (MW)	Required Investment (US$ billion)
2023-2030	800	0.8
2031-2041	800	0.9
2042-2050	3,400	3.6
Total	5,000	5.3

3.2.3 The Biogas sector in Bangladesh

The first biogas plant in Bangladesh was constructed in 1972 and has since emerged as a promising RE technology within Bangladesh's Nationally Determined Contribution (NDC). This technology offers a two-fold benefit - energy needs and waste management challenges, thereby making biogas a strategic technology for Bangladesh's sustainable development journey. The technologies present in the country are fixed-dome, floating-drum, balloon, low-cost polyethylene tube digesters and ferro-cement plants [27].

a) Biogas implementation status in Bangladesh

In Bangladesh, biogas technology has become a powerful ally for both farmers and poultry owners by converting cattle and agricultural waste into biogas while generating nutrient-rich fertilizer for their crops. Biogas can be used for cooking or generating electricity. With many government and private organizations actively engage in this sector, electricity generation from Biogas has seen the installation of approximate 87,536 biogas plants in Bangladesh as of 2022 – 61,134 by IDCOL, 1,500 by the GIZ, 24,774 by Bangladesh Council of Scientific and Industrial Research (BCSIR) and 128 by the Ministry of Disaster Management and Relief (MoDMR) [28]. Among these projects are, 13 large projects (Table 6) with a MoD MR total electricity generation capacity of **1,450.5kWp**. Currently, 8 are active providing 990 kWp of electricity. The Bangladesh biogas development foundation (BBDF) plays a coordination role between private and public sector [17].

Table 6: Large biogas projects completed or in planning in Bangladesh as of September 2024 [17]

Project name	Location	Agency	Capacity (kWp)	Grid Connectivity	Status
Oasis Services (Agro) Ltd	Bhaluka, Mymensingh	IDCOL	300	Off-Grid	Completed & running
Phenix Agro Ltd. at Member Bari, Gazipur	Whole Bangladesh, Gazipur	IDCOL	400	Off-Grid	Completed & running
UAL Bio-Electricity project	Whole Bangladesh, Gazipur	IDCOL	60	Off-Grid	Completed & running
KKT Bio-Electricity project	Whole Bangladesh, Panchagarh	IDCOL	100	Off-Grid	Completed & running
ZPL Bio-Electricity project	Whole Bangladesh, Chuadanga	IDCOL	30	Off-Grid	Completed & running
UK Bio-Electricity project	Whole Bangladesh, Tangail	IDCOL	30	Off-Grid	Completed & running
Seed Bangla Foundation Bio-Electricity Project	Whole Bangladesh, Gazipur	IDCOL	20	Off-Grid	Completed & running

Project name	Location	Agency	Capacity (kWp)	Grid Connectivity	Status
RKKL Bio-Electricity Project	Whole Bangladesh, Mymensingh	IDCOL	50	Off-Grid	Completed & running
Dutch Dairy Ltd	Lohajang Upazila, Munshiganj	IDCOL	400	Off-Grid	Implementation ongoing
Brahmanbaria Power Plant	Brahmanbaria Sadar Upazila, Brahmanbaria	BPDB*	11	On-Grid	Under planning
Narayanganj Power Plant	Naryanganj Sadar Upazila, Narayanganj	BPDB	6	On-Grid	Under planning
Municipal Solid Waste-based Power Plant	Dhaka City, Dhaka	BPDB	42.5	On-Grid	Under planning
Power Plant Based on Municipal Solid Waste	Keraniganj Upazila, Dhaka	BPDB	1	On-Grid	Under planning
Total			**1,450.5kWp**		

* Bangladesh Power Development Board (BPDB)

b) National strategies, plans, and targets for biogas development

Infrastructure Development Company Limited (IDCOL), a non-bank financing institution offers a comprehensive range of subsidy and concessionary loans to viable RE programs/projects and has invested about 2.8 million USD in biomass-based technologies, which include biogas power plants, biomass power plants and biomass gasification plants. The Ministry of Power, Energy, and Mineral Resources of Bangladesh finalised a policy in 2008 on overall renewable energy, which included biogas technology as a renewable energy technology, but at this moment there is no specific approved policy nor targets for biogas diffusion in Bangladesh [29].

3.3 Power grid expansion / smart grids

Power grids are used for the transmission and distribution of generated electricity to consumers. A smart grid uses digital technology for two-way communication between utilities and consumers, allowing for improved management and integration of diverse energy sources and shifting demand patterns. It essentially leverages automation and computerization to create a more responsive and sustainable electricity infrastructure [30]. In addition, the smart grid makes better use of energy generated from alternative sources, such as from solar panels, wind turbines, and other energy-generating systems, through improved storage and transmission. Technologies that make up the smart grid include advanced metering infrastructure (AMI), electricity distribution systems, electricity transmission systems, and energy storage capabilities [31].

a) Power/smart grid implementation status in Bangladesh

Power generated in different power plants in Bangladesh is transmitted to the national grid through 400 kV, 230 kV and 132 kV transmission lines. Power Grid Company of Bangladesh Ltd. (PGCB)[6] is solely responsible for operation, maintenance and development of transmission system all over Bangladesh while six companies namely, Bangladesh Rural Electrification Board (BREB), Dhaka Power Distribution Company (DPDC), Dhaka Electric Supply Company (DESCO), Bangladesh Power Development Board (BPDB), North Electricity Supply PLC

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[6] *As of October 2024, it has been renamed to be "Power Grid Bangladesh PLC"*

(NESCO) and West Zone Power Distribution Company Limited (WZPDCL) are in charge of distributing electricity in specific zones of the country (Table 13). The Bangladesh Power Development Board (BPDB) is the single buyer that purchases electricity from generation licensees and sells to distribution licensees using the transmission network owned and operated by Power Grid Company of Bangladesh (PGCB) while six distribution utilities handle power distribution [32].

The total number of transmission lines in the country as of September 2024 is 15,624.6 circuit km. Table 7 below shows year wise transmission system line as on June 2024 developed by PGCB. The transmission network links 224 substations with a capacity of 71,599 MVA [33]. Over the years there has been a significant decrease in system losses from 14.73% in the fiscal year 2010-11 to 6.58% in 2024. Facing the challenges of ageing and inefficiency under growing demand, the current conventional grid is reaching its limits despite ongoing improvements resulting in opting for a "smart grid" solution.

Table 7: Transmission line as on September2024 by PGCB [33]

400kV	2,497 Circuit km
230kV	4,263.3 Circuit km
132kV	8,864.3 Circuit km
Total Line	**15,624.6** Circuit km

On the other hand, the total distribution line in the country fall in two categories: primary distribution voltages of 11 KV, 6.6 KV, and 3.3 KV and Secondary distribution voltage of 400V and 220V. As of June 2023, Bangladesh has about 643,167 km of distribution lines. The distribution companies continuously work on upgrading their system (such as having smart grids) to meet the increasing demands, improve efficiency, enhance sustainability and incorporate advance technologies that promote energy efficiency and reduce system losses during distribution [32].

a) National strategies, plans, and targets for power/smart grid

Presently, Bangladesh is advancing its power sector by expanding the power grid and integrating smart grid technologies, aligning with Vision 2041 for sustainable, reliable, and efficient electricity supply ([34]; [30]). The initiative, supported by the Ministry of Power, Energy and Mineral Resources and various regulatory bodies, includes regulatory frameworks to facilitate this transformation. Key projects focus on upgrading the transmission grid, incorporating advanced metering, grid automation, and demand response systems, with support from international entities like the World Bank and ADB, and are guided by strategic plans like the Power System Master Plan.

Dhaka Power Distribution Company (DPDC) with support from the French Development Agency (AFD) and the European Union (EU), paved the way for the first Smart Grid in Bangladesh by initiating several smart grid projects [34]. The DPDC's pilot project, currently underway in 05 selected substations (Asad Gate, Green Road, Jigatola, Lalmatia and Satmosjid out of 68) across Dhaka, aims to demonstrate the tangible benefits of a smart grid [35].

NKSoft Corporation, a US-based organization, is leading the automation and smart grid conversion of DPDC's selected portion of the network as well as that of West Zone Power Distribution Company Ltd. (WZPDCL). NKSoft as the main consultant for the entire system (integration design), will be creating the whole system with software and other tools. The customers from both utilities are estimated to enjoy the benefit by the end of 2025 [36]. Other renowned companies involved in the project are Esri, Schneider, E-tabs etc. The smart grid project status in the WZPDCL zone is summarized in the following table (Table 8).

Table 8: WZPDCL smart grid project status [37]

#	Project Name	Date	Total project Cost	Financed by	Progress / Remarks
1	Modernization of Power Distribution Smart Grid Phase-I	Jul’21 – Dec'25	€109.59 million	KfW Bank	Ongoing
2	Smart Prepayment Metering Project for West Zone Power Distribution Company Ltd. (WZPDCL) Area.	Jan' 22-Dec'24	€92.60million	Govt. & WZPDCL	Ongoing
3	Underground Power Distribution System Project (Phase-1)	Jan' 22- Dec '25	€741.71million	Govt.	Fund Searching
4	Smart Pre-payment Metering Project for WZPDCL area (Phase-III)	July’2024 - Jun’2028	€7.5 billion	Govt. & WZPDCL	Pending approval

At the distribution level especially in Dhaka, the following measures (Table 9) are necessary to enable efficient supply of the generated RE power while maintaining stability and reliability of the network in Bangladesh [6].

Table 9: Measures to realize the maximum grid connection of RESs in Bangladesh [6]

Measures	Description
RES connections	- Development of technical requirements for RES connections - Installation of sensors for gaining power data in medium-voltage lines - Introduction of voltage control equipment to medium-voltage lines - Introduction of Distribution Management System (DMS) to obtain power data - Remaining proper voltage by optimal control of line equipment based on DMS results
Improving of Reliability	- Insulation covered wires (in practice) - Lightning resistant equipment - Introduction of MDMC configuration - Hybrid Overhead/Underground equipment combination - Improvement on fault point probing technology
Operational Efficiency	- Introduction of smart meters and data operation with management technology - Improvement of communication environment - Facility management using GIS (Geographic Information System) - Data management integrated with DMS, DAS, SCADA and distribution simulation software - Underground related technology (system configuration, equipment configuration, construction technology, and measurement technology) - Ensuring cyber security at GIS, SCADA, DAS, DMS etc. systems - Introduction of a Time-of-Use Tariff systems - Use of water heaters and air conditioning systems with ice storage - Introduction of batteries and electricity storage equipment

The power transmission sector on the other hand requires a significant expansion during the period covered by IEPMP. Three points are important and priority in the country [6] - **increase of South to North Power Flow** through new transmission lines, **reliability improvement of supply network to Capital Dhaka** through the construction of a 230 kV underground **system** and **interconnection** through diversify interconnections with respect to partner countries and modes. With the renewable energy sources in the mix, Power Grid Bangladesh PLC has within its 17 on-going and 5 upcoming projects, activities that are aimed at enhancing and modernising the grid to accommodate variable sources of electricity [33].

Table 10 shows the amount of new major transmission infrastructure to be constructed by 2030. These facilities include both overhead transmission lines with conductors and underground transmission lines. The table also shows that the total construction cost by 2030 is about **US$ 2 billion (€1.85 billion)**, which indicates the annual required investment in the transmission sector of about **US$ 0.4 billion (€0.36 billion)** [6].

Table 10: Power Transmission Capacity Additions and Required Investment [6]

Sl. No.	Component	Unit	Unit price (in lac taka)		US $ /BDT		
Transmission line				**km**	**lac taka**	**0.0094**	**US $**
1	765 kV Double circuit Line	km	1,760	350	616,000.00		
2	400 kV Double circuit Line (Quad ACSR Finch)	km	980	141	138,180.00		
3	230 kV Double circuit Line (Twin ACSR Mallerd)	km	410	369.556	151,517.96		
4	132 kV Double circuit Line* (single Grosbeak)	km	150	527.5	79,125.00		
				Sub.total	984,822.96		925,733,582.40
Substation				**no.**			
1	400 kV Substation AIS	no.	55,000	17	935,000.00		
2	230 kV Substation AIS	no.	13,000	10	130,000.00		
3	132 kV Substation AIS	no.	6,500	7	45,500.00		
				Sub.total	1,110,500.00		1,043,870,000.00
						Total	1,969,603,582.40

Source: IEPMP Study Team based on the provided material from PGCB

With its plans to make the most of installed generation capacity by expanding grids and making some of the existing facilities smart, the government of Bangladesh in 2024 has allocated around a third of the budget set aside for the power division to be for the Power Grid Company of Bangladesh (PGCB). The finance minister has set aside Tk 29,230 crore (€2.3 billion) for the power division for 2024-25. PGCB will get Tk 10,634 crore (€825.6 million) [38].

3.4 Energy storage (Battery Energy Storage Systems)

The pursuit of a sustainable and reliable energy future in Bangladesh, has led to growing emphasis on energy storage solutions, particularly Battery Energy Storage Systems (BESS). As the nation strives to meet its increasing electricity demand while transitioning towards renewable energy (RE) sources, the role of energy storage in enhancing grid stability, managing power output variability, and optimizing energy utilization has become increasingly crucial. The government highlight BESS's potential to increase RE generation and support electric vehicle (EV) adoption [39].

a) Energy storage implementation status in Bangladesh

Although Bangladesh recognizes the potential of energy storage technologies to transform its power sector, there are currently no operational utility-scale energy storage systems. The EU delegation conducted a study and developed an Energy Storage Roadmap to increase the share of renewable energy in Bangladesh, integrate it into the grid, and enhance electricity supply security and grid stability [40].

Presently, Bangladesh is not entirely devoid of energy storage solutions. Distributed energy storage systems, primarily BESS, are finding increasing application in the design of solar mini-grids and solar home systems across the nation. This trend is further amplified by the growing number of residential, commercial, and industrial customers opting for rooftop solar PV systems, often accompanied by the inclusion of BESS during installation.

Toshiba Infrastructure Systems & Solutions Corp provided the substation traction energy storage system for the Dhaka Metro Line 6. This system employs long-life Li-ion batteries to store regenerated braking energy, aiding in accelerating trains among other things [41].

The country has also seen a push towards electrification in the transport sector calling for the use of electric vehicles as well as three-wheelers (currently ~1-1.2 million on the roads) and four-wheeler EVs [42]. These EVs absolutely depend of battery storage systems and charging stations. Bangladesh currently has four designated EV charging station and 400registered EVs [43].

b) National strategies, plans, and targets for energy storage

Bangladesh intends to reduce 3.39 million tonnes of carbon dioxide (CO2) emission from road transport by 2030 as stated in its National Determined Contributions (NDCs). The goal is to achieve 30% EV penetration by 2030 [43].

A National Renewable Energy Laboratory (NREL) assessment showed that while the country's power system is technically viable for storage solutions to support peak demand and ancillary services, the current policy framework offered minimal support [42].

The Dhaka North and South City Corporations climate action plan envisions a future in with 95% of private cars and 100% public transportation to be electric by 2050. It foresees 10% private automobile to be electric by 2030 and 50% by 2040. For the public transit, it talks about 80% by 2030 and 100% by 2040 [43].

Battery manufacture: The initiation of Bangladesh Lithium Battery Limited, alongside the establishment of an EV manufacturing plant, aims to replace the lead-acid battery-powered 3-wheelers with more efficient Li-ion batteries and establish charging stations nationwide. With a BDT 600 crore investment, this initiative is setting up a modern manufacturing plant in Chattogram to produce lithium batteries for electric vehicles (EV) and BESS-based systems. The plant's annual production of 1000 MWh Li-ion batteries could power approximately 20,000 mid-range EVs, assuming an average battery capacity of 50 kWh per vehicle [44]. The facility, with a 1 GWh annual capacity, is expected to start production in 2024 [44].

The lead-acid battery market is forecasted to grow, driven by increasing automotive sales and low-cost lead availability. Starting, Lighting, and Ignition (SIL) lead acid batteries will dominate due to the thriving automotive sector, with opportunities from decreasing solar PV costs and renewable energy initiatives [45]. The European Union and the Government of Bangladesh have signed a €400 million agreement to support RE projects, with a €45 million blending support package potentially enabling the incorporation of BESS alongside other initiatives [46].

3.5 Energy efficiency (EE) in Bangladesh

According to the IEA, Energy efficiency is called the “first fuel” in clean energy transitions, given that it provides some of the quickest and most cost-effective CO_2 mitigation options while lowering energy bills and strengthening energy security. It is the single largest measure to avoid energy demand, along with the closely related measures of electrification, behavioural change, digitalisation and material efficiency [47]. It is within this context that Bangladesh is prioritising EE across sectors as it relies heavily on imported fossil fuels and has already experienced the shocks of the unstable international fuel market.

The **“Energy Efficiency and Conservation Master Plan up to 2030 (EE&CMP)”** published by SREDA in 2016 indicates a roadmap up to 2030 with an action plan that outlines a long-term national target to enhance the country's energy efficiency by 20% improvement of primary energy consumption per GDP by the fiscal year 2029-30, compared to the baseline of fiscal year 2013-14. The summary of the action plan (Table 11) includes five core actions to be achieved with SREDA as the responsible authority. These targets are:

- implementation of EE financing programme,
- introduction of energy management (audit) programme,
- introduction of EE labelling programme,
- introduction of EE building rating programme and
- implementation of awareness raising program

The sectors of interest for EE measures within this study are **commercial / residential buildings, industrial production (RMG / textiles, fertilizers, etc.), transport, refrigeration and air conditioning (RAC) sector** while looking into **Energy management / auditing** too.

Table 11: Summary of EE&C programs in action plan [48]

Program	Target	Methodology
Energy Management Program (EMP)	Large Industrial Energy Consumers	• Large energy consumer designation • Energy Manager, Certified Energy Auditor, and Accredited Energy Auditor certification with qualification and examination system • Energy audit (mandatory/voluntary) • Energy consumption reporting (mandatory) • Benchmarking
EE Labeling Program (EELP)	Residential Consumers	• Label certification / Laboratory accreditation system • Standardization of EE measurement method and Star Label Rating criteria • Star Label Standardization (Unification) • Participation of manufacturers, importers, and retail shops (mandatory/voluntary) • MEPS (Minimum Energy Performance Standard) • Effective means to be developed to stop entry of below-standard and energy-inefficient products/items in the market
EE Building Program (EEBP)	Buildings	• New version of BNBC [Revised] Implementation • GBG (Green Building Guidelines) development • Manual and Rating system introduction • Incentive mechanism to be developed for following GBG and its implementation • Certification of GB (Green Building)

Program	Target	Methodology
EE&C Finance Incentive Program	Private Companies	• Low-interest loan for EE&C investment • Preferential taxation on high-efficiency equipment/appliances and/or EE&C investment • Subsidy for EE&C investment • Other incentive mechanisms
Government's Own Initiatives	Government	• Green Purchase Program for Eco-friendly public procurement • Obtain ISO 14001 and 50001 certifications
Energy Consumption Data Collection	Government	• Energy consumption data by fuel • Energy consumption data by sector and sub-sector • Energy intensity data
Global Warming Countermeasure	All	• Formulation and quantification of national carbon market • Carbon abatement project as capacity development • Awareness raising

3.5.1 Energy efficiency in commercial / residential buildings

Buildings contribute enormously to greenhouse gas (GHG) emissions through the production of cement and steel which accounts for around 10% of the world's annual GHG and also through its operational emissions using energy to light, heat, and cool space. Cooling accounts for about one-fifth of all electricity used in buildings and consumes more than lighting, lifts, or water pumps [49].

EE of buildings, encompasses strategies, technologies, and practices aimed at reducing energy consumption while maintaining or improving overall performance [50]. Given that the production of cement and steel is an industrial process, we shall be looking at this topic within the section "EE in industrial production" section 3.5.2. This section shall only focus on the construction and management side of commercial and residential buildings which optimizes of energy consumption within a building.

The common steps to achieve energy efficiency in Buildings are:

- Reducing HVAC System Reliance by upgrading to efficient HVAC systems, harness natural heating and cooling resources, and use data-driven automation to optimize HVAC usage.
- Optimizing Natural Light by maximizing the use of natural light sources to reduce the need for artificial lighting.
- Leveraging Smart Technology through implementing smart tech solutions to monitor and manage energy consumption, identify opportunities for improvement, and promote energy efficiency [50].

All the above can be achieved in one way or the other during the design, construction, operation, and maintenance of a building requiring different types of qualified workforce. EE technologies related in the buildings sector are [51]:

- Appliances
- Battery Technologies
- Energy-Saving Building Materials
- Energy-Saving Consumer Products
- Green Architecture and Construction Services
- HVAC and Building Control Systems
- Lighting
- Professional Energy Saving
- Smart Grid
- Water Efficient Products

In Bangladesh, rapid urbanisation, coupled with rising population and prosperity, is accelerating the construction of buildings, particularly high-rise buildings. Rising temperatures also increases energy demand and consumption [49]. Consequently, the consideration of saving energy and resources during the design, construction and operation in the building sector is imperative.

a) EE in commercial / residential buildings implementation status in Bangladesh

Bangladeshi's residential and commercial sectors (including public buildings) represent about 53.4% of the total electricity consumption [47].

The expansion of commercial buildings, largely driven by the garment industry, is forecasted to reach a collective market value of approximately €8.5 billion by 2025, with an estimated 10% earmarked for the "green market" (IFC, 2018). Despite the evident advantages of Green Building (GB) certified through different existing internationally recognised standards such as Building Research Establishment's Environmental Assessment Method (BREEAM), Excellence in Design for Greater Efficiencies (EDGE), Leadership in Energy and Environmental Design (LEED), its adoption in Bangladesh is still in the developmental stage with the absence of an official national policy, rating system, or code. Nevertheless, there is a discernible demand, particularly for green commercial structures.

While BREEAM certified buildings are absent and EDGE certifications are limited, Bangladesh boasts over 150 LEED certified buildings, with more than 130 being commercial properties. The country holds substantial potential to address its unique construction challenges; however, the finalization of a regional GB system has encountered delays [52].

b) National strategies, plans, and targets for EE in buildings

In energy efficiency (EE) for buildings, buildings have to measures up to established energy consumption benchmarks for a particular type of building under defined climatic conditions[7]. The Bangladesh National Building Code (BNBC) and various green building rating systems such as the Building Energy Efficiency & Environment Rating (BEEER) developed by SREDA put an emphasis on sustainable construction by integrating climate-responsive design elements which are low cost and energy efficient [53]. The Energy Efficiency & Conservation (EE&C) Master Plan prepared by the Ministry of Energy & Mineral Resources has set specific EE&C programmes to achieve energy saving in the building sector.

Bangladesh sets the following target to achieve energy efficiency in the buildings:

- A 70% market share of improved biomass cookstoves, to reach 20 million households in 2030.
- 40% market share of improved gas cookstoves by 2030.
- 10% market switch from biomass to LPG for cooking compared to the business as usual by 2030.
- 25% reduction of overall energy consumption of the commercial sector compared to the business as usual by 2030.

[7] *Building energy consumption benchmarks which are representative values against which a building's actual performance can be compared are applied mainly to heating, cooling, air-conditioning, ventilation, lighting, fans, pumps and controls, office or other electrical equipment, and electricity consumption for external lighting [106]. Commonly used energy indicators for buildings are kWh/m2 (energy consumption in kilowatt hours per metre square of floor area) or CO2 emissions [46].*

- Use energy-efficient appliances in households and commercial buildings (achieve 5% and 12% reduction in emission respectively) [54].

3.5.2 Energy efficiency for industrial production (RMG / textiles, fertilizers, etc.)

The ready-made garment (RMG) and textile industries are the cornerstones of Bangladesh's economy, contributing significantly to its export earnings and generating millions of jobs, particularly for women. This vibrant sector with about 4000+ functional factories [55], often referred to as the "garment engine," has propelled the nation's economic growth and social development over the past few decades.

However, with this remarkable success comes the responsibility to ensure environmental sustainability. The RMG and textile industries are inherently energy-intensive, relying heavily on fossil fuels for powering various processes like dyeing, weaving, and knitting. This dependence translates to significant greenhouse gas (GHG) emissions, posing a challenge to Bangladesh's commitment to environmental responsibility and its aspirations for a greener future.

Energy efficiency in garment/textile industry may be enhanced by reducing generation of steam by gas or liquid fuel and increase direct electricity-based heating in activities like dyeing, stenting and ironing. Steam generation using gas or liquid fuel and transporting the heat through a network of piping to different locations of a factory give rise to losses and higher energy costs.

a) EE for industrial production implementation status in Bangladesh

Key organizations - Bangladesh Garment Manufacturers and Exporters Association (BGMEA), Bangladesh Knitwear Manufacturers and Exporters Association (BKMEA), Bangladesh Textile Mills Association (BTMA), and individual RMG brands- in Bangladesh's RMG industry, play a crucial role in promoting EE in the sector. These entities contribute by:

- **Implementing energy efficiency (EE) measures:** Encouraging and facilitating the adoption of EE technologies and practices within their member factories thereby significantly reducing energy consumption and associated emissions.
- **Collaborating with stakeholders:** Working alongside government agencies, NGOs, and international organizations and leveraging collective expertise and resources so as to develop and implement effective strategies for GHG reduction in the RMG sector.
- **Raising awareness and advocating for change:** Educating consumers and stakeholders about the environmental impact of the industry and advocating for policies that incentivize sustainable practices so as to drive wider adoption of GHG reduction initiatives.

So far, major RMG brands, such as H&M, M&S, C&A, and Tesco, have set ambitious global targets to reduce their GHG emissions through EE measures. This commitment creates a ripple effect, influencing their supplier factories in Bangladesh to adopt similar EE measures in order to meet brand requirements and remain competitive in the global market.

- **H&M**: H&M has set ambitious goals for reducing its greenhouse gas (GHG) emissions across its entire value chain. The company aims to achieve a **56% reduction in absolute CO_2 emissions** in its own operations (scope 1), purchased energy (scope 2), and all upstream and downstream activities in its supply chain (scope 3) **by 2030,** compared to a 2019 baseline. To achieve this ambitious goal, H&M is implementing various strategies such as promoting sustainable materials, collaborating with suppliers to improve their environmental performance.

- **Tesco:** Tesco, a leading supermarket chain in the UK and a prominent sourcing player from the Bangladesh RMG sector, has embarked on an ambitious journey to achieve net zero emissions across its entire value chain by 2050. This will also create pressure for the Bangladesh RMG factories to become more energy efficient.
- **German Brands:** C&A, Lidl, and Aldi, three leading German retail giants, are actively pursuing ambitious sustainability goals, recognizing the environmental impact of the clothing and food industries. They are committed to reducing their greenhouse gas (GHG) emissions across their entire value chains, demonstrating their dedication to a more sustainable future.

b) National strategies, plans, and targets for EE for industrial production

Bangladesh has pledged to cut greenhouse gas emissions by 10% from a baseline of 101.99 million metric tons of CO2 equivalent by 2030, as part of its Nationally Determined Contribution (NDC). A key part of this commitment is promoting a green industrial sector, with Bangladesh Bank supporting this through green financing for energy efficiency (EE) in the RMG and textile industries.

3.5.3 Energy efficiency in the refrigeration and air conditioning (RAC) sector

The Refrigeration and Air Conditioning (RAC) sector presently holds a significant portion of energy usage in Bangladesh with expectations to surge owing to global warming and rapid economic, per capita income, population and urban growth [53].

a) EE in the refrigeration and air conditioning implementation status in Bangladesh

The RAC sector in Bangladesh includes manufacturing, installation and service and cuts across different sectors which are:

- **Space cooling in the building sector** through air conditioning and refrigeration. Here there is the need for the reduction of cooling requirements and energy consumption.
- **Automobile sector**: there is a rise in demand for transport air-conditioning, especially in-car air-conditioning (this shall be looked into later).
- **Cold chain and refrigeration**: for the preservation of perishable foods, such as fruit and vegetables, dairy and fish and meat.

Space cooling in the building sector can be tackled by incorporating energy efficient design in construction strategies making buildings have inherently reduced energy consumption over their operating lifetime (see section above) or through the usage of cooling equipment. The following equipment are present in the Bangladesh market for RAC services in space cooling:

1. **Room Air Conditioners**: According to Bangladesh Refrigeration Air Condition Merchant Association (BRAMA), the sales figures for air conditioners keeps increasing exponentially. Based on the average capacity of room air conditioners in the Bangladeshi market, the stock of air conditioners sales in 2019

was estimated to be 6.0 million Tons of Refrigeration (TR) with expected increase in future demands (Figure 4).

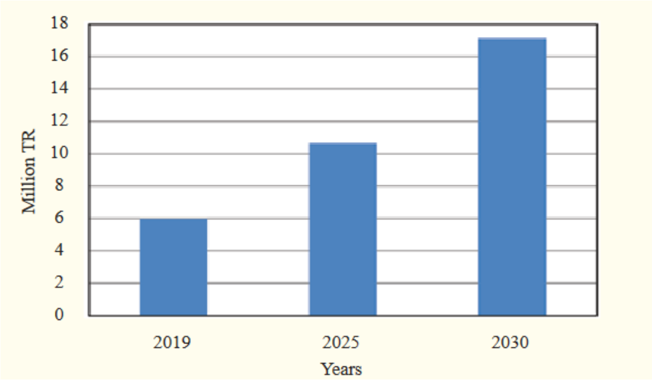


Figure 4: Projection scenario of room air conditioner demand from 2019 to 2030 [53]

2. **Chillers** are mostly imported into the Bangladesh. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), commercial buildings consume approximately 80% of all chillers sold in Bangladesh, while the remaining 20% goes into industrial AC applications. Industry experts suggest that the chiller market will grow at an average compound annual growth rate (CAGR) of around 10 percent in the next decade (Figure 5).

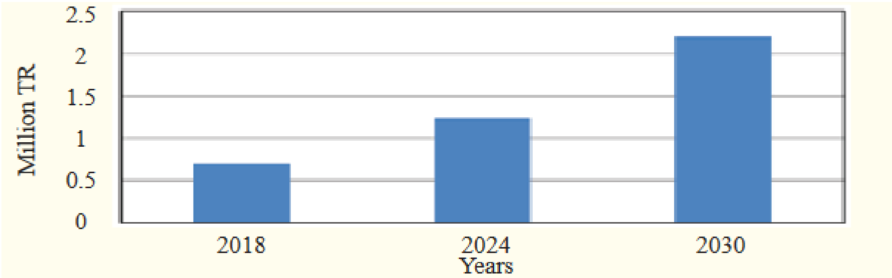


Figure 5: Projection scenario of chiller demand from 2018 to 2030

3. **Fans**: The use of electric fans alone accounts for around 30% of energy demand in the residential sector making EE essential. Energy-efficient ceiling fans of around 50W, as compared to ordinary fans of around 70W, makes possible an energy saving of 10-15 percent. As such, mainstreaming super-efficient 35W fans can bring even greater savings.
4. **Air coolers**: Air coolers are not yet popular in the country, though during extreme summer weather, units are imported from India and China. It is estimated that 10-20 percent energy savings are possible in the next decade, with more air coolers being fitted with energy-efficient fans and pumps.

Cold chain and refrigeration in Bangladesh can be grouped into three main categories: domestic, commercial and industrial refrigeration.

1. **Domestic refrigerator** which can be frost-free and direct-cool are used in households as well as commercial setups for the storage of perishable food, vaccines, etc. Around 90% of the domestic refrigerator demand is met by local manufacturers and assemblers. Walton Hi-Tech Industries Ltd is the leading manufacturer in the country. The previous annual increase in sales of 15% will reach

saturation point this year (2024) or next year according to estimates by the Ministry of Environment, Forestry and Climate Change (Figure 6). To improve EE in this sector, inverter technology has been introduced by local manufacturers. Energy efficiency and conservation (EE&C) labelling is also progressively moving towards higher energy efficiency. [53].

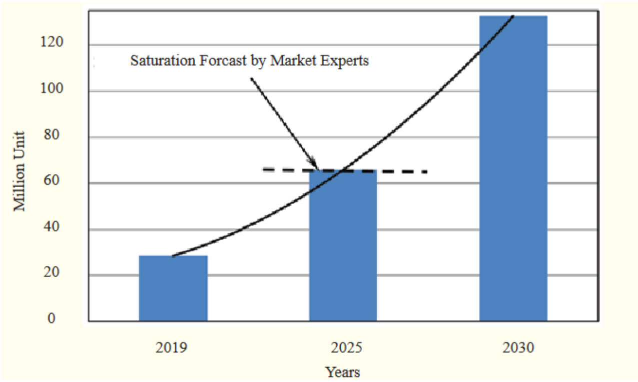


Figure 6: Projection scenario of domestic refrigerator demand from 2019 to 2030

2. **Commercial refrigeration**. Three systems are manufactured and/or assembled in Bangladesh - centralized systems installed in supermarkets; condensing units installed mainly in small shops and restaurants; and self-contained or stand-alone units. Commercial refrigeration equipment covers equipment of different capacities: deep freezers (glass top or hard top) (<1 kW); visi-coolers (<1 kW); remote condensing units (1-20 kW); water coolers (>2kW); supermarkets (60-100 kW); and hypermarkets (100-200 kW). Polar, Igloo, Lovello, Kwality, Zaan Zee and Golden Harvest ice cream distribution chains make up a good proportion of the market. Market experts believe that various kinds of commercial refrigeration units will see a steady growth of around 10% CAGR increase over the next 10 to 15 years (Figure 7) due to commercial space growth, cold chain, GDP growth and the lowering of prices.

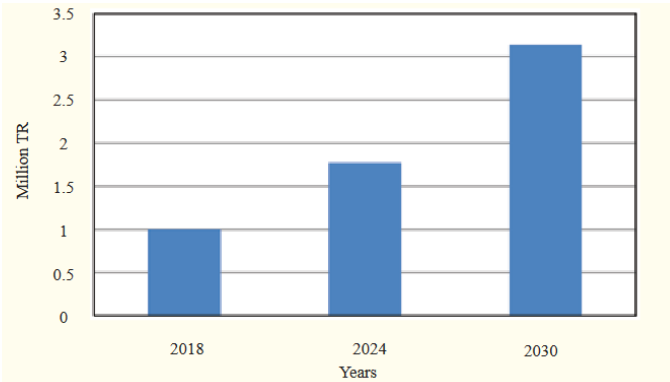


Figure 7: Projection scenario of commercial refrigeration demand, 2018 to 2030

3. **Industrial refrigeration (cold chain)** is used for milk, meat, fish, fruit/vegetable processing and storage; ice-cream manufacturing and storage, pharmaceuticals etc and other purposes. Made up of four links: pack-house or source point; reefer transport; cold storages; and ripening chambers or retail. Cold chain infrastructure in Bangladesh predominantly comprises highly insulated and refrigerated warehouses designed to store perishable products. It has great potential to reduce

cooling, refrigerant requirements and energy consumption through improved design, including proper insulation and the use of energy-efficient cooling equipment.

Room air conditioners and commercial refrigerators generate the biggest demand for servicing. The servicing in refrigeration and air conditioning sector sees a wide variation in failure rates due to the limited knowledge and skill levels of technicians. The technicians primarily work in the informal sector, without proper access to technology and training.

The EE rate and EE&C potential of home appliances are shown in Table 12. This reveals the benefits of using energy efficiency equipment in GWh/year (i.e., in terms of electricity consumption / cost).

Table 12: Energy efficiency rate and EE&C potential of home appliances [48]

Appliance	EE Technology	Current Energy Consumption (GWh/year)	EE Rate	EE&C Potential (GWh/year)
Fan	High efficiency motor	6,181	-25%	1,545
Refrigerators /Freezers	Variable speed compressor, high-performance heat insulation	2,299	-55%	1,264
ACs	High COP with large heat exchanging coil and variable speed compressor	2,237	-50%	1,119

b) National Strategies, Plans, and Targets for EE in the refrigeration and air conditioning

Under the EE&CMP, three EE&C programmes - the Energy Management Programme; the Energy Efficiency Labelling Programme; and the Energy Efficiency Buildings Programme cover some prospects for achieving energy efficiency in the RAC sector (Table 11) [53]. Bangladesh has taken several policy measures to address EE in the RAC sector, coupled with regulatory frameworks and financial incentives.

- Programmes includes awareness campaigns, capacity building initiatives, and incentives for adopting energy-efficient technologies.
- The government has specific targets for energy efficiency improvement in the RAC sector as part of its broader energy and climate goals.

3.5.4 Energy efficiency in transport

Energy efficiency in transportation which looks into ways that people/goods can get around using less energy includes things like electric/hybrid cars, expanded public transport or adopting more energy efficient practices, such as cycling and walking. Though the transport system spans different modes of air, sea and land transport, this study deals with land-based road transport for passengers and goods only and focuses on urban mobility. Bangladesh which has experienced rapid economic growth relies on fossil fuels and inefficient vehicle technologies for its transportation needs. With inadequate infrastructure there is a lot of traffic congestion which can be solved through initiatives like expanding and improving bus and rail networks or providing subsidies or incentives for public transport users.

A ‘mobility transition’ is therefore required, whereby people move away from private transport and gravitate towards new usage models and shorter journeys. Sustainable transport is characterised above all by the following three axes [56].

- **Avoid**: Avoid journeys altogether through 'smart' urban and transport planning. This can be done by developing mixed-use instead of separate commercial and residential districts, and by incorporating redensification into zoning plans instead of new developments.
- **Shift**: Move away from motorised private transport towards non-motorised and local public transport (e.g., by expanding the bus system or building new bikeways).
- **Improve**: Increase the EE of vehicles by supporting clean propulsion technologies and fuels (e.g., electricity, hydrogen, compressed natural gas, biofuels and other fuels)

The transition towards EE in transport will affect a number of closely interlinked industries, business sectors and value chains that will be needed to develop, introduce and operate sustainable mobility systems. There will also be an overlap with other sectors, such as the renewable energies needed to charge electric vehicles [56] .

a) EE in transport implementation status in Bangladesh

Energy consumption of the transport sector in Bangladesh has been steadily increasing since 2008, with the sector consuming 12% of total energy in 2019 [57]. The share of electricity consumption is currently 1% and is envisages to grow up to 4-9% by 2030 and 21-24% by 2050 in analysed 1.5°C compatible pathways. All scenarios see a rapid decline in direct CO_2 emissions from transport sector to 0-5 $MtCO_2$/yr by 2050 from 12 $MtCO_2$/yr in 2019, mostly driven by a high electrification rate and introduction of biofuels in the fuel mix.

b) National strategies, plans, and targets for Energy Efficiency in transport

To achieve greater efficiency in transport, Bangladesh aims to expand its Mass Rapid Transit and Bus Rapid Transit system in Dhaka City with maiden electric bus service. Bangladesh government plans to construct 798 km of new rail line by 2025 and to introduce energy-efficient locomotives [57].

Bangladesh is addressing some of its transport sector problems by developing new automative strategy to introduce more EE vehicles and various policy measures aimed at promoting sustainable mobility. Some are:

- 15% of all registered vehicles in Bangladesh by 2030 should be EV [43]
- Promoting EE vehicle assembly throughout the country. The draft Automative Industry Development Policy-2020 includes a tax break or holiday for investment in EE vehicle assembly plants
- The government offers incentives such as tax breaks and subsidies for the purchase of electric and hybrid vehicles, as outlined in the Bangladesh Energy Regulatory Commission (BERC) Act of 2013.
- EV importation only with prior certification by the user guaranteeing recycling and disposition of lithium-ion batteries used in vehicles.
- Up to around a 20% shift in passenger traffic from road to rail by 2030, compared to the business as usual [58].
- Fitness of Automobiles which includes strategies for strengthening vehicles and modernising BRTA inspection facilities for safety, quality and pollution levels satisfaction control.

3.5.5 Energy management / auditing

Energy audits und energy management are important elements in EE strategies as they allow companies to identify their energy-saving potential and hence to reduce their energy consumption significantly. While energy audits can be made mandatory for large companies, small to medium-sized enterprises (SME) can also benefit.

a) Energy management / auditing implementation status in Bangladesh

The Energy Efficiency and Conservation Master Plan (EECMP) (Table 11), entails programmes that focus on EE management and auditing namely, Energy Management Program, EE Labelling Program and EE Buildings Program. This targets large energy consuming entities and equipment in the industrial, residential and commercial sectors.

Energy management: Bangladesh has made progress towards implementing energy management systems across sectors, especially in large industrial facilities and commercial buildings. Government initiatives, such as the Energy Efficiency & Conservation Promotion Financing Project (EECPFP) in Bangladesh aim to improve EE and reduce greenhouse gas emissions focuses on capacity building, technical assistance, and providing finance for energy-efficient projects.

Energy auditing: The practice of energy auditing has gained traction in Bangladesh over the past decade. Several national and international organizations, such as the International Finance Corporation (IFC) and the United States Agency for International Development (USAID), support energy audit activities in the country. A growing number of private companies also offer energy audit services, helping businesses identify opportunities for cost savings while reducing environmental impacts. Despite these advancements, several challenges remain, including limited funding, lack of skilled human resources, and insufficient enforcement mechanisms for compliance with energy efficiency requirements.

While the number of specialized financial institutions dedicated to EE financing remains small in Bangladesh, key players like Infrastructure Development Company Ltd (IDCOL), Bangladesh Infrastructure Finance Fund Limited (BIFFL), and Industrial and Infrastructure Development Finance Company Limited (IIDFC) play a crucial role. These institutions primarily serve as channels for international funding from organizations like KfW, ADB, and WB, subsequently re-financing public and private entities for their EE projects.

b) National strategies, plans, and targets for energy management / auditing

In its updated Nationally Determined Contribution (NDC) [54], Bangladesh identifies the **industry (energy) sub-sector** as the largest contributor to national emissions, accounting for **24.91%**, followed by the power and transport sectors within the broader energy sector. The NDC therefore proposes a **10% energy efficiency improvement target** specifically for the industrial sector. This plan leverages the **Energy Efficiency and Conservation Master Plan (EECMP)**, promoting **green industries** and **carbon financing** as key strategies. Furthermore, **energy management practices**, including **energy auditing**, are identified as crucial for achieving this target and fostering the development of a more sustainable and low-carbon industrial sector.

Designated Consumer (DC) initiatives: Aiming to boost industrial EE, SREDA designated four high-energy-consuming industries (**textile, readymade garment, jute and cement**) for mandatory energy audits and reduction plans. At present it encompasses 150 businesses – 81 belonging to textile RMG industries, and 7 belong to the cement industry [59]. Eleven more sectors are envisaged to be added for a mandatory submission of energy audit in 2024. However, the initiative faces hurdles due to a lack of skilled energy managers, auditors and limited awareness among businesses. SREDA has been certifying energy auditors for the last three years, and the country currently has 18 such auditors.

Development Partners (e.g. JICA, World Bank, ADP, UNDP, GIZ, KfW) have shown strong support for EE&C programme. International banks like HSBC which are supporting carbon emission reduction are also financing large scale EE&C projects. GIZ collaborates with SREDA to identify key industries and train energy auditors. Baseline energy consumption measurements in these industries are ongoing.

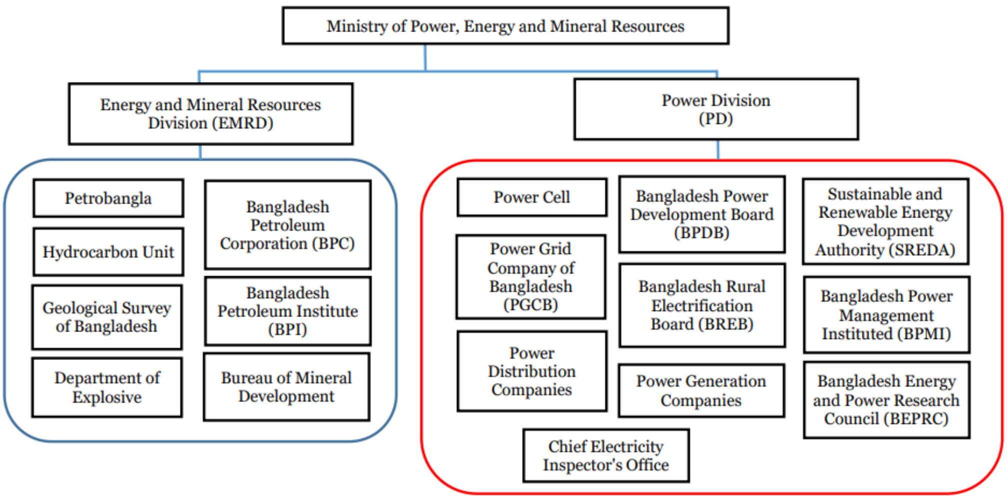
3.6 Regulations and laws promoting the different RE and EE Market segments in Bangladesh

According to the website of SREDA [60], government policies have significant impact on the pace and direction of economic development. Policies create the required enabling environment for the involvement of the private sector and attract private investments in economic activities. As per SREDA Act, SREDA has been created as a nodal organization of the Government to promote and develop RE and EE activities in the country.

To foster the RE development and EE measures in Bangladesh, the Government has adopted several policies spelt out in Annex 5 to show its commitment in producing 30% of electricity from renewable sources by 2030 and 40% by 2041.

3.7 Key actors in the energy sector in Bangladesh

The actors responsible for the thriving of the energy sector include policy-makers, public utilities, private sector and foreign investors, educational and R&D institutes, development partners, system operators and technicians, suppliers and manufacturers, all sorts of end-users, etc. Among these key actors, institutional ones responsible for putting in place policies and framework conditions can be seen in Figure 8.



Source: Ministry of Power, Energy and Mineral Resources

Figure 8: Ministry of power, energy and mineral resources organization chart [6]

Together with non-institutional actors, they complement each other in their role in pushing forward the sector through incentivizing, capacity building or skill development among other things. From electricity production and distribution to control and regulation, the key actors involved in both Bangladesh's renewable energy / EE sector are listed in Table 13.

Table 13: Key actors involved in Bangladesh's renewable energy / EE sector

Actor	Function	Responsibilities
The Government of the People's Republic of Bangladesh	Politics, investment	Implementing energy investment programme
Ministry of Power, Energy & Mineral Resources power division	Ministry	Responsible for formulating and implementing national energy policy and regulations and mobilising funding in the energy sector.
The Power Division	Governance and development of the power industry	Responsible to develop in collaboration with other national structures, policies, laws, strategy, in the power sector, including in the renewable energy and energy efficiency.
Sustainable and Renewable Energy Development Authority (SREDA)	Government agency	Dedicated to advancing RE and EE by coordinating government initiatives, standardising and certifying products, piloting innovative technologies and facilitating their integration, fostering an investment-friendly environment, undertaking research and development, building institutional capacity, creating public awareness, and establishing connections with international organisations.
Bangladesh Energy Regulatory Commission (BERC)	Regulator	Regulate electricity, gas and petroleum products for the whole of Bangladesh creating an enabling environment for providing energy at just & reasonable cost, and protection of consumers interest & satisfaction through fair practice. They establish regulations that promote energy efficiency throughout the entire supply chain.
Office of the Electrical Adviser & Chief Electric Inspector.	Government agency	This office provides approval of low & medium pressure electrical substation, issue electrical license.
Power Grid Bangladesh (PGB) PLC	Utility/ Transmission	Efficient and effective management of national power grid for reliable and quality transmission of electricity throughout the country.
Bangladesh Rural Electrification Board (BREB)	Government agency/ distributor	Responsible for rural electrification and implements state policy on the supply of electrical energy. Deals with IPP for power purchase agreement
Dhaka Power Distribution Company Ltd (DPDC)	Public Limited Company / distributor	Manages the distribution of electricity to the customers of the Dhaka City Corporation area.
Dhaka electric supply company (DESCO)	Utility / distributor	Distributes electricity at the northern parts of Dhaka City and Tongi Town of Gazipur District.
Bangladesh Power Development Board (BPDB)	Government agency/ distributor	Oversees the generation, transmission, and distribution of electricity mainly in urban areas except Dhaka and West Zone of the country. Involved in promoting energy-efficient practices and technologies in buildings to reduce electricity consumption.
North Electricity Supply PLC (NESCO)	Utility / distributor	Distribution system of the North West Zone
West Zone Power Distribution Company Limited (*WZPDCL*)	Utility / distributor	Distribution system of the Western Zone
Infrastructure Development Company Limited (IDCOL)	A non-bank financial institution	Catalyses and optimizes private sector participation in the promotion, development, and financing of infrastructure as well as renewable energy, and energy efficient projects in a sustainable manner through public-private-partnership initiatives.

Besides these aforementioned actors, international organizations like the World Bank, Asian Development Bank (ADB), and United Nations Development Programme (UNDP) provide funding, technical assistance, and expertise to support the development of RE /EE projects and infrastructure in Bangladesh. There are however some which are particularly for the RE and EE sector.

3.7.1 Key actors in the RE sub-sector

Each of these actors plays a unique role in driving the growth and sustainability of the renewable energy industry in Bangladesh, contributing to energy security, environmental protection, and economic development (Table 14).

Table 14: Key actors involved in Bangladesh's RE sector and their responsibilities

Institution	Function	Responsibilities
Bangladesh Solar and renewable Energy Association (BSREA)	Association	To accelerate Bangladesh's energy transition to a sustainable future by promoting clean energy adoption, fostering stakeholder engagement, and advocating for policies and investments that enhance the sector's growth and resilience."
Bangladesh Independent Power Producers' Association (BIPPA)	Association	To promulgate a platform for discussion. Independent Power Producer Companies must (compulsory) be the members of Bangladesh Independent Power Producers' Association (BIPPA) will strengthen our Combined platform.
Bangladesh Biogas Development Foundation (BBDF),	Foundation	Plays a central coordinating role within the private sector, fostering collaboration amongst biogas installers and facilitating knowledge sharing between various stakeholders
Infrastructure Development Company Limited (IDCOL)	Quality standards	Help ensure economic development of Bangladesh and improve standard of living of the people through sustainable and environment-friendly investments by catalysing and optimizing private sector participation in promotion, development, and financing of infrastructure as well as renewable energy, and energy efficient projects in a sustainable manner through public-private-partnership initiatives.

3.7.2 Key actors in the EE sub- sector

Just like the RE sector, several actors play key roles in promoting the EE sector in Bangladesh. These actors collaborate through various initiatives, programs, and projects to promote energy-efficient practices, raise awareness, develop policies and regulations, provide technical assistance, and implement energy efficiency measures in commercial and residential buildings across Bangladesh (Table 15).

Table 15: Key actors involved in Bangladesh's EE sector and their responsibilities

Institution	Function	Responsibilities
Department of Environment (DOE)	Government Agencies	Responsible for formulating and implementing environmental policies, regulations, and standards, including those related to energy efficiency in buildings.
Rajdhani Unnayan Kartripakkha (RAJUK)	Government Agencies	Capital development authority responsible for urban planning and development in Dhaka. Involved in implementing building codes and regulations related to energy efficiency.

Institution	Function	Responsibilities
Public Works Department	Government Agencies	The architectural plans and designs of almost all Government infrastructural projects are done by the Department of Architecture in close consultation with PWD
Bangladesh Association of Construction Industry (BACI)	Trade organisation	Promote mutual cooperation amongst contractors, to protect their rights and interests, and to strive for improvement of construction related legislations, economic policy, as well as construction technology/technique to contribute towards efficient progress and development of the nation's construction industry.
Bangladesh Refrigeration and Air Conditioning Merchants Association (BRAMA)	Industry Associations	Advocate for the adoption of energy-efficient practices and technologies within the RAC sector. They also provide support and guidance to their members regarding energy efficiency standards and best practices.
Bangladesh Steel Manufacturers Association (BSMA)	Industry Associations	BSMA represents more than 41 largest steel producers of the nation. Pioneer steel research and control quality of the production of steel, building a better Bangladesh
Bangladesh Cement & Steel Industry (BCSI)	Trade organisation	Promote mutual cooperation amongst contractors, to protect their rights and interests, and to strive for improvement of the industry.
Ministry of Road Transport and Bridges	Government of Bangladesh	Responsible for formulating and implementing policies related to road transport.
Bangladesh Road Transport Authority (BRTA)	Government of Bangladesh	Oversees the registration of all vehicles, including EVs. They play a crucial role in defining and enforcing standardization guidelines for EVs to ensure safety and quality.
Bangladesh Standardization and Testing Institute (BSTI)	Government	Defines EE standards. They develop and issue the Bangladesh Standards (BDS) used for the national Energy Labelling Program. These standards establish benchmarks for measuring energy consumption in appliances and equipment.
Ministry of Industry (MOI)	Government	Oversees the industrial sector, which is a key participant in various energy efficiency programs. They collaborate with SREDA to encourage appliance manufacturers to participate in the EE Labelling Program and ensure compliance with energy efficiency standards

3.8 Gender aspect in the RE/EE sector of Bangladesh

For energy transition to be effective, it should be intricately linked to the people who directly or indirectly influence energy consumptions in households within a community like women, girls, and gender-diverse groups. These persons who are the main users and often producers of energy, need to be involved as skilled, semi-skilled or unskilled workforce in the different planned measures. However, the energy sector itself wrestles with gender imbalances, with a glaring under representation of women and their participation remaining extremely low in terms of employment throughout the years. As such the RE / EE sector remains the least diversified. Addressing these multidimensional challenges require policymakers to acknowledge the gender-specific impacts of energy insecurity and empower women in the energy sector [61].

3.8.1 Legislative and programme support for gender mainstreaming in the RE / EE Sector

The gender aspects of energy have been acknowledged by the policies in the energy sector in Bangladesh. In the context of gender inclusion within the energy sector of Bangladesh, our study found some gender considerations within certain policies and budgetary dimensions such as:

1. National Policy for Women's Advancement 1997 revised in 2004 and 2008

2. National Women's Development Policy for 2011
3. Gender Budget 2023-2024

While there are these considerations, there is still the need for gender inclusion within targeted support for participation and development of women practitioners in the sector [62].

3.8.2 Gender inclusion in the RE / EE sector

Bangladeshi policy framework for the energy sector strives to encourage the participation of all gender and also to be socially inclusive. Some instruments recognize the importance of working with rural communities and mostly women [63], but does not address how women can participate in the sector or profit from access to these energy technologies [62]. Table 16 gives us an overview of policies that addresses gender inclusion in the energy sector.

Table 16: Gender inclusion in energy-related policies [62]

Energy policies	**women's energy needs mentioned**	**Women's energy needs**	**Integration of gender mainstreaming**
National Energy Policy 2004	Yes	Wide scale electrification throughout the country. How remote and isolated areas are potential sites for renewable technologies.	No
Remote Area Power Supply System (RAPSS) Guidelines 2007	Yes	Promotes investment to facilitate electricity supply to households in remote areas.	No
Renewable Energy Policy 2008	No		No
Guideline for the Implementation of Solar Power Development Program (2012-2016)	No		No
Action Plan for Energy Efficiency and Conservation 2013	Yes	Take into consideration the impact of improved EE at the household level and the need for awareness raising actions	No
Solar Guidebook 2013	Yes	Women benefit from solar electrification, irrigation, and other technologies	No
Country Action Plan for Clean Cookstoves, 2013	Yes	Reduced household air pollution, improved maternal/child health, and women's economic empowerment through participation in cookstove-related entrepreneurship. Bringing in women's distribution networks and leverage women entrepreneurs' ability to reach female consumers directly. Linking women-led companies/ business entrepreneur groups to existing Government funding channels.	Yes
Energy Efficiency and Conservation Master Plan up to 2030 published in 2014	No	-	No
Renewable Energy Development Target, 2015-2021	No	-	No
Power System Master Plan 2016 (PSMP 2016)	No	-	No
National Solar Energy Roadmap 2020	No	-	No

Energy policies	women's energy needs mentioned	Women's energy needs	Integration of gender mainstreaming
Draft National Renewable Energy Policy 2023	No	-	No
Integrated Energy and Power Master Plan 2023	No	-	No

In all, existing RE / EE policies in Bangladesh, women are primarily portrayed as energy consumers, with limited consideration given to their potential roles in employment within the energy and renewable energy sectors. However, there are some of the existing country plans, policies that are gender responsive and propose ways in empowering women in renewable sector.

The Perspective Plan of Bangladesh, 2021-2041 [62]:

- The Long-term Goals include developing youth (both male and female) into a skilled workforce.
- The Employment Strategies include —To bring more women into the labour force, a combination of measures will be adopted ranging from promoting the growth of sectors that are more amenable to their employment (e.g., labour-intensive industries like garments, shoes, electronics, etc.) to removing barriers to their employment and establishing infrastructure to facilitate their employment, affirmative action and direct intervention, providing maternity leave and childcare.
- Skill Development Strategies include making additional investments in female literacy, greater participation of women in skill development programs, increased female labour force participation in formal sector employment and creating greater opportunities for women in business.
- Strategy the Educational Sector includes elimination of gender gap in higher education through scholarship for women and emphasis on establishing public colleges for women at each district level.
- Strategy for Training and Skills Formation include encouraging more women's participation in vocational training to eliminate all forms of gender gap in vocational and skill-based training. It also includes, establishing rural based training institutes in high demand areas to facilitate the participation of women.

Bangladesh Climate Change and Gender Action Plan (ccGAP) 2013

- Identifying a group of gender experts to support the review of the energy and technology policies and incentives to promote efficient production, consumption, distribution, and use of energy.
- Incorporating women's participation, access, and benefit in the energy policy.
- Stakeholder's workshop including women to identify the current status and gaps regarding energy access.
- Disseminating information on environment friendly and green technology regarding the positive impact of these technologies on the health of women.
- Training and creating access of women to renewable alternative energy solutions (wind, solar).
- Introducing energy efficient low-cost cooking technology.
- Expansion of bio-gas technology amongst women livestock enterprise owners.

- Promoting —Solar Bottle Bulb for reducing daytime energy consumption.
- Including energy consumption methodology in the national school curriculum.
- Organizing energy fair at school, college, and university with parents (women and men) with information, services.
- Soft credits/ loans for women to use green technology.
- Training women to develop as a resource pool (local service provider at the local level).

National Women Development Policy 2011

- Under Women Development Training Institute —Technical and Vocational Training centres at division, district and Upazilla shall be set up in addition to strengthening of the existing Women Development Training Institute at Dhaka.
- Under Workplan and Program Strategies —Gender perspective shall be reflected in the respective work plans of all the ministries/divisions/ departments/organizations to protect balanced rights and interests in all sectors.
- Under Financial Condition —Gender responsive policies shall be followed in the matter of adopting development projects.
- Under Financial Condition —Commercial banks, Bangladesh Bank and other financial institutions shall offer financial assistance to small and medium entrepreneurs for development of women.
- Under Co-operation with the NGOs and Social Organizations in Women Development —Programs shall be adopted and implemented with assistance from voluntary and social organization to change social attitude to women to play proper role in the process of women empowerment.
- Under Women and Gender Related Research —Separate gender research and educational institutes shall be set up wherefrom necessary information inputs shall be supplied to the policy makers.

By combining these strategies, regulations, and programs, stakeholders can work towards creating a more inclusive and diverse RE / EE labour market. It is essential to involve government bodies, industry associations, companies, and educational institutions to implement and sustain these initiatives effectively.

3.8.3 Funding gender mainstreaming in the RE / EE sector

In Bangladesh, the gender budget is a part of the national budget that reflects the government’s commitment to address the gender gaps and inequalities in various sectors and areas. For the fiscal year 2023-2024, an allocation of 3,7 Mio EUR has been proposed for the Ministry of Women and Child Affairs, which is an increase of 10.8 percent from the previous year (this is to focus primarily on women's programs and initiatives). The power division also allocated 34 % of its 2023-2024 budget to women’s programmes which where:

- **Power generation and reconstruction**: increasing power capacity results in uninterrupted power, which encourages women to engage in self-reliance activities.
- **Transmission and distribution infrastructure**: increasing women's participation in economic endeavours by creating industries and employment and expanding power access.
- **Renewable energy and energy-saving**: expanding these technologies empowers rural women through income generation and energy-saving practices.

- **Load management**: allowing women to optimize their electricity consumption improves time management and increases work hours.

It should be noted that, the budget is for expenditures to improve women's consumer participation, energy efficiency education, and overall quality of life but not practitioners. Women are portrayed mainly as beneficiaries. There are no budget capacity-building initiatives specifically tailored for women. This restricts the women practitioner development in the power sector [62].

3.8.4 Women's involvement in the RE / EE value chain

a) Solar PV

In the solar project supply chain, women's involvement can be seen in every step, however, the rate of contribution varies for each step according IRENA. In Bangladesh, women are mostly involved in the following roles:

- Distributed or off-grid solar technology where rural women got the opportunity to become entrepreneurs and agents of change in their communities. They operate and install solar products.
- Solar infrastructure requires ongoing day-to-day maintenance, presenting employment opportunities, particularly for women. These opportunities include roles like solar panel cleaning and inspection, technical support and troubleshooting, community engagement and education, administrative tasks, and entrepreneurship.

In spite of these opportunities to be involved, women still find it difficult to gain access in the sector due to lack of education, or communication. This is due to the fact that women especially have low access to information such as the role they can play in this sector. Women also face the barrier of access to technical and vocational training. As a result, they have comparably lower employability opportunities in the sector. They also have low access to finance and household decisions for which they cannot make decisions regarding installation of solar systems in households.

b) Biogas

The biogas industry in Bangladesh which can be either a biogas plants for domestic use or a biogas plant for industrial use, offers opportunities for women to actively participate in its projects. For its domestic usage, it plays a crucial role in reducing kitchen pollution and promoting clean cooking solutions in Bangladesh. In as much as women are the main users of biogas (domestic usage), the biogas supply chain sees low to medium participation of woman in the installation phase of this technology. They however can take part in decision-making during the design and procurement. The construction is mainly male-driven given that women lack masonry experience and essential skills. Women are engaged in feedstock collection. Their participation is this sector is hindered by lack of information, training and finance.

c) Wind energy

Although there are opportunities for women in the wind energy generation sector, both as users and practitioners, such as involvement in project management, installation, and maintenance, this sector is relatively new in Bangladesh and has yet to fully integrate a gender perspective into its operations and workforce development strategies. As the industry matures, there is a growing potential for enhancing gender inclusivity and recognizing the role women can play in this RE source. The sector currently faces lack of skilled manpower which cannot be easily filled by women due to the absence of technical training for capacity building of women as societal and cultural norms limit women’s entry into this sector. Again, most of the RE project locations are in remote areas, women are discouraged from participating in technical roles for security purpose [62].

4 Results

The findings of the study are categorized into three distinct parts: country visit, questionnaires and desktop research and analysis.

4.1 Results of the country mission

The mission comprised workshops and Key Informant Interviews (KIIs).

4.1.1 Workshops

The three separate half-day workshops hosted groups of TVET / educational institutions, RE companies and EE companies.

With focused on the supply side of skills, the TVET/ Educational institutions workshop’s20 participants provided information on existing occupational standards if any, trainings (offers, duration, type, curriculum, etc.) providing skilled workforce for different sector and how they are linked to the industry. They also indicated their opinion on the role of women in this sector

The workshop with the private sector looked into the skills demanded for RE and EE implementation in Bangladesh. Of the 89 invitations sent out to identified companies and NGOs active in the RE sector, 20 persons were present. On the other hand, 22 persons of the 100 invited took part in the EE workshop. The participants also gave input on the different RE/EE subsectors with emphasises on the need to address job roles along the entire value chain of industry production.

4.1.2 Key Informant Interview (KII)

Twenty-one different organisations took part in the KII (Annex 4). The KIIs identified the specific women inclusion problem faced in the energy sector of the county. Access to education, training, and careers for women were the three major aspects that were considered for the IDIs.

The main outcomes of the country mission according to the technologies are presented in Table 17. Table 18 and Table 19.

Table 17: Outcome of workshop with TVET/ Educational institutions workshop

	Existing occupational standards and required skills for the sector	Existing trainings (duration, type, theory, practical, continuous Education)	Some Identified gaps	Women in the sector	Co-operation with the industry
PV/Solar	• **Under NTVQF**: solar electrical installation and maintenance (level 2,3). Level 2 - 520 hours; Level 3 - 521 hours. • **TVET**: (NSDA; BTEB) certifications and recertification for Vendors and Technicians • **Occupational standard:** – Solar home systems electrification for technicians – Last year Construction Industry Skills Council (CISC) developed 7 competency standards for technicians in the solar sector: • Electrical systems (Solar rooftop) - field level technicians • Electrical systems (solar grid tied) - Field level technician • Electrical systems (solar irrigation) - Field level technician • Solar irrigation pumping and water distribution systems • Agriculture and operation (solar irrigation systems)- field level supervisor • Masonry training (solar irrigation system) - Field level technician • Improved cook stove construction and installation • **Required skills** – Technical experts in drawing & designing, installation, and O&M – Engineers and technicians – Stability of storage – Technology for maintenance – Assessors of the potential in specific places.	**TVET**: – **Type**: Technical – **Curriculum**: exist for solar home systems electrification for technicians – **Topic**: Wiring, Installation, operation and Maintenance – **Qualification**: technicians – **Duration**: 3 months, theory +hands on (30-70%) – **Standards:** CBT Standards -CBLM (manuals) – **Assessment**: Formative & Summative assessments; internal & external evaluations – **Trainers**: Lengthy recruitment process, trainers must have practical experience **University**: – **Type**: courses – **Topic**: Design, Marketing/Venders – **Qualification**: Farm designers (EPCs) and Marketing, research – **Duration**: courses **Other trainings** – BPMI provides training on Digsilent Power factory, Homer, PVSyst and SAM software tools for utility engineers	TVET: separate program should be developed if demand increases. The 7 competency standards developed by CISC have not yet been approved by NSDA. As such cannot be developed to trainings	About 10% of the workforce	Not mandatory at the moment that all TVET offer internship Most trained people find jobs in the solar industry as technicians (installers),
Wind	• **Occupation needs to be defined** • **Required skills** – Consultants, technicians, supervisors as well as trainers – Design systems and project management – health, safety, and environment (HSE), operations and maintenance (O&M), and bid management.	**Training**: No specific course or training just in-house training **Certification**: License / Certification (Global) required **Trainers**: a few trainers with practical experience	Develop a curriculum for installers.	Absent. Can be encouraged in design and simulation	Internship should be mandatory
Biogas	• No **defined occupational standard** • **Required skills** – The sector requires both highly skilled individuals such as engineers, construction engineers, and technicians.	No existing training in Biogas;	Training for technician and entrepreneurship in biogas.	Women are usually users of the technology.	

	Existing occupational standards and required skills for the sector	Existing trainings (duration, type, theory, practical, continuous Education)	Some Identified gaps	Women in the sector	Co-operation with the industry
Energy Efficiency	• **Energy auditors** are trained and certified by SREDA. 29 SREDA energy auditors certified between 2019-2024 are in the SREDA register. 100 energy auditors are envisaged for 2024 to 2034. • **Energy managers:** As of August 2023, SREDA has issued certificates to 48 energy managers. • System in place requiring assessment of buildings and providing LEED certification. Presently 150 designated customers require certification from SREDA. • Workforce for certification.	**TVET:** – No existing training nor curriculum at the TVET level are covering EE subjects – EE topics are addressed within the trainings on electrical, general maintenance, welding, etc. **Other trainings**: – **Type**: Energy efficiency and conservation. – **Qualification**: Auditors Consultants technicians' supervisors – **Duration**: 360Hrs. Types: 1- Offline, 2- Theoretical: 20%, 3- Practical: 80% – **Curriculum**: Existing curriculum are developed, reviewed and update as per industry standards / need – **Assessment**: BTEB/ NSDA / Licencing board – **Certificate:** Issued by BTEB/ NSDA / Licencing board – **Trainers**: Not sufficient. Existing ones need industrial experience	In corporate energy management & efficiency in the training curriculum for sustainable all sectors. Energy Audit/ Energy management training which exist at a higher level should be introduce in the TVET sectors including Diploma and competency-based trainings.	In very small numbers. They should be motivated, set allocation for female target.	Yes, it should be mandatory
Power Grid/ battery storage	Store home system solar energy	**TVET**: – **Training**: No such training corresponding to the technology but there are trainings under NTVQF to store home system solar energy. – **Qualification**: Installing DC part of solar power plant system. – **Assessment**: According to the national qualification framework, national assessment system. – **Certification**: Yes, under qualification framework **Uni**: There are also subjects in the academic course like SSC, VOC, Diploma in electrical engineering (2 or 4 years). Practical: 80%; Theory: 20%; Academic program theory: 40%; Practical: 60% **Trainers**: trainers exist for the offered courses	Dedicated training for: a) Power grid expansion / smart grids. b) large battery energy storage system from existing power system	The occupation is suitable and encouraging women friendly workplace	Yes, for the program offered by BTEB

Table 18: Outcome of workshop with RE private sector

	Needed personnel in the RE skills	Skills need	How to support RE training
PV/Solar	– Installers – Designers – Product control experts – Technicians – Engineers	– Identification of product quality – Drawing and designing skills – Interpretation of designs	– Developing policies to support on-the-job training for newly recruited human resources following the Bangladesh National Qualification Framework. – Encouraging EPC companies that pioneer in human resource capacity building, improving the skills of design engineers, technicians, and other professionals.
Biogas	– Design and planning of biogas – Technicians		– The NSDA should define skills demands in the biogas sub-sector

	– Highly skilled individuals such as engineers, construction engineers		
Wind	– design systems and project management – health, safety, and environment (HSE), operations and maintenance (O&M)		– Integrate industry-specific training and knowledge-based education into the curriculum and academic programs. – On-the-job training, hands-on experience, and regular skill upgrades. – The private sector can collaborate with training institutions to provide targeted training to deserving candidates, thereby benefiting the field-level workforce as the primary target group.
Power Grid/ energy storage	– Technicians and engineers		

Table 19: Outcome of workshop with EE private sector

Skills needed
• **Executive level**: leadership, practical knowledge, understanding of codes and standards, drafting skills, and proper standard operating procedures (SOPs). • **Technician level**: Environmental Health and Safety (EHS) and Heating, Ventilation, and Air Conditioning (HVAC), maintenance heads and sustainability/energy managers, certified welders and individuals with design skills for projects, experienced auditors with hands-on, real-life field experience.
Reason for skill gap
• Lack of proper training avenues, which limits the pool of skilled individuals. • Absence of offers for training from regulatory authorities further exacerbates this issue, leaving employees without structured pathways for skill development. • Shortage of skilled trainers or institutions specializing in these fields hinders the acquisition of relevant knowledge and expertise.
Addressing skill gaps
• Targeted training and skill development initiatives for the growth and sustainability of the sector markets. • Collaboration between academic institutions and practical training centres. • Collaboration between the public and private sectors to create a solid training framework. • The private sector can support training by investing in initiatives such as training for trainers to develop a skilled workforce, organizing product-centric sessions to promote their offerings, collaborating with institutions to fund energy-relevant labs and training programs, and facilitating expert-oriented training for local manufacturers.

4.2 Results of the questionnaire

Twenty-one companies voluntarily responded to the questionnaire, which sought additional information on the RE/EE sector not covered in workshops. These 21 companies indicated being active in some of the studies focused subsectors with most being engaged in solar energy and energy storage, and none in the EE in transport sector (Figure 9).

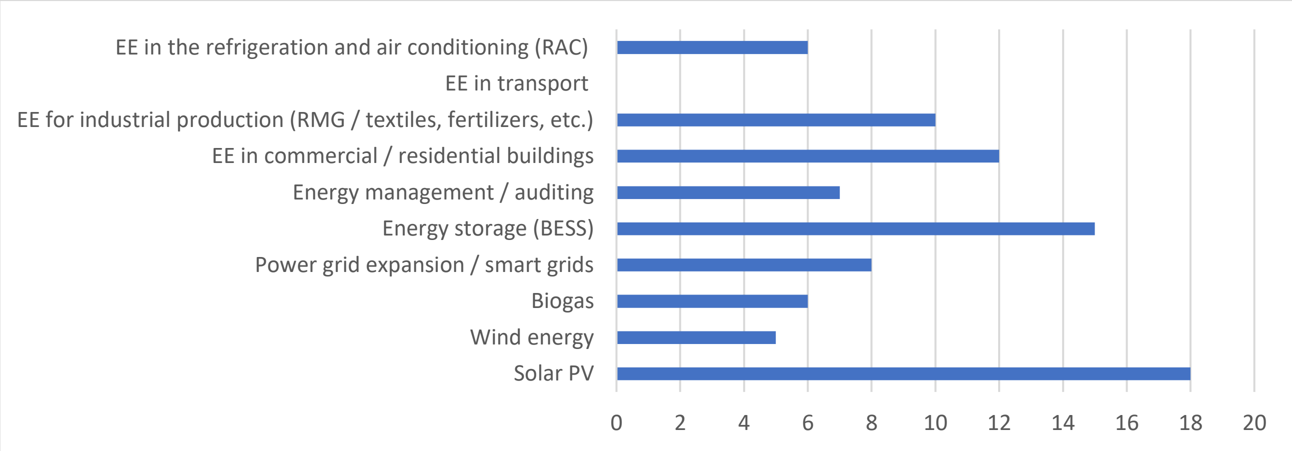


Figure 9: Sectors of those who answered the questionnaire

Other results from the questionnaire are as follows:

- Of the 21 respondents, most are service provider and energy producers. Some however indicated being manufacturers. All but 2 are small and medium size enterprises (SME) with below 250 employees
- The employees working in these companies are mostly engineers. All indicated having electrical / electronic engineers, with some having mechanical, civil, environmental and energy engineers as part of their workforce. While some of these engineers were female, less that 8 of these companies had females on their payroll.
- All indicated having electrical technicians. These were all male but for one company which indicated having 4 out of its 20 technicians as female.
- There are however still looking for skilled
  - solar system installers
  - service technicians
  - electrical technicians
  - skilled technicians
  - CAD designer
  - mechanical technicians
  - energy managers
  - energy auditors
- Of the difficulties they face in finding qualified staff, they indicated the following (from highest to lowest):
  - Lack of necessary professional skills / qualifications
  - Lack of sufficient work experience

- Insufficient number of applications
- Higher salary expectation
- Unpopular working environment and conditions
- Being a dangerous or very dangerous profession

- Nineteen of the 21 companies planned investing in RE sector in the coming years. Some of the areas indicated for this planned investment are:
  - Making efficient manpower
  - Rooftop Solar in OpEx Model Establish a Renewable Energy Institute in Bangladesh to develop the skills of existing technical expert.
  - IPP, ESS and EV
  - Manufacturing Facilities
  - Project development
  - EPC
- To address the lack of skills in their workforce, they always carry out in house trainings and are ready to offer internship positions.

5 The demand side for renewable eergy / energy efficiency skills in Bangladesh

For a country deploying RE technologies or EE measures, the potential to create jobs depends on which industries along the different segment of the value chain (Figure 10) are present locally. These jobs are to be carried out by qualified persons with the right skills so as to ensure that the industry thrives. Both low, mid and higher levels qualifications are needed but for the scope of this study, we only focussed on the mid- and low- level qualifications which are the qualifications covered by TVET. The demand side for skills looked at the required qualifications of workforce particularly the occupation and skills needed along the various value chains of chosen RE / EE sectors. It particularly looks at the workforce existing or to be created in Bangladesh in the next 10 to 15 years using the derived "employment factors" (Employment factor as stated section 2.4). Employment factors are defined as the number of jobs created (skilled and unskilled workers needed) per unit of investment or activity[8]. Technology-specific employment factors are based on observed job creation and specific demand for labour within numerous real-world projects, and as analysed retrospectively.[9]

Figure 10: Main activities in (most of) the renewable energy value chain

[8] In the case of renewable energy (and energy storage) projects, this is typically expressed as "jobs per MW"; for energy efficiency projects, in terms of "jobs per MW energy saved"; and for smart grid projects, in terms of "jobs per 1 million USD invested".

[9] Such information tends to be collected through exhaustive and rigorous consultations with industry and market players, in a standardized way, and which is then subjected to data analysis to yield and industry average employment factor for a given technology (e.g., solar PV energy) or specialist service (e.g., energy management / auditing).

5.1 Workforce qualifications and occupations along the RE / EE value chains

This section of the report focuses on the required qualification of workforce for the respective renewable energy, energy efficiency, energy storage and smart grid technologies in Bangladesh. It presents the respective occupations along selected sections of the value chain of the focused sub-sectors. In the further analysis of the occupations and these qualifications, those that presently exist in Bangladesh are highlighted in bold.

5.1.1 Solar PV workforce qualifications and occupations

According to an IRENA publication which talks about the different occupational groups (full-time equivalent Job-Years, over a time period of interest (e.g. 20 years)) at different stages in the solar PV value chain, only 1% participation can be seen during the planning stage. In the procurement & manufacturing stage, the rate increases to 22% as this step is associated with purchasing equipment, parts, documentation, cost calculation etc. The highest participation, i.e., 56%, can be seen during operation and maintenance, which comprises cleaning and annual inspections. 2% in transport, 17% in installation and grid connection and 2% in decommissioning stages [64]. Nearly all these stages are present in the Bangladesh PV solar market but for manufacturing.

A look at the occupations and qualification needed for these different segments so as to effectively establishing a strong PV market in Bangladesh can be seen in Table 20. It should also be noted that some of the following occupations need complementary trainings on special subjects.

Table 20: Occupations along the solar PV value chain [65]

	Manufacturing	Project development	Installations / O & M
Mid-Level	• **Process control technician** • Instrumentation and electronics technician • Quality assurance specialist	• **Engineering technician** • **Residential PV system designer** • IT specialist • Electrical inspector with solar expertise • Code official with solar expertise • Building inspector with solar expertise • Solar marketing specialist • Solar sales representative • Utility interconnection engineer	• Solar crew lead • **Electrician with solar expertise** • **Solar O&M technician** • **Solar service technician** • Lead PV installer • Plumbers specializing in solar • HVAC technician with solar expertise • Roofer with solar expertise • **Equipment operator**
Entry	• **Advanced manufacturing technician** • Computer numerical control operator	• Solar site assessor	• Energy storage installer • **Entry-level solar installer** • **Solar construction worker**

5.1.2 On- and off-shore wind energy workforce qualifications and occupations

The different occupational groups at different stages of the wind energy project value chain (Figure 10) in the IRENA publication indicates that, only 2% of the workforce for the whole project is needed for the planning stage. In the procurement & manufacturing stage, the percentage increases to 17%. Off-shore wind sees more persons (59%) working in this section as compared to on-shore. The highest participation in onshore, i.e., 43%, can be seen during operation and maintenance, 1% in transport, 30% in installation and grid connection and

7% in decommissioning stages [64]. Life cycle stages of a wind power plant and the occupations featuring mid and lower levels are given in Table 21.

Table 21: Occupations along the wind energy value chain for vocational careers [66]

	Manufacturing	Project Development	Installation	O & M
Mid-level	• Electrician • Machinists and tool and die makers		• Wind technician • Construction inspectors • Electrician • Crane/ tower operators	• Electrician • Wind technician • Power plant operator • Assistant site manager
Entry level	• Assembler and fabricator • Brick mason/stonemason • Iron and steel worker • Trade worker • Welder, cutter, solderer, and brazer • Machine setter, operator, tender	• Survey/mapping technician • Environmental science technician • Field/meteorological technician	• Iron and steel workers • Assemblers/ fabricators • Machine setter, operator & tender • Rigger • Construction worker • Construction equipment operator • Brick mason / stonemason • Welding, soldering & brazing worker	• Wind technician

5.1.3 Biogas energy workforce qualifications and occupations

The life cycle stages of Biogas Energy system (BES) to generate electricity just like the other technologies includes machinery and equipment manufacturing, construction/ installation, operation and maintenance stages (Figure 10). Various qualifications are needed for the occupations along life cycle stages of a biogas power plant Table 22. In contrast to other REs considered in this study, biogas energy projects have an additional step within its life cycle which is “feedstock collection and preparation”. Biogas energy resource is biogas produced from various feedstock.

Table 22: Occupations along the bioenergy value chain [67]

	Feedstock collection and preparation	Manufacturing	Installation	Operations & Management
Mid-Level	• Physical scientist • Forester • Natural resource management specialist • Agriculture extension specialist • Farmer • Biological scientist • Plant scientist	• **Chemical/Biological Engineer** • Civil/Environmental Engineer • Mechanical Engineer • Computational Scientist	• Construction Foreman • Safety and Occupational Health Specialist • Industrial Equipment Mechanic • Plumber • **Electrician**	• **Budget Analyst** • **Policy Analyst** • **Economist** • Business Operations Analyst • **Electrician** • Plant Operator
Entry Level	• Physical scientist technician • Biological sciences technician • Plant sciences technician • Forestry technician • Natural resources technician	• Computational Science Technician • Mechanical Engineer Trainee • Chemical/Biological Engineer Trainee • Civil/Environmental Engineer Trainee	• Motor Vehicle Operator • Construction Worker • Safety Technician • Plant Operator • **Pipefitters**	• Storage Facility Operator • Regulations Compliance Workers • Legal Assistant • **Business Operations Assistant**

5.1.4 Power grid expansion / smart grids workforce qualifications and occupations

With increase RE in the electricity mix, there is the need to expand and upgrade the grid. Modernizing the system through "smart grid" technology not only improves the way we store and get power; it provides jobs for workers who have the right training [31]. Expanding the grid and implementing and operating the smart grid requires many workers in various occupations along the life cycle stages of power grids/ smart grids which covers both the transmission and distribution grid. The occupations featuring in Table 23 require persons with different levels of qualifications and skills.

Table 23: Occupations along the power grids/ smart grids value chain [68] [69] [70]

	Manufacturing	Installation and maintenance	Operations, management, & business
Mid-Level	• Operator shaping • SAP consultant (sap pm) • SAP ABAP / AIF developer • IT enterprise service bus consultant • PRAM electrician • Specialist welder	• Grid connection expert eMobility • Maintenance electrician • Electricity designer • **Electrician** • Electrician (Electrical power-line installers and Repairers) • **Grid connection & compliance engineer** • Telecommunications equipment installers and repairers	• Technical service engineer • IT operations engineer • Intelligent metering systems measure analyst • Sales/ business dev't manager • Grid connection & compliance engineer • Energy & climate policy consultant • **Power distributors /dispatchers** • **Power plant operators**
Entry Level	• Power system planning & dev't • Grid solutions graduate engineer • EMIR / power integrity engineer • Electrical project engineer for hybrid power plants off grid solutions • Electrical/electronic equipment assemblers	• **Electrician** • **Natural gas distribution operator** • **Installer (natural gas distribution operator)** • Station operation electrician • **Power lines installers / repairers** • **Power line worker**	• **Station operation electrician** • **Administrator** • **Product manager grid components** • **Assistant in the area of grid control service** • **Meter readers**

5.1.5 Battery energy storage system (BESS) workforce qualifications and occupations

Just like the RE technologies, BESS have the same stages in their life cycle Figure 11.

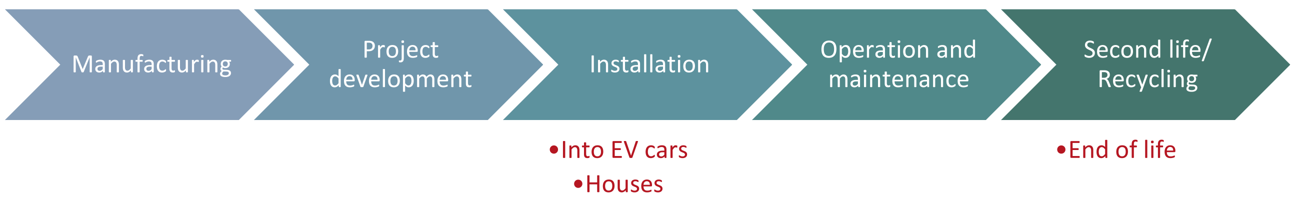


Figure 11: life cycle of a battery energy storage systems (BESS) [71]

The occupations featuring within the aforementioned sections are given in Table 24.

Table 24: Occupations along the battery energy storage systems (BESS) value chain [72]

	Manufacturing	Project development	Installation	Operation and Maintenance (O&M)
Mid-level	• Chemical engineer • Materials scientist • Software engineer • Civil engineer • Research engineer • Battery manufacturing technician • Environmental engineer • Product development engineer for cell prototyping • Electrical engineer • Mechanical engineer • Battery management system engineer • Energy storage systems engineer	• Project development manager • Project engineers – wind • Engineering & logistics managers – BESS • Estimators, energy storage • Renewable development specialists • SCADA engineers • Renewable energy engineering technician	• Project manager (renewables/solar/BESS) • Project development manager • Engineering & logistics managers – BESS • Associate project analyst - energy storage development • Renewable development specialists • Project engineer, energy storage • Renewable energy engineer	• O&M managers • Site operations managers • Senior integration engineers • Supplier quality engineers • Product manager energy storage systems • Field service specialist • Lead PV engineer • Senior procurement manager - solar & battery storage • Battery energy storage systems specialist (manager) • Technical asset manager (solar and storage) • Project manager • Safety and occupational health specialist • Computational scientist • Buyer • Industrial engineer • Power systems/transmission engineer • Battery system maintenance technicians • Sales engineer • Laboratory technician • Power marketer • Logistician • Energy storage project manager • Battery manufacturing technician
Lower level	• Electrician • Instrumentation & electronics technician • Advanced manufacturing technician • **Assembler and fabricator** • Computer numerical control (CNC)operator • Fabrication and characterization of printed flexible micro supercapacitors using different aqueous ink formulations • Plant operator • Industrial equipment mechanic		• Legal assistant • Salesperson • Trade worker • Construction worker • Transportation worker • Electrochemical lab technician • Battery system installers	• BESS technicians • Service field technician • Solar technician • Reliability technician •

5.1.6 EE in commercial / residential buildings workforce qualifications and occupations

Occupation necessary along the value chain of EE in commercial / residential buildings occupations are given in Table 25.

Table 25: Occupations along the EE in commercial / residential buildings value chain [73]

	Manufacturing[10]	Construction[11]	Operation and Maintenance[12]
Mid-level	• Real estate agent (with green building expertise) • Real estate appraiser (with green building expertise) • Certified home energy rater /assessor/home inspector • **Junior architect** • Junior engineer • Building performance diagnostician • Sustainability specialist	• Building automation systems technician • **Building operator**	• Building performance crew leader • Healthy home evaluator • **Residential energy auditor** • **Multifamily energy auditor** • Residential quality control inspector
Entry level	• Draftsperson	• Building maintenance worker • Building automation systems trainee • Building maintenance technician	• Building performance installer • Energy efficiency program assistant • Energy efficiency technician (residential) • Energy efficiency sales representative

5.1.7 EE for industrial production workforce qualifications and occupations

EE for industrial production (RMG / textiles, fertilizers, etc.) value chain stages and the occupations are given in Table 26.

Table 26: Occupations along the EE for industrial production value chain [74]

	Production (Manufacturing)	Design & Engineering (Product development)	Assembly & Fabrication (Packaging)
Mid-Level	• Manufacturing engineer • Production supervisor • Quality technician • Electrical engineer • Advanced manufacturing technician • Semiconductor manufacturing technician ii	• Process & product design engineer • Mechanical engineer • Product development specialist • Associate engineer	• Assembly manager • Procurement specialist • Quality control inspector • Assembly supervisor
Entry Level	• Semiconductor manufacturing technician i • Production associate • Machine operator • Production operator • Maintenance technician • CNC machinist • **Production worker**	• **CAD technician** • CAD drafter	• Fabricator • **Welder** • **Packaging technician** • **Assembler** • Electrical / electronic assembler

[10] *Architecture, Engineering & Other Professional Services*

[11] *Building Operations/Facility Management*

[12] *And other / Commercial & Institutional Construction & Retrofitting*

5.1.8 Workforce qualifications and occupations in the EE in transport sector

With the setting of new technologies and fundamental changes in mobility models, EE measures in the transport sector depends on the availability of a broad spectrum of low to highly skilled workers along the entire process and value chains (Figure 12). For the sake of this study a part of this value chain which entails vehicles maintenance, fleet services, sales and supports, energy suppliers and retailer shall be grouped as one "public transport improvement".

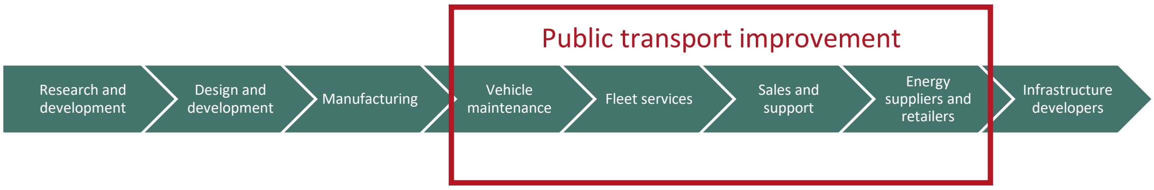


Figure 12: Value chains for EE in the transport sector

Job creation along the value chain can be broadly split into three categories:

1. Jobs in energy efficient vehicle manufacturing (e.g., electric or hybrid vehicles) and upgrading existing vehicles (e.g., retrofitting existing vehicles with new energy efficient technologies).
2. Improvements to public transit systems (e.g., energy efficient trains, cars, buses, and supporting infrastructure).
3. Infrastructure development, including creating critical infrastructure such as smart traffic management systems, and electric vehicle charging networks, or cycle networks.

In general, it is assumed that implementing EE measures will require the adaptation of existing occupational (Table 27) profiles to new technologies and models rather than the creation of entirely new profiles [75].

Table 27: Occupations needed to implement EE measures in transport along the value chain

	Vehicle manufacture and upgrading	Public transport improvements	Infrastructure development
Mid-Level	• Electrical and electronic equipment assemblers, • Engine and machine assemblers, • Machinists, • Designers • Production managers, • Tool operators • Final product assembly	• Automotive service technicians and mechanics • Operators, • Dispatch, • Planners, • Accountants • Retail persons, • customer support representative • Auto dealers	• Urban and regional planners, • Electrical power line installers • Electricians
Entry	• Automotive service technicians and mechanics	• Drivers, • Technicians • Staff at battery swapping and charging centres	• Repairers, •

5.1.9 Workforce qualifications and occupations in EE in the RAC sector

The Refrigeration and Air Conditioning (RAC) technology is implemented in both residential and commercial building. Even though this technology entails installation, other occupations are necessary for its proper functioning. Table 28 gives an overview of the different, occupations in different stages of EE in the refrigeration and air conditioning (RAC) sector.

Table 28: Occupations along value chain of EE in the refrigeration and air conditioning (RAC) sector value [76]

	Residential	Commercial	Automated control	Design engineering
Higher Level	• Residential contractor • Residential service manager	• **Commercial contractor** • Facilities managers • Commercial service manager • **Stationary engineer** • **Journey level HVAC technician** • Journey level refrigeration technician	• Building automation system manager • **Building automation system engineer** • Senior operation system analyst	• **Mechanical engineer with HVAC expertise** • **Project manager** • HVAC instructor • **Energy engineer** • Code inspector • Commissioning specialist • **Energy analyst**
Mid-Level	• Service dispatcher • Residential service technician	• Commercial service technician • Cooking equipment service technician • Facility maintenance technician	• Building automation system technician	• Test and balance technician
Entry Level	• Residential installer • Residential trainee	• Commercial installer • Apprentice • **Tradesperson** • **Commercial trainee**	• Control installer	• CAD assistant

Job creation in energy efficiency in the RAC sector is typically split into four categories, namely:

1. Energy auditors and specialists that analyse the energy efficiency of existing RAC systems and identify potential efficiency improvements.
2. Engineering and technical specialists that design and implement solutions to retrofit existing RAC systems, and to optimize performance in terms of efficiency.
3. Technical specialists that install new, energy-efficient RAC systems and components.
4. O&M specialists that provide regular maintenance of RAC systems, to ensure that they operate optimally.

5.1.10 Energy management / auditing workforce qualifications and occupations

Life cycle stages of Energy management / auditing sector and the occupations featuring are given in Table 29. These jobs are undertaken by energy auditors, energy performance consultants and building performance analysts. These workers assess building energy performance and develop specific recommendations on energy performance improvements.

Table 29: Occupations along the energy management / auditing sector value chain [73]

	Building Operations/Facility Management	Architecture, Engineering & Other Professional Services	Commercial & Institutional Construction & Retrofitting	Residential & Multifamily Construction & Retrofitting
Mid-Level	• **Energy Manager** • Energy Engineer • Building Operator • Building Engineer • Building Automation Systems Technician	• Architectural Engineer • Lighting Designer	• Product Sales Specialist • Sustainable Construction Supervisor / LEED AP • Commercial Construction Foreperson	• Residential quality control inspector • Multifamily energy auditor • Residential energy auditor • Healthy home evaluator • Building performance crew leader
Entry Level	• Facilities Manager • Building Automations Systems Trainee • Building Maintenance Technician	• Sustainability Specialist • Real Estate Agent (with green building expertise) • Certified Home Energy Rater/Assessor/Home Inspector • Real Estate Appraiser (with green building expertise) • Draftsperson • Junior Architect • Registered Architect • Mechanical Engineer • Junior Engineer	• Commercial Energy Auditor • Insulation Apprentice • Commercial Lighting Auditor • Insulation/Air Sealing Technician • Insulation Apprentice • EE Technician (Commercial)	• EE sales representatives • EE Technician (Residential) • EE programme assistant • Building performance Installer

5.2 Quantity of workforce needed (employment projections) in the selected RE/ EE sectors

This section of the report focuses on the size of the workforce needed (also considered as the number of jobs created) for various renewable and low carbon energy, energy efficiency, energy storage and smart grid technologies in Bangladesh in 2024, 2030 and 2041. It presents the respective employment factors for the focused sub-sectors according to the study in Bangladesh. Taking the scope of our study into consideration, we shall focus only on manufacturing, installation and commissioning as well as operation and maintenance steps of the value chain.

According to the methodological approach to determining the workforce needed (2.4.1), knowing the current and the forecasted development over time (present, 2030, and 2041) of the respective energy subsectors, forms the basis of estimating the workforce. With this information (chapter 3)and the calculated employment factor, an estimate of the workforce needed per sector is then determined.

The employment factors define a relationship between installed capacity (MW) and employment (job years) and gives possibility to estimate the number of jobs generated at all stages of a life cycle. It is calculated as:

$$Employment\ factor = \frac{\text{full−time equivalent job−years}}{\text{megawatt of installed capacity}}$$ *given in [job-year/MW]*.

As such the workforce in terms of full- time equivalent job-years was gotten by:

$$Full - time\ equivalent\ job - years = Employment\ factor * megawatt\ of\ installed\ capacity$$

From this study, it is very clear that the government of Bangladesh has prioritised the power sector and has undertaken immediate, short, medium and long-term plans to meet the increasing demand of electricity. As of 2023, the country had an installed capacity of 28.461 MW coming from both renewable and non-renewable sources and its citizens have 100% access to electricity.

Bangladesh with its growing population/needs and its commitment to fight climate change with energy transition, has set targets as per vision 2041 to implement power generation capacity of 40GW by 2030 and 60 MW by 2041. Of this envisaged capacity, 15% in 2030 and 40% by 2041 will be from clean energy.

Using significant data from different information sources (i.e., studies, national plans, strategies, etc.) and key assumptions, the workforce size was calculated for the respective focus technologies (subsectors). The work force needed expressed in this section is according to the "full-time equivalent job-years". This implies full time employment and five working days (Sunday to Thursday) per week in the sectors.

5.2.1 Solar PV sector workforce estimation

The employment factors for **distributed rooftop scale solar PV energy** and **utility scale solar PV** energy in Bangladesh are shown below in Table 30. It is estimated that, on average, each MW of distributed solar PV energy generation capacity creates 13.8 jobs in Bangladesh, across the three key value chain segments.

Table 30: Employment factors for distributed rooftop and utility scale solar PV in Bangladesh

Type of PV system	**Manufacture** (Job-years / MW)	**Construction** (Job-years / MW)	**O & M** (Jobs / MW)
Distributed rooftop scale solar PV energy	5.5	7.2	1.1
Utility scale solar PV energy	5.5	2.9	0.6

Given the significant economy of scale benefits compared to rooftop scale projects, utility scale solar PV energy is estimated to create 9 jobs per MW generation capacity installed in Bangladesh, across the identified key value chain segments.

Specific official data on installed solar PV generation capacity for the year 2024 was taken from the Sustainable and Renewable Energy Development Authority (SREDA), with data published as of 12 September 2024 [17]. According to SREDA (2024), that the total installed solar PV capacity in September 2024 in Bangladesh is 1085.5 MW. Of this, 708.4 MW is utility-scale solar PV generation capacity; and 377.1 MW are distributed generation (rooftop) solar PV systems.

The assumptions on installed capacities for 2030 and 2041 were based on the specific solar PV targets set out in Bangladesh's Integrated Energy and Power Master Plan (IEPMP).

In relation to component manufacturing jobs in the solar PV energy segment, it is assumed that, in 2024, 2030 and 2041, approximately 10%, 20% and 30% respectively of all components used in projects installed in Bangladesh in those target years will be manufactured in Bangladesh. It is understood that, currently in 2024, none of the major components of the solar PV systems being installed are manufactured locally (i.e., in Bangladesh), but rather are all imported from other countries. But cables and some mounting systems are produced locally. The specific split of local manufacturing versus import of equipment is not, however, reported in the publicly available literature. Hence, the 10%, 20% and 30% assumption for the years 2024, 2030 and 2041 respectively is estimated but not officially confirmed.

The following is a brief example of the methodology used to calculate utility-scale solar PV job numbers in the year 2030, using the specific employment factor for that technology and the official installed capacity target for that year.

Table 31: Example of worked calculation for solar PV job numbers in 2030

Job calculation formula:

$$Full - time\ equivalent\ job - years\ (manufacturing = Employment\ factor\ (manufacturing) * megawatt\ of\ installed\ capacity\ in\ 2030 * \text{Expected Local Content (\%) Level}$$

= 5.5 * 392MW * 20% = **432.2 jobs** in solar PV system manufacturing (2030)

Where:

- *5.5 is the employment factor for the solar PV Manufacturing segment.*
- *392 MW is the total amount of solar PV systems that are expected to be manufactured in 2030 for installation in that same year. **
- *20% is the assumed proportion of local manufacturing content (i.e., the proportion of total solar PV equipment, systems and supporting infrastructure needed to be manufactured and for installation in Bangladesh in 2030, that is expected to be manufactured in Bangladesh in that same year). ***

Please note:

***** In total, solar PV systems with a combined generation capacity of 392MW are expected to be manufactured for installation in Bangladesh in 2030. This value is calculated considering the Bangladesh governments solar PV target for 2030 (3,061MW) and the actual installed capacity of 2024 (708MW). Therefore, in Bangladesh and to meet its target, solar PV systems with a cumulative generation capacity of 2,353MW need to be manufactured and installed in the 6-year period from 2024 and 2030. It is considered that the rate of manufacture and installation will be approximately equally spread throughout the 6-year period. (This assumption is valid, also given that there is no specific indication of how the sector will develop on an annual basis). Therefore, through the calculation of 2,353MW / 6 years, the value of 392MW is derived.

****** The Local Content Level for solar PV systems in Bangladesh in 2030 is proposed to be 20%. In other words, 20% of all solar PV systems to be manufactured for installation in Bangladesh in 2030 are anticipated to be manufactured by companies located within Bangladesh (with the other 80% being imported). This assumption is speculative, and not based on official government targets for local content requirements in solar PV.

If the reader wishes to calculate the number of manufacturing jobs with different scales of local content requirement, the % can be adjusted accordingly. For example, if the local content requirement is zero (0%), then manufacturing jobs for Bangladesh would also be zero. This is currently the case, in the year 2024, where most solar PV systems are imported to Bangladesh from other countries (mainly China). By contrast (and for example), if three quarters (75%) of all solar PV systems were to be manufactured in Bangladesh in 2030, the number of manufacturing jobs would increase, reaching 1,618 in 2030 (as compared to 431.2 with a 20% Local Content).

Local Content Levels (%) are difficult to forecast, especially over long-term horizons. They are affected by numerous factors, including how specific markets develop, and the presence or absence of government targets / objectives to encourage local production of renewable energy technologies.

All job calculations in the Operation and Maintenance segment assume a Local Content Level of 100%. In other words, all O&M jobs are considered to be undertaken by people that live full time in Bangladesh. A similar assumption is made for all jobs in the energy efficiency and energy management segments, where all workers are considered to be trained Bangladeshi nationals that reside in the country.

The workforce size for **distributed rooftop scale solar PV energy** and **utility scale solar PV energy** in Bangladesh is shown below in Table 32.

For **distributed rooftop scale solar PV energy,** it is estimated that total workforce size (i.e. across all key value chain segments) will be 2,570 in 2024; and increasing to 4,446 by 2030; and reaching 9,818 in 2041 as new installations drop off significantly in the period 2030-2041**.**

The job numbers in the manufacturing segment assume that in 2030 and 2041, 20% and 30% of all solar PV systems installed in those respective years are systems that will be manufactured in Bangladesh. The other 80% and 70% of systems installed in the years 2024, 2030 and 2041 are assumed to have been manufactured outside of Bangladesh and then imported. It is assumed that 10% manufacturing of solar PV systems is taking place in Bangladesh in 2024.

Table 32: Workforce needed for the solar PV sector in Bangladesh (2024, 2030, 2041)

		Manufacture (Job-years)	**Construction** (Job-years)	**O&M** (Job-years)	**Total** (Job-years)
distributed rooftop scale solar PV	**2024**	207	1,948	414	2,570
	2030	298	1,948	2,200	4,446
	2041	600	2,618	6,600	9,818
utility scale solar PV	**2024**	390	1,137	424	1,951
	2030	432	1,137	1,836	3,405
	2041	66	116	2,100	2,282

Given the significant economy of scale benefits compared to rooftop scale projects, utility scale solar PV energy generally require fewer workers per MW installed. The workforce size for **utility scale solar PV energy** in Bangladesh is also shown in Table 32. It is estimated that total workforce size (i.e. across all key value chain segments) will be 1,951 in 2024; 3,405 in 2030; and 2,282 in 2041.

As can be appreciated from Table 32, the total number of jobs in 2041 (i.e., 2,282) is lower than in 2030 (i.e., 3,405). This is because new installations in utility scale solar PV generation capacity in the period 2030-2041 is markedly low (i.e., 439MW total of new capacity to be installed over an 11-year period, which is equivalent to just 40MW per year), in-line with the official government targets. Therefore, jobs in the manufacturing and construction segments will be very low in the years between 2030 and 2041, if sectoral growth remains in-line with government targets.

5.2.2 Wind power sector workforce estimation

The employment factors for **on-shore and off-shore wind energy** in Bangladesh are shown below in Table 33. For each MW of installed on-shore wind energy generation capacity, it is estimated that on average 5.5 jobs will be created across the full value chain segments.

Table 33: Employment factors for on- and off- shore wind energy in Bangladesh

	Manufacture (Job-years / MW)	**Construction** (Job-years / MW)	**Operation and Maintenance** (Jobs / MW)
On-shore wind	2.0	3.3	0.2
Off-shore wind	0.3	1.5	0.2

Compared to on-shore wind energy projects, off-shore wind energy creates relatively fewer jobs per MW. This is largely attributable to the economy of scale benefits of off-shore wind energy turbines (and projects) generally being of notably large scale compared to on-shore turbines. For each MW of off-shore wind energy installed generation capacity, it is estimated that on average 2 jobs will be created across the full value chain segments in Bangladesh.

The assumptions on installed capacities are also drawn from the Bangladesh's Integrated Energy and Power Master Plan (IEPMP), the official year-specific targets for 2030 and 2041. The assumption on installed capacity, and activity on manufacture and construction during 2024 is based on data published by SREDA on 12 September 2024 [17]. Specifically, that 62.9 MW of wind power generation capacity is currently installed and operational in Bangladesh.

It is worth underlining that an official target for offshore wind power exists for 2041, but not for 2030. All manufacture and construction activity are anticipated to take place post-2030 for offshore wind power in Bangladesh. In relation to component manufacturing jobs in the wind power segment, it is assumed that approximately 10% of all components used in projects are manufactured in Bangladesh.

The workforce size for **on-shore wind energy** in Bangladesh is shown below in Table 34. It is estimated that total workforce size (i.e., across all key value chain segments) for onshore wind in Bangladesh will be 414 in 2024; 413 in 2030; and then reducing slightly to 578 in 2041 as the rate of new installations reduces from 2030 onwards.

Table 34: Workforce needed for on-shore and off-shore wind energy in Bangladesh (2024, 2030, 2041)

		Manufacture (Job-years)	Construction (Job-years)	O&M (Job-years)	Total (Job-years)
On-shore wind	**2024**	23	379	12	414
	2030	15	248	150	413
	2041	15	248	315	578
Off-shore wind	**2024**	0	0	0	0
	2030	0	0	0	0
	2041	12	600	1,200	1,812

The total workforce size (i.e., across all key value chain segments) needed for **off-shore wind energy** in Bangladesh (Table 34) is estimated to be 0 in 2024; 0 in 2030 and 1,812 in 2041.

5.2.3 Biogas energy sector workforce estimation

On average, biogas energy projects create 8.7 MW of jobs per MW of installed generation capacity in Bangladesh. The employment factors for **biogas energy** in Bangladesh are shown below in Table 35.

It is also worth underlining that, as regards the employment factors expressed below, activities within the Operation and Maintenance segment of the biogas energy value chain include upgrading biogas to biomethane and managing both the storage system and the immediate distribution network connection to the biogas power generation project.

Table 35: Employment factors for biogas energy in Bangladesh

Feedstock collection and preparation (Jobs / MW)	**Manufacture** (Job-years / MW)	**Construction** (Job-years / MW)	**Operation and Maintenance** (Jobs / MW)
1.5	2.0	3.0	2.2

The development of the biogas energy sector in Bangladesh is assumed to unfold in line with the biogas targets set within Bangladesh's Integrated Energy and Power Master Plan. Specifically, total installed generation capacity is expected to be 5 MW in 2030. The workforce (jobs) calculations for 2024 in the biogas energy sector are calculated based data publish by SREDA; specifically, that 0.69 MW are installed and operational as of 12 September 2024 [17].

It is assumed that by 2041 some 10 MW of total biogas energy generation capacity will be installed in Bangladesh. This is a somewhat conservative estimation but is broadly in line with expectations.

Bangladesh's Integrated Energy and Power Master Plan does not set a specific biogas energy target for 2041. However, Table 2-3-6 of that document makes reference to the country's Power Sector Master Plan of 2016 which sets a target of increasing domestic production of biogas (note: not biogas energy installed capacity) from 0.79 Mm3/day in 2030 to 3 Mm3/day in 2041. Whilst this does not strictly mean that biogas energy installed capacity will scale in a precisely similar way, it does point to a general trend towards increased use of biogas in the country. Nevertheless, the biogas energy sector, overall, will be small in comparison with solar PV and wind power.

The workforce needed for the biogas energy sector has some unique characteristics compared to both the solar PV and wind power sectors. Firstly, the biogas energy sector has an additional jobs category; specifically, that of feedstock collection and preparation. Secondly, the workforce in O&M segment undertake tasks to upgrade biogas to biomethane and manage the storage system and the immediate distribution network connection to respective biogas power generation projects.

Taking the above into account, the workforce needed for **biogas energy** in Bangladesh is shown below in Table 36. The biogas energy workforce in Bangladesh is understood to currently be small in scale, given the limited installed generation capacity (i.e., only 5 MW, currently), and a similar situation holds for the projection to 2030 and 2041; albeit minor increases in installed capacities are expected by 2041, in line with official targets.

It is estimated that total workforce size (i.e., across all key value chain segments) for biogas energy in Bangladesh will be 2.5 in 2024; 19 in 2030; and 76 in 2041.

Table 36: Workforce needed for biogas energy in Bangladesh (2024, 2030, 2041)

	Feedstock collection and preparation (Job-years)	**Manufacture** (Job-years)	**Construction** (Job-years)	**O&M** (Job-years)	**Total** (Job-years)
2024	1	0	0	1.5	2.5
2030	8	0	0	11	19
2041	15	0	22	39	76

5.2.4 Power grid expansion / smart grids sector workforce estimation

Activities related to power grid expansion and the rollout of smart grids include a broad range of technical solutions and grid management techniques and systems. Employment factors for power grid expansion and smart grids are typically expressed in terms jobs per USD 1 million (or equivalent monetary unit) invested. The employment factors for **power grid expansion / smart grids** in Bangladesh are shown below in Table 37. On average, 5.5 jobs are created for each USD 1 million investment made in power grid expansion and smart grid (technologies and solutions) in Bangladesh.

Table 37: Employment factors for power grid expansion / smart grids in Bangladesh

Manufacture (Job-years / USD 1 mn. invested)	**Installation and maintenance** (Jobs-years / USD 1 mn. invested)	**Ongoing professional services (in particular, IT services)** (Job-years / USD 1 mn. invested)
1.4	3.0	1.1

Workforce needs are calculated based on forecasts of total annual financial investment required in grid and smart solutions technologies, considered at the national scale. Bangladesh's Integrated Energy and Power Master Plan specifies the expected the annual financial investment required in Bangladesh to facilitate the country's planned energy sector development to 2041. These assumptions form the basis of the calculations on workforce needed.

Furthermore, assumptions are made regarding the proportion of grid technologies and systems that will be manufactured in Bangladesh (as opposed to imported). Currently, Bangladesh manufactures some electrical components, including transformers, switchgear, and conductors, and several local companies are active in this segment. Nevertheless, for more advanced and large-scale equipment, Bangladesh often relies on imports currently. Within the workforce calculations it is assumed that half (50%) of smart grid and power network systems being installed (in 2024) in Bangladesh are manufactured locally (i.e., in Bangladesh). The calculation methodology assumes that during the next two decades Bangladesh will increase its domestic industry for the manufacture of these systems, and by 2030 some 75% of installed systems will be manufactured in Bangladesh, with the level increasing to 100% by 2041. It is important to note that this assumption is not based on an official forecast or stated goal / target but is rather more speculative and proposed by the study author.

The workforce needed for **power grid expansion / smart grids** in Bangladesh is shown below in Table 38. The workforce numbers remain relatively similar across the three focus years. This is in line with the Ministry of Energy's understanding that annual investment needed will be 400 USD million during each respective year. The minor changes in workforce numbers (between the three focus years) are due to variations in assumptions around local manufacturing capacity, and workforce learning rates (efficiency improvements) over time.

Table 38: Workforce needed for power grid expansion / smart grids in Bangladesh (2024,2030, 2041)

	Manufacture (Job-years)	**Installation and maintenance** (Job-years)	**Ongoing professional services (in particular, IT services)** (Job-years)	**Total** (Job-years)
2024	280	1,200	440	1,920
2030	395	1,128	414	1,937
2041	465	996	365	1,826

5.2.5 Energy storage (battery energy storage systems) sector workforce estimation

In the case of Bangladesh, 12.5 jobs are created per MW of installed battery storage capacity, considered throughout the full value chain. The specific employment factors for **energy storage (battery energy storage systems)** in Bangladesh are shown below in Table 39.

Table 39: Employment factors for energy storage (battery systems) in Bangladesh

Manufacture (Job-years / MW)	**Installation** (Job-years / MW)	**Operation and Maintenance** (Jobs / MW)
6.6	4.7	1.2

Bangladesh does not have any specific targets for energy storage (batteries) for 2024, 2030 or 2041. To understand likely battery storage capacities required for 2030 and 2041, and from a power grid stability perspective, calculations are based on industry-standard best practice and international experience (as reported by the US National Renewable Energy Laboratory, e.g., in its "*Renewable Electricity Futures Study*", and others) and linked to Bangladesh's renewable energy installed capacity expansion plans for 2030 and 2041. Assumptions consider the average level of battery energy storage installed and required for balancing variable renewable energy generation capacity at a scale similar to that planned for Bangladesh by 2030 and 2041.

The workforce needed for **energy storage (battery energy storage systems)** in Bangladesh is shown below in Table 40. It is estimated that total workforce size (i.e., across all key value chain segments) for energy storage (battery energy storage systems) in Bangladesh will be 0 in 2024; 1,526 in 2030; and 2,744 in 2041.

Table 40: Workforce needed for energy storage (battery systems) in Bangladesh (2024, 2030, 2041)

	Manufacture (Job-years)	**Installation** (Job-years)	**O&M** (Job-years)	**Total** (Job-years)
2024	0	0	0	0
2030	318	963	246	1,527
2041	870	1,493	381	2,744

5.2.6 Energy management / auditing sector workforce estimation

The employment factor for **energy management / auditing** in Bangladesh is calculated as 0.48 jobs (direct) per MW of energy saved.[13]

The modelling of the workforce needs in the energy management and auditing segment takes into consideration a range of factors.

Firstly, the expected development in total final energy consumption in Bangladesh, as stated in the country's Integrated Energy and Power Master Plan for the period 2015-2041 is drawn on as the basis for establishing the potential maximum volume of energy consumption that could, theoretically, be audited.

Secondly, assumptions were drawn concerning the proportion of key energy consumers that will contract energy auditing and/or energy management services in a typical year. To this end, and in-line with international observed experience, it is assumed that approximately 10% of major energy consumers (by volume) will contract an energy audit in 2024, with this proportion rising to around 25% in 2030, and 40% by 2041.

The workforce needed for **energy management / auditing** in Bangladesh is calculated as 158 qualified experts in 2024; 523 qualified experts in 2030; and 1,411 qualified experts in 2041[14]. These jobs are undertaken by energy auditors, energy performance consultants and building performance analysts. These workers assess building energy performance and develop specific recommendations on energy performance improvements.

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[13] *Given the nature of the work undertaken in the energy management / auditing sector, employment factors are not split within sub-categories (e.g., manufacture, construction, etc. as for renewable energy categories) and given that they are not applicable for energy management and auditing.*

[14] Given the nature of the work undertaken in the energy management / auditing sector, the workforce is not split within sub-categories (e.g., manufacture, construction, etc. as for renewable energy categories) and given that such categories are not applicable for energy management and auditing.

5.2.7 Energy efficiency in commercial / residential buildings sector workforce estimation

The employment factors for **this sector** in Bangladesh are shown in Table 41.

Table 41: Employment factors for EE in commercial / residential buildings in Bangladesh

Manufacture (Jobs / MW energy saved)	**Installation** (Jobs / MW energy saved)	**Operation and Maintenance** (Jobs / MW energy saved)
0.4	2.2	1.0

The workforce modelling assumes that Bangladesh will meet its energy efficiency target for 2030 (i.e., a 20% improvement in energy efficiency, compared with 2013, measured as improvement in primary energy consumption per GDP), and as set within the Bangladesh government's Energy Efficiency and Conservation Master Plan (2015) and reiterated in the Integrated Energy and Power Master Plan. It is forecast that Bangladesh will achieve an energy efficiency improvement of 40% by 2040 and as compared with 2013.

Relevant data on total annual energy demand in the commercial and residential (buildings) sector are drawn from the Integrated Energy and Power Master Plan.

With regard to the manufacturing segment of the energy efficiency in the commercial and residential (buildings) sector, it is assumed that 25% of the relevant equipment and systems will be manufactured in Bangladesh in 2024; and with this proportion rising to 50% by 2030, and on to 75% by 2041.

The workforce needed for **EE in commercial / residential buildings** in Bangladesh is shown below in Table 42.

Table 42: Workforce needed for EE in commercial / residential buildings in Bangladesh (2024, 2030, 2041)

	Manufacture (Job-years)	**Installation** (Job-years)	**O&M and other** (Job-years)	**Total** (Job-years)
2024	97	2,141	973	3,211
2030	191	2,103	956	3,250
2041	427	3,133	1,424	4,984

5.2.8 Energy efficiency for industrial production (RMG / textiles, fertilizers, etc.) sector workforce estimation

The employment factors for **energy efficiency in industrial production** (with particular focus subsectors such as on RMG / textiles, fertilizers, etc.) in Bangladesh are shown below in Table 43.

Table 43. Employment factors for industrial production in Bangladesh

Manufacture (Jobs / MW energy saved)	**Solutions design and construction** (Jobs / MW energy saved)	**Operation, Optimization and Maintenance of solutions** (Jobs / MW energy saved)
0,3	0,4	0,5

On average, 1.2 jobs are created for each MW of energy saved (i.e., energy efficiency improvements yielded) within industrial production activities.[15]

The calculation methodology, background assumptions and key references (specifically, for energy efficiency targets; forecasted annual energy consumption in the sector; and local manufacturing of relevant equipment) used in to model the workforce needed for energy efficiency services and interventions in industrial production are essentially the same as those outlined in subsection 2.1.7 (i.e., for the commercial and residential sector).

The workforce needed for **EE in industrial production** (with particular focus subsectors such as on RMG / textiles, fertilizers, etc.) in Bangladesh is shown below in Table 44. It is estimated that total workforce size (i.e., across all key value chain segments) for energy efficiency for industrial production in Bangladesh will be 2,777 in 2024; 2,904 in 2030; and 5,170 in 2041.

Table 44: Workforce needed for energy efficiency in industry in Bangladesh (2024, 2030, 2041)

	Manufacture (Job-years)	**Solutions design and construction** (Job-years)	**Operation, Optimization and Maintenance of solutions** (Job-years)	**Total** (Job-years)
2024	78	1,726	973	2,777
2030	171	1,879	854	2,904
2041	443	3,250	1,477	5,170

5.2.9 Energy efficiency in transport sector workforce estimation

Table 45 shows the employment factors for direct job creation per category in Bangladesh. (Note that the three respective employment factors should be considered as "standalone", and not part of a single value chain).

Table 45: Employment factors for energy efficiency in transport in Bangladesh

Vehicle manufacture and upgrading (Jobs / MW energy saved)	**Public transport improvements** (Jobs / MW energy saved)	**Infrastructure development** (Jobs / MW energy saved)
1.2	0.4	0.6

Please also refer to the description set out in "**Energy efficiency in commercial / residential** buildings", which describes the key documents and approach used to derive the relevant energy efficiency targets, and energy consumption forecasts, which was also applied in the calculation of workforce needs for energy efficiency improvements in the transportation sector.

As in section 5.1.8, job creation in energy efficiency within the transportation sector can be broadly split into three categories. Table 46 shows the workforce needed for direct job creation per category in Bangladesh.

[15] This relatively low level of job creation per MW of energy saved reflects both the relatively large scale of industrial production activities (and hence the substantial economy of scale potential) as well as the relatively low labour inputs of energy efficiency measures (including low-cost, behavioural and low hanging fruit interventions).

(The three respective workforce groups should also be considered as “standalone”, and not part of a single value chain).

Table 46: Workforce needed for energy efficiency in transport in Bangladesh (2024, 2030, 2041)

	Vehicle manufacture and upgrading (Job-years)	**Public transport improvements** (Job-years)	**Infrastructure development** (Job-years)	**Total** (Job-years)
2024	37	823	374	1,234
2030	95	1,042	474	1,611
2041	288	2,114	961	3,363

5.2.10 Energy efficiency in the refrigeration and air conditioning (RAC) sector estimating workforce estimation

Table 47 shows the employment factors for direct job creation per category in Bangladesh.

Table 47: Employment factors for energy efficiency in the RAC sector in Bangladesh

Preparation	**Construction**		**O&M**
Energy auditors and identification of efficiency improvements (Jobs / MW energy saved)	**Engineering and technical specialists for retrofit solutions** (Jobs / MW energy saved)	**Technical specialists for new EE system installations** (Jobs / MW energy saved)	**Operation and Maintenance** (Jobs / MW energy saved)
0.4	0.7	0.6	0.4

The following key assumptions and points were taken into consideration when calculating workforce needs for energy efficiency in Bangladesh’s refrigeration and air conditioning sector.

Firstly, Bangladesh does not have a specific designated target for energy efficiency in the refrigeration and air conditioning sector. The pace of energy efficiency improvements in the RAC segment, for the years 2024, 2030 and 2041, respectively, are based on observed international average target levels (and especially for South Asian countries). Assumed energy efficiency improvement levels applied for 2024, 2030 and 2041, respectively, are also aligned with key prevailing energy efficiency goals such as IRENA’s objective to double the pace of energy efficiency improvements internationally, which was also an outcome of the COP28 and has been incorporated into several emerging economies updated NDCs.

Secondly, energy consumption in the refrigeration and air conditioning segment is not specified in government or official energy statistics. It is assumed that electricity consumption in refrigeration and air conditioning currently comprises approximately 20% of Bangladesh’s total electricity consumption (2024). This is broadly in line with the international average.

Third, assumptions around total annual electricity consumption nationally in 2024, 2030 and 2041 are based on data within Bangladesh’s Integrated Energy and Power Master Plan for the years 2030 and 2041. Whereas total annual electricity consumption in Bangladesh in 2024 is currently unknown (data not available), and hence was forecasted based on a forward projection of average annual consumption, based on official data published by the International Energy Agency for Bangladesh, for the years 2010-2021 and projected to 2024.

Job creation in energy efficiency in the RAC sector is typically split into four categories, namely:

1. Energy auditors and specialists that analyse the energy efficiency of existing RAC systems and identify potential efficiency improvements.
2. Engineering and technical specialists that design and implement solutions to retrofit existing RAC systems, and to optimize performance in terms of efficiency.
3. Technical specialists that install new, energy-efficient RAC systems and components.
4. O&M specialists that provide regular maintenance of RAC systems, to ensure that they operate optimally.

Table 48 shows the workforce needed for direct job creation per category in Bangladesh.

Table 48: Workforce size for energy efficiency in the RAC sector in Bangladesh (2024, 2030, 2041)

	Preparation (Job-years)	**Construction** (Job-years)		**O&M** (Job-years)	**Total** (Job-years)
	Energy auditors and identification of efficiency improvements	**Engineering and technical specialists for retrofit solutions**	**Technical specialists for new energy efficient system installations**	**Operation and Maintenance**	
2024	15	26	22	15	78
2030	38	66	56	38	198
2041	94	163	141	94	492

It is estimated that total workforce size for energy efficiency in the refrigeration and air conditioning sector in Bangladesh will be 39 in 2024; 111 in 2030; and 296 in 2041.

6 Supply side of renewable energy and energy efficiency skills in bangladesh

The presence of skilled force in RE /EE in any society or country is the major way of ensuring the successful usage of the technology. Even when ambitious political strategies are in place, a country needs an adequate supply of professionals from a skill development / educational system to plan, develop, install, operate and maintain systems in the long term. In Bangladesh, the skill development/ educational system could be classified into 5 segments [77]:

- Public (delivered by a number of ministries),
- private (receive a government subsidy e.g., grant),
- private (commercial training institutions, madrasahs, non-government and not-for-profit institutions)
- industry-based (institutions managed by industry)
- training delivered in the workplace, including apprenticeships).

6.1 The educational sector of Bangladesh

The education system of Bangladesh has three levels - primary, secondary, and higher education. Primary education consists of eight years, while secondary education lasts four years. Secondary education is divided into a lower level and an upper level, and public examinations are held at the conclusion of each level of schooling [78]. Primary and secondary education are both compulsory (Figure 13). Public examinations are held with a certificate awarded at the conclusion of each level of schooling. There are three types of lower secondary education in the country: general education, madrasah (a combination of general and Islamic education) and technical and vocational education.

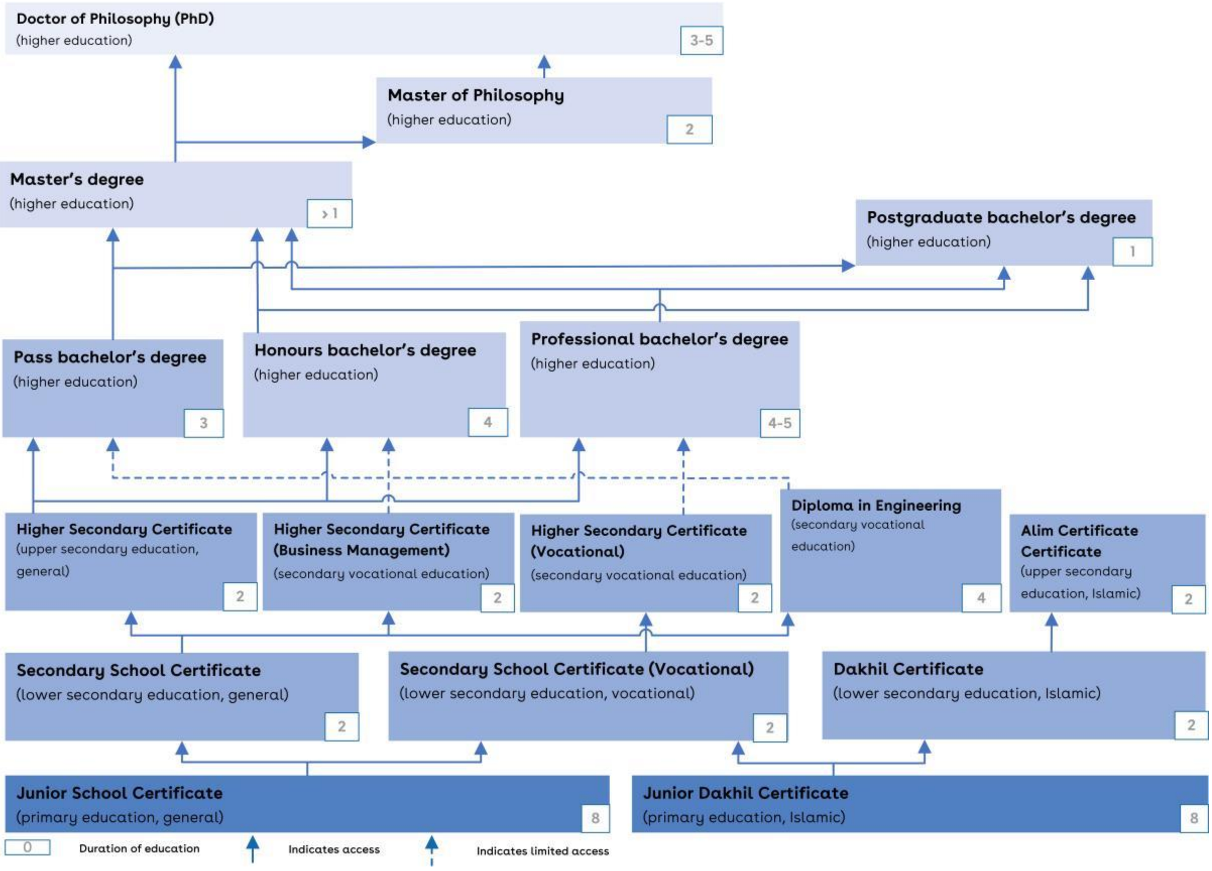

Figure 13: Educational Structure of Bangladesh and certificates gotten at the end of each stage [79]

The total number of institutions offering Junior and Secondary education in Bangladesh were 21,086 (93.79% privately managed, 3.28% publicly managed and upgraded govt) in 2023 including 638 upgraded government primary schools having student from grade 6 to 8. The total enrolment was 9.41 million among them 5.16 million (54.84%) were girls giving gender parity index near 1.21. The number of students per institution was 446 in 2023. Total teachers were 278,518 with 85,751 female teachers. In 2023, the teacher-student ratio (TSR) was 1:34 and the average number of teachers per institution was only 13. Among all teachers 71.86% were trained. This percentage was 33.50% in Junior Schools 77.24% in Secondary School and 62.79% in School & College [80].

6.2 The main actors in the educational sector

Education System in Bangladesh is being managed and administered by two Ministries, Ministry of Education (MoE) and Ministry of Primary and Mass Education Division in association with the attached Departments and Directorates as well as a number of autonomous bodies (Table 49).

Table 49: Main actors in the TVET educational sector Bangladesh

Institution	Role
Ministry of Education (MoE)	Policy formulation, planning, monitoring, evaluation and execution of plans and programs related to post primary secondary and higher education including technical & madrasah education.
Directorate of Secondary and Higher Education (DSHE)	Administration, management and control of post primary secondary and higher education including madrasah and other special types of education.
Directorate of Technical Education (DTE)	Management and administration of technical & vocational institutions like polytechnics, monotechnic and other similar types of institutes. Makes the general policy for secondary vocational education.
Bangladesh National Curriculum and Textbook Board (BNCTB)	Autonomous organization under the MoE responsible for the development of curriculum, production and distribution of textbooks at primary, secondary and higher secondary levels.
Bangladesh Technical Education Board (BTEB)	Conducting certificate and diploma examinations in technical education. Reorganization of the non-government technical and vocational educational institutions. Checks educational institutions.
National Skills Development Authority (NSDA)	Spearhead and coordinate all efforts in the skills development sector.

6.3 Technical and vocational education and training (TVET) in Bangladesh

The TVET sector in Bangladesh is diverse, with 10,595 existing institutions catering for to more than 1,818,522 students from different curriculum ranging from lower secondary level right up to diploma or post-secondary non-tertiary levels. With an average of 172 students per institution, total girls' students were 536,923 (29.53%) of the total enrolment. Total number teachers in the 10,595 institutions were 55,338 including 13,575 (24.53%) female teachers. The average teacher per institution was 5. The gender parity index was 0.32 (female to male). Teacher-student ratio was 1:33 for all types of institutions [80].

Of the 10,595 existing institutions mentioned above, 3,667 are of lower secondary level offering an HSC certificate and 1,533 of upper secondary level offering an SSC certificate (Table 51). The rest offer diplomas. The Secondary vocational education (lower and upper) varies according to the admission requirements, content, duration and transfer entitlement (Table 50) [79].

Table 50: Difference between lower and upper secondary vocational education [79]

	Lower secondary vocational education	Upper secondary vocational education
Duration	2 years (grade 9 – grade 10).	2 years (grade 11- grade 12).

Content	• **General education subjects**, such as Bangla, chemistry, mathematics and physics. • **Two subjects** for a particular profession (Trade 1 and Trade 2), such as tailor (dress making and tailoring) or plumber (plumbing and pipe fitting).	• **Theoretical and practical subjects** for a practical profession (trade). • **Various professions** are possible, such as fish farmer (fish culture and breeding) or woodworker (wood working and cabinet design).
Admission requirements	Junior School Certificate (JSC) or a Junior Dakhil Certificate (JDC).	Secondary School Certificate-SSC (Vocational).
Diploma	Secondary School Certificate -SSC (Vocational) from the BTEB	Higher Secondary Certificate-HSC (Vocational) from the BTEB.
Function of the diploma	Access to upper secondary education and secondary vocational education.	Work or access to further secondary vocational education.

There are three types of TVET/skills training in Bangladesh – formal training, informal and non-formal training (rely on several engineering colleges, a network of polytechnic and specialized colleges) dedicated to training students in different areas [77]. Some of the formal TVET training existing in Bangladesh in 2023 and the number institutions, teachers and students can be seen in Table 51.

Table 51: Number of some TVET institutions, teachers and enrolment by curriculum [80]

Name of curriculum	Type of TVET	Number of institutions	Teachers			Students		
			Total	Female	% of female	Total	Female	% of female
Diploma level or post-secondary non-tertiary	Diploma in Engineering	482	12,897	2422	18.78	187,975	22,860	12.16
	Diploma in Engineering (Army)	3	0	0	0	0	0	0
Upper secondary level	HSC vocational	65	1,337	144	10.77	57,321	8,543	14.90
	HSC Business management	1,460	12,993	2,290	17.62	473,484	147,578	31.17
	Diploma in commerce	8	173	40	23.12	25,850	8,535	33.02
Lower secondary level	SSC vocational course	3,059	11,257	2,802	24.89	462,093	136,766	29.60
	Dakhil-vocational	408	491	135	27.49	11,836	3,654	30.87
	SSC vocational textile	51	552	109	19.75	10,852	2536	23.37
	JSC vocational	150	76	23	30.26	32,739	10,030	30.64
Short courses	Such as basic trade course (360 hours, 95 trades) and CBT&A course (51 occupations)	3,913	8,550	1,918	22.43	350,074	114,176	32.61

Other Upper secondary level curriculum not mentioned in Table 51 are diploma in commerce, textile engineering, agriculture, fisheries, forestry, livestock, tourism and hospitality, medical given that they are not of particular interest to this study.

6.3.1 Qualification systems in Bangladesh

The National Technical Vocational Qualifications Framework (NTVQF) which is a comprehensive, nationally consistent yet flexible framework for all qualifications in TVET, improves the acceptability of the "qualification" certified in Bangladesh. Together with the National Skills Quality Assessment System, NTVQF ensures quality, demand-based skills development in Bangladesh. The NTVQF levels and job classification and description is defined as in Annex 6. Implementation of the NTVQF in Bangladesh is affected via three essential components which are Nationally-recognised competency standards, Competency-Based Training (CBT) Delivery System and Competency Assessment and Certification System (CACS):

6.4 Nationally-recognised competency standards for the RE / EE sector

National competency or occupational standards are nationally-agreed, industry-determined sets of knowledge, skills and attitudes that are required for workers to be able to effectively perform work activities to the standard expected in the workplace. It usually based on these standards that training programmes are developed. The occupational standards can take the form of job task descriptions (appropriate for, for example, PV installers) or competency profiles (appropriate for, for example, energy efficiency professionals). Our study identified some of existing standards in the RE/EE sector in Bangladesh.

6.4.1 Existing occupational standards for the RE sector

In Bangladesh, there is one official existing competency standard for RE developed by BTEB for the solar occupation. There are however, some others related to RE in electrical system (Table 52).

Table 52: Existing competency standards according to BTEB [81]

Sector	Occupation	Level
Informal (13)	Solar Electrical System (119)	National Skill Certificate-I (23)
Informal (13)	Solar Electrical System (119)	National Skill Certificate-II (24)
Transport Equipment (18)	Electrical Installation and Maintenance (103)	National Skill Certificate-I (23)
Transport Equipment (18)	Electrical Installation and Maintenance (103)	National Skill Certificate-III (25)
Transport Equipment (18)	Electrical Installation and Maintenance (103)	National Skill Certificate-II (24)
Transport Equipment (18)	Electrical Installation and Maintenance (103)	National prevocational Certificate-II (22)
Pharmaceutical (22)	Electrical & Electronics Installation and Maintenance (177)	National Skill Certificate-II (24)
Construction (12)	Electrical Installation and Maintenance (Civil Construction) (117)	National Skill Certificate-Level_ I & IV (23)
Construction (12)	Electrical Installation and Maintenance (Civil Construction) (117)	National Prevocational Certificate-II (22)

Construction (12)	Electrical Installation and Maintenance (Civil Construction) (117)	National Skill Certificate-III (25)
Construction (12)	Electrical Installation and Maintenance (Civil Construction) (117)	National Skill Certificate-IV (26)
Construction (12)	Electrical Installation and Maintenance (Civil Construction) (217)	National Skill Certificate-I (23)
Construction (12)	Electrical Installation and Maintenance (Civil Construction) (217)	National Skill Certificate-II (24)

In 2023, Construction Industry Skills Council (*CISC*), developed additional 7 competency standards for technicians in the solar sector. These standards which are still in the process of approval are:

- Electrical systems (Solar rooftop) - field level technicians
- Electrical systems (solar grid tied) - Field level technician
- Electrical systems (solar irrigation) - Field level technician
- Solar irrigation pumping and water distribution systems
- Agriculture and operation (solar irrigation systems)- field level supervisor
- Masonry training (solar irrigation system) - Field level technician
- Improved cook stove construction and installation

6.4.2 Existing occupational standards for the EE Sector

For the energy efficiency sector, there is no defined occupation for the TVET level. There is however an occupation for refrigeration and air-conditioning.

Sector	Occupation	Level
Transport Equipment (18)	Refrigeration & Air-conditioning (125)	National Skill Certificate-I (23)
Transport Equipment (18)	Refrigeration & Air-conditioning (125)	National Skill Certificate-II (24)
Transport Equipment (18)	Refrigeration & Air-conditioning (125)	National Skill Certificate-III (25)
Transport Equipment (18)	Refrigeration & Air-conditioning (125)	National Skill Certificate-IV (26)

6.5 Training and training facilities in RE / EE

The growing demands arising in the RE/EE sector necessitates acquiring education and appropriate skills with the aid of educational facilities which includes courses, institutions, programmes etc. Bangladesh adopted a “Competency-Based Training (CBT) Delivery System” which teachers and trainers use to develop learners’ competency in necessary areas. In this system, instead of concentrating on developing theoretical knowledge, CBT places emphasis on the real work skills that a person can apply in the workplace. There already some existing infrastructure covering RE/ EE sector in Bangladesh

6.5.1 Existing RE trainings, curricula, programmes and Facilities

With the occupation mentioned in 6.4.1, the course “solar electrical system” has been developed for TVETs technician level 1, 2 and 3. The hands-on curriculum is to be inserted in the NQF manual. Table 53 shows the existing trainings in the TVET sector. These are all for NTVQF level II and requiring the Junior School Certificate with NTVQF I certificate to be admitted. Details on the content of these courses can be seen in Annex 7 # 1.

Table 53: Existing solar TVET courses in Bangladesh

Course name	Level	Duration
Electrical Installation and Maintenance Level- II & III	NTVQF level II	360 hours
Work in Solar Home System (SHS) service industry	NTVQF level II	24 hours
Use concept of climate change, renewable energy and solar energy	NTVQF level II	10 hours
Apply basic electrical concept and circuits	NTVQF level II	30 hours
Install Solar Home System (SHS)	NTVQF level II	40 hours
Make trouble shooting for SHS Course Code	NTVQF level II	26 hours
Assemble charge controller, inverter and light fixtures	NTVQF level II	30 hours
Carry out customer counselling and marketing of SHS	NTVQF level II	40 hours
Manage inventory and storage of SHS equipment and accessories	NTVQF level II	16 hours
Collect instalment and maintain accounts	NTVQF level II	30 hours

Other solar trainings are:

- BPMI training on Design and Implementation of Solar Power Plant which is on the job training running for 78 hours (Annex 7, number 2)
- Power and Energy Training Academy (PETA), United International University Certificate Course on "Operations & Maintenance of Power Plant a certificate course of 40 Hours (Annex 7, number 3).
- Bangladesh Technical Training Institute (BTTI) on inverter manufacturing, installation (Annex 7, number 10),

A couple of universities also offer some RE programmes. In Bangladesh, there is only a limited range of regular biogas training programmes. There are just some short courses, but not at TVET level.

For any work on the transmission grid, Power Grid Bangladesh PLC internally trains its workforce according to their own defined standards.

6.5.2 Existing EE trainings, curricula, programmes and Facilities

So far EE is not really a subject in terms of TVET training in the country. There are courses for higher levels or the university such as the Energy Auditor, Energy Manager certificate course for professional which is a 10 days exam preparation training and four phase analytical exam offered by SREDA. A detail of some of these programmes can be seen in Annex 8.

6.5.3 Other available training in BD

Outside of a formal school environment, the skills system in Bangladesh has trainings being offered by several government ministries, large private enterprises that create formal pre-service and apprenticeship training programs, and NGOs delivering formal training for the informal economy [77]

6.6 International best practice for RE/ EE skills development

In this section we look at international best practice examples in renewable energy (RE) and energy efficiency (EE) TVET and briefly outline their key success factors. All international best practice examples covering solar PV, wind and EE are presented in more detail in Annex 9. Alongside providing a quality benchmark, these programmes were chosen because they represent a range of forms that RE and EE TVET can take, such as:

- **Modular programs** extending over several months, which are coupled to full vocational qualifications, for example the wind power modules offered by the Bremerhaven Wind Centre (Germany) as part of the 3.5-year Electrical Service Engineers qualification;
- **Short continued professional development programs** extending over a few days up to a few weeks, aimed at people who already have relevant competencies, for example, the 5-day City & Guilds (UK) accredited course on installing and testing domestic PV systems for qualified electricians.

Key success factors of the listed training programs are:

- **Developing training programmes collaboratively by industry for industry:** For example, the Solar Energy International (USA) Residential and Commercial PV Systems Certificate program is based on the NABCEP PV installers job task analysis (JTA). The JTA in turn was developed collaboratively by many solar PV industry experts and is recognised and valued by the industry as the standard for required competencies for this role.
- **Developing training programmes that meet a clear market demand**: All of the listed programs were developed in recognition of the fact that there was a clear and growing market demand. In the Bangladeshi context, the 100% renewable energy by 2060 target drives the need for a highly skilled labour force in the technologies which will need to be rolled out.
- **Having some formal recognition of quality:** Although this is not essential (for example, the Danish Wind Power Academy has no formal accreditation, but is nonetheless well-recognised), having the training provider and the training programme accredited by an official accreditation authority will provide a quality guarantee that gives added value to the qualification obtained. For example, NABCEP will only accept candidates for their certification exam if they have completed training with an accredited training provider.
- **Ensuring high quality trainers:** Having skilled and experienced trainers/instructors plays the most essential role in effectively imparting knowledge and skills. Trainers should be skilled in the subject area as well as in teaching. Ideally trainers will have acquired their subject competencies through several years on the job, and will strive to stay up-to-date on industry developments through, for example, refresher training and regular exchanges with the industry.
- **Offering flexible learning:** Training providers can reach a wider audience by building flexible learning into their training programme concept. This can help overcome geographical as well as time restrictions, making it easier for participants, who live far away or have work, family or other commitments to participate. More flexibility can be offered through, for example
    - Offering the training programme as a series of modules that can, to an extent, be completed whenever it best suits the participant.
    - Offering a blended learning approach where knowledge can be transferred via online learning as a complement to practical face-to-face training.
    - Offering face-to-face modules on weekends or evenings.

- **Offering a high proportion of practical, hands-on training:** All TVET should incorporate a high proportion of practical, hands-on training to give participants the opportunity to apply their acquired knowledge, and to develop their practical skills. Well-designed practical training delivered by qualified trainers in an appropriately equipped training centre is the core of any TVET program.
- **Offering equipment and didactic teaching:** material that enables high-quality hands-on training adapted to local conditions, as well as the development of the associated didactic teaching and learning materials for learners.
- **Having the backing of industry:** The importance of collaboration with industry has already been highlighted in terms of development and recognition of the training program. Further areas where industry support can significantly enhance the training offer are
    - Internships to give trainees on-the-job experience
    - Sponsorship of the program or of individuals
    - Offering site visits, e.g., to solar PV, wind or biogas installations, as part of the practical training.

7 Gap analysis and identification

A skills gap in any sector is the difference between skills that employers want or need versus skills their existing workforce offers. In this section, the findings of the study are analysed in three distinct parts. The first part analysis the acquired information and comes out with the broad workforce occupational structure of the different sectors, major tasks and required skills of the employees as well as the education /trainings levels to provide the qualification and skills. The second part goes on to provides information on the mismatch between the actual and desired level of skills across occupations, hard-to-fill occupations or skill shortages, and employer's perception of employees' skill levels that help to identify the skill gap. The third part then provides information for the identification of the trainings to support the skills development that will foster the growth of the RE / EE market and enable Bangladesh achieve its targets.

7.1 Sectorial occupational structures and potential areas for intervention in Bangladesh

According to IRENA's publication "Renewable Energy and Jobs Annual Review 2022", Bangladesh ranked 5th among 161 countries providing solar PV employment in the world in 2021 [82]. Using employment factor and the envisaged targets of the country mostly according to the "Integrated Energy and Power Master Plan (IEPMP) 2023", the quantity of workforce needed in selected segments of the value chain of each of this study's 10 subsectors has so far been estimated for 2024, 2030 and 2041(Chapter 5).

Each of these ten sectors require different types and levels of occupations along their individual value chains (section 5.1). For the study's chosen segment of the value chain (manufacturing, installation/ construction and O&M), there are occupations that require qualified persons with an entry-level, mid-level of education such as technicians as well as higher-level of education such as engineers.

In each table within section 5.1, workforce/occupations are listed that are needed to be present for a successful subsector in Bangladesh. Within the framework of the study, some of these occupations which are highlighted in bold were identified to be already present in the country. From all indications, most of these persons who carried out the occupations presently in the country at the entry and midlevel gained their skills through on-the job training. They were said to have been broadly trained or educated in affiliated subject but not specifically in relation to the particular RE/ EE sector in which they worked. Reason given for opting for this way of training persons for required occupations, was the absence appropriate training programmes in the country or existing curriculum that address some of these required themes.

In terms of the quantity of workforce required to meet the present and future targets (section 5.2), a comparison all the workforce in the RE sectors of solar, wind and biogas as well as those of power/smart grid and BESS can be seen in Figure 15 and those for the EE sector in Figure 15.

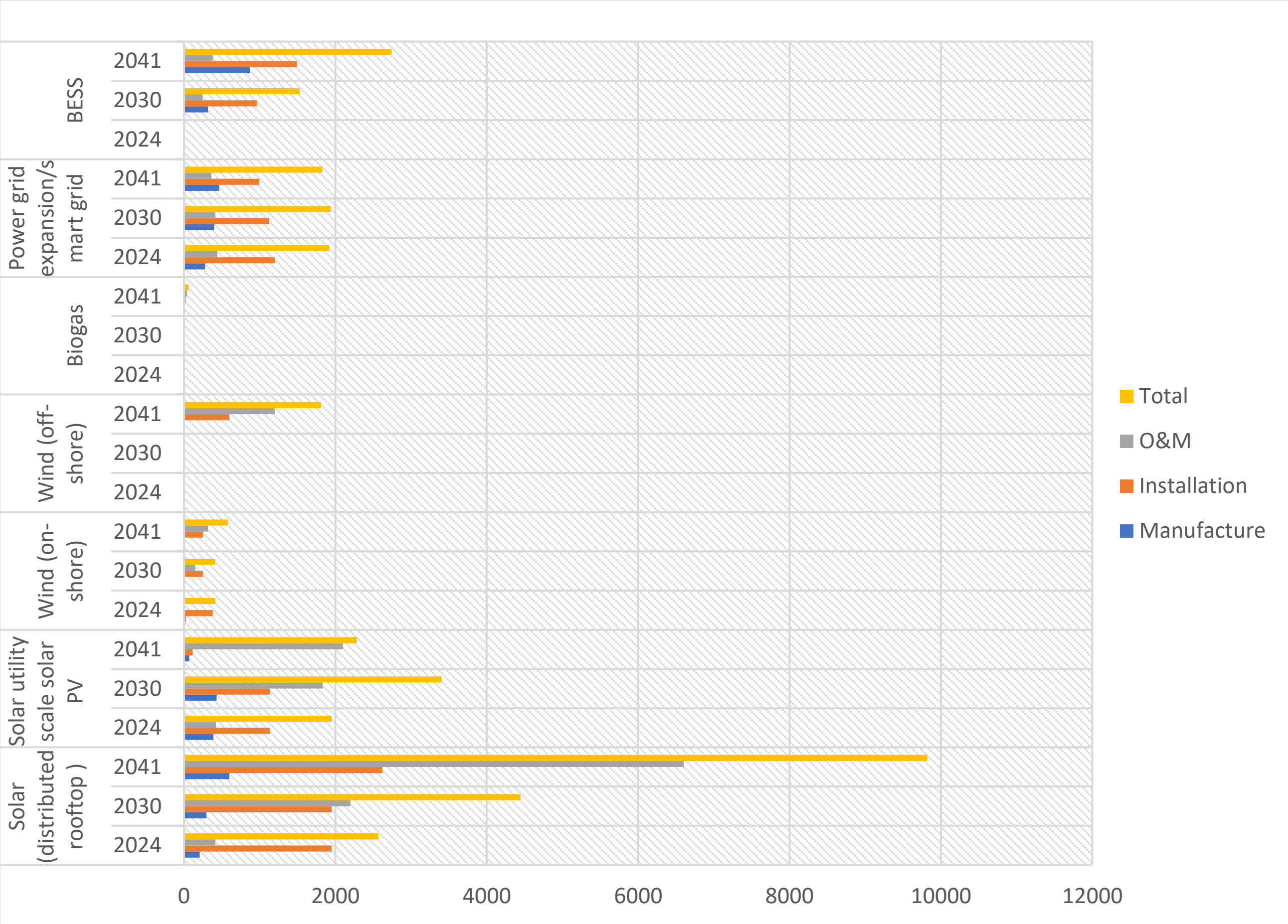

Figure 14: Workforce demand in the RE sector

The figures indicate the envisaged workforce needed to carry out manufacturing, installation and O&M jobs as a whole (not the individual occupations) in 2024, 2030 and 2041. It also sums up all these numbers to give the total workforce needed in a particular sector.

A look at "total employment" in the RE sector (Figure 14), indicates that the solar roof top sector will need the highest number of qualified persons particularly by 2041 offering 9,818 full-time equivalent job-years opportunities. This sector will also be the sector of interest in 2030 in terms of employment followed by the utility scale solar in 2030 and BESS sector in 2041. Presently (2024), BESS and off-shore wind sector does not provide any jobs nor need any workforce in accordance with the existing targets set by the country. This fact is visible in the absence of indication of any of the existing occupations in the country (Table 21 and Table 24).

The biogas sector too does not need much workforce in 2024 nor 2030 but just a few in O&M in these years. A fact somehow confirmed by the industry and the absence of any envisaged biogas targets.

Having a look year wise and according to the respective sections of the value chain (manufacturing, installation, O&M), Figure 14 indicates that, the manufacturing workforce needed in 2024 is highest in the power grid expansion sector. With plans and targets to expand the grid and making it smart, there is the need for equipment and supporting structures manufacture. Hence, jobs created in the sector. Workforce is greatly needed for construction/ installation in nearly all the sub-sectors but for BESS, biogas and off-shore wind. The highest demand for skilled workforce in 2024 is for installation in the distributed rooftop followed by power grid expansion/smart grids and then utility scale solar. As of 2024 there is not so much need for workforce on O&M in all the RE sectors. By 2030 there is a substantial increase in the demand in almost all the subsectors. Solar still takes the lead in installation and should the country invest more in manufacturing (20%) of the solar components, there shall be an increase in the demand for manufacturing skilled workforce in 2030 particularly in the utility scale sector (432 full-time equivalent job-years).

In all, there is already a demand in skilled workforce presently in Bangladesh particularly in the solar and grid expansion sector. With Bangladesh's projects and plans, these figures are expected to increase over the next 5 years and 10 years. 2030 will see the demand spread across the other sectors with the highest still being in the solar sector. The demand for labour for onshore wind turbines will also increase. As of now and in the next 15 years, there no indication that the country will be looking out for skilled workforce in the biogas sector nor off-shore wind. However, the 2041 which is the target planned year in the country's strategies, there will be the highest workforce demand in solar PV in all the years. Getting enough persons with the right skills for these jobs is imperative.

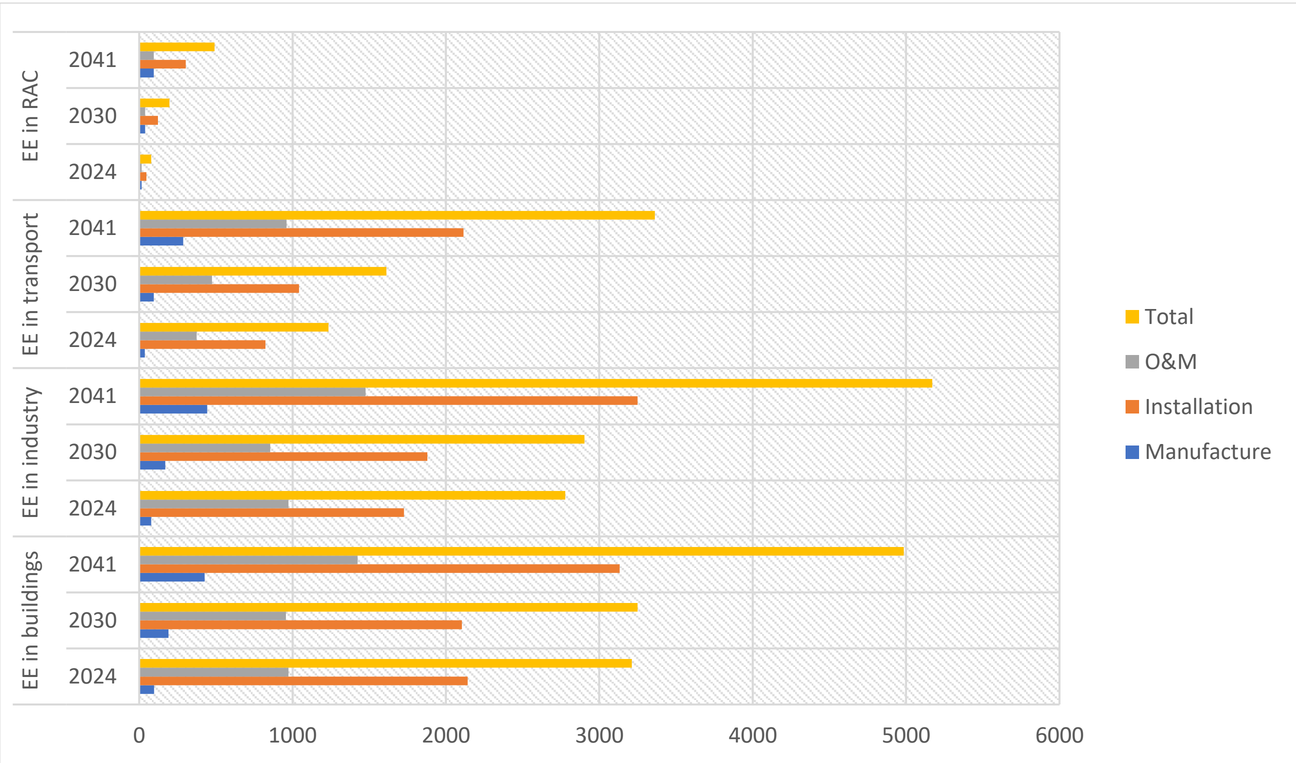

Figure 15: Workforce demand in the EE sector

Figure 15 looks in detailed at the workforce demand of the four EE sub sectors in 2024, 2030 and 2041. It also looks at the job demands in manufacturing, installation as well at O&M. There is an ample need of trained human resources in the EE sector. EE in industry shall be the sector looking out for the highest total number of workforces followed by the building sector and then the transport sector given the plans and targets of the country. The RAC sector does not see any significant change in its total demand across the years.

However, year wise, Figure 15 indicates that in 2024 there is more demand for qualified workforce in construction/installation as compared to manufacturing and O&M in all the sectors. This trend is same for 2030 and 2041 with a rise demand at the various jobs.

It should also be noted at this juncture that, the workforce needed for **energy management / auditing** in Bangladesh not included in Figure 15 is calculated as 158 qualified experts in 2024; 523 qualified experts in 2030; and 1,411 qualified experts in 2041.

From the above analysis and the findings from the workshops, KIIs and desk research, we were able to list the RE/EE jobs with their quantitative demand (Table 54).

Table 54: List of RE jobs with high demand

Distribution	Demand Category	Jobs
Sector-wise	High demand	Solar jobs, EE in buildings and industry jobs
	Medium Demand	EE in transport and power grid expansion
	Low demand	Biogas jobs, off-shore wind, EE in RAC
Occupation-wise	High demand	Skilled technician support staff
	Medium Demand	Skilled engineers
	Low demand	Others
Skill-wise	High demand	Jobs that require minimal training
	Medium Demand	Professionals
	Low demand	Others

Sector wise, it is clear that the solar industry is and will be the leading sector in Bangladesh right up to 2041 making it a sector with a high demand for skilled labour. This is corroborated by the responses to the questionnaire. EE in building and industry should also see a high demand should the various strategies to save energy in these sectors be implemented. Presently, there is lack of awareness on the benefit of green buildings or LEED certified buildings among the people in the construction sector.

Occupational-wise, the RE/EE industry in Bangladesh is looking more for skilled technicians as compared to engineers. Input to the study indicated that most of the existing RE/EE companies in Bangladesh workforce are engineers. These high qualification staffs such electrical / electronic, mechanical, civil, environmental and energy engineers are easier to find but they still lack some of the RE /EE skills companies are looking for such as system design. The engineers usually possess a lot of theoretical knowledge but lack hands on skills and application. Skilled technicians and installers are difficult to find due to absence of specific TVET programmes on the subject. As such they take on those with basic skills and up-skill them on the job.

Skill-wise and based on our various conversions with different players in the different sectors, there is a high demand for persons having minimal training such as the TVET level and below. There is however also a medium demand for skilled professional like engineers with practical skills to direct those with minimal skills in Bangladesh. In some cases, like EE in building, the Architects and engineers need to be more skilled on using the EE applications and equipment in building design and construction respectively.

The solar sector faces significant challenges, including a high rate of employee turnover driven by the lack of job security, training programs, and job benefits. The lack of career opportunities, job stability, and competitive wages discourages skilled workers from entering this field. Additionally, the stigma associated with informal employment and family discourages young graduates from pursuing careers in smaller sectors that require high technical skills. Although employers are eager in retaining skilled labour, they often have to compromise on skills in order to fit within the constraints of their salary structures.

The skills sorted for by the industry should come from trainings. From all indications, technicians are required for the analysed sectors and currently TVET is not playing any vital role in providing these skills technicians. The university is providing some engineers but not those with the right skills for RE and EE. The technical education system can play a more involved role to produce a skilled labour force needed now and in the next 5 to 15 years. However, except for the solar PV TVET training on “Solar Electrical System” with a handful of courses (Table 53) available in the NQF to be offered by TVET institutions, there are no other existing curriculum in the country to address these needed skills.

Additionally, of all the existing TVET institutions in the country, none is offering the course and are not able to reach this threshold of minimum quality. During the in-depth interviews, no TVET was found, which is enough reason for building up this sector. While the industry relies on on-the-job training, VET could fulfil this role with practical and theoretical training and combine it with internships in the industry. According to the study, these occupations should be defined more precisely and TVET programmes developed, while strictly maintaining the standard to produce the required number of skilled workers.

7.2 Skills demand versus supply

There is a significant gap in the demanded skills and training/education, for RE/EE in Bangladesh. Those working in the industry demand the staff they employ in each sector to have the right skills and qualification for the job they seek or are employed to do.

However, in reality, there are almost non-existent training programmes for the required skills. Employers resort to hiring unskilled labour and offering them short training courses so that they can start work. These companies hire technicians with basic skills and train them on their premises. The private sector companies arrange on the job trainings. This means that employers compromise on educational qualifications when workers have additional skills. This is generally the case in the study’s chosen RE / EE sub-sectors.

7.2.1 Mismatch in skills demanded by the industry versus supply through training

Some RE courses such as solar PV courses for electricians[16] have been introduced into the TVET curriculum and also in recent years by international development programmes but still the lack of qualified RE /EE trainers and well-equipped training institutions among other things still remains an issue in supply the qualified

[16] Solar home systems electrification for technicians with “Wiring, Installation, operation and Maintenance” topics offered by 3 TVETs only

personnel for this developing industry in Bangladesh. The following mismatch were identified between demand and supply:

- There is the need to have competency standards (CS) and job task description (JTD) for the various occupations upon which competency-based TVET training curricula are to be defined. So far there are 7 existing and pending approval CS for solar PV defined by the Construction Industry Skills Council (CISC) in association with IDCOL but none for the other sectors. As such no existing competency-based TVET training curricula for the RE/EE sectors.
- In Bangladesh, there are assigned skilled council that look into the skills needed for a designated industry. No skills council has been assigned with the task of looking into the RE/ EE skills demand. These skill councils work to define the occupational / competency standards,
- Industry requires skilled workforce with qualification based on a curriculum which has been developed in accordance with competency standards in place. So far, existing curriculums are drawn based on other factors such as market analysis and not skills analysis. Graduate do not have the appropriate skills for employment. The industry thereby tends towards in-house training.
- Apart from the training on Solar home systems (SHS) electrification for technicians with “Wiring, Installation, operation and Maintenance” which is being offered by 3 TVETs, there are no officially accredited TVET training curricula for the other RE /EE themes considered in this study.
- Industry looks out for persons with hands on practical skills but the TVETs that are offering courses like the (SHS) course are not equipped to offer students hands-on practical sessions.
- The industry does have some experience personal who train new employees on the job within their companies or though other short trainings offered by donor organisations while TVETs are lacking well qualified and experienced trainers.
- Qualifications are assured through certification which the RE/EE industry is looking out for in Bangladesh but there no existing certification process for at the TVET for RE /EE occupations.

Development of RE and EE skilled workforce demands competency standard, programmes/syllabus developer and more trained instructors to incorporate RE and EE into existing courses, and provision of additional equipment and practical training materials. BTEB has a solid reputation and impact within the labour market for adults and courses can be attractive to youth, however they will require corporate support from industry.

7.2.2 Training gap analysis

	Status quo in Bangladesh	***International best practice***	***Gap***
Programme scope and approach (Modular programmes / continued professional development programmes)	•There are implemented curricula & modular courses / programme course on solar PV - solar electrical system. • No TVET curricula for wind, biogas, grid extension or EE •A TVET NTVQF Level 2 competency standard on “solar PV” exists but a curriculum has not yet been developed.	•Modular programmes extending over several months coupled to full vocational qualifications exist on RE and EE •Short continued professional development programs exist for strengthening competencies on RE/EE	•There is the absence of TVET curricula on RE/EE topics required for the 100% energy transition by 2030 and 2041 •Corresponding new occupational /competency standard should be developed

Training programmes implemented in collaboration with industry	• There have been on-off experiences on RE trainings in the past (e.g., e-vehicle technicians for Mega power). • At SJPI, curricula are developed with advice from the local industry • No TVET offering solar course is working with the industry.	• Internships • Sponsorships • Site visits	• Absence of a continuous dialogue with the local private sector representatives on the future demand of RE /EE related qualifications. • Dual education based on industry integration (e.g., internships) is not common
Training programmes meet market skills demand	• TVET trainings are based on market and not the skill demand. • There is limited information at the TVETs on the required skills or amount of labour force in the long-term • Courses are related to the needs of BTEB's implementations.	• Intense cooperation between institutions and exchange of information attempt to meet future market demand	• Coordination, transparency and information exchange between institutions and the industry on the required skills • Analysis of resulting market demand for qualified labour not readily available
Formal recognition of quality	• Institutions provide individual certification	• Official certification process guarantees standards and facilitates movement between different job opportunities and countries	• No existing TVET curriculum nor certification aimed for RE/EE
High quality trainers/instructors	• Qualified trainers not available and in some cases do not have relevant practical experience	• Instructors have several years of relevant on-the-job experience as well as being trained in teaching	• Collaboration with the industry to use some of their experience staff • Lack of RE /EE training courses for trainers or additional subject matter training
Offering flexible learning	• TVET trainings are in-person trainings requiring classroom presence.	• Training programme as a series of time-flexible modules. • Blended learning approach via online learning as a compliment to practical face-to-face training. • Face-to-face modules on weekends/evenings	• Possibility to transfer knowledge via online learning, and skills via practical learning in the lab • Lack of online training offers such as, short technical training videos on relevant topics, e.g., aspects of PV installation, • Lack of technical software that students learn to use through online training
High proportion of practical, hands-on training	• Material, kits and laboratories not available even for PV	• Practical training delivered by qualified trainers in an appropriately equipped training centre	• Particularly for RE technologies equipment is needed

7.3 Capacity building measures for TVETs Training and Facilities in RE / EE

The recommendations are split into: 1) education of TVET teachers and trainers and 2) TVET for relevant labour force required in future for energy transition.

a) Education of teachers and trainers for TVET institutions

For enhancing the integration of RE and EE education in the teaching approaches and mindsets of teachers, additional resources are required. The following are possibilities to achieve that:

- Develop or expand the existing teaching unit on RE/EE at teachers training institutions
- Develop and provide general material on RE/EE (for future teachers, teachers in practice)
- Encourage teachers to acquire additional qualifications for renewables / energy efficiency (for TVET). This can be operationalized through regulated obligations (mandatory qualifications needed in defined frequency) or through incentives.
- One incentive is to provide a certified teacher learning programme on RE/EE.

b) TVET for relevant labour force education

Given that skills related to RE /EE shall play a big role in the future job market in Bangladesh, the TVET sector has to reflect this increasing demand [75]. Current programmes and trainings seldom consider RE technologies nor EE measures but they should be scaled-up based on the following recommendations:

- Enhance the cooperation and exchange of information between educational institutions and the Ministries involved (i.e., Ministry of Energy, Ministry of Education and Ministry of Labour): Share reliable projections about required labour force in the energy sector to allow TVET institutions appropriate mid-term planning and proper allocation of resources.
- Develop occupation / competency standards for the RE / EE sector
- Development of new programmes / trainings: For the integration of further modules on RE /EE or the development of new qualifications, the TVET institutions should seek advice from specialized training institutions in this area.
- As is already being done, aim for high standards and comparability through national or international certification of existing or new curricula.
- Train the existing teacher staff / instructors in RE/EE related skills: As knowledge gaps related to RE/EE have been identified within the existing teacher staff, they should be encouraged and supported by the TVET organisations to gain on-the-job experience and seek further training.
- Enhance equipment and materials for students: The teaching within the TVET sector takes a very practical approach, therefore suitable equipment and material needs to be available for the students (e.g., related to RE technologies). In case students should receive online training, it also needs to be ensured that they have access to a reliable internet connection and a device (e.g., tablet).

- Launch a more continuous exchange with the private sector: Within the TVET sector, there should be a mutual exchange on the skill demand regarding RE/EE. As a lot of programmes are designed as apprenticeships, the TVET organisations already maintain an exchange with private sector institutions.

8 Conclusion

Bangladesh has made progress in increasing the amount of RE in its energy mix. While, it has also set targets for the RE amounts to be in the 2030 and 2041 mix, the country also works to reduce energy waste through EE measures. The study has seen that, despite notable progress in embracing renewable energy (RE) and energy efficiency (EE) measures to meet increasing energy needs and address environmental concerns, a key obstacle remains: a skills gap in the local labour market. There is little or unavailability of skilled workforce source existing at the level of TVETs. So far, the workforce present in the country is being trained by the industry.

Through this study, information about the broad skills present in Bangladesh in the different sectors was identified. The occupational structure of each sector and the minimum level of educational qualification and experience were identified. With this information valuable insights on the mismatch between the actual and desired level of skills across occupations, hard-to-fill occupations or skill shortages, and employer's perception of employees' skill levels needed helped the analysis and conclusions of the skill gaps. The provided information enabled the identification of the trainings needed to support skills development in Bangladesh.

9 Recommendation for building up a skilled RE/EE workforce in Bangladesh

The Government of Bangladesh is putting a lot of effort in its energy transition plans which focuses on usage of more renewable energy and applying energy efficiency method. With these efforts, it is clear in this study that a large number jobs will be created between 2024 and 2041. A total 14,156.9 of "full-time equivalent job-years" in Renewable Energy (RE)/Energy Efficiency (EE) currently exist in 2024, which is to increase to 19,700.8 by 2030 and 33,130 by 2041 based on the Bangladesh's targets according to its Integrated Energy and Power Master Plan (IEPMP) 2023 [6]. The country therefore is in need of building up its pool of skilled workforce according to the value chain of each technology.

In order to achieve this workforce pool which will enable Bangladesh reach its planned RE and EE goals, RENAC strongly recommends the development of a comprehensive long-term strategy (roadmap) for skills development and TVETs in the areas of RE and EE. The setting-up of this roadmap requires the input of all relevant stakeholders on the need for skills development most especially through TVETs. These players should together put forth actions that are to be carried out to fill the identified skill gaps.

It is recommended that Bangladesh starts the process of building this needed workforce by putting in place standard education and training services so as to create the foundation of the skills and the knowledge. While putting in place standard education, Bangladesh should consider the fact that individuals can develop competencies in the RE/EE profession through a combination of on-the-job training and attending training courses with proof of competency being achieved via an examination (or assessment). As such the RE/ EE industry in Bangladesh should be highly involved in the development of this strategy and equally provide employment. The private sector can further strengthen this approach by collaborating with TVET centres and also providing employment only to persons with prove of skills and competences via certification.

In all the roadmap should take the following points into consideration as to how to foster skills development in the RE/ EE industry while including the steps below in their plan.

- There is the need to establish training in RE and EE sector in Bangladesh, get them accredited so that certificates can be recognised in Bangladesh and beyond the country.
- Trainers and training infrastructures are also greatly needed.
- University could include these subjects in existing programmes and graduate studies.
- Women are rarely seen in the field of RE/EE. They should be engaged in the sector. There should be a strategy to build awareness and encouraging women to be part of this sector.
- TVET should work with the private sector to build the needed skills

Step 1: In-depth assess of skills demand

In the course of the study, the role of the different skill councils was identified in the development of the skills needed in a certain industry. The National Skills Development Council (NSDC) which is the apex authority on skills in Bangladesh has been working on defining occupational skill for EE auditors. The NSDC in collaboration with the industry should carry out an in-depth assessment of the various skills needed in the 10 RE/EE sectors. This will also require NSDC to have institutional capacity building as well as support to the industry.

Step 2: Occupational standards

TVET curriculums are usually based on skills needed in the industry which are spelt out in occupational standards. As per the study, the country needs persons along the value chain of all 10 sectors. There is a high need for installation as oppose to manufacturing and O&M. RENAC recommends occupational standards for installation, the operation and maintenance. Manufacturing should only come in depending on the industry in place.

Step 3: Training curriculums and certification

Once the occupational standards are in place, BTED should take upon itself to develop the hands-on training curriculum for TVETs according to the skills needed in this study. The training curriculums courses should be a specialty in existing qualifications programmes such as electricity, plumbing, masonry etc. This is because for work in the RE/ EE sector one also needs complimentary skills. The curriculum should also be accompanied by a rigorous assessment and evaluation systems before certificates are awarded.

Step 4: Setting up TVET training centres

Well-equipped training centres are the backbone of hands-on training. A visit of a TVET centre in Dhaka showed it is equipped for other occupations like tailoring and electricity. For skills to be developed for all 10 sub-sectors, there should be the establishment well equipped TVET centres. These centres should be assessable to both the rural and urban population. Mobile training Centres is also an option.

Step 5: Building up a local trainer pool through Train-the-Trainer trainings.

Select trainers from BTEB, other training institutions and from the industry who are knowledgeable in the areas. Conduct Train-the-Trainer programmes comprising preparatory online trainings, face-to-face trainings, and exams (both theoretical and practical). These Train-the-Trainer programmes should be technicians Train the Trainers (T-t-T).

Step 6: Awareness and collaboration with the industry

Skills acquired by hands-on training at school should be complemented by real life experience which can be gotten by through internships. The industry should be involved to get persons on board to acquire these skills

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11 Annexes

Annex 1: key studies and datasets used to derive the employment factor for the respective technology categories

Renewable energy (solar PV energy, wind energy, biogas)

- IRENA, 2023. Renewable energy and jobs: annual review 2023.
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- International Energy Agency, 2022. World Energy Employment.
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- Net Zero Australia (University of Melbourne, The University of Queensland, Princeton University and management consultancy Nous Group), 2022.
- Employment impacts – modelling methodology & preliminary results.
- Global Wind Energy Council, 2023. Global Wind Report 2023. Power grid expansion / smart grids
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- American Recovery and Reinvestment Act

Energy storage

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Energy efficiency, and energy management / auditing

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Annex 2: Questionnaire to RE/EE companies

Study on Skills Gaps and Local Labour Market Needs for RE/EE in Bangladesh

Invitation for RE/EE companies to participate in a survey

Dear Sir/ Madam,

The experience of German development cooperation in Bangladesh has shown that insufficient knowledge and a lack of skilled personnel in the energy sector are major barriers to the implementation of the energy transition in the country. The project "Skills Development for Sustainable Energy Solutions" (Skills4SE) by the GIZ is to create the necessary conditions for an improved range of vocational education and training opportunities in the energy sector that are adapted to the requirements of the labour market.

One of the indicators of the project is to have a long-term strategy for education and training in EE and grid-connected RE that is aligned with the needs of the labour market. For this, there needs to be an analysis of the market to identify the skills that are needed but lacking. RENAC is currently undertaking a country assessment to identify the skills needed so as to be able to recommend ways of reducing the skills gaps in the energy transition in Bangladesh.

With this survey we would like to get your input and recommendations for the skills needed in your country. As such, this questionnaire is aimed to collect information about the employment structures, needs, expectations and criteria of the enterprises operating in the renewable energy/ energy efficiency sector, the difficulties encountered in meeting the employment needs, and the trainings organized for the employees who have started to work in the enterprise.

It would be great if you can devote 20 minutes of your time to fill out the questionnaire.

Thank you in advance for your cooperation! With kind regards on behalf of GIZ,

Berthold Breid
Director RENAC

Consent Form

Within the scope of the survey, your answers will be kept completely confidential and anonymous. Your responses will not be shared with third parties under any circumstances. Your answers to the questions will be analysed and reported collectively after all the data are combined. Detailed explanations of the study will be given by the expert who will apply the questionnaire. We thank you for your time and interest in the project.

I agree to participate in this research voluntarily. ☐ Yes ☐ No

Questions for Companies

General Information

1. Please provide some information about your Enterprise:

Name of Enterprise:	Click to type text.
Where it is located:	Click to type text.
Year it was founded:	Click to type text.
E-mail:	Click to type text.
Respondent's role in the company? (please select one)	☐ Business owner / senior manager ☐ Human resources / personnel manager ☐ Other (Explain Click to type text.

Company Information

2. What is the main activity of the enterprise you represent? If more than one, highest income activity. (Please mark all the activities that apply).

	Market segment		
Re /EE market segments	Energy production	Service provider	Manufacturer
• Solar photovoltaic energy	☐	☐	☐
• On-shore wind energy	☐	☐	☐
• Biogas systems	☐	☐	☐
• Power grid expansion / smart grids	☐	☐	☐
• Energy storage (battery energy storage systems)	☐	☐	☐
• Energy management / auditing	☐	☐	☐
• Energy efficiency in commercial / residential buildings	☐	☐	☐
• Energy efficiency for industrial production (RMG / textiles, fertilizers, etc.)	☐	☐	☐
• Energy efficiency in the refrigeration and air conditioning (RAC) sector	☐	☐	☐
	Annual Production / distribution capacity (MW): Click to type text.	How much of your services it covers in %? Click to type text.	How much of your production does it cover in %? Click to type text.

3. How many people work in your business?
   a) ☐ 1-9 full time employees
   b) ☐ 10-49 full time employees
   c) ☐ 50-249 full time employees
   d) ☐ More than 250 full time employees

4. How many people were working in your business a year ago?

Click to type text.

Employment

5. Please specify the number and type of staff currently working in your company the field of RE / EE.

	Staff	***Number Male***	***Number Female***
Engineers	Electrical / electronics engineer		
	Civil engineer		
	Mechanical Engineer		
	Environmental Engineer		
	Energy Engineer		
Technician	Electrical technician		
	Construction technician		
	Machine technician		
	Energy Efficiency Auditor		
	Unskilled or semi-skilled staff with non-formal education and degree		
	Other, please specify: Click to type text.		

Company skills and occupational needs

6. Are you currently looking for employees in your workplace? ☐ Yes ☐ No

7. In what ways do you generally search to fill vacant positions?

item	
Kaj Bangla	☐
Newspaper advertisement	☐
Internet - social media (career sites)	☐
Relative - spouse, friend	☐
Through my own employees	☐
Private employment agencies	☐
Career fairs	☐
TVET collaborations	☐
University collaborations	☐
Other, please specify: Click to type text.	☐

8. Provide details about open positions in your company and indicate the gender you are looking for (1=female, 2=Male or 3=Gender does not matter)

	The vacant position	**Number of vacancies**	**Gender**
1	*Click to type text.*		
2	*Click to type text.*		
3	*Click to type text.*		
4	*Click to type text.*		
5	*Click to type text.*		

9. How many employees do you expect to have in your organization after a year? Where needed, specify how much you expect it to be.

 a. ☐ More Click to type text.   b. ☐ Less Click to type text.

c. ☐ Same number Click to type text.
d. ☐ No idea

10. Indicate the positions in which you have experienced difficulty recruiting staff within the last year, the number of people you have searched for these positions and the reason for difficulty in the recruitment.

			Reason for Difficulty in Recruitment (multiple responses)						
	Positions difficult to obtain	**# of people who were needed**	*Insufficient number of applications*	*Lack of necessary professional skills / qualifications.*	*Lack of sufficient work experience.*	*Unpopular working environment and conditions*	*Higher salary expectation*	*Having shift work*	*Being a dangerous or very dangerous profession*
1	*Click to type text.*		☐	☐	☐	☐	☐	☐	☐
2	*Click to type text.*		☐	☐	☐	☐	☐	☐	☐
3	*Click to type text.*		☐	☐	☐	☐	☐	☐	☐
4	*Click to type text.*		☐	☐	☐	☐	☐	☐	☐
5	*Click to type text.*		☐	☐	☐	☐	☐	☐	☐

Labour market overview and investment

11. What will be the reflection of technological advancements on employment in your sector in the next 10 years?

a. ☐ Increase in employment
b. ☐ decrease in employment
c. ☐ No change
d. ☐ No idea

12. What are the criteria are you looking for in your selection of personnel in general? (please select the 3 most important)

a) ☐ Practical skills
b) ☐ Theoretical knowledge
c) ☐ Driving licence
d) ☐ Work experience
e) ☐ Reference
f) ☐ Computer and technology skills
g) ☐ Age
h) ☐ Foreign language
i) ☐ Certificate of professional competence
j) ☐ Business environment skills (communication, motivation, problem, solving ability, work ethic, stress management, etc.)
k) ☐ School of graduation
l) ☐ Compliance with shift working hours
m) ☐ Other (please explain) Click to type text.

13. Do you have an investment planning in the field of RE/ EE in coming years? ☐ Yes ☐ No

Training

14. Does your company offer specific in-house training?

a. ☐ Yes. Which ones? Click to type text.

b. ☐ No

15. If you answered 'yes' to the question above, what is the main reason(s) for doing so?

a) ☐ There is lack of relevant training programs.

b) ☐ Entry-level personnel acquire fundamental skills at training centres, but usually require more specific training.

c) ☐ The company always requires internal training for its services.

d) ☐ Other reasons. Please specify.Click to type text.

16. For whom are these trainings organized. (More than one can be selected)

a. ☐ New staff

b. ☐ Experienced employees.

c. ☐ Production and field workers.

d. ☐ Office and administrative staff

17. Are you collaborating with vocational or private training providers? If so, how?

Click to type text.

18. Does your company recruit interns? ☐ Yes. ☐ No

19. If yes above, how many apprentices / trainees did you have last year, what sector and gender?

		Number and gender		
	Position	**Number**	**Male**	**Female**
1	Electrician			
2	Electrical /electrotechnology			
3	Plumber			
4	Business administration			
5	Technicians			
6	Others: *Click to type text.*			

20.

Further

21. Please describe any specific recommendations you may have for the assignment team of this project.

Click to type text.

Annex 3: Category of jobs considered within this study

Jobs	Description
Manufacturing	Covers the number of jobs necessary to manufacture a unit of power generation capacity. Manufacturing of equipment and components for a power plant project may require several weeks, months or at most a few years' worth of work. As such, they represent relatively temporary employment in comparison to the entire plant lifetime. Hence, they are expressed as job-years, or the total number of full-time jobs needed for manufacturing over the plant's lifetime (IRENA, 2013).
Construction and Installation	Includes all the jobs associated with constructing and installing a unit of power generation capacity. It is assumed that a local workforce will undertake the installation and construction of all energy projects, as is in most cases. These are also expressed as job-years, or the total number of full-time jobs needed for construction and installation over the plant's lifetime. These jobs are predominantly in the beginning phase of a power plant (that is in the first few years) and last during the period in which the power plants are built until the first operation.
Operation and Maintenance	Comprises all the jobs associated with operating and maintaining the operational condition of a power plant over its technical operational lifetime. As power plants are usually designed to run for decades, operation and maintenance jobs last for a relatively longer duration and therefore interpreted as jobs per capacity of power generation. These jobs are considered for the lifetime of the respective power plants and are further annualised to get total number of jobs during the transition period.
Decommissioning	Consists of all jobs associated with the decommissioning of installed power plants at the end of their operational lifetimes, especially if plants are repowered or if certain elements are recycled or reused. These jobs are comparable to construction and installation jobs and are expressed as job-years, or the total number of full-time jobs needed for decommissioning over the plant's lifetime. These jobs are further annualised during the transition period to derive the total number of jobs created.
Transmission	Includes all the jobs associated with power transmission activities. In context to this study, transmission jobs are expressed in terms of investments made in transmission infrastructure, i.e., jobs per unit investments (in billion euros).

Annex 4: Key Informant Interviews Respondents

Cohort	Respondents	KII No
Policy makers and government	• Power Division • Bangladesh Power Development Board (BPDB) • Power Cell of the Ministry of Power, Energy, and Mineral Resources (Power Cell)	4
Skills development organisations	• Sustainable and Renewable Energy Development Authority (SREDA) • National Skills Development Authority (NSDA) • Bangladesh Technical Education Board (BTEB) • Bureau of Manpower, Employment and Training (BMET)	4
Development partner	• GIZ	1
Industry association	• Bangladesh Garment Manufacturers and Exporters Association (BGMEA) • Bangladesh Sustainable and Renewable Energy Association (BSREA)	2
Private sector agency/ trade organisations	• Informal Sector Industry Skills Council (ISISC) • Construction Industry Skill Council (CISC) • Metropolitan Chamber of Commerce and Industry, Dhaka (MCCI)	3
Private Organizations and Research Organization	• Bangladesh Auto mobile industries ltd. (BAIL) • Manusher Jonno Foundation (MJF) • House Building Research Institute (HBRI)	3
Private Organization	• ActionAid Bangladesh AAB (Just Energy Transition)	1
Training institutions	• Underprivileged Children Education Programmed (UCEP) • Bangladesh Power Management Institute (BPMI)	2
Gender experts	• Bangladesh Women Chamber of Commerce and Industry (BWCCI)	1

Annex 5: key policy, regulations, guidelines and national action plans that aim to support energy development goals [83]

Energy policies	
Policy	**Intended action**
National Energy Policy, 1996 (MPEMR, 1996)	– To provide energy for sustainable economic growth – To ensure optimal development of all indigenous energy resources – To ensure environmentally sound sustainable energy development
National Energy Policy 2004 (MPEMR, 2004a)	– To bring the entire country under electrification by 2020 – To ensure a reliable supply of energy to the people at a reasonable and affordable price – To develop a regional energy market for rational exchange of commercial energy to ensure energy security
Remote Area Power Supply System (RAPSS) Guidelines 2007	–
Private Sector Power Generation Policy Revised, 2004 (MPEMR, 2004b)	– Key fiscal incentives: IPPs are exempt from corporate income tax, and allowed to import plant and equipment and spare parts; foreign lenders are exempt from income tax in Bangladesh; and foreign investors will be free to enter into joint ventures.
Statutory Regulatory Order 2004: Import Duty Exemptions for Solar and Wind (NBR, 2004)	– This order creates an exemption in import duties for certain renewable energy products, particularly photovoltaic cells, even if they are assembled into modules or panels and solar powered lantern/lamps having no provision for electrical power.
Renewable Energy Policy, 2008 (MPEMR, 2008c)	– To harness the potential of renewable energy resources and technologies everywhere, encouraging and facilitating both public and private sector investors – To scale up the contribution of renewable energy to power generation – To promote and train efficient and environmentally friendly use at every level of energy usage – To produce 5% of the total electricity demand from renewable energy by 2015 and to increase the portion to 10% by 2020. In comparison, the country achieved only 1.01% percent of total demand by 2021 – Develop financing mechanisms and facilities for public and private sector investments in all forms of sustainable energy. – Renewable energy project investors in both the public and private sectors should be exempt from corporate income tax for a period of five years. – An incentivized tariff may be considered for electricity generated from renewable energy sources; the tariff may be 10 percent higher than the highest purchase price of electricity by the utility from private generators.

	– All renewable energy equipment and related raw materials used in manufacturing renewable energy equipment will be exempt from the applicable 15 percent VAT rate [63].
Policy Guideline for Enhancement of Private Participation, 2008 (MPEMR, 2008b)	– To promote further private participation, harness competition, ensure optimal use and conservation of gas resources – To develop local private sector entrepreneurship to develop power projects – The government intends to allow the private sector to 1) set up commercial power plants, 2) use transmission and distribution lines of the PGCB, 3) rehabilitate old and inefficient power plants and 4) develop new joint venture power plants in partnership with public sector power utilities
Policy Guideline for Small Power Plants (SPP) in Private Sector 2008 (MPEMR, 2008a)	– To allow for fast-track private sector establishment of SPPs for their own electricity needs, and to sell the surplus to others. SPPs are to be developed with a capacity of 10 MW or less (larger plants are possible with government permission) and are to be established on a build-own-operate basis.
Bangladesh Climate Change Strategy and Action Plan, 2009 (MoEF, 2009)	– The Government of Bangladesh adopted the Climate Change Strategy and Action Plan, which is built on six pillars and a total of 44 programs. Renewable energy development is listed as the fourth program out of ten programs under the fifth theme titled "Mitigation and Low Carbon – Development." The objective of this program is to maximize the use of renewable energy sources to lower GHG emissions and ensure energy security.
Sustainable and Renewable Energy Development Authority Act, 2012 (MPEMR, 2012)	– SREDA is authorized to organize the renewable energy sector to maintain coordination among the private and public sector; to promote, facilitate and disseminate sustainable energy; and to ensure the energy security of the country.
Guidelines for the implementation of solar power development program, 2013 (MPEMR, 2013)	– Promote environment-friendly power generation considering the – potential of solar energy, – Enhance and improve solar technology, – Attract donor organizations and private investors to invest in the solar technology as an art of renewable energy, – Reduce the use of fossil fuels by using the potentials of solar energy, – Achieve "green energy," – Create public awareness of rooftop solar systems, and – 7) Decrease the dependency on imported liquid fuel via solar-powered irrigation pumps.
Energy Efficiency and Conversation Master Plan up to 2030, 2015 (MPEMR, 2015)	– To improve energy intensity – To save a total of 95 million tons of oil equivalent by 2030 – Energy savings will amount to BDT 768 billion – To decrease the amount of fuel imports for power generation, resulting in a cumulative savings of BDT 2.3 trillion between 2015 and 2030

Power Sector Master Plan 2016 (PSMP, 2016)	– Five viewpoints of PSMP 2016: – Enhancement of imported energy infrastructure and its flexible operation – Efficient development and utilization of domestic natural resources – Construction of a robust, high-quality power network – Maximization of green energy and promotion of its introduction – Improvement of human resources and mechanisms related to the stable supply of energy – 10 percent share of RE-based power generation capacity by 2021 (PSMP 2016); 2470 MW equivalent to 10 percent share of RE based power
Net Metering Guideline, 2018 (MPEMR, 2018)	– To utilize rooftop space as a response to land scarcity, increase the contribution of renewable energy and reduce the dependency of grid electricity with additional earnings
Bangladesh Delta Plan 2100 (Planning Commission, 2018b)	– The General Economics Division of the Bangladesh Planning Commission formulated the Bangladesh Delta Plan 2100, which as approved by the government in September 2018. It is the first report to combine long-term strategies and subsequent interventions for ensuring long-term water and food security, economic growth and environmental sustainability while – effectively reducing vulnerability to natural disasters and building resilience to climate change and other delta challenges through robust, adaptive and integrated strategies and equitable water governance. This report is also important for the renewable energy project because it has guidelines for the potential usages of land.
Renewable Energy Development Target, 2015-2021	–
National Solar Energy Roadmap 2020	–
Renewable Energy Policy of Bangladesh 2022	– The 'Renewable Energy Policy (Draft) 2022' covers more aspects than its predecessor, 'Renewable Energy Policy 2008'.
Integrated Energy and Power Master Plan (IEPMP) 2023	– This policy guideline outlines the installation target, the environmental and social considerations, the institutional framework and some issues regarding the grid integration. While the IEPMP 2023 does not delve into specific policy details like feed-in tariffs or subsidies, it provides a comprehensive overview of the government's plans and aspirations for developing the on-shore wind sector in Bangladesh (Ministry of Power Energy and Mineral Resources GOB, 2023).
National Development Plans	
Policy	**Intended action**
Bangladesh Delta Plan 2100 published in 2018	
Perspective Plan of Bangladesh 2021-2041	

Eighth Five Year Plan 2020-2025	
Climate policies	
Policy	**Intended action**
Mujib Climate Prosperity Plan (MCPP) 2023-2041	– The Mujib Climate Prosperity Plan (MCPP) 2023-2041 focuses more on the broader vision for climate change adaptation and economic prosperity, with less emphasis on specific policy details for individual renewable energy sources like wind power. While the MCPP mentions the Bongoposagor Independence Giga Array project, which includes a large-scale offshore wind component, it doesn't directly discuss on-shore wind policies. However, the MCPP does emphasize the overall government commitment to increase the share of renewable energy and transitioning towards a low-carbon economy (Ministry of Environment Forest and Climate Change - Government of the People's Republic of Bangladesh, 2022).
Nationally determined contributions (NDCs)	– Bangladesh's NDC to reduce GHG emissions by implementation of RE projects of 911.8 MW (unconditionally) and by 4114.3 MW (with international support) by 2030 and 30% percent share of VRE-based power generation capacity by 2030, 40% by 2041, and 100% by 2050 (Mujib Climate Prosperity Plan 2030).
Bangladesh Climate Change and Gender Action Plan (ccGAP) 2013	–
National Adaptation Plan 2023-2050	–
Other policy guidelines	– The Bangladesh Energy Regulatory Commission Act, 2003 – Policy Guidelines for Power Purchase from Captive Power Plant, 2007 – Policy Guidelines for Public Private Partnership – Guidelines for Remote Area Power Supply System (RAPSS), 2008 –

Bangladesh has several policies and laws on Energy Efficiency and Conservation sector. These are:

a) The Bangladesh Private Sector Infrastructure Guidelines
b) National Energy Policy 1996
c) The Energy Efficiency and Conservation Rules, 2016
d) Action Plan for Energy Efficiency and Conservation 2013
e) The Energy Audit Regulation, 2018
f) Energy Efficiency and Conservation Master Plan up to 2030 published in 2014
g) Bangladesh National Building Code 2020
h) 8^{th} Five Year Plan
i) Electric Vehicle Charging Station Guideline, 2022
j) Country Action Plan for Clean Cookstoves, 2013

Annex 6: NTVQF levels, qualification and job classification in Bangladesh

NTVQF Level	Pre-Vocational Education	Vocational Education	Technical Education	Job Classification	Job description
NTVQF 6			Diploma in Engineering or Equivalent	Middle level Manager / Sub Assistant Engr. etc.	Manage a team or teams in a workplace where unpredictable change exists
NTVQF 5		National Skill Certificate 5 (NSC 5)		Highly Skilled Worker/Supervisor	Take overall responsibility for completion of tasks in work or study
NTVQF 4		National Skill Certificate 4 (NSC 4)		Skilled worker	Take responsibility, within reason, for completion of tasks in work or study
NTVQF 3		National Skill Certificate 3 (NSC 3)		Semi-skilled worker	Work under supervision with some autonomy
NTVQF 2		National Skill Certificate 2 (NSC 2)		Basic-Skilled worker	Work under indirect supervision in a structured context
NTVQF 1		National Skill Certificate 1 (NSC 1)		Basic worker	Work under direct supervision in a structured context
Pre-Voc 2	National Pre-Vocation Certificate 2 (NPVC 2)			Pre-vocational trainee	Work under direct supervision in a well-defined, structured context
Pre-Voc 1	National Pre-Vocation Certificate 1 (NPVC 1)			Pre-vocational trainee	Simple work under direct supervision in a well-defined, structured context

Annex 7: Existing RE Trainings and Facilities in Bangladesh

1. **Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.**

Course name	Electrical Installation and Maintenance Level- II
Level	Bangladesh National Qualification Framework (previously known as National Technical and Vocational Qualifications Framework (NTVQF)
Duration	360 hours
Required qualification	Junior School Certificate with NTVQF I certificate
Final qualification	NTVQF-II
(NTVQF)Fee	As set by the training institute
Content	This is a competency-based curriculum designed for unemployed and underemployed people to enhance their knowledge, skills and attitudes for an Electrical Installation and Maintenance occupation meeting the industry standards. The curriculum covers various competencies such as installing socket, performing concealed work, conduct wiring and electrical home appliance repairing.

Course name	Work in Solar Home System (SHS) service industry. (Course code INF1 001)
Level	NTVQF level II
Duration	24 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF)Fee	As set by the training institute
Content	a) Describe the activities performed in Solar Home System (SHS) service industry. b) Identify workplace Requirements. c) Identify tools, equipment and materials to install and operate an SHS unit. d) Observe OSH status in the SHS service industry.

Course name	Use concept of climate change, renewable energy and solar energy (Course Code: SHS1 001A1)
Level	NTVQF level II
Duration	10 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF)Fee	As set by the training institute
Content	1. Explain climate change and its causes, 2. Explain impact of climate change, 3. Explain role of renewable energy to mitigate climate change.

Course name	Apply basic electrical concept and circuits (Course Code: SHS1002A1)
Level	NTVQF level II
Duration	30 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF)Fee	As set by the training institute
Content	1. Practice OSH, 2. Apply electrical concept and working principle, 3. Explain the principle of electricity generation, 4. Use electrical conductor, semiconductor and non-conductor, 5. Perform wiring and circuits

Course name	Install Solar Home System (SHS) (SHS 1 003 A1)
Level	NTVQF level II
Duration	40 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF)Fee	As set by the training institute
Content	1. Follow OSH practices, 2. Set the solar panel, 3. Locate and prepare place on the roof top, 4. Install panel and accessories, 5. Set and test connections of SHS, 6. Clean and store the tools and equipment

Course name	Make trouble shooting for SHS Course Code: (SHS1005 A1)
Level	NTVQF level II
Duration	26 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF)Fee	As set by the training institute
Content	1. Diagnose faults in SHS units and wiring, 2. Repair the faults in SHS unit and wiring, 3. Clean and store the tools and materials.

Course name	Assemble charge controller, inverter and light fixtures (Course SHS1 006)
Level	NTVQF level II
Duration	30 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF) Fee	As set by the training institute
Content	1. Collect different parts of charge controller, inverter and light fixtures, 2. Solder the elements on PCB, 3. Check the function of assembled unit of charge controller and inverter, 4. Clean the tools and workplace,

Course name	Carry out customer counselling and marketing of SHS (Course No. SHS 1 007 A1)
Level	NTVQF level II
Duration	40 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF) Fee	As set by the training institute
Content	1) Identify and select potential market and customers, 2) Establish friendly relation with customer, 3) Counsel the customer on SHS benefit, 4) Motivate target customer for purchasing SHS

Course name	Manage inventory and storage of SHS equipment and accessories (Course Code SHS1 008A1)
Level	NTVQF level II
Duration	16 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II

(NTVQF) Fee	As set by the training institute
Content	1) Prepare storage place, 2) Prepare inventory book for control and records, 3) Manage inventory

Course name	Collect instalment and maintain accounts (Course Code SHS1 009A1)
Level	NTVQF level II
Duration	30 hours
Required qualification	Junior School Certificate with NTVQF I certificate N.B. Accredited providers assessing against this unit of competency must meet the quality assurance requirements set by BTEB.
Final qualification	NTVQF-II
(NTVQF) Fee	As set by the training institute
Content	1) Prepare customer list and instalment collection schedule, 2) Collect instalment, 3) Enter data to cash and ledger book.

2. **Training offered by BPMI**

Course name	Training on Design and Implementation of Solar Power Plant
Level	On job training
Duration	78 hours (13 days- 10 days class room+ 3 days field visit)
Required qualification	Assistant Engineers to Superintending Engineers
Final qualification	Certificate
(NTVQF) Fee	Cost covered by respective entities under the power division
Content	1) Study of Solar Radiation and PV materials, 2) Solar Energy Technology, 3) Global Needs and Scope of Solar Power Plant, 4) Electrical & Electronic Engineering of Solar Cell Equipment, 5) PV Electricity Production, 6) Justification of using Different Types Equipment: (PV Module, Inverter, etc.) Electrical Drawing (SLD, Substation Layout, Earthing and LPS) and Design, 7) Feasibility Study and Design of a new Solar Power Plant Project, Fundamentals of Inputs: Assessing Site Conditions Geographical & Meteorological Parameter Analysis 8) Mechanical and Electrical Designing of a new Solar Power Plant, 9) Demonstration of Simulation Tools (SAM/ PVSyst), 10) Selecting suitable PV technology (Case Basis), 11) Simulation Test, 12) Designing Test, 13) System Analysis Test, 14) Conceptual Design for Preferred Variant, 15) Hybrid Plant Operation, 16) Detail Modelling of Solar Power Plant and Component wise parametric Analysis, 17) Software/Simulator (RETScreen) for Financial and economic analysis of a Solar power plant model, 18) Designing of Grid Tied Solar Park, 19) Design Variants, 20) Site Condition, 21) HOMER software for microgrid and distributed generation power system design and optimization, 22) Development Project Proposal of Solar Power Plant Project (Project description & preparation according to DPP format; Objective, Target, Log Frame; DPP Approval Procedure), 23) Development Project Proposal (DPP) for Solar Power Plant (Cost Estimation; Cash Flow; Operating Cost and relative Profit calculation; Financial & Economic Analysis: Discount Rate; BCR, NPV, IRR; Project Viability 24) Development Project Proposal (DPP) for Solar Power Plant (Prospects and Challenges of

	Renewable Energy Development in Bangladesh, Legal Framework of Renewable Energy in Bangladesh, Renewable Energy Development in Bangladesh: Role of SREDA, Introducing Floating Solar PV Technology in Bangladesh, Basic of Solar Power Plant; Government Planning on Solar Power Plant; Solar Power generation scenario in other countries), 25) Project Model, 26) Structure of the Feasibility Study Report of the PV System, 27) Economic Analysis of Solar Power Generation Project, 28) Summary of Financial and Economic Assessment, 29) Financial Analysis of Solar Power Generation Project, 30) Tariff Modelling & Exercise, 31) Tariff negotiation on unsolicited Solar Power Project, 32) Billing, Payment, Liquidated Damages; 33) Termination and Compensation , 34) Field Visit on the study of Soil test, Erection and Structural Issues of Solar Power Generation System; 35) Report Presentation

3. **Power and Energy Training Academy (PETA), United International University**

Course name	Course Name: Certificate Course on “Operations & Maintenance of Power Plant”17
Level	certificate course
Duration	40 Hours (4 Months) Friday (9:30 AM to 12:30 PM)
Required qualification	Anyone of the following four Electrical & Electronics Engineering students Mechanical Engineering students Marine Engineering students Graduates and Trainee Engineers. (MSc/BSc/Diploma Engineers
Final qualification	Certificate
(NTVQF) Fee	After 30% discount: BDT 15000 = 135 $ (4.3.2024) Admission fee: BDT 500 = 4.50 $
Content	Standard Operation Philosophy (SOP) of Power Plants. Integrated Load Management System Procedures of Power Plant. Internal Combustion Engine Details, Different Systems Associated with the Engine & Its Power Plant Application. HFO Handling, Processing System & Treatment Procedures, and Troubleshooting. Introduction to the Governing & Control System of the Power Plant. How to Read Electrical Systems Drawings & Troubleshooting Procedures. Mechanical Major Overhauling Procedures for Scheduled & Unscheduled Maintenance. Introduction to the Protection Systems for Gensets, and Feeders. Introduction to the Co-generation Power Plant Operations & Heat Recovery Steam Generator (HRSG) System. Lube Oil System & Quality Analysis. Cooling Water System & Quality Analysis. Industrial Sensor Applications & Calibration Technics. Introduction to the LV, MV, and HV Switchgear and Application in Power Plants.

[17] *https://eee.uiu.ac.bd/news/power-energy-training-academy-peta-uiu/*

	Insulation Resistance (Megger) Testing Procedure of different Electrical Equipment. Electrical System Introduction for a Power Plant. Different Types of Pumps' & Motors' Principles & Applications in Power Plant.

4. Bangladesh University of Engineering and Technology (BUET)

Course name	Optoelectronics (Course code EEE 459)
Level	Under- graduation in Electrical and Electronics Engineering
Duration	3 Credit Hours, 3 Contact Hours per Week
Required qualification	Higher Secondary School Certificate
Final qualification	BSc in EEE (partial completion)
(NTVQF) Fee	As set by the University
Content	Optical properties in semiconductor: Direct and indirect band-gap materials, basic transitions in semiconductors, radiative and non-radiative recombination, optical absorption, photo-generated excess carriers, minority carrier life time, luminescence and quantum efficiency in radiation. Properties of light: Particle and wave nature of light, polarization, interference, diffraction and blackbody radiation. Light emitting diode (LED): Principles, materials for visible and infrared LED, internal and external efficiency, loss mechanism, structure and coupling to optical fibers. Double-Hetero- structure (DH) LEDs, Characteristics, Surface and Edge emitting LEDs. Stimulated emission and light amplification: Spontaneous and stimulated emission, Einstein relations, population inversion, absorption of radiation, optical feedback and threshold conditions. Semiconductor Lasers: Population inversion in degenerate semiconductors, laser cavity, operating wavelength, threshold current density, power output, elementary laser diode characteristics, hetero-junction lasers, optical and electrical confinement. single frequency solid state lasers-distributed Bragg reflector (DBR), distributed feedback (DFB) laser. Introduction to quantum well lasers. Introduction to quantum well lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), optical laser amplifiers. Photo-detectors: Photoconductors, junction photo-detectors, PIN detectors, avalanche photodiodes, hetero-junction photodiodes, Schottky photo-diodes and phototransistors. Noise in photo-detectors. PIN and APD. Photo-detector design issues. Solar cells: Solar energy and spectrum, silicon and Schottkey solar cells. Modulation of light: Phase and amplitude modulation, electro-optic effect, acousto-optic effect and magneto-optic devices. Introduction to integrated optics.

Course name	Energy Conversion III (Course Code EEE 471)
Level	Under- graduation in Electrical and Electronics Engineering
Duration	3 Credit Hours, 3 Contact Hours per Week
Required qualification	Higher Secondary School Certificate
Final qualification	BSc in EEE (partial completion)

(NTVQF) Fee	As set by the University
Content	Basic principles of energy conversion: electromagnetic, electrostatic, thermoelectric, electrochemical, and electromechanical. Acyclic machines: generators, conduction pump and induction pump. Nonconventional energy conversion: solar-photovoltaic, solar-thermal, wind, geothermal, wave and tidal energy, MHD (Magneto Hydrodynamic) systems. Motors and drives: series universal motor, permanent magnet DC motor, brushless DC motor (BLDC), stepper motor, reluctance motor, switched reluctance motor, hysteresis motor, repulsion motor, permanent magnet synchronous motor, linear induction motor, electro static motor.

Course name	Renewable Energy (Course Code EEE 473)
Level	Under- graduation in Electrical and Electronics Engineering
Duration	3 Credit Hours, 3 Contact Hours per Week
Required qualification	Higher Secondary School Certificate
Final qualification	BSc in EEE (partial completion)
(NTVQF) Fee	As set by the University
Content	Renewable energy sources: Solar, wind, mini-hydro, geothermal, biomass, wave and tides. Solar Photovoltaic: Characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems, Maximum Power Point Tracking (MPPT): chopper, inverter. Sizing the PV panel and battery pack in stand-alone PV applications. Modern solar energy applications (residential, electric vehicle, naval, and space). Solar power plants connected to grid. Solar thermal: principles of concentration, solar tower, parabolic dish, receiver, storage, steam turbine and generator. Wind turbines: Wind turbine types and their comparison, power limitation, Betz's law; Control mechanism: pitch, yaw, speed. Couplings between the turbine and the electric generator, Wind turbine generator - DC, synchronous, self-excited induction generator and doubly fed induction generator. Grid interconnection: active and reactive power control.

5. **Institute of Energy; University of Dhaka**

Course name	Electrical and Electronic Devices (Couse Code MRET-102)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (3 credits)
(NTVQF) Fee	University of Dhaka sets the fees

Content	Electronic Devices: Semiconductor Materials, PN junction diode, BJT-construction and operation, BJT as a switch, MOSFET- types, construction, operation, MOSFET as a switch, IGBT- construction, construction, advantages and disadvantages of IGBT switch compared to others, Solar Cell-construction, operation and properties. Student will learn the detailed construction and operation of common electronics devices and their applications Electrical Machines: Transformer, Induction motor and generators, Synchronous generators, DC motor; Introduction to modern speed control techniques, Fuel cell- Introduction to the principles and operation of fuel cells, stack configurations and fuel cell systems. Fuel cell system design, optimization and economics. Overview of fuel cell technology. Thermodynamics of fuel cells, introduction to electrochemical kinetics, transport- related phenomena and conservation equations for reacting multicomponent systems. Power Transmission and Distribution, Power Quality and controls, Power factor Improvements Remote Sensing: Definition: Ideal Remote Sensing System, Sensors and Types, Remote Sensing Satellite, IRS and INSAT specifications, Applications of remote sensing, DIP Techniques. Electrical and Electronic Sensors GIS: Definition: Data and Types, Sources of data, Global Positioning System (GPS), Data Structure, Types of Analysis, Errors, Applications of GIS Sustainable Urban Development Planning using GIS. Environmental Degradation Assessment using RS and GIS.

Course name	Climatology (MRET 103)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (3 credits)
(NTVQF) Fee	University of Dhaka sets the fees
Content	Meteorology: Instrumentation, siting and measurement of solar radiation, sunshine duration, cloud cover, humidity, rainfall, temperature, wind speed and direction, dust, greenhouse gases, etc. Solar energy resource assessment: Solar constant, sun path, day length, solar and clock time, sunrise and sunset time, extra-terrestrial radiation, estimation of hourly and daily terrestrial radiation using different isotropic and anisotropic models, estimation of solar radiation on different tilted surfaces Wind energy resource assessment: Wind power density, turbulence intensity, gust, air density, wind speed variation with height: log law and power law, power coefficient of a wind turbine, Lancheter Betz limit, Weibull distribution of wind data: shape factor and scale factor, wind rose Atmospheric turbidity: spectral distribution of solar radiation at the top of the atmosphere and at the earth’s surface, air mass, aerosols, attenuation

	and scattering of solar radiation, atmospheric turbidity: Linke and Angstrom's turbidity coefficients Climate system and climate change: climate system and its components, atmospheric layers, vertical temperature and pressure profile of the atmosphere, lapse rate, global radiation balance, radiative forcing, natural and manmade radiative forcing, natural greenhouse effect and enhanced greenhouse effect, Necked planet and other anthropogenic climate models Greenhouse gases: chemical bond, stretching and bending vibration of bonds, types and sources of greenhouse gases, carbon cycle, water vapor window, band saturation effect, earth system climate sensitivity, global warming, global warming potential of greenhouse gases, models for GHG, global warming, global warming potential of greenhouse gases, models for GHG emission estimation Climate change mitigation policies and institution: UNEP, IPCC, WMO, UNFCCC, Kyoto protocol and carbon trading mechanisms, international emission trading, clean development mechanism, joint implementation, sequestering atmospheric Carbon di Oxide, carbon capture and storage.

Course name	Renewable Energy Technology (MRET 104)
Level	Masters Course
Duration	3 Credits of 1.5 years MSc programme
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (course complete)
(NTVQF) Fee	University of Dhaka sets the fees
Content	Solar Energy: Introduction, Solar Radiation, Collectors, Solar Cells, Applications of Solar Energy Wind Power plant: Introduction, Wind power density, Site selection Biomass Energy: Introduction, Biomass Conversion and Direct Combustion, Waste management, Biogas power plants Geothermal Energy: Introduction, Geothermal Resource Types, Resource Base, Applications for Heating and Electricity Generation. Tidal Energy: Introduction, Origin of Tides, Power Generation Schemes. Wave Energy: Introduction, Basic Theory, Wave Power Devices. Ocean Thermal Energy Conversion (OTEC)

Course name	Solar Photovoltaic Energy and System (MRET 203)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (course complete)
(NTVQF) Fee	University of Dhaka sets the fees
Content	Electrochemical Storage for Photovoltaics: General Concept of Electrochemical Batteries, Classification of Batteries in PV Systems; Lead Acid Battery: Construction, Chemical reaction, efficiency, effect of charging and discharging on available energy, DoD and effect of DoD on life cycle, Deep cycle and shallow cycle battery, VRLA, NiCd Batteries, Nickel-metal Hydride (NiMH) Batteries, Lithium-ion and Lithium-polymer Batteries, Double-layer Capacitors, ECS. Solar Cells and Modules: Construction and operation of solar cell, manufacturing process of solar cells, Equivalent circuits, I V curves, Effect of temperature, series resistance and shunt resistance, properties of efficient solar cells, Solar cells in series and parallel, construction of PV module, Shading effect and bypass diode. Power Conditioning for Photovoltaic Power Systems: Charge Controllers-classification, various set points of charge controller, circuit and operation of series, shunt and microcontroller-based charge controller, Maximum power point trackers, Inverters- Principle of operation, half bridge, full bridge, modified sine wave, sine wave inverter using PWM, specifications of inverter, Grid- connected Inverters PV in Architecture: PV in Architecture, Architectural Functions of PV Modules, PV as Part of "Green Design", PV Integrated as Roofing Louvres, Facades and Shading, Well-integrated Systems, Integration of PV Modules in Architecture, BIPV Basics Stand-Alone PV Systems: Solar Home Systems, Hybrid Systems their design and operations, Solar Water Pumping: Types of water pumping, Heads, different configurations of pump-motor systems, types of motors and pumps, design of solar water pumping system Utility interface PV systems: Decentralized Grid-Connected PV Systems, Central Grid- Connected PV Systems, Standardization of Interconnection Requirements, PV System Installation Considerations, Metering of PV System Output, Technical Considerations for Connecting to the Grid, IEEE Standard Issues, National Electrical Code Considerations, Other Issues; Small (<10 kW) Utility Interactive PV Systems-Array Installation, PCU Selection and Mounting, Other Installation Considerations Efficiency and Performance of PV Systems: Stand-Alone PV Systems, Grid-Connected PV Systems-Final Yield, Performance Ratio, Possibilities of Quality Control and Control of Energy Yield of Grid-Connected PV Systems, Long-Term Behaviour of Grid-Connected PV Systems Economic Analysis: Key Concepts, General Methodology, Life cycle analysis of power production chains, LCA of greenhouse gas emissions, Case Studies

Course name	Practical and Laboratory Experiments (MRET 204)
Level	Masters Course
Duration	6 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (course complete)
(NTVQF) Fee	University of Dhaka sets the fees
Content	The target of this course is to give practical concept of the theory described in various courses. Some example areas are mentioned below: Practical based on solar radiation measurement. Practical based on solar cells and PV modules. Practical based on charge controllers. Practical based on inverters. Practical based on water pumping system. Practical based on solar thermal systems. Practical based on solar home system/off-grid system. Practical based on Grid-Tied power system. Practical based on ICS performance study Practical based on biogas plant/Biomass Practical based on wind turbine and hybrid systems Practical based on Hydro/OTEC Practical based on EV, Fuel Cells Practical based on energy efficiency, energy audit, energy management. Practical based on Power Electronics Practical based on system design using RET screen/HOMER

Course name	Advanced Electronic of Photovoltaic System (MRET 301)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (Course complete)
(NTVQF) Fee	University of Dhaka sets the fees
Content	The pn junction: Periodic table, Crystal structure, the energy momentum diagram, density state's function, statistical mechanics, the semiconductor in equilibrium, the extrinsic semiconductor, built in potential barrier of a pn junction, pn junction as a diode, pn junction as a photovoltaic cell, efficiency limits, losses and measurement: spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization Crystalline solar cell preparation technology: standard and improved mono crystalline and poly crystalline silicon solar cell module technology, Module fabrication and testing, design of silicon solar cells Thin film solar cells: Amorphous silicon solar cells, micro morph, tandem and multi-junction solar cells, Concentrating solar cells, High efficiency solar cells, III-V, II-VI thin-film solar cells (GaAs, Cu (In, Ga) Se2, CdTe), PERL cells, (DSSC), Pervoskite thin film solar cells, etc.

	Thin film solar cell preparation technology: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), atmospheric pressure CVD, low pressure CVD, plasma assisted CVD, plasm enhanced CVD, high density plasma CVD, hot wire CVD, Epitaxy, MOCVD, MBE, VPE, etc. Characterization of solar cells: Scanning Electron Microscope (SEM), Secondary-Ion Mass Spectrometry (SIMS), Atomic Force Microscope (AFM), Transmission Electron Microscope (TEM), etc. Materials and devices for energy storage: Batteries, CNT in energy storage, Ultra-capacitors, Fuel cells, Superconducting Magnetic Energy Storage (SMES)

Course name	Solar Thermal Energy and System (MRET 302)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (3 credits)
(NTVQF) Fee	University of Dhaka sets the fees
Content	Solar Water Heating: Types of Solar Water Heater Natural and Forced Circulation Flat Plate Collector: Description of the components of Flat plate collectors Performance analysis (energy balance equation, heat transfer coefficient, temperature distribution and time constant) Solar Cookers: Types of solar cookers, performance of box-type solar cooker, testing of a solar cooker Natural and Forced Circulation Solar Desalination: Simple solar still, basics of solar still, material problems in solar stills, performance prediction of basin-type still, solar disinfection Solar Dryers: Basics of solar dryer, types of solar dryers-natural convection or direct type solar dryers, mixed mode type solar dryer; forced circulation type dryers-hybrid dryer, bin-type grain dryers, solar timber drying Passive Heating and Cooling: Passive heating of buildings-direct gain, thermal storage wall, attached greenhouse (sunspace), thermal storage roof, convective loop; passive cooling of building-shading, ventilation, evaporation, radiation cooling, ground coupling, dehumidification Solar Refrigeration and Air Conditioning: Carnot refrigeration cycle, Reverse Carnot Cycle Absorption cooling- principles of absorption cooling, basics of absorption cooling, Lithium Bromide-Water absorption refrigeration system, Aqua-ammonia absorption refrigeration system, intermittent absorption refrigeration system Vapor compression refrigeration, desiccant cooling Solar Thermal Energy Storage:

	Need of thermal energy storage, size and duration of storage, thermal energy storage-sensible heat storage, storage in phase change materials; storage in reversible chemical reactions Mechanical Energy Storage Economic Analysis of Solar Thermal Technology: Net present value concept- investment with money from hand, investment with money from loan; life cycle cost method- residential systems, commercial systems; cost benefit comparison method, pay-back period method

6. University of Liberal Arts

Course name	Renewable Energy Systems (EEE 477)
Level	BSc in EEE
Duration	3 Credits
Required qualification	HSC/ A Levels
Final qualification	MSc (3 credits)
(NTVQF) Fee	University sets the fees
Content	Renewable energy sources: Solar, wind, mini-hydro, geothermal, biomass, wave and tides. Solar photovoltaic: Characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems. Maximum power point tracking: chopper, inverter. Sizing the PV panel and battery pack in stand-alone PV applications. Solar energy applications In residential, electric vehicle, naval, and space. Solar power plants connected to grid. Solar thermal: principles of concentration, solar tower, parabolic dish, receiver, storage, steam turbine and generator. Wind turbines: Turbine types, power limitation, Betz's law; Control mechanism: Pitch, yaw, speed. Couplings between turbine and electric generator. Wind turbine generator – DC, synchronous, self-excited induction generator and doubly fed induction generator. Grid interconnection: Active and reactive power control. Biomass and biogas electricity generation.18

7. Department of Energy Science and Education under the Khulna University of Engineering and Technology

Course Name	BSc Engineering in Energy Science and Education
Level	BSc Engineering
Duration	3 Credits
Required qualification	HSC/ A Levels
Final qualification	BSc Engineering (160 credits)
(NTVQF) Fee	University sets the fees
Content	Bachelor degree course is to be completed in eight Terms earning total 160 credits covering the fundamental aspects of this discipline. Being a multi-disciplinary department, students get foundational courses from electrical, mechanical, chemical and process engineering domains during freshman

[18] https://ulab.edu.bd/course/electrical-and-electronic-engineering-eee/eee-477

	and sophomore years. Students take core courses on Solar PV and Thermal Systems, Bio and Wind Energy Systems, Thermo-fluid Devices, Heat and Mass Transfer, Coal Power Generation, Power Plant Engineering, Fuel and Engine Combustion, Petroleum and Natural Gas Engineering, Nuclear Power Engineering, Energy Audit and Management, Instrumentation and Control, Energy Systems in Buildings, Energy and Process Integration, Industrial Hazard and Safety Management, Hydrogen and Fuel Cells to name a few. During the senior year students also take individual thesis and optional courses that encompass wide verity of topics and application of energy engineering such as Modern Fuel, LNG and LPG, Cryogenic Engineering, Piping System Design, Energy System Design and Optimization. In order to meet the local and global challenges of twenty first century, the department emphasizes on applied mathematics, scientific computing, and computer added engineering throughout the undergraduate program. Students get intensive training on Octave and Scilab for general purpose scientific computing, Maxima and Sage Math for computer aided algebra, and Ansys Academic for finite element analysis (FEA) and CFD analysis. For engineering system dynamic and control students also learn Modelica and Scox. The use of these modern tools enables our students to model, analyse, and design engineering systems and prepares them for successful professional and research career.

Course Name	MSc and PhD Engineering in Energy Science and Education
Level	MSc or PhD
Duration	36 Credits- MSc, 60 credits- PhD
Required qualification	BSc Engineering for MSC enrolment, MSc Engineering for PhD
Final qualification	MSc Engineering in Energy Science and Education (160 credits)
(NTVQF) Fee	University sets the fees
Content	The postgraduate program leads to the degree of Master of Energy Science & Engineering (M.Sc. Eng.) and Doctor of Philosophy (Ph.D.) To be awarded a M.Sc. Eng. degree, a student should have to complete minimum 36 credit hours of which g credit hours of project work or 18 credit hours of thesis work in 3 Semesters. The degree requirements of Ph.D. are 6o credit hours of which a maximum of 45 credit hours of thesis works to be completed in 6 Semesters. The postgraduate program is designed for advanced study and research in energy engineering to create intellectually sound and professionally skilled manpower to contribute in the energy sector of Bangladesh. B. Sc. Engineering degree in related discipline may enter the M. Sc. Engineering program through the post-graduation admission procedures of this university. Candidates may register as a full time or part time student. Full students are eligible to get TA ship from the university based on the academic performance. The minimum duration to complete the requirements of M. Sc. degree shall normally be three semesters and generally not be more than five academic years from the date of his/her admission19.

8. **Department of Electrical and Electronics Engineering (EEE) in the American International University**

[19] https://www.kuet.ac.bd/department/ESE/index.php/welcome/academicprogram

Course Name	RENEWABLE ENERGY TECHNOLOGY (Course Code EEE 4231)
Level	BSc Engineering
Duration	3 credits
Required qualification	HSC/ A levels & completion of the course: EEE3211.
Final qualification	BSc in Engineering
(NTVQF) Fee	University sets the fees
Content	To understand about basics of energy, current energy scenario and fossil fuel reserves, sustainability and renewable energy and importance and drawbacks of renewable energy. To know about solar spectrum, extra-terrestrial radiation, radiation on earth surface, geographical distribution, atmospheric factors, optimal tilt, monthly averaged global radiation at optimal tilt, solar tracking arrangements. Identify and formulate solar angles, times, radiation and other factors for a given location, date, and time. To become familiarized with solar thermal technologies. This will include a brief review of thermodynamic cycles, absorption and radiation, solar thermal collectors (flat plate and concentrating devices), and solar thermal power plants. To understand the solar photovoltaic technology. This includes the advantage and limitations of pv, basic semiconductor theory of pv cells, i-v characteristic curves, power rating, efficiency, maximum power point (mpp), pv systems and components, stand-alone pv systems, grid connected pv systems, hybrid pv systems. To perform solar pv calculations as well as design pv systems per given specifications or energy demand. This includes synthesis of information to provide valid conclusions. To learn about wind flow, motion of wind, energy and power calculation, distribution of wind speed, types of wind turbine, components of wind turbines, wind turbine characteristics, sizing and system design, wind power converters. To perform wind energy calculations as well as design wind turbines per given specifications or energy demand. This includes synthesis of information to provide valid conclusions. To understand biomass energy which includes types of biomasses and application, energy content in biomass, biomass from quickly growing plants, energy conversion process of biomass, biomass based fuel, application of biomass energy: biogas and biofuel. To perform biomass energy calculations. To learn about geothermal energy and different types of energy storage techniques (conventional and non-conventional). To perform research on different recent trends in renewable energy. The topics include (but are not limited to) prospects of ocean, tidal and geothermal energy in bangladesh, vehicle to grid technology, smart grids technology, renewable energy policy of bangladesh, solar air conditioning and solar cooker, rice husking for electricity generation: perspective bangladesh, clean development mechanism (carbon credits) and zero energy buildings.20

9. Department of Electrical and Electronics Engineering (EEE) in the BRAC University

Course Name	Energy Conversion II (Course Code EEE 437)
Level	BSc Engineering
Duration	3 credits

[20] https://www.aiub.edu/faculties/engg/departments/eee/program/undergraduate-program/course-description

Required qualification	HSC/ A levels & completion of prior courses
Final qualification	BSc in Engineering
(NTVQF) Fee	University sets the fees
Content	Basic principles of energy conversion: electromagnetic, electrostatic, thermoelectric, electrochemical, and electromechanical. Acyclic machines: generators, conduction pump and induction pump. Nonconventional energy conversion: solar-photovoltaic, solar-thermal, wind, geothermal, wave and tidal energy, MHD (Magneto Hydrodynamic) systems. Motors and drives: series universal motor, permanent magnet DC motor, brushless DC motor (BLDC), stepper motor, reluctance motor, switched reluctance motor, hysteresis motor, repulsion motor, permanent magnet synchronous motor, linear induction motor, electro static motor. Three phase induction motor design: stator frames and teeth, stator core and winding, shape, number and area of stator slot, length of air gap, rotor windings, number of rotor slots, area of rotor bars, and choice of ampere conductors per meter21.

10. Rainbow Automation offers Solar System Training

Course Name	Solar System Training (Training Code 1304)
Level	certificate
Duration	10 hours
Required qualification	- B.Sc. (Electrical, Mechanical and Computer) - Diploma in Engineering - I.T.I. minimum 3 years of industry experience. - Engineering students (2nd year and above)
Final qualification	Certificate
(NTVQF) Fee	BDT 3000.00 (Regular) = 27 $ BDT 3000.00 (Friday) = 27 $
Content	Solar Systems topics

11. Technical Youth Training Centre

Course Name	Certificate in Electrical Technology
Level	Technical Certificate Courses
Duration	3 months/ 6 months
Required qualification	Not mentioned
Final qualification	Certificate in Electrical Technology
(NTVQF) Fee	BDT. 12,000/= 108 $ or 24000.00 (In instalment); BDT 6000.00 (USD 54)
Content	Electrical Technology related courses

Course Name	Certificate in Electronics Technology
Level	Technical Certificate Courses
Duration	3 months/ 6 months

[21] https://www.bracu.ac.bd/academics/departments/electrical-and-electronic-engineering/bachelor-science-electrical-and-9-3

Required qualification	Not mentioned
Final qualification	Certificate in Electrical Technology
(NTVQF) Fee	BDT. 12,000/= 108 $ or 24000.00 (In instalment); BDT 6000.00 (USD 54)
Content	Electronics Technology related courses

12. Bangladesh Technical Training Institute (BTTI) offers training on Electronics

Course Name	Off grid Solar Inverter Manufacturing (Course Code OSIM101)
Level	Certificate
Duration	12 Classes
Required qualification	Not mentioned
Final qualification	Certificate
(NTVQF) Fee	BDT 7000.00
Content	Not mentioned

Course Name	Off Grid Solar System Design, Installation and Maintenance
Level	Certificate
Duration	16 Classes
Required qualification	Not mentioned
Final qualification	Certificate
(NTVQF) Fee	BDT 8000.00
Content	Not mentioned

Course Name	On Grid Solar System Design, Installation and Maintenance
Level	Certificate
Duration	24 Classes
Required qualification	Not mentioned
Final qualification	Certificate
(NTVQF) Fee	BDT 14000.00
Content	Not mentioned

Course Name	Solar based product design 01. Solar based colour TV or Lighting or Fan
Level	Certificate
Duration	10 Classes
Required qualification	Not mentioned
Final qualification	Certificate
(NTVQF) Fee	BDT 4000.00 per project
Content	Not mentioned

Annex 8: Existing EE Trainings and Facilities

1. Trainings offered by the Institute of Energy, University of Dhaka

Course name	Foundation of Energy Engineering (MRET 101)
Level	Masters course
Duration	3 credit of 1.5 years MSc
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (course complete)
Fee	University of Dhaka sets the fees
Content	Laws of Thermodynamics: 1st and 2nd law and its application, Entropy, Irreversibility, Refrigerators, Air Conditioners, and Heat Pumps Heat Transfer: Conduction, convection, Radiation Heat Engines: Working principle and classification of Internal Combustion Engine, two stroke and four stroke cycle (Diesel and petrol engine) Basic Power generation Cycles: Carnot and Rankine Cycle Thermionic conversion and Magneto hydrodynamic Generator Fluid Mechanics: Stress-Strain, Viscosity, Bernoulli's Equation

Course name	Solar Thermal Energy and System (MRET 302)
Level	Masters course
Duration	3 credit of 1.5 years MSc
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (course complete)
Fee	University of Dhaka sets the fees
Content	Solar Water Heating: Types of Solar Water Heater Natural and Forced Circulation Flat Plate Collector: Description of the components of Flat plate collectors Performance analysis (energy balance equation, heat transfer coefficient, temperature distribution and time constant) Solar Cookers: Types of solar cookers, performance of box-type solar cooker, testing of a solar cooker Natural and Forced Circulation Solar Desalination: Simple solar still, basics of solar still, material problems in solar stills, performance prediction of basin-type still, solar disinfection Solar Dryers: Basics of solar dryer, types of solar dryers-natural convection or direct type solar dryers, mixed mode type solar dryer; forced circulation type dryers-hybrid dryer, bin-type grain dryers, solar timber drying Passive Heating and Cooling:

	Passive heating of buildings-direct gain, thermal storage wall, attached greenhouse (sunspace), thermal storage roof, convective loop; passive cooling of building-shading, ventilation, evaporation, radiation cooling, ground coupling, dehumidification Solar Refrigeration and Air Conditioning: Carnot refrigeration cycle, Reverse Carnot Cycle Absorption cooling- principles of absorption cooling, basics of absorption cooling, Lithium Bromide-Water absorption refrigeration system, Aqua-ammonia absorption refrigeration system, intermittent absorption refrigeration system Vapor compression refrigeration, desiccant cooling Solar Thermal Energy Storage: Need of thermal energy storage, size and duration of storage, thermal energy storage-sensible heat storage, storage in phase change materials; storage in reversible chemical reactions Mechanical Energy Storage Economic Analysis of Solar Thermal Technology: Net present value concept- investment with money from hand, investment with money from loan; life cycle cost method- residential systems, commercial systems; cost benefit comparison method, pay-back period method

Course name	Practical and Laboratory Experiments (MRET 204)
Level	Masters Course
Duration	6 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (course complete)
(NTVQF) Fee	University of Dhaka sets the fees
Content	The target of this course is to give practical concept of the theory described in various courses. Some example areas are mentioned below: • Practical based on solar radiation measurement. • Practical based on solar cells and PV modules. • Practical based on charge controllers. • Practical based on inverters. • Practical based on water pumping system. • Practical based on solar thermal systems. • Practical based on solar home system/off-grid system. • Practical based on Grid-Tied power system. • Practical based on ICS performance study • Practical based on biogas plant/Biomass • Practical based on wind turbine and hybrid systems • Practical based on Hydro/OTEC • Practical based on EV, Fuel Cells • Practical based on energy efficiency, energy audit, energy management, etc. • Practical based on Power Electronics

	• Practical based on system design using RET screen/HOMER

Course name	Advanced Electronic of Photovoltaic System (MRET 301)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (Course complete)
(NTVQF) Fee	University of Dhaka sets the fees
Content	1. The pn junction: Periodic table, Crystal structure, the energy momentum diagram, density state's function, statistical mechanics, the semiconductor in equilibrium, the extrinsic semiconductor, built in potential barrier of a pn junction, pn junction as a diode, pn junction as a photovoltaic cell, efficiency limits, losses and measurement: spectral response of solar cells, quantum efficiency analysis, dark conductivity, I-V characterization 2. Crystalline solar cell preparation technology: standard and improved mono crystalline and poly crystalline silicon solar cell module technology, Module fabrication and testing, design of silicon solar cells 3. Thin film solar cells: Amorphous silicon solar cells, micro morph, tandem and multi-junction solar cells, Concentrating solar cells, High efficiency solar cells, III-V, II-VI thin-film solar cells (GaAs, Cu (In, Ga) Se2, CdTe), PERL cells, (DSSC), Pervoskite thin film solar cells, etc. 4. Thin film solar cell preparation technology: diffusion, oxidation, photolithography, sputtering, physical vapor deposition, chemical vapor deposition (CVD), atmospheric pressure CVD, low pressure CVD, plasma assisted CVD, plasm enhanced CVD, high density plasma CVD, hot wire CVD, Epitaxy, MOCVD, MBE, VPE, etc. 5. Characterization of solar cells: Scanning Electron Microscope (SEM), Secondary-Ion Mass Spectrometry (SIMS), Atomic Force Microscope (AFM), Transmission Electron Microscope (TEM), etc. 6. Materials and devices for energy storage: Batteries, CNT in energy storage, Ultra-capacitors, Fuel cells, Superconducting Magnetic Energy Storage (SMES)

Course name	Solar Thermal Energy and System (MRET 302)
Level	Masters Course
Duration	3 Credits
Required qualification	BSc/BSc (Hons)/BSc Engineering (Electrical Engineering/ Electronics and Communication Engineering / Mechanical Engineering/Civil Engineering/Textile Engineering/Architecture/ Physics/ Chemistry/ Mathematics/ Bio science etc. are encouraged to apply)
Final qualification	MSc (3 credits)
(NTVQF) Fee	University of Dhaka sets the fees
Content	1. Solar Water Heating:

	A. Types of Solar Water Heater B. Natural and Forced Circulation 2. Flat Plate Collector: A. Description of the components of Flat plate collectors B. Performance analysis (energy balance equation, heat transfer coefficient, temperature distribution and time constant) 3. Solar Cookers: A. Types of solar cookers, performance of box-type solar cooker, testing of a solar cooker B. Natural and Forced Circulation 4. Solar Desalination: A. Simple solar still, basics of solar still, material problems in solar stills, performance prediction of basin-type still, solar disinfection 5. Solar Dryers: A. Basics of solar dryer, types of solar dryers-natural convection or direct type solar dryers, mixed mode type solar dryer; forced circulation type dryers-hybrid dryer, bin-type grain dryers, solar timber drying 6. Passive Heating and Cooling: A. Passive heating of buildings-direct gain, thermal storage wall, attached greenhouse (sunspace), thermal storage roof, convective loop; passive cooling of building-shading, ventilation, evaporation, radiation cooling, ground coupling, dehumidification 7. Solar Refrigeration and Air Conditioning: A. Carnot refrigeration cycle, Reverse Carnot Cycle B. Absorption cooling- principles of absorption cooling, basics of absorption cooling, Lithium Bromide-Water absorption refrigeration system, Aqua-ammonia absorption refrigeration system, intermittent absorption refrigeration system C. Vapor compression refrigeration, desiccant cooling 8. Solar Thermal Energy Storage: A. Need of thermal energy storage, size and duration of storage, thermal energy storage-sensible heat storage, storage in phase change materials; storage in reversible chemical reactions B. Mechanical Energy Storage 9. Economic Analysis of Solar Thermal Technology: A. Net present value concept- investment with money from hand, investment with money from loan; life cycle cost method- residential systems, commercial systems; cost benefit comparison method, pay-back period method

2. Department of Electrical and Electronics Engineering (EEE) in the American International University

Course Name	RENEWABLE ENERGY TECHNOLOGY (Course Code EEE 4231)
Level	BSc Engineering

Duration	3 credits
Required qualification	HSC/ A levels & completion of the course: EEE3211.
Final qualification	BSc in Engineering
(NTVQF) Fee	University sets the fees
Content	To understand about Basics of Energy, Current Energy Scenario and Fossil Fuel Reserves, Sustainability and Renewable Energy and Importance and Drawbacks of Renewable Energy. To know about Solar Spectrum, Extra-terrestrial Radiation, Radiation on earth surface, Geographical Distribution, Atmospheric Factors, Optimal Tilt, Monthly Averaged Global Radiation at optimal Tilt, Solar Tracking Arrangements. Identify and formulate solar angles, times, radiation and other factors for a given location, date, and time. To become familiarized with solar thermal technologies. This will include a brief review of Thermodynamic cycles, Absorption and Radiation, Solar Thermal Collectors (flat plate and concentrating devices), and solar thermal power plants. To understand the Solar Photovoltaic Technology. This includes the advantage and limitations of PV, Basic Semiconductor Theory of PV cells, I-V characteristic curves, Power rating, Efficiency, Maximum power point (MPP), PV systems and components, Stand-alone PV systems, Grid connected PV systems, Hybrid PV Systems. To perform solar PV calculations as well as design PV systems per given specifications or energy demand. This includes synthesis of information to provide valid conclusions. To learn about Wind flow, Motion of wind, Energy and Power Calculation, Distribution of Wind Speed, Types of Wind Turbine, Components of wind turbines, Wind Turbine characteristics, sizing and system design, Wind Power Converters. To perform Wind Energy calculations as well as design wind turbines per given specifications or energy demand. This includes synthesis of information to provide valid conclusions. To understand Biomass Energy which includes types of biomasses and application, Energy content in biomass, Biomass from quickly growing plants, Energy conversion process of biomass, Biomass based fuel, Application of Biomass energy: Biogas and Biofuel. To perform biomass energy calculations. To learn about geothermal energy and different types of energy storage techniques (conventional and non-conventional). To perform research on different recent trends in renewable energy. The topics include (but are not limited to) Prospects of Ocean, Tidal and Geothermal Energy in Bangladesh, Vehicle to Grid Technology, Smart Grids Technology, Renewable Energy Policy of Bangladesh, Solar Air Conditioning and Solar Cooker, Rice Husking for Electricity Generation: Perspective Bangladesh, Clean Development Mechanism (Carbon Credits) and Zero Energy Buildings.22

3. Bangladesh University of Engineering and Technology (BUET)

Course name	Optoelectronics (Course code EEE 459)

[22] https://www.aiub.edu/faculties/engg/departments/eee/program/undergraduate-program/course-description

Level	Under- graduation in Electrical and Electronics Engineering
Duration	3 Credit Hours, 3 Contact Hours per Week
Required qualification	Higher Secondary School Certificate
Final qualification	BSc in EEE (partial completion)
(NTVQF) Fee	As set by the University
Content	Optical properties in semiconductor: Direct and indirect band-gap materials, basic transitions in semiconductors, radiative and non-radiative recombination, optical absorption, photo-generated excess carriers, minority carrier life time, luminescence and quantum efficiency in radiation. Properties of light: Particle and wave nature of light, polarization, interference, diffraction and blackbody radiation. Light emitting diode (LED): Principles, materials for visible and infrared LED, internal and external efficiency, loss mechanism, structure and coupling to optical fibers. Double-Hetero- structure (DH) LEDs, Characteristics, Surface and Edge emitting LEDs. Stimulated emission and light amplification: Spontaneous and stimulated emission, Einstein relations, population inversion, absorption of radiation, optical feedback and threshold conditions. Semiconductor Lasers: Population inversion in degenerate semiconductors, laser cavity, operating wavelength, threshold current density, power output, elementary laser diode characteristics, hetero-junction lasers, optical and electrical confinement. single frequency solid state lasers-distributed Bragg reflector (DBR), distributed feedback (DFB) laser. Introduction to quantum well lasers. Introduction to quantum well lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), optical laser amplifiers. Photo-detectors: Photoconductors, junction photo-detectors, PIN detectors, avalanche photodiodes, hetero-junction photodiodes, Schottky photo-diodes and phototransistors. Noise in photo-detectors. PIN and APD. Photo-detector design issues. Solar cells: Solar energy and spectrum, silicon and Schottkey solar cells. Modulation of light: Phase and amplitude modulation, electro-optic effect, acousto-optic effect and magneto-optic devices. Introduction to integrated optics.

4. Trainings offered by the Technical Youth Training Centre

Course name	Certificate in Refrigeration & Air Conditioning
Level	Technical Certificate Courses
Duration	3 months/ 6 months
Required qualification	Not mentioned
Final qualification	Certificate in Electrical Technology
Fee	BDT. 12,000 (3 months) or 24000.00 (6 months) (In instalment); BDT 6000.00 (3 months) or 12000.00 (6 months) (50% discount at a time)
Content	Electrical Technology related courses

Course name	Diploma In Refrigeration & Air Conditioning

Level	Technical Certificate Courses
Duration	12 months
Required qualification	Not mentioned
Final qualification	Diploma Certificate
Fee	BDT. 36,000.00 (In instalment); BDT 18000.00 (50% discount at a time)
Content	Electrical Technology related courses

Course name	Energy Auditor, Energy Manager certificate course
Level	Professional
Duration	10 days exam preparation training and four phase analytical exam
Required qualification	University degrees (engineering preferred)
Final qualification	Certificate of Completion issued by SREDA.
Fee	12000BDT
Content	Module 1: Fundamentals of Energy Management and Energy Audit (Paper 1) • Introduction to energy management and audit • Energy concepts and units • Energy audit methodologies • Data collection and analysis • Energy performance indicators • Energy saving opportunities identification • Report writing and presentation Module 2: Energy Efficiency in Thermal Systems (Paper 2) • Thermal energy fundamentals • Heat transfer principles • Insulation and energy efficiency • Heating, ventilation, and air conditioning (HVAC) systems • Boiler and furnace efficiency • Steam systems and energy optimization • Cogeneration and combined heat and power (CHP) Module 3: Energy Efficiency in Electrical Systems (Paper 3) • Electrical fundamentals • Power quality and energy efficiency • Motors and drives • Lighting systems and controls • Electrical distribution systems • Demand-side management strategies Module 4: Energy Performance Assessment for Equipment and Utility Systems (Paper 4) • Energy performance assessment methodologies • Equipment and system benchmarking • Energy modelling and simulation • Life cycle cost analysis • Energy efficiency technologies and applications • Case studies and best practices

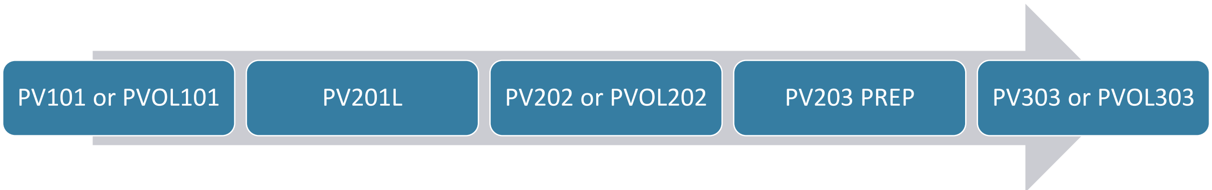
Annex 9: International best-practice for Technical and Vocational Training

a) Residential and Commercial PV Systems Certificate Course run by Solar Energy International, USA

This is a training program offered by Solar Energy International and accredited by the Interstate Renewable Energy Council (IREC). It is made up of 7 modules, 5 of which must be successfully completed in order to obtain the certificate. This program provides approved credit hours towards NABCEP Certifications and Recertifications.

Indicator	Description
Cost	Full programme costs USD 4175-5575 depending on whether online or in-person modules are chosen.
Entry level requirements	No entry level requirements specified. It is however a selective admissions program requiring each candidate to submit an application
Duration	See course summary below
Course content	Topics covered include grid-connected residential and commercial photovoltaic design and installation applications. Participants receive comprehensive theoretical material with a strong emphasis on the National Electricity Code and job-site safety considerations. The program is nationally recognized and satisfies the requirements for the NABCEP Entry Level Exam and the NABCEP PV Certification Exam
Assessment	Final online exam requiring 70% pass mark; 100% attendance for hands-on practical training element

Training progression towards receiving the certificate is:



The full training program content is summarized below. For further information, refer to Solar Energy International[23].

Course title	Course description	Course duration
PV101 – Solar Electric Design and Installation (Grid-Direct)	Fundamentals of grid code compliant design and installation of residential grid-connected PV systems	PV101 PREP + 5 Day Workshop: 50 contact training hours
PVOL101 - Solar Electric Design and Installation (Grid-Direct) – Online	Online course – content as for PV101	6 weeks online access
PV201L – Solar Electric Lab Week (Grid-Direct)	Hands-on practical experience with grid-connected PV systems	1 week in-person workshop: 40 contact training hours
PV202 – Advanced PV System Design and the NEC (Grid-Direct)	Application of National Electric Code (NEC) standards and industry best practices to residential and commercial grid-connected PV systems	1 week in-person workshop: 40 contact training hours

[23] *Solar Energy International 2020*

Course title	Course description	Course duration
PVOL202 - Advanced PV System Design and the NEC (Grid-Direct) – Online	Online course – content as for PV202	6 weeks online access
PV203 – Battery-based PV System Fundamentals – On Demand	Fundamentals of battery-based PV systems	18 contact training hours or 6 weeks online access
PVOL203 – Battery-based PV System Fundamentals – Online	Online course – content as for PV203	6 weeks online access
PVOL303 – Advanced Battery-based PV System design: Series I – Online	3 course series in advanced design and installation of battery-based and grid-connected PV systems	6 weeks online access

b) Installing and testing domestic PV systems, developed and accredited by City & Guilds, UK

This is a City & Guilds accredited course, one of the UK's leading Awarding Organizations.

Indicator	Description
Cost	GBP 1195
Entry level requirements	QCF (Qualifications and Credit Framework) Level 3 electrician. This is equivalent to the EQF[24] (European Qualifications Framework) Level 3 and corresponds to a full-time theory and practical course of at least 16 weeks duration. Levels 1 & 2 must be completed prior to Level 3. To become a fully qualified electrician with NVQ (National Vocational Qualification) requires gaining and documenting on-site installation experience.
Duration	5 days (30 Guided Learning Hours)
Course content	Topics covered include systems and components, standards and regulations, health & safety, approvals, installations, commissioning and testing, customer care. Practical hands-on training includes installation, labelling, grid-connection, commissioning and testing, fault diagnosis, operational inverter testing
Assessment	participants must pass a written and a practical examination

For further information, refer to 'Certificate in Installing and Testing Domestic Photovoltaic Systems (2372)' Qualification Handbook and, e.g., Trade Skills 4 U.[25]

c) Bremerhaven Wind Centre BFW (TVET College)

The Bremerhaven Wind Centre, in Germany, has been offering vocational training in wind power since 2004. It contributes wind power modules to the 3.5-year 'Electrical Service Engineers' vocational qualification run by the Bremerhaven Vocational Education (Berufliche Bildung) College.[26] The three main wind power modules which the Bremerhaven Wind Centre offers are:

- Service technician for wind energy systems (onshore and offshore)
  - Duration: 8.5 months including 1.5-month internship
  - Entry level requirement: vocational qualification in metal or electrical work
  - Qualification: BFW certificate of attendance; BZEE certificate of completion; upon passing an exam, certificate from the relevant Chamber of Industry and Commerce
- Wind energy system (onshore and offshore) installer
  - Duration: 3.5 months

[24] *The European Qualifications Framework (EQF) attempts to standardize qualifications across Europe so that a qualification achieved in one European country will be understood and recognized in another.*

[25] *City & Guilds 2004, Trade Skills 4 U n.d.*

[26] *bfw – Unternehmen für Bildung n.d., Berufliche Bildung Bremerhaven n.d.*

    - Entry level requirement: vocational qualification in metal or electrical work, or equivalent experience, or job offer in a relevant field
    - Qualification: BFW certificate of attendance; certificate for skilled electrician for specified activities
- Wind energy system assembly technician
    - Duration: 4.5 months including 3-week internship
    - Entry level requirement: technician in metal or electrical work, or at least 3 years' experience in a relevant field, or completion of 4-week suitability assessment
    - Qualification: BFW certificate of attendance; BZEE certificate of completion

d) Danish Wind Power Academy in Denmark

The Danish Wind Power Academy (DWPA) is recognized as the premier, independent industry-training organization within the wind turbine industry.[27] Typical clients are owners and operators, third party service providers, sub-suppliers, turbine manufacturers. DWPA provides 2–5-day training on all the top manufacturers' turbines, turbine operation & maintenance, plant commissioning, trouble-shooting, main components. Neither the academy nor the courses have any national or international accreditation but are well-recognized and well-regarded within the industry.

e) EUREM training program by the Chamber of Commerce & Industry Nürnberg, Germany

EUREM (European Energy Manager) was started in 1999 by the Chamber of Commerce & Industry in Nürnberg, Germany.[28] It is a high quality and standardized training program and network for energy managers, to date operating in 27 countries worldwide (14 in the EU and 13 in other countries). The EUREM Consortium was formed in 2009 from training providers from 10 countries. The EUREM Consortium is represented by the EUREM Steering Committee which meets at least biannually and counts amongst its tasks updating training material, quality assurance and licensing of new partners. The EUREM Steering Committee is financed by license fees and candidate training fees.

An important factor about the EUREM program which is relevant to this project is that it operates internationally with a standardized set of training materials which are adapted for and to each country by energy experts from that country.

Also interesting is the process by which new countries join the EUREM program: EUREM has developed a licensing model whereby a training provider from a new member country sign a license agreement giving it the right to provide the EUREM training exclusively in that country. The training provider then also becomes a partner in the rapidly growing EUREM Community. The new partner commits to maintaining the high EUREM quality standards, and can show that the know-how and infrastructure to achieve these are available. If other training providers in that country now also want to provide the EUREM training, they can apply to become regional partners of the main country Licensed Partner. This model has proven to be successful in Germany with 36 training providers, Austria with 3 training providers, and Brazil also with 3 training providers.

[27] *DWPA n.d.*

[28] *European Energy Manager n.d.*

EUREM is not based on any standards as such and is not accredited or certified but is guaranteed by the Nürnberg Chamber of Commerce & Industry, the German Chamber of Commerce & Industry, and the German Chamber of Commerce & Industry Educational Service.

The EUREM training program is taken part-time and typically takes 6-8 months to complete. It is internationally successful and has a widespread reputation largely because key personnel from member countries (for example, employees of energy agencies, energy regulators and other energy institutions) have themselves completed the training and have EUREM certificates.

Indicator	Description
Course title	EUREM
Training provider	First training provider was the Chamber of Commerce & Industry in Nürnberg, Germany
Type of institution	Usually run by the local Chamber of Commerce & Industry
Target audience	Professionals from industry and services sector
Technology	Energy Management
Accreditation	EUREM guaranteed by Nürnberg Chamber of Commerce & Industry, the German Chamber of Commerce & Industry, and the German Chamber of Commerce & Industry Educational Service
Government funded	EUREM has received European funding via Intelligent Energy Europe, EUREM.net and EUREMplus schemes. Most EUREM projects in the different countries are self-funding.
Number of similar training institutions	There are 36 training providers in Germany. Each other country has at least one training provider.
Trainers' qualifications	There are up to 25 trainers available at each training location. The trainer team is interdisciplinary and highly qualified. Trainers come from industry.
Quality assurance	EUREM Steering Committee checks quality of joining training providers through a standardized application procedure. Each year the EUREM Steering Committee performs the 'EUREM Quality Assurance' of each EUREM training provider. Each country has an expert jury, who oversee the candidate assessments, made up of previous EUREM certificates from well-reputed organizations such as energy agencies, energy regulators, other energy institutions within the country.
Pre-requisites	No entry level requirements
Qualification received	Internationally-recognized EUREM certificate
Learning method	Combination of attendance and online carried out part-time typically over 6-8 months
Cost	EUR 2,000 – EUR 3,600 (fees vary from country to country)
Course curriculum	Energy efficiency and renewable energy in buildings and industry; energy management in buildings and industry