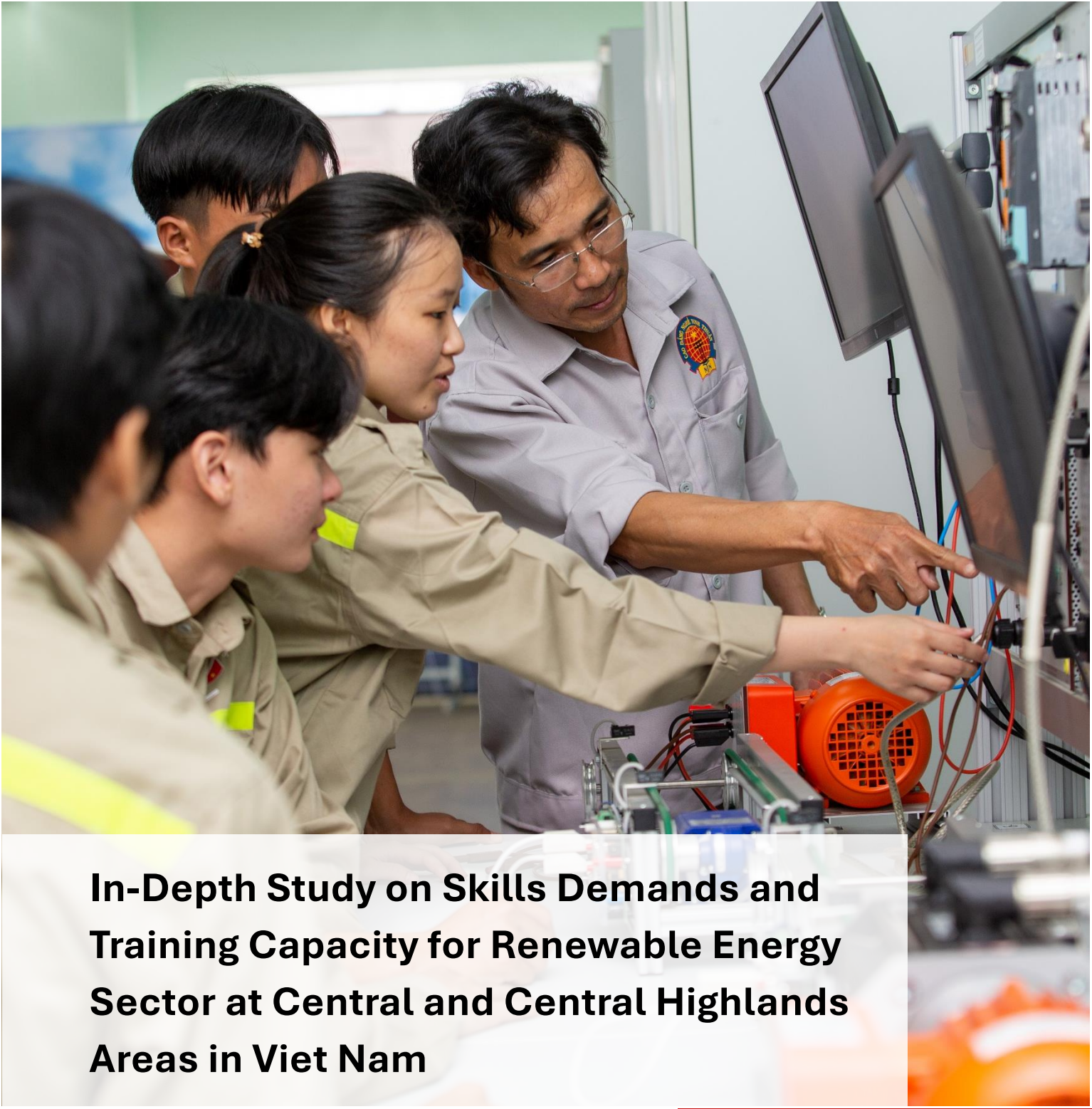

In-Depth Study on Skills Demands and Training Capacity for Renewable Energy Sector at Central and Central Highlands Areas in Viet Nam

REPORT

Hợp tác Đức
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

REPORT

IN-DEPTH STUDY ON SKILLS DEMANDS AND TRAINING CAPACITY FOR RENEWABLE ENERGY SECTOR AT CENTRAL AND CENTRAL HIGHLANDS AREAS IN VIET NAM

Prepared by: Nghiem Ba Hung, Le Quang Trung, Nguyen Giao Hoa
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ASEAN	Association of Southeast Asian Nations
BMZ	German Development Ministry
BST	Basic Safety Training
C&I	Construction & Installation
EVN	Vietnam Electricity Corporation
FGDs	Focus Group Discussion
FiTs	Feed-in tarriffs
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GWO	Global Wind Organisation
HSE	Health, Safety, and Environment
IRATA	Industrial Rope Access Trade Association
IRENA	The International Renewable Energy Agency
JETP	Just Energy Transition Partnership
KIIs	Key In-depth Interview
MoLISA	Ministry of Labour, Invalids and Social Affairs
NABCEP	North American Board of Certified Energy Practitioners
NEC	National Electrical Code
NLDC	National Load Dispatch Center
NSMO	National Power System and Electricity Market Operation (One Member Limited Liability) Company
NTVC	Ninh Thuan Vocational College
O&M	Operational & Maintenance
OHSA	Occupational Safety and Health Administration
PDP VIII	Power Development Plan VIII
PTSC	PetroVietnam Technical Services Corporation
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
RTS	Rooftop Solar

SCADA	Supervisory Control and Data Acquisition
SSC	Sector Skills Council
TOR	The Terms of Reference
TVET	Technical and Vocational Education and Training
UTE	University of Technology and Education
VCMI	Vietnam College of Machinery and Irrigation

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We are also grateful to the TVET institutions, businesses in the sector, and Provincial TVET Councils in Ninh Thuan and Thua Thien Hue provinces, along with all individuals who participated in interviews and consultations. Your active involvement and valuable input, particularly regarding skills needs in the renewable energy sector, were instrumental in identifying key gaps and opportunities for workforce development.

This report stands as a testament to the collective effort, expertise, and shared vision of all involved parties. We are deeply grateful for your trust, collaboration, and support in making this initiative a success.

EXECUTIVE SUMMARY

Vietnam's ambitious pursuit of a sustainable energy future hinges on the robust development of its renewable energy (RE) sector, particularly in wind and solar power within the Central and Central Highlands regions. However, a significant skills gap threatens to derail this progress. This report underscores a critical mismatch between the skills currently possessed by the workforce and the increasingly complex demands of RE system operation and maintenance (O&M). This disparity not only hinders the efficient deployment and utilization of existing RE infrastructure but also impedes the adoption of cutting-edge technologies crucial for future growth. The core issue lies in the lack of advanced technical expertise, specialized certifications, and practical experience required to effectively manage and maintain these sophisticated systems. This deficiency is further compounded by the rapid pace of technological advancements within the sector, creating a moving target for training and workforce development initiatives.

The challenges are multifaceted and interconnected. The existing workforce often lacks proficiency in crucial areas such as advanced electrical engineering principles, specialized RE technologies like solar PV and wind power systems, advanced energy storage solutions, and essential safety protocols. This deficiency is mirrored within the Technical and Vocational Education and Training (TVET) system, which struggles to equip graduates with the necessary skills. TVET institutions face significant constraints, including outdated equipment and infrastructure, curricula that fail to adequately address current industry needs and lack practical application, limited access to proprietary technologies and hands-on training opportunities, and insufficient collaboration with businesses. Weak cooperation between educational institutions and businesses restricts internship and practical work opportunities for students. This disconnects between training and real-world requirements leaves graduates ill-prepared for the demands of the RE industry.

The rapid pace of technological innovation further exacerbates the skills gap. Advancements in areas such as energy storage, artificial intelligence, the Internet of Things, offshore wind power, and advanced grid management systems are outpacing the capacity of training programs to adapt. This constant evolution of technology requires a workforce capable of continuous learning and adaptation, a capacity that is currently underdeveloped. Furthermore, the rapid expansion of RE projects presents challenges to the power transmission infrastructure. Increased transmission demand, dispersed power sources, and the inherent volatility of renewable energy generation place immense pressure on the grid, necessitating significant investments and policy adjustments to ensure grid stability and efficient integration of RE sources. Additionally, Vietnam's ambitious energy transition goals necessitate a significant increase in the number of

skilled human resources within the sector. The confluence of these factors creates a critical need for a comprehensive and coordinated strategy to address the skills gap and ensure Vietnam can effectively realize its RE potential.

This report proposes a multi-pronged approach involving TVET institutions, state management agencies, the business sector, and GIZ's TVET program to address these interconnected challenges and pave the way for a skilled and adaptable RE workforce.

Recommendations:

- **For TVET Institutes:**
  - Strengthen core electrical engineering and RE knowledge.
  - Specialize wind and solar modules/units and integrate in existed formal training programs.
  - Review and update the training program to align with international standards.
  - Offer short-term training courses to businesses.
  - Facilitate access to international certifications.
  - Enhance English language proficiency and essential working skills which include emphasizing occupational safety and compliance training.
  - Foster industry partnerships and provide practical training opportunities.
  - Regularly reviews and updates training curriculum with the involvement of RE businesses.

- **For State Management Agencies**
  - Incentivize industry collaboration with TVET institutions such as tax incentives, public recognition, etc.
  - Establish clear accreditation and workforce development standards.
  - Improve skills development in the renewable energy sector, the government should establish and facilitate a robust and reliable Labour Market Information System (LMIS) specifically tailored to this sector.
  - Promote Sustainable Power Transmission solutions.
  - Improve the legal framework on skills development and promote lifelong learning in the sector.
  - Enhance budget allocation for skills development and training based on sector-specific needs.

- **For the Business Sector:**
  - Address and brigde the skills gaps through collaboration with educational and training institutes to develop customized training programs for industry-relevant skills and also assess the graduates' outcome.

- Promote the empowerment of the local workforce by collaborating with educational institutions to enhance the quality and quantity of skilled labour which reduces reliance on foreign expertises.
- Foster sustainable growth by developing customized training programs that ensure graduates and employees possess industry-relevant skills, leading to sustainable employment and long-term business success.
- Invest in employee upskilling and career development programs to enhance employee motivation, retention and productivity.
- Address specific training and certification requirements in the sector.
- Provide regular insights into present and future workforce skill requirements for the sector.
- Promote collaboration and knowledge exchange.

- **For GIZ's TVET Programme:**
  - Provide technical input and sharing experience to support TVET Institute aligning training with industry certifications and standards.
  - Foster industry-TVET Institute collaboration.
  - Leverage successful existing TVET programs, share knowledge, experience and best practices.
  - Provide the sufficient policy recommendations for legal framework development and implementation
  - Share international practical experience to support educational and training Institutes and businesses to prepare graduates for the global RE market.
  - Facilitate access to advanced technologies and hands-on experience.

CHAPTER I – INTRODUCTION

1.1. BACKGROUND

Vietnam is among the countries most vulnerable to the impacts of climate change in the world. In recent years, extreme weather events have had tremendous economic and social consequences in Vietnam. The country, therefore, is committed to a resilient and decarbonized future. According to the Power Development Plan 8 (2023), Vietnam intends to decrease the proportion of coal-fired power plants to 20% by 2030 and eliminate them by 2050, while simultaneously boosting the share of renewable energy. By adopting a "just energy transition" (JET) approach, the nation aims to balance rapid economic growth with environmental sustainability. Investing in renewable energy, particularly solar and wind power, is a strategic move to ensure energy security and accelerate the transition to a low-carbon economy. The nation's energy path will determine its economic prosperity, job market, and people's well-being.

Vietnam is well-positioned to embrace a low-carbon future by prioritizing renewable energy sources, particularly solar and wind power, which are becoming increasingly cost-effective[1]. The country's Renewable Energy (RE) sector stands at a crucial juncture of development, particularly in the Central Region and the Central Highlands, with their vast open spaces and strong wind and solar resources. The sector has demonstrated significant growth potential, backed by strong governmental commitments to promote sustainable energy development. However, stakeholders and decision-makers must carefully consider and plan the potential impact on employment within the power sector and the broader economy. This study specifically focuses on two key segments of the RE sector: onshore wind power and solar photovoltaic (PV) systems. While offshore wind power represents another potential avenue for renewable energy development, it remains under governmental deliberation and thus falls outside the scope of this study.

The International Renewable Energy Agency (IRENA) report *"World Energy Transitions Outlook - 1.5°C Scenario"* (2023 edition[2]) projects that, under the 1.5°C Scenario, the renewable energy sector will create up to triple the 2021 level, about 40 million jobs worldwide by 2050. In the same scenario, solar energy jobs are expected to rise to around 18 million (around 45% of the total renewable energy jobs) by 2050, almost a four-fold increase compared to 2021, while wind energy is expected to rise five-fold from 2021, reaching over 6 million (around 17% of the total renewable energy jobs). In 2023, renewables reached a record 30% share of global electricity generation, primarily driven

[1] Renewable Power Generation Costs in 2023, IRENA, 2024. At https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Sep/IRENA_Renewable_power_generation_costs_in_2023.pdf

[2] Ditto

by solar and wind power. Vietnam's electricity mixes also saw growth, with renewables contributing 13%[3]. It is estimated that, just for the transition of the two wind and solar power industries, the potential contribution to Vietnam's GDP is up to 70 - 80 billion USD, creating about 90 - 105,000 direct jobs[4].

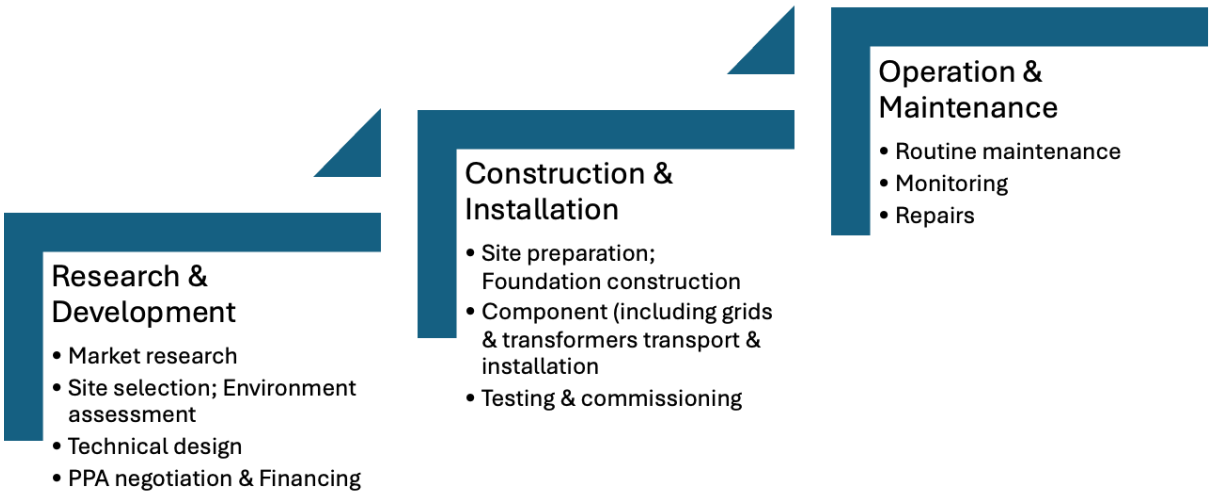
The potential of renewable energy and related sectors to drive job creation as part of a global energy transition is highlighted in this report. The jobs span sectors such as solar, wind, bioenergy, and hydrogen, emphasizing the need for policies to support skills development and just transition strategies.

According to statistics from the National Power System and Electricity Market Operation One Member Limited Liability Company (NSMO), the total renewable energy capacity in the nine provinces of the South-Central Coast and Central Highlands region (Binh Dinh, Phu Yen, Khanh Hoa, Gia Lai, Dak Lak, Dak Nong, Lam Dong, Ninh Thuan, and Binh Thuan) is 13,212 MW[5]. This includes 48 wind power plants (2,969 MW); 97 solar power plants (5,863 MW); 405 MW from transitional renewable energy wind power projects and 242 MW from transitional renewable energy solar power projects; 120 small hydropower plants (1,092 MW); and 3,288 MW from rooftop solar.

The growth of the RE sector in Vietnam, particularly in the Central and Central Highlands regions, is expected to create numerous employment opportunities across various stages of the project lifecycle. This expansion is creating a multitude of job opportunities across various stages of the RE project lifecycle. These include:

[3] EMBER, 2024. Global Electricity Review 2024.
[4] https://baochinhphu.vn/nang-luong-tai-tao-co-tiem-nang-dong-gop-lon-vao-gdp-cua-viet-nam-102230419094025384.htm
[5] https://www.erav.vn/tin-tuc/t14684/khu-vuc-nam-mien-trung-va-tay-nguyen-nang-luong-tai-tao-dat-hon-13-000mw-chiem-gan-60-ca-nuoc.html

Figure 1: Stages in a regular RE project[6]



***Source**: Author's own compilation*

i. Research and Development (R&D)

- Opportunities in this stage: Engineers, scientists, and researchers are needed to conduct baseline research, survey, develop innovative technologies and designs, improve the efficiency of RE systems, adapt solutions to the specific needs of the local/Vietnamese contexts.
- Relevance to TVET institutions: While R&D often requires advanced degrees, TVET graduates can contribute as technicians and support staff, assisting researchers with data collection, equipment maintenance, and laboratory work.

ii. Construction and Installation

- Opportunities in this stage: The construction and installation phase of RE projects creates a high demand for skilled workers in civil engineering, electrical engineering, and project management. This includes jobs such as:
    - Civil engineers for site preparation, foundation work, and road construction.
    - Electrical engineers for grid connection, power electronics, and control systems.
    - Project managers to oversee the entire construction process, ensuring timely completion and adherence to safety standards.

[6] In some RE projects, they refer to dismantling and recycling, yet these stages have not been available in Vietnam: https://vuphong.vn/nha-may-tai-che-tam-pin-mat-troi/ and https://nangluongvietnam.vn/xu-ly-canh-tua-bin-gio-cuoi-vong-doi-bai-hoc-tu-quoc-te-dinh-huong-cua-viet-nam-32591.html

    - Welders, electricians, and technicians for on-site installation and assembly of equipment.
- Relevance to TVET institutions: TVET graduates with relevant skills in electrical engineering, mechanics, and construction can directly contribute to the on-site installation and commissioning of RE projects.

iii. Operation and Maintenance (O&M)

- Opportunities in this stage: Once RE projects are operational, a skilled workforce is required for ongoing maintenance and optimization. This includes:
    - Turbine technicians for wind farms, responsible for inspecting, repairing, and maintaining wind turbines.
    - Electrical engineers for monitoring and maintaining power grids and electrical systems.
    - Maintenance workers for general upkeep of the facility, including cleaning, painting, and minor repairs.
    - Data analysts for monitoring system performance, identifying areas for improvement, and optimizing energy output.
- Relevance to TVET institutions: TVET graduates are well-suited for many O&M roles, particularly those requiring technical skills and practical knowledge. They can be trained to perform routine maintenance tasks, troubleshoot equipment malfunctions, and ensure the smooth operation of RE facilities.

Along with the above stages, the RE sector also requires a robust supply chain to source and deliver equipment, materials, and components. This creates opportunities in procurement and provision of equipment, materials, and services, and transportation and storage of goods. TVET graduates to a large extent can contribute to the supply chain and logistics sector by working as logistics assistants, warehouse workers, and inventory managers.

1.2 STUDY OBJECTIVES

Building on GIZ's extensive experience in Vietnam's energy sector—particularly in renewable energy (RE) and technical and vocational education and training (TVET)—the TVET Programme in 2023 provided crucial technical support for mapping stakeholders and assessing initial skills needs and training capacities in the RE sector. As part of this effort, a training program was conducted for various stakeholders, including businesses and TVET institutions, to develop a comprehensive methodology for conducting a detailed study. This methodology included the design of questionnaires and the formulation of interview guidelines.

The Central and Central Highlands regions of Vietnam present significant potential for the development of renewable energy. However, to capitalize on this potential, it is essential to gain a deeper understanding of the skills demand and the training capacity of TVET institutions in these regions. This information will be pivotal for enhancing training programs and formulating targeted policy recommendations. Building on the initial findings, the TVET Programme and its partners have commissioned a team of consultants to carry out a comprehensive study in 2024. This study will focus on further assessing the skills demand and training capacity within the RE sector in the specified regions.

According to the Terms of Reference (TOR), this comprehensive study aims to achieve four primary objectives:

1. Assess the Current and Future Skills Needs in the RE sector: The study will conduct a thorough analysis of the current labor market dynamics and future skills requirements in the RE sector, considering:
    - Technical requirements;
    - Technological advancements;
    - Socio-economic and cultural factors;
    - The broader energy transition context.
2. Identify Gaps Between Industry Skills Requirements and Workforce Capabilities: A detail gaps analysis will be carried out to compare:
    - Industry-specific skill requirements for job positions;
    - Gaps in Technical skills between Viet Nam's standards and international standards;
    - Existing disparities between available skills and those required in the sector;
    - Reason for the demand for new skills in sector;
    - Root causes and potential impacts of the skills gaps.
3. Evaluate the Current Training Landscape: The study will examine the existing training ecosystem, including:
    - Overview of training programme offered by TVET Institutes, University and other Training providers.
    - Depth analysis on the TVET Institute which cover the orientation of TVET Institutes to ensure the relevance and effectiveness of training programmes; Soft skills development and English skills offered by TVET Institutes; Factors and challenges influencing training quality and Forms of collaboration between TVET Institutes and businesses to enhance training programmes
4. Develop Actionable Recommendations for Skills Development Initiative: Based on the findings, the study will propose practical recommendations, including:
    - Strategies for fostering closer collaboration between training institutions and potential employers in the RE sector.

- Recommendations for government policies and regulations to support workforce development in the RE sector, such as incentives for training providers and businesses, accreditation standards, and workforce development programs.

The objectives will guide the study's approach in addressing the skills gaps and enhancing training capacity, ensuring that the workforce is equipped to meet the demands of Viet Nam's growing renewable energy sector, especially wind and solar energy.

1.3 SCOPE OF THE STUDY

The study concentrates on Vietnam's Central and Central Highlands regions, areas that posess significant potential for renewable energy development due to their unique geographical features and resources.

- Central Highlands: The mountainous topography of the Central Highlands generates strong wind speeds, making it a prime location for onshore wind power projects. With advanced wind turbin technology, large-scale wind farms can efficiently capture this kinetic energy and convert it into clean and renewable electricity.
- Central Region: The Central region benefits from extensive coastal areas and abundant sunlight, offering significant opportunities for solar photovoltaic (PV) power generation. Both large utility-scale solar farms and smaller-scale rooftop solar installations can be deployed to capture and utilize region's abundant solar energy.

These regions, with their favorable natural resources, align with the Vietnamese government's strong commitment to renewable energy. Coupled with supportive national policies, they are poised to play a critical role in the country's transition towards a sustainable energy future. The study will analyse the skills demand and training capacities needed to support this growing sector in these regions, aiming to ensure that the workforce is adequately prepared to meet future industry needs.

1.4 APPROACH AND METHODOLOGIES

To achieve the study's objectives, a robust and comprehensive mixed-methods approach is employed in this study. This approach combines qualitative and quantitative research techniques to gather in-depth insights into the current state of the renewable energy sector and its training requirements.

A mixed-methods approach, utilizing:

- Analysis of secondary data sources.
- In-depth interviews.
- Focus group discussions.
- Comprehensive surveys.

Qualitative data collection methods include:

- Conducting desk review of existing secondary data and information. The documents reviewed encompass, but are not limited to:
    - Current national and regional policies related to RE, and the TVET system in Vietnam, particularly those focused on orientation and RE human resources training at both national and provincial levels,
    - Existing studies on stakeholder mapping within the RE field, and human resource development in the RE sector,
    - Relevant reports and publications on the RE sector relevant to the study's scope including GIZ's existing materials i.e. the Inception Report: *Analysis of Employment and Skill Needs for a Just Energy Transition in Vietnam* (GIZ, 2023), and the Inception Report: *Assessment of Skill Needs and Training Capacity in the Renewable Energy Sector in the Central Region and Central Highlands of Vietnam*.
- Consulting various stakeholders via in-depth interviews and survey with various stakeholders, including business entities in the RE sector, TVET institutes, current workforce employees, etc. This helps capture firsthand insights into the skills gaps, training needs and current workforce capabilities.
- Participating in key events and forums relevant to RE enterprises in Vietnam and internationally, to stay updated on global and national best practices and trends.

In sequence, the team took the following steps:

- Preparation phase: this involves the development of the overall workplan, methodology, approach, report outline. Relevants documents were also reviewed at this stage.
- Data collection: Key In-depth Interviews (KIIs), focus group discussion (FGD), and surveys conducted with businesses, TVET institutions and other relevant stakeholders in the RE sector.
- Data Analysis: All collected data was analysed to identify the key trends, gaps and insights regarding skills demand and training capacity in RE sector.
- Draft Report development: Based on the analysis, a draft report will be prepared outlining the findings and preliminary recommendations.

- Consultative Feedback: Another round of consultations was conducted with some relevant stakeholders to ensure that report reflects accurately the perspectives of key stakeholders.
- Finalize the report: The final report incorporates the received feedbacks ensuring that it provides a comprehensive, actionable set of recommendations for policy makers, training institutions, and businesses.

By following this methodology, the study aims to deliver a comprehensive, evidence-based analysis of the skills demand and training capacity in the renewable energy sector, with practical recommendations for addressing identified gaps.

1.5 REPORT STRUCTURE

This report is structured into seven chapters, each focusing on a key aspect of the study to ensure a comprehensive analysis of the renewable energy (RE) sector and the training capacity in Vietnam's Central and Central Highlands regions. The chapters are organized as follows:

- Chapter 1 (this chapter) gives an introduction to the study, its objectives, scope, and methodology. It provides the background to the research and sets the context for understanding the importance of assessing skills demand and training capacity in the renewable energy sector.
- Chapter 2 provides an overview of the current state of RE development in Viet Nam and the regions, including installed capacity, key RE projects, and investment trends which help to contextualize the skills and training needs for the sector.
- Chapter 3 analyzes the current and projected skills demands and employments' needs in the RE sector, considering different phases of an RE project development (design, development, construction, O&M). It outlines the specific skills required for each phase of project development and identifies the growing demand for specialized workers in the sector.
- Chapter 4 provides a comprehensive overview of the training programs offered by TVET institutions and other training providers in the regions. It analyzes the collaborations/cooperation between the enterprises and the TVET / training institutions, and evaluates the quality, relevance, and accessibility of these programs in meeting the workforce needs of the RE sector.
- Chapter 5 analyzes the gaps between the skills demand identified in Chapter 3 with the available training capacity assessed in Chapter 4. It highlights any mismatches or gaps between the skills demand by the RE sector and the skills available in the current workforce and identify key areas where improvements are needed.

- Chapter 6 provides actionable recommendations for skills development initiatives including the recommendations for enhancing collaboration between training institutions and potential employers in the RE sector in the selected region. It also offers suggestions on how government policies and regulations can support the development of skilled workforce for RE including incentive for training providers and businesses, accreditation standards, workforce development programs tailored to the RE sector's need, etc.
- Chapter 7 concludes the study by recapping the key findings, emphasizing the critical role of addressing skills gaps in ensuring the successful development of the renewable energy sector in the Central and Central Highlands regions. The chapter highlights the potential benefits of investing in skills development and training, including increased employment opportunities, improved productivity, and accelerated RE deployment. Finally, the chapter reiterates the key recommendations outlined in the study, such as strengthening industry-academia partnerships, investing in training infrastructure, and developing tailored training programs to meet the specific needs of the renewable energy sector.

CHAPTER II: THE RE SECTOR IN THE CENTRAL AND CENTRAL HIGHLANDS OF VIETNAM

2.1 CURRENT STATUS OF RE DEVELOPMENT

The Central and Central Highlands regions of Viet Nam have experienced significant growth in renewable energy, particularly in wind and solar power, driven by government commitments and private investments. As of 2023, renewable energy has emerged as a key component of Vietnam's strategy to meet its energy security goals and contribute to climate action. The focus has been primarily on onshore wind and solar photovoltaic (PV) systems, which align with Vietnam's unique geographic advantages in these regions.

Ninh Thuan, one of the provinces in the regions, has been recognized as a national hub for renewable energy in Vietnam, leveraging its abundant sunlight and wind resources. To support this growth, local government authorities are investing in the development of a highly skilled workforce tailored to the renewable energy sector. The goal is to become National Center for energy and renewable energy and produce a proficient labor force by 2030, ensuring the sustainable development of the industry within the province.[7]

Wind energy development

As of 2023, Vietnam's total wind energy capacity reached approximately 4,000 MW, encompassing both onshore and nearshore installations. The Power Development Plan VIII (PDP VIII) outlines ambitious targets, aiming for about 28 GW of wind capacity by 2030, with 22 GW allocated to onshore and nearshore projects and 6 GW to offshore developments.[8]

The development of wind power involves several key phases: project development, construction, operation, and maintenance (O&M). Domestic manufacturers, such as PetroVietnam Technical Services Corporation (PTSC) and collaborations with foreign entities like CS Wind are helping enhance Vietnam's capacity to produce essential components, including towers and turbine bases[9,10]. However, the country still lacks the capability to produce wind turbineblades and other specialized equipment, often relying on imports and foreign expertise to fill this gap.

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[7] https://vietnamnews.vn/society/1663749/ninh-thuan-makes-investment-in-green-labour-force-for-renewable-energy-sector.html

[8] https://www.wfw.com/articles/vietnam-offshore-wind-status-and-recent-developments

[9] https://www.ptsc.com.vn/en-US/ptsc-and-rsted-signed-contract-for-manufacture-and-supply-of-foundations-for--the-greater-changhua-2b-4-offshore-wind-farms

[10] https://en.vneconomy.vn/cs-wind-vietnam-unveils-southeast-asias-largest-offshore-wind-tower-factory.htm

Currently, most of the operational and maintenance activities are handled by suppliers and international service providers. The high costs associated with these outsourced services are driving a shift towards greater localization. To reduce costs and increase efficiency, some wind power projects are now investing in development of local O&M capabilities. A key objective is to reduce dependence on foreign technicians by training Vietnamese professionals and skilled local workforce, particularly in critical O&M roles such as wind turbine technicians and blade repair specialists.

Solar PV development

The Central and Central Highlands region of Viet Nam also have high potential for solar PV installations, given the region's high average solar radiation of up to 5 kWh/m^2/day [11], particularly in provinces like Ninh Thuan, Binh Thuan, and the Central Highlands. The solar energy sector in Vietnam has experienced rapid growth, fueled by government incentives like Feed-in tariffs, which have encouraged the installation of both ground-mounted and rooftop solar systems.

Solar PV capacity in Vietnam reached approximately 16.6 GW by the end of 2021, with more than 11,6 GW added in 2020 alone.[12] However, this rapid expansion of solar energy has been accompanied by challenges, particularly related to grid limitations and the need for enhanced energy storage solutions. Unlike wind projects, solar PV installations are more standardized, allowing for shorter construction times and fewer logistical hurdles.

Recent policy updates, including Decree 135/2024/ND-CP, aim to further support the growth of rooftop solar (RTS) in Vietnam.[13] The government has set an ambitious goal under PDP VIII to equip 50% of residential and public buildings with solar PV by 2030. Despite this target, fewer than 1% of roofs in Vietnam currently have RTS installations, indicating significant untapped potential. Achieving the 50% target will require approximately 5 million solar systems on residential buildings and over 40,000 systems on public buildings.[14]

The RTS market in Vietnam is being driven by a new wave of incentives and a focus on self-consumption.[15] The latest policies encourage a major wave of bottom-up solar PV adoption, emphasizing systems designed to meet on-site energy needs without exporting surplus to the grid. This approach includes micro-PV systems, typically between 200W

[11] World Bank, Vietnam: Achieving 12 GW of Solar PV Deployment by 2030 An Action Plan, Oct 2018.
[12] IRENA, Renewable Energy Statistics, 2023
[13] https://www.frasersvn.com/legal-updates-and-publications/decree-135-2024-nd-cp-on-rooftop-solar-power
[14] https://solarquarter.com/2023/06/12/vietnam-aims-for-50-rooftop-solar-adoption-in-office-and-residential-buildings-by-2030/?utm_source=chatgpt.com#google_vignette
[15] https://solarquarter.com/2024/05/16/vietnam-propels-rooftop-solar-power-for-self-consumption-not-trading-industry-ministry/?utm_source=chatgpt.com#google_vignette

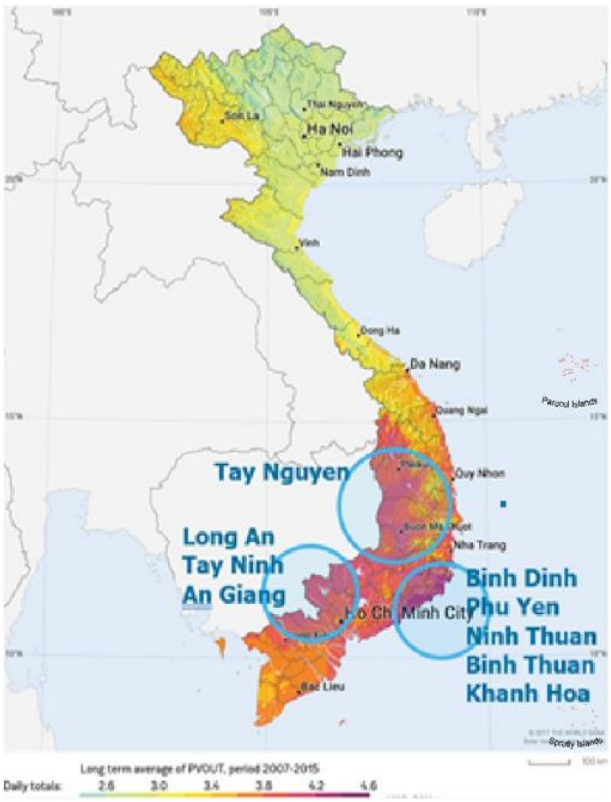
and 800W, which can be directly plugged into residential or commercial power sockets, and larger RTS systems ranging from 1kW to 5MW for public and industrial buildings.[13] Notably, the emphasis on self-consumption aims to avoid grid overload and improve the financial return for system owners.

Cost reductions have also played a significant role in making solar PV more accessible. The price of solar modules has dropped significantly, with costs reduction ofaround 50% in 2023 and a further 21-34% in 2024.[16] As a result, solar PV is now entering a new era of widespread deployment in Vietnam, supported by decreasing costs and improved technology. The financial model for RTS is especially attractive for smaller systems, where payback times can range from four to six years depending on the region, with shorter paybacks in the southern regions due to higher solar insolation.

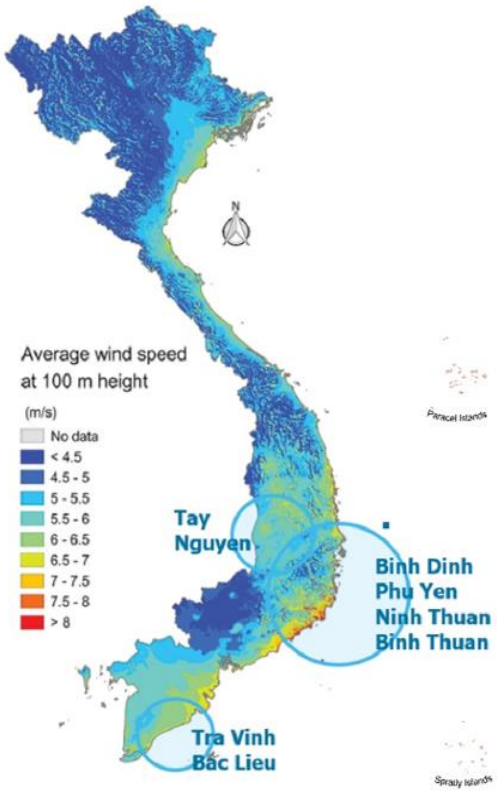
While utility-scale solar power is becoming increasingly constrained by infrastructure limitations, rooftop solar continues to receive support, particularly for self-consumption purposes. The government's current policies have shifted away from encouraging solar PV systems that sell excess energy back to the grid, focusing instead on installations that enhance energy independence for businesses and households. The new RTS Decree provides clarity on the market structure and supports initiatives that promote a thriving local solar PV market, which in turn is expected to generate new jobs and strengthen local supply chains.

[16] https://www.pv-magazine.com/2023/11/23/solar-module-prices-may-reach-0-10-w-by-end-2024

Figure 2: Detail of Solar PV Wind Technical Potential in Viet Nam. [17]



Province with Solar PV Potential in Viet Nam



Province with Wind Potential in Viet Nam

Source: *National Load Dispatch Center – EVN, 2023 and McKinsey, 2023*

2.2 POTENTIAL GROWTH

Growth opportunities

Both wind and solar energy have substantial potential for expansion in the Central and Central Highlands regions. Government targets set under PDP VIII aim to transform Vietnam into a renewable energy hub, not only meeting domestic electricity needs but also positioning the country as a regional energy exporter, particularly to neighboring ASEAN countries. The region's geographic advantages—coastal winds and high solar irradiance—provide a strong foundation for growth.

[17] https://www.mckinsey.com/featured-insights/sustainable-inclusive-growth/charts/vietnams-potential-for-renewables

Table 1: On-shore wind power capacity of provinces in PDP VIII[18]

#	Provinces	Capacity (MW)
1	Dien Bien	300
2	Bac Kan	400
3	Yen Bai	200
4	Bac Giang	500
5	Lang Son	1,444
6	Thai Binh	70
7	**Thanh Hoa**	**300**
8	**Nghe An**	**70**
9	**Ha Tinh**	**350**
10	**Dak Lak**	**870**
11	**Lam Dong**	**118.9**
12	**Ninh Thuan**	**553,7**
13	**Phu Yen**	**298**
14	**Binh Dinh**	**30**
15	Ba Ria - Vung Tau	150
16	Ben Tre	713.5
17	Bac Lieu	741
18	Tien Giang	200
19	Tra Vinh	872,5
20	Soc Trang	733.2
21	An Giang	50
22	Ca Mau	900
23	Hau Giang	100
24	Kien Giang	137
	Total	**8675.6**

Source: *Author's Own Compilation*

Wind energy, especially offshore, offers significant export potential. With the recent partnerships for offshore wind projects, such as those between PTSC and international companies like Sembcorp, Vietnam is looking to tap into offshore wind opportunities, especially from 2027 onward, when the industry is expected to grow significantly.

[18] *Decision No. 262/QD-TTg dated April 01, 2024 on approving the plan to implement the National Power Development Planning for 2023 - 2030 period, with a vision toward 2050 (PDP 8)*

Table 2: Off-shore wind power capacity by regions in PDP VIII[19]

No.	Region	Increase in Capacity 2023-2030 (MW)
1	Northern region	2,500
2	North Central Coast	0
3	Central region	500
4	Central Highlands	0
5	South Central Coast	2,000
6	Southern region	1,000
	Total capacity	**6,000**

Source: *Author's Own Compilation*

For solar PV, opportunities remain strong in distributed generation, particularly rooftop solar (2,6 GW for the whole country). This segment is well-positioned to support local energy independence and stabilize energy supply, especially as policies evolve to support more self-consumption rather than grid-export models. The RTS market segments include residential, public building, and commercial/industrial applications, each with different system size ranges and regulatory frameworks that encourage their adoption (Detail in Appendix).

2.3 GOVERNMENT POLICIES AND INITIATIVES FOR RE IN PDP VIII

The Vietnamese government has implemented a range of initiatives to promote renewable energy, focusing on financial incentives, regulatory simplification, and fostering international partnerships. PDP VIII serves as the strategic framework for energy planning until 2030 and beyond, with a vision to increase the share of renewables in the national energy mix to nearly 47% by 2050.

To drive the sector's growth, the government has also introduced Feed-in tariffs that initially spurred the rapid growth of solar and wind installations. Recent shifts in policy focus on enhancing local capabilities, fostering private-public partnerships, and introducing programs that can help align educational training with industry requirements. The establishment of a Sector Skills Council (SSC) for renewable energy is also under discussion, intending to bridge the skills gap by aligning training programs with the actual needs of the industry.

[19] *Decision No. 262/QD-TTg dated April 01, 2024 on approving the plan to implement the National Power Development Planning for 2023 - 2030 period, with a vision toward 2050 (PDP 8)*

Such initiatives are crucial for ensuring that the benefits of renewable energy are maximized—both in terms of energy security and economic opportunity. By providing incentives for local manufacturing, skills development, and collaboration between stakeholders, the government aims to build a sustainable renewable energy ecosystem that can support continued growth in these regions.

Challenges for wind and solar PV in the development of PDP VIII

The development of Vietnam's Power Development Plan VIII (PDP VIII) faces several significant challenges, including:

1. Mobilizing Investment Capital: Vietnam, alongside South Africa and Indonesia, aligns with the Just Energy Transition Partnership (JETP) to support its energy transition. The initial JETP commitment of $15.5 billion remains modest compared to the estimated $650 billion required over the coming decades.[20,21] Vietnam faces the risk of international commitments potentially not materializing, burdening local investors and institutions to fill funding gaps.

Securing investment for large-scale renewable projects is difficult due to perceived risks associated with regulatory instability and potential delays. Additionally, the absence of favorable pricing mechanisms, such as feed-in tariffs (FiTs), has diminished the financial attractiveness of these projects. The transition from fixed FiTs to competitive bidding processes has introduced uncertainty. Developers who missed FiT deadlines are now subject to lower tariffs, affecting project viability and financial planning.

2. Grid Integration and Stability: Although PDP VIII aims to increase the share of RE, developing these sources faces challenges related to policy mechanisms, grid infrastructure, and integration into the national power system. The rapid expansion of RE has outpaced the development of transmission infrastructure. This mismatch has resulted in grid congestion and curtailment of RE output, where generated power cannot be fully utilized due to transmission constraints. The pressures on the power transmission system includes:

- Increased transmission demand: The rapid increase in renewable energy projects, especially in coastal and mountainous areas, requires rapid expansion and upgrading of the transmission system.

[20] https://www.reuters.com/sustainability/climate-energy/global-jetp-plans-help-developing-nations-clean-up-power-sectors-2024-09-25
[21] https://vietnamnews.vn/economy/1663373/forum-seeks-to-accelerate-transition-to-a-net-zero-economy.html

- Dispersion of power sources: Renewable energy projects are often widely distributed and not concentrated, making it difficult to collect and transmit electricity.
- Volatility of power sources: Electricity output from renewable energy sources depends on natural factors such as wind and sunlight, causing large fluctuations in the power system.

Due to insufficient transmission capacity, the allocation of power capacity across regions is imbalanced, leading to supply-demand mismatches, increased transmission losses, and curtailment of RE when generation exceeds grid capacity. Notably, the northern region faces potential power shortages due to a lack of new power supply sources.

3. Legal and Policy Framework: PDP VIII seeks to increase renewable energy's share in the national energy mix, notably through rooftop solar. However, clear execution plans are lacking, particularly for the ambitious target of equipping half of Vietnam's buildings with rooftop solar. Without further regulatory support and clarity, challenges around infrastructure integration and grid overloads persist.

The RE sector also faces regulatory and administrative challenges. Policies and procedures for acquiring permits, conducting environmental assessments, and negotiating power purchase agreements can be inconsistent, slowing project timelines. For offshore wind, specifically, issues like overlapping maritime zones and a lack of clear guidelines for foreign investors remain barriers.

Another challenge lies in workforce development. As detailed in further sections, there is a skills gap, particularly in specialized areas such as wind turbine maintenance. Training institutions in the Central and Central Highlands are beginning to offer more tailored programs, but these efforts need to be scaled up significantly to meet growing industry needs.

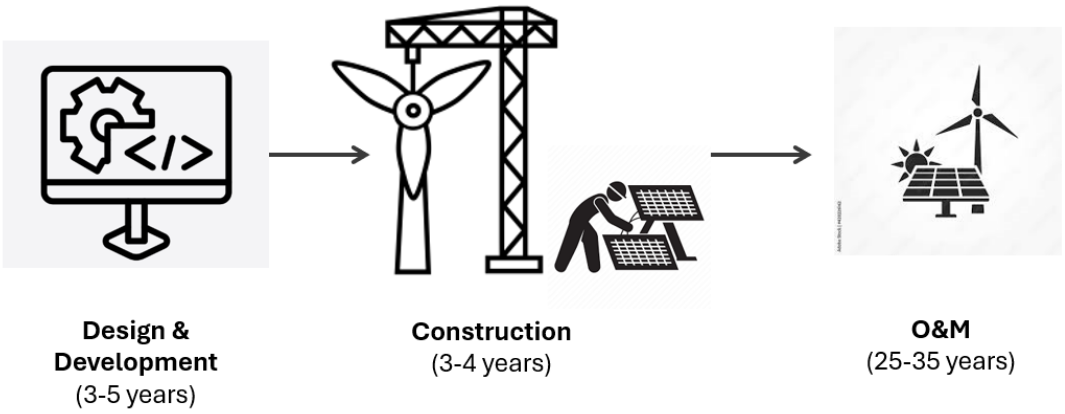
4. Transitioning from Fossil Fuels: Under PDP VIII, Vietnam aims to reduce the share of coal-fired power to 20% by 2030 and phase it out completely by 2050, while increasing RE, especially wind and solar power. Despite strong government commitments to promote RE development, this transition still faces many difficulties, especially in terms of funding and ensuring equity in the transition. The transition will require not only significant investments in RE but also in retraining workers and managing the social and economic impacts of moving away from fossil fuel industries. In addition, the dispersion of RE sources also creates challenges in terms of electricity collection and transmission, requiring the expansion and upgrading of the existing transmission system.

5. Technological and operational challenges: are also a major issue. Integrating RE into the grid requires advanced energy storage solutions and smart grid management systems to address the instability of these energy sources. The lack of proprietary technology and specialized software in the wind industry also makes it difficult to train and develop human resources. Furthermore, policies and legal processes related to licensing and environmental impact assessments can be inconsistent, causing delays to projects. Although TVET institutions have begun to offer more specialized training programs, they still need to expand further to meet the growing needs of the industry. In addition, international certification standards for renewable energy technicians are still limited in Vietnam, making it difficult to participate in the global labor market.

CHAPTER III – HUMAN RESOURCE DEMAND IN THE RE SECTOR

Given the fact that Vietnam's RE sector is experiencing rapid growth, the successful development and operation of RE projects heavily rely on a skilled workforce. This chapter delves into the current and projected skills demands and employment needs in the RE sector, considering different phases of an RE project development (design, development, construction, and O&M) and the specific skills required for each phase.

Figure 3: Three phases of a RE project for countries like Vietnam.

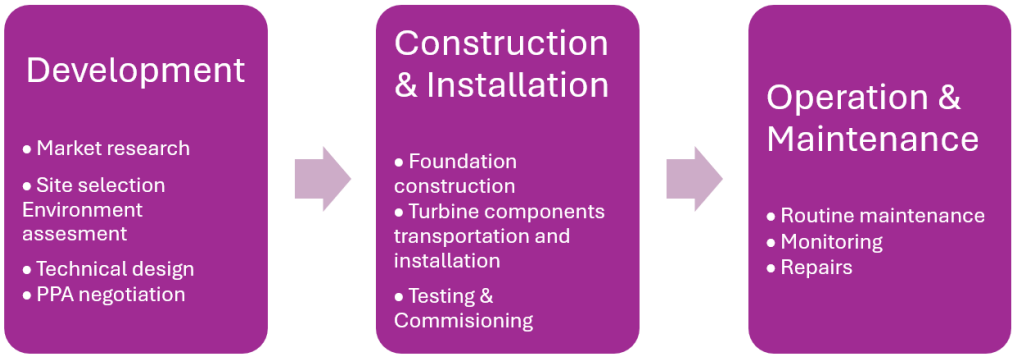


Source: *Author's Own Compilation*

3.1 KEY POSITIONS IN THE VALUE CHAIN OF WIND POWER ENERGY

The wind power industry operates through three key phases in its value chain, i.e. Project Development, Construction & Installation (C&I) and Operational & Maintenance (O&M). Vietnamese businesses report that they have mastered the first two phases – project development and construction. Currently, the focus is on O&M phases. With more detailed guidance and anticipated under PDP VIII, businesses expect that new projects will start C&I in 2027. The Table 3, 4 and 5 below list detailed activities and key personnel typically observed in the global wind power value chain.

Figure 4: Typical key activities along the value chain of wind power.



Source: *Author's Own Compilation*

Table 3: Typical positions in the Development phase of wind power

Development phase	Positions
Before starting an offshore wind project, significant groundwork is needed, including market research, technology evaluation, lease auctions, and power purchase agreements. Developers, aided by consultants and specialized teams, handle this phase. Once underway, a dedicated team of 30-50 members is formed, growing over the project's 3- to 5-year duration. This team manages tasks like environmental assessments, design, and interconnection studies, often contracting specialists.	**Management and Oversight** • Chief Executive Officer (CEO) • Chief Commercial Officer • Chief Finance Officer (CFO) • Finance Manager • Project Development Manager • Procurement Director/Manager • Environment and Consent Manager • Legal Counsel • Project Management Officer (PMO) • Planning Manager • Wind energy system designer

Source: *Author's Own Compilation*

Table 4: Typical positions in C&I phase

Construction & Installation Phase	Positions (together with previous needed management positions)
Site Preparation Before construction begins, the site must be prepared. This involves clearing vegetation, leveling the ground if required, and ensuring suitable access roads are built for transporting heavy machinery and turbine components. Onshore wind farms are usually in rural or hilly areas, so road construction may be necessary to handle large loads and equipment.	**Management and Oversight** • HSE Manager • Risk Manager • Human Resources Manager • Construction Manager • Site Manager **Engineering and Technical Support** • Project Engineer

Construction & Installation Phase	Positions (together with previous needed management positions)
Foundation Construction Wind turbine foundations are critical for stability and are typically made of reinforced concrete. The foundation design depends on the soil type and wind load requirements. The construction process involves: • Excavation to create a stable base. • Setting up formwork and placing steel reinforcements. • Pouring concrete and allowing it to cure. These steps ensure the foundation can support the turbine's weight and withstand operational stresses. **Turbine Components Transportation and Installation** Wind turbines consist of the tower, nacelle (housing the generator and gearbox), and rotor blades. The construction process includes: • **Transportation:** Logistics planning is crucial to transport turbine components to often remote sites. Transport challenges like narrow roads, sharp turns, and local infrastructure limitations must be addressed. • **Assembly:** ○ *Tower Assembly:* Tower sections are lifted and stacked using cranes. ○ *Nacelle Installation:* The nacelle is placed on top of the completed tower. ○ *Rotor and Blades Installation:* The rotor and blades are assembled on the ground and lifted as one unit or attached piece by piece to the nacelle.	• Foundation Engineer • Electrical Engineer/Supervisor • Mechanical Engineer/Supervisor • SCADA Engineer • Quality Manager **Field and Site Roles** • Fabrication Supervisor/Manager • Heavy Lift Supervisor • Crane Operator • Installation Technician • Site Administrator • Blade Repair Technician • Wind Turbine Technician **Specialized Roles** • Document Control Manager • Community Affairs Officer • Communication Manager • Localization Manager **Support and Logistics** • Site Logistic Coordinator • Warehouse Stores Assistant • Transport and Equipment Supervisor **Other Specialized Roles for Installation** • Geotechnical and Soil Analysis Expert • Environmental Assessment Coordinator • Coating Inspector • Painter/Rope Access Technician

Source: *Author's Own Compilation*

Table 5: Typical positions in the O&M phase

Operation & Maintenance	Positions (together with previous needed management positions)
The O&M phase focuses on ensuring the wind farm operates efficiently and reliably throughout its lifecycle, typically 20-25 years. Key activities include regular inspections, preventive and corrective maintenance, and performance optimization of turbines and associated systems. Maintenance tasks cover mechanical components, electrical systems, and software, requiring skilled technicians and engineers to address potential issues promptly. Routine inspections involve monitoring turbine performance, SCADA system functionality, and environmental compliance. Preventive measures such as blade cleaning, lubrication, and minor repairs minimize downtime and extend equipment lifespan. Corrective maintenance includes addressing faults like blade damage or gearbox issues to restore operational capacity. A dedicated team oversees site operations, with roles ranging from technicians to managers responsible for safety, compliance, and resource planning. Effective logistics, spare part management, and data analysis are critical for maintaining high availability and optimizing energy output. This phase also includes community engagement and environmental stewardship, ensuring the wind farm remains a sustainable and accepted part of the local landscape.	**Technical and Engineering Roles** • Wind Turbine Technician • Electrical Technician/Supervisor • Mechanical Technician/Supervisor • SCADA Engineer • Performance Monitoring Engineer • Blade Repair Technician **Specialist Roles** • Wind Yield Performance Analyst • Environmental Compliance Manager • Quality Assurance Inspector • Coating Inspector • Rope Access Technician (for blade or tower maintenance) **Field and Site Support** • Site Administrator • Maintenance Planner/Scheduler • Inventory/Warehouse Manager • Logistics Coordinator **Support and Other Roles** • Document Controller • Community Affairs Officer • Communication Manager

Source: *Author's Own Compilation*

Value chain for offshore wind is much more complex due to the maritime operation (Annex 5).

Key considerations for Vietnam in the value chain

Wind projects in Vietnam follow a similar structure to the globally observed value chain during in Development and C&I phases in table 3 and 4. However, in O&M phase, local teams tend to have a simpler organizational structure with positions that can take on multiple tasks. Many windfarms in Vietnam currently reply on O&M contract with suppliers, which means their demand on human resources in this phase is relatively low. Some local businesses are beginning to form O&M teams to serve the growing domestic

markets.[22, 23] Others adopt an in-house O&M strategy of self-reliance, and workforce development. By developing in-house capabilities and contracting local firms, wind farms minimize O&M reliance, saving costs and improving efficiency. Skilled local teams are increasingly supporting other projects, enhancing sector-wide independence. The in-house teams involve turbine maintenance, substation management, and personnel training.

Table 6: Approach of Vietnamese business to develop in-house O&M capacities for wind energy

Organizational structure	Functions	Details
Maintenance	OEM and In-House Roles	Initially managed by OEMs, maintenance is increasingly handled in-house to lower costs and enhance control, with some turbines maintained internally while newer ones remain under OEM care for comparison.
	Specialized Repairs	Blade repairs, excluded from OEM warranties, are outsourced to local contractors at about half the OEM cost. Farms are also developing in-house expertise for repairs, focusing on materials, procedures, and environments.
	Skilled Workforce	Certified technicians with GWO or similar credentials handle maintenance tasks like climbing, safety, and repair, often requiring multiple, renewable certifications.
	Certification Specificity	Task-specific certifications are essential, ensuring technicians meet the requirements for roles like blade repair.
Substation Management	Certified Personnel	Substations linking wind farms to grids are operated by certified staff, such as "operation technician" and "shift supervisor".
	Training Services	Many farms train operators internally and extend these services to other projects.
Personnel and Training	Local Expertise	Farms prioritize local teams to reduce reliance on foreign experts, cutting costs while maintaining quality.
	Targeted Training	Personnel are matched to specialized programs for their roles, with operators often advancing from vocational training and engineers assuming leadership positions. For example, workers at substations will go through training with EVN, while turbine technicians receive training from GWO-certified local training centers.

Source: *Author's Own Compilation*

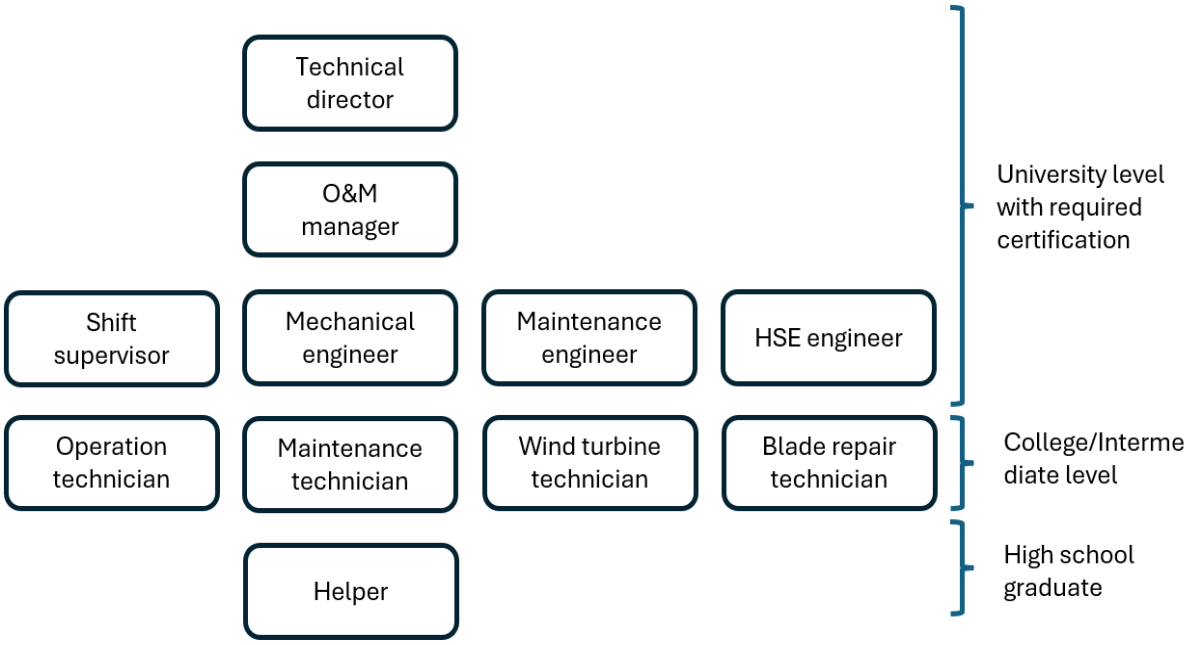
[22] https://vuphong.vn/toi-uu-van-hanh-gia-tang-gia-tri-nha-may-dien-gio/
[23] https://nangluongvietnam.vn/xu-huong-moi-trong-van-hanh-va-bao-tri-nang-luong-gio-27911.html

In general, there is a clear trend toward the localization of O&M services in Vietnam. By developing in-house capabilities and contracting local firms, wind farms are reducing their reliance on external O&M service, which helps lower costs and improve efficiency. Skilled local teams are playing an increasingly important role in supporting other projects, contributing to greater independence across the sector and strengthening the overall capacity of the industry.

O&M team – current focus for Vietnam's wind industry:

Figure 5 illustrates the typical organizational structure of wind power O&M teams in Vietnam, along with the qualifications required for each position. In this structure, the workforce with College and Intermediate level qualifications typically fills technical roles. Table 7 provides a detailed breakdown of the responsibilities, required qualifications, and skills for each job position within the O&M team.

Figure 5: Typical structure of wind power O&M teams in Vietnam



Source: *Author's Own Compilation*

Table 7: Key personnel in Vietnam's O&M teams for wind power

Positions	Responsibilities	Qualifications
Technical director	• Oversee production operations and manage technical and operational functions for the wind power plant. • Organize inspections and evaluations of equipment, plan and oversee regular maintenance and repairs. • Directly handle and coordinate responses to equipment failures. • Register daily and weekly power output on the national power system's platform. • Liaise with stakeholders to address equipment issues and optimize solutions. • Develop management measures, operating procedures, and technical regulations. • Plan training and recruitment to meet plant staffing needs. • Build relationships with local authorities and government agencies to address operational challenges. • Report on plant operations and incidents to company leadership monthly. • Manage staff, assign shifts, evaluate performance, and implement labor rewards and penalties. • Identify and address risks during production and propose solutions.	• Bachelor's degree or higher in Electrical Engineering or Power Systems. • At least 5 years in the electrical field, including 2+ years in wind power plant operations (minimum 40 MW capacity and 220 kV grid connection). • Minimum of 3 years in a management role. • Comprehensive understanding of renewable energy projects and the energy market. • Familiarity with corporate culture, vision, and mission. • Strong leadership, management, negotiation, and presentation skills. • Strategic planning and people development. • Proficiency in English for communication and project requirements.
O&M Manager	• Manage and oversee wind farm O&M activities, ensuring optimal performance and adherence to schedules. • Supervise O&M contractors and team, providing guidance, support, and recruitment when necessary. • Track and maintain operational records, including site performance, downtime, maintenance, and inspections. • Develop and implement strategies to enhance efficiency, reduce costs, and extend turbine lifespan.	• University degree in Engineering, Electricity. • Minimum 3 years experience managing wind farm project operation • Good technical understanding of wind farm • Strong leadership and management skills • Good command of English speaking and writing • Analytical thinking and Problem-solving skills • Good interpersonal skills, ability to effectively manage the relationship

Positions	Responsibilities	Qualifications
	• Oversee maintenance of wind farm infrastructure, such as towers, transformers, and roadways. • Liaise with customers, authorities, and contractors while managing spare parts inventory. • Establish goals and priorities for operations, handle dispatch matters, and address issues promptly to ensure smooth operations.	with other teams • Advanced computer skills
HSE Engineer	The HSE Manager ensures that all O&M activities are conducted safely, protecting the well-being of employees and the environment. A strong focus on health and safety reduces the risk of accidents and enhances the overall operational reliability of the wind farm. • Oversee occupational safety and ensure compliance with regulations. • Provide safety guidance for on-site staff and suppliers. • Maintain traffic and safety systems at the site. • Enforce safety policies and address violations. • Update company practices based on new safety laws. • Manage safety equipment and inspect machinery. • Conduct audits, training, and incident investigations.	• Graduated from university with a major in Engineering, Occupational Safety, or Labor Protection. • At least 2 years of experience in a similar field. • A certification in Occupational Safety and Health such as GWO Basic Safety Training • Proficient in safety regulations, wind power standards, and risk assessment. • Strong leadership, communication, and ability to promote a safety-first culture. • Skilled in compliance reporting and safety management software.
Mechanical /Hydraulic Engineer	• Performs routine maintenance and repairs on mechanical components of substation. • Keeps detailed records of maintenance activities and electrical system performance. • Understand wind turbine construction and operation principles. • Plan and manage mechanical equipment and turbine installation, maintenance and repair. • Work independently or in teams for maintenance and troubleshooting.	• Bachelor's degree in Hydraulic Mechanics or related fields. • Over 2 years of experience. • Proficiency in relevant design software. • Experience diagnosing, repairing, and servicing hydraulic machines and their components • Experience with SCADA systems, remote operation and fault finding of complex power generation equipment

Positions	Responsibilities	Qualifications
	• Supervise maintenance teams and resolve operational issues, ensuring adherence to safety and quality standards	• Careful, honest, responsible, and team-oriented • GWO Basic Safety training, IRATA rope access certification • English listening and reading.
Maintenance Engineer	• Supervise and monitor the operation of the wind power plant. • Make plans, propose maintenance and service of electrical equipment at the power plant. • Report an abnormal condition of the system or equipment. • Participate in the analysis process to find the core cause of the problem, thereby providing preventive and corrective actions. • Collaborate with the chief operator to diagnose, repair, maintain, and service electrical equipment, ensuring the continuous optimal functioning of the system.	• Bachelor's degree in power systems, electrical engineering, or automation control engineering • 3-5 years of experience. • Proficient in using design and office software computer software. • Analytical skills, quick judgment in all situations. • Creative skills at work. • Communication skills at work • GWO Basic Safety training, IRATA rope access certification • Team organisation/teamwork skills. • English listening and reading skills.
Maintenance Technician	• Monitoring turbine operations, inspecting towers and blades, troubleshooting nacelle electronics, mechanics, and hydraulics, and proposing solutions for abnormalities. • Collecting test data, replacing faulty parts, working on substations and fiber optic systems, starting generator systems, and performing periodic maintenance. • Monthly operational reports with proposed improvements and detailed post-maintenance documentation are prepared. • Managing tools and handling assigned tasks demonstrate a proactive and flexible approach	• College or intermediate or above degree in power systems, electrical engineering, or automation control engineering. • Proficient in using design and office software computer software. • GWO Basic Safety training, IRATA rope access certification • Hardworking, diligent, with a positive attitude, high independence, and proactive. • Strong communication and presentation skills. • Responsible, able to work under high pressure. • English listening and reading skills.
Wind Turbine Technician	• Conducts regular inspections and maintenance on wind turbines.	• College or intermediate or above degree in electrical engineering, or mechanical engineering.

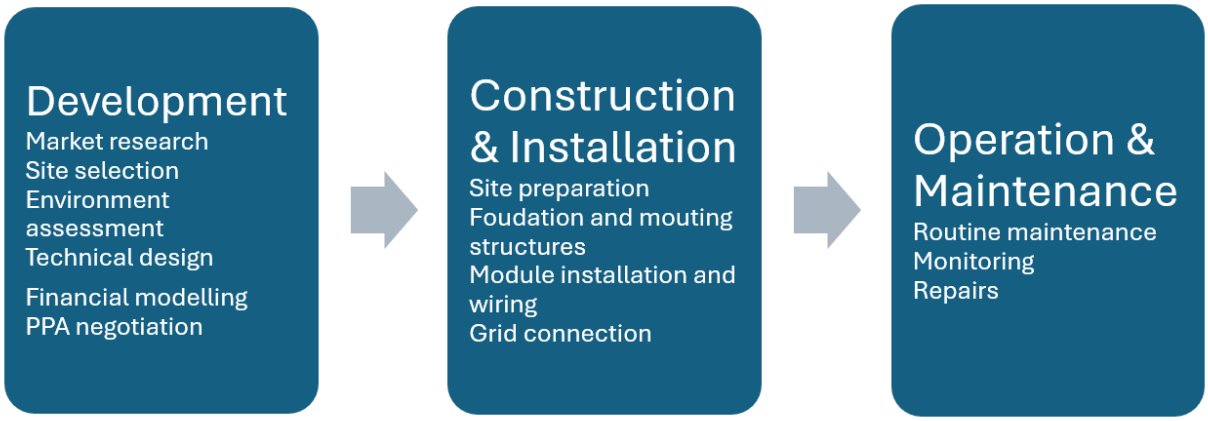
Positions	Responsibilities	Qualifications
	• Diagnoses and repairs faults in turbine systems, including electrical, mechanical, and hydraulic components. • Ensures that turbines are operating at peak efficiency and performance. • Records and reports maintenance activities and turbine performance metrics. Wind Turbine Technicians are on the front lines of maintaining the functionality and efficiency of the turbines. Their hands-on work ensures that the turbines remain operational and effective, contributing directly to the wind farm's energy production.	• GWO Basic Safety training and blade repair training, IRATA rope access certification • Mechanical skills, with the ability to repair mechanical, hydraulic, braking, and electrical systems of wind turbines. • Skilled in documentation, troubleshooting, and problem-solving. • Hardworking, proactive, and highly independent. • Strong communication. • Responsible and capable of handling high-pressure situations. • Proficient in English listening and reading.
Blade Repair Technician	• Inspects and repairs wind turbine blades, addressing issues such as cracks, erosion, and structural damage. • Uses specialized equipment and techniques to perform repairs. • Conducts regular maintenance to prevent blade deterioration. • Documents repair activities and blade condition. The condition of the turbine blades significantly impacts the efficiency of the wind turbines. Blade Repair Technicians ensure that the blades are in optimal condition, which is essential for maximizing energy capture and production.	• College or intermediate or above degree in electrical or mechanical engineering. • GWO Basic Safety training and blade repair training, IRATA rope access certification • Skilled in repairing mechanical, hydraulic, braking, and electrical systems of wind turbines. • Proficient in documenting and reporting repairs, testing, and inspections. • Strong troubleshooting abilities with innovative problem-solving skills. • English listening and reading skills.
Shift Supervisor	• Be responsible for operating the plant in accordance with relevant processes and regulations. • Organise, manage, supervise, and operate all human resources on duty, ensuring safe and effective operation. • Coordinate with all levels of national load dispatch centers (national: A0, regional: A2),	• Bachelor's degree in Power systems, electrical engineering, or automation control engineering. • 2-3 years of experience. • Operation certificate by National Load Dispatch Center (A0) • Proficient in using design and office software computer software. • Creative skills.

Positions	Responsibilities	Qualifications
	and other relevant units to ensure safe and reliable operation of the wind power plant. • Coordinate with relevant units to quickly handle incident situations and prioritise incidents that have serious impacts on the grid system.	• Strong communication skills. • Team organisation/teamwork skills. • English listening and reading skills.
Operation Technician	• Coordinate with all levels of dispatch (A0, A2), and relevant units at the request of the shift supervisor to ensure safe and reliable operation of the plant. • Responsible for the operation of closing/switching off high-voltage equipment at the substation following the procedures and regulations under the supervision of the chief operator. • Fully record the operation status of electrical equipment, support handling and investigation when incidents occur at the plant.	• College/ University bachelor's degree in Power systems, electrical engineering, or automation control engineering. • At least 1 year of experience. • Proficient in using design and office software computer software. • Creative skills. • Strong communication skills. • Motivational skills and self-control, ability to self-manage work. • Team organisation/teamwork skills.

Source: *Author's Own Compilation*

3.2 KEY POSITIONS IN THE VALUE CHAIN OF SOLAR PV POWER ENERGY

Figure 6: Key activities along the value chain of solar PV power.



Source*: Author's Own Compilation*

Similar to the wind power industry, the solar PV power industry has three phases in its value chain. Vietnamese businesses report that they have mastered the first two phases, with a current focus on the O&M phase. Businesses anticipate that with more detailed guidance from PDP VIII, new projects will begin the C&I phase in 2027. The table 8,9 and 10 below outline the key activities and personnel typically found in the global wind power value chain.

Table 8: Typical positions in the Development phase of solar PV power

Design & Development Phase	Positions
Before starting a solar PV project, substantial groundwork is required, including market assessment, site selection, technology selection, and securing power purchase agreements. The design phase involves: • Identifying suitable land with optimal sunlight exposure. • Conducting solar resource assessments using tools like GIS and drone surveys. • Engaging stakeholders for permits, environmental clearances, and grid access.	**Management and Oversight** • Chief Development Officer • Solar Project Development Manager • Environmental and Social Impact Manager • Legal Counsel • Financial Analysts • Site Planners **Specialized Roles** • Solar Energy System Designer • PV Technology Specialist • GIS Analyst • Grid Interconnection Specialist • Permitting and Compliance Manager

Source: *Author's Own Compilation*

Table 9: Typical positions in the C&I phase of solar PV power

Construction & Installation Phase	Positions (together with previous needed management positions)
The solar PV construction process is relatively simpler than wind but equally intensive, especially for utility-scale projects: **Site Preparation:** Land clearing and grading for ground-mounted systems. Installation of access roads and drainage systems. **Foundation and Mounting Structures:** Installation of racking systems or trackers to support PV modules. Use of specialized mounting systems for sloped or uneven terrain. **Module Installation and Wiring:** Mounting PV panels and connecting them to the electrical system. String inverters or central inverters are installed alongside AC combiner boxes. **Grid Connection:** Installing transformers, switchgear, and high-voltage transmission lines for grid integration.	**Key Roles in Construction** • Construction Manager • Site Engineer • Electrical Engineer • Structural Engineer • Quality Control Inspector • Logistics and Material Coordinator • Safety and Compliance Officer **Field Technicians** • PV Installers • Electricians • Heavy Equipment Operators • Crane Operators for mounting large modules or prefabricated units.

Source: *Author's Own Compilation*

Table 10: Typical positions in the O&M phase of solar PV power

Operation & Maintenance	Positions (together with previous needed management positions)
Solar PV systems have lower O&M requirements than wind farms but still demand regular attention to maintain performance and extend lifecycle: **Performance Monitoring:** Using SCADA systems to monitor output and detect issues. Employing drones for thermal imaging and module inspection. **Preventive Maintenance:** Cleaning modules to reduce soil losses. Checking connections, inverters, and tracking systems. **Corrective Maintenance:** Repairing or replacing damaged modules and electrical components. Addressing inverter failures and tracker alignment issues.	**Key O&M Roles** • Solar Field Technician • Performance Analyst • SCADA Engineer • Electrical Maintenance Specialist • Environmental Compliance Officer **Specialized Roles** • Soiling Loss Mitigation Specialist • Asset Performance Engineer • Warranty Claims Manager **Support Roles** • Site Administrator • Logistics and Inventory Manager • Community Liaison Officer

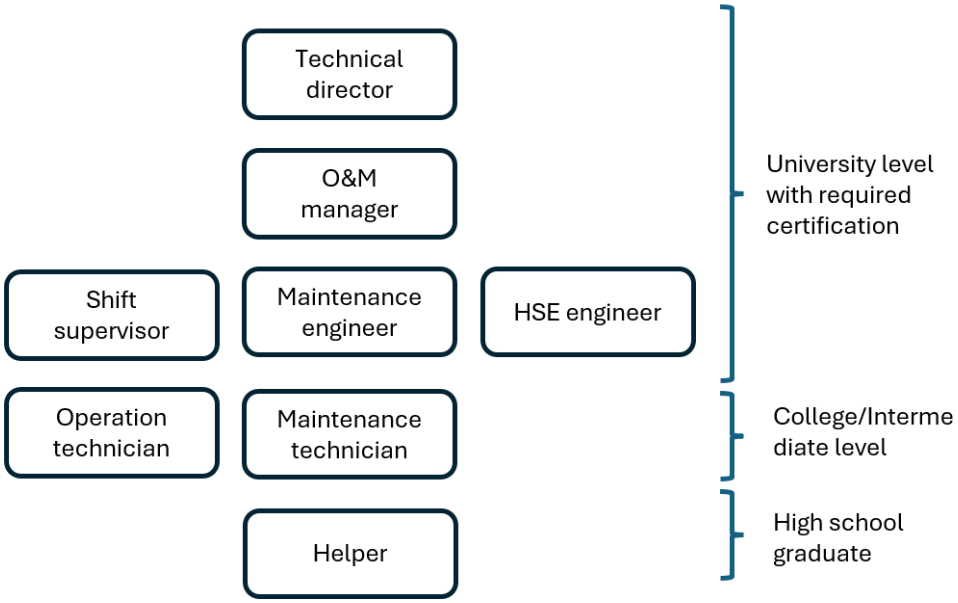
Source: *Author's Own Compilation*

O&M team – current focus for Vietnam's solar PV industry:

Our interviews with solar PV farms in Vietnam reveal a structure similar to global practices during the Development and C&I phases. In the O&M phase, however, the team structure is generally simpler, with positions capable of handling a variety of tasks.

The operation and maintenance (O&M) framework for Vietnam's large solar PV farms typically relies on a structured approach involving skilled staffing, well-planned maintenance schedules, and effective collaboration with third-party contractors.

Figure 7: Typical structure of a solar PV team in Vietnam.



Source: Author's Own Compilation

Table 11: Approach of Vietnamese business to develop in-house O&M capacities for solar PV

Organizational structure	Function	Detail
Staffing	**Technical and Maintenance Roles**	Technical staff oversee plant performance, address operational challenges, and ensure efficient energy production. Maintenance workers handle specific tasks to maintain functionality.
	Qualifications	Substation operations are managed by shift supervisors with university degrees and certifications. Operational staff typically have intermediate to college-level qualifications. Maintenance roles are flexible, but higher qualifications like university degrees add technical depth.

Organizational structure	Function	Detail
	Recruitment and Training	Both recent graduates and experienced technicians are employed. Continuous skill development is prioritized through internal training programs. Preference is given to candidates with electrical systems backgrounds, who receive further training to meet facility standards.
Maintenance	**Comprehensive Schedules**	Maintenance is scheduled daily, weekly, and monthly to ensure year-round consistency. Schedules are adaptable to weather and operational demands.
	Routine Tasks	Solar panels are cleaned every two months using robotic systems to minimize soiling losses. Periodic equipment testing ensures system functionality and reduces downtime.
	Repairs and Replacements	Repairs are not performed on-site. Replacement parts are supplied by manufacturers, and the facility's technical team installs and integrates them.

Source: *Author's Own Compilation*

Partnerships with third-party contractors are essential for maintaining solar PV farms, as contractors prepare and execute detailed maintenance plans reviewed by the facility's management. They recruit and train their personnel to meet operational and quality standards, while close collaboration ensures maintenance tasks are carried out efficiently and in line with industry's best practices.

In general, positions in solar PV power plants do not require certifications for working on heights and other tasks relating to turbine and blades, as is the case in wind energy. The maintenance of solar PV is also less intensive technically. For example, many of the cleaning of panels now can be performed by using robots. Businesses in solar PV can use their own technician team for routine maintenance or outsource the work to contractors as needed. Table 12 details all responsibilities and required qualifications and skills for each job position in O&M phase.

Table 12: Key personnel in Vietnam's O&M teams for solar PV power

Positions	Responsibilities	Qualifications
Technical director	• Oversee production operations and manage technical and operational functions for the wind power plant. • Organize inspections and evaluations of equipment, plan and oversee regular maintenance and repairs.	• Bachelor's degree or higher in Electrical Engineering or Power Systems. • At least 5 years in the electrical field, including 2+ years in wind power plant operations

Positions	Responsibilities	Qualifications
	• Directly handle and coordinate responses to equipment failures. • Register daily and weekly power output on the national power system's platform. • Liaise with stakeholders to address equipment issues and optimize solutions. • Develop management measures, operating procedures, and technical regulations. • Plan training and recruitment to meet plant staffing needs. • Build relationships with local authorities and government agencies to address operational challenges. • Report plant operations and incidents to company leadership monthly. • Manage staff, assign shifts, evaluate performance, and implement labor rewards and penalties. • Identify and address risks during production and propose solutions.	(minimum 40 MW capacity and 220 kV grid connection). • Minimum of 3 years in a management role. • Comprehensive understanding of renewable energy projects and the energy market. • Familiarity with corporate culture, vision, and mission. • Strong leadership, management, negotiation, and presentation skills. • Strategic planning and people development. • Proficiency in English for communication and project requirements.
O&M Manager	• Manage and oversee wind farm O&M activities, ensuring optimal performance and adherence to schedules. • Supervise O&M contractors and team, providing guidance, support, and recruitment when necessary. • Track and maintain operational records, including site performance, downtime, maintenance, and inspections. • Develop and implement strategies to enhance efficiency, reduce costs, and extend turbine lifespan. • Oversee maintenance of wind farm infrastructure, such as towers, transformers, and roadways. • Liaise with customers, authorities, and contractors while managing spare parts inventory. • Establish goals and priorities for operations, handle dispatch matters, and address issues promptly to ensure smooth operations.	• University degree in Engineering, Electricity. • Minimum 3 years experience managing wind farm project operation • Good technical understanding of wind farm • Strong leadership and management skills • Good command of English speaking and writing • Analytical thinking and Problem-solving skills • Good interpersonal skills, ability to effectively manage the relationship with other teams • Advanced computer skills

Positions	Responsibilities	Qualifications
HSE Engineer	The HSE Manager ensures that all O&M activities are conducted safely, protecting the well-being of employees and the environment. A strong focus on health and safety reduces the risk of accidents and enhances the overall operational reliability of the wind farm. • Oversee occupational safety and ensure compliance with regulations. • Provide safety guidance for on-site staff and suppliers. • Maintain traffic and safety systems at the site. • Enforce safety policies and address violations. • Update company practices based on new safety laws. • Manage safety equipment and inspect machinery. • Conduct audits, training, and incident investigations.	• Graduated from university with a major in Engineering, Occupational Safety, or Labor Protection. • At least 2 years of experience in a similar field. • A certification in Occupational Safety and Health such as GWO Basic Safety Training • Proficient in safety regulations, wind power standards, and risk assessment. • Strong leadership, communication, and ability to promote a safety-first culture. • Skilled in compliance reporting and safety management software.
Mainternance Engineer	• Supervise and monitor the operation of the wind power plant. • Make plans, propose maintenance and service of electrical equipment at the power plant. • Report the abnormal condition of the system or equipment. • Participate in the analysis process to find the core cause of the problem, thereby providing preventive and corrective actions. • Collaborate with the chief operator to diagnose, repair, maintain, and service electrical equipment, ensuring the continuous optimal functioning of the system.	• Bachelor's degree in power systems, electrical engineering, or automation control engineering • 3-5 years of experience. • Proficient in using design and office software computer software. • Analytical skills, quick judgment in all situations. • Creative skills at work. • Communication skills at work • Team organisation/teamwork skills. • English listening and reading skills.

Positions	Responsibilities	Qualifications
Maintenance Technician	• Monitor the performance of PV systems, inspect panels, inverters, and wiring for abnormalities, and troubleshoot electrical or mechanical issues. • Perform periodic maintenance, including cleaning panels, replacing damaged components, and ensuring proper functionality of energy storage systems and transformers. • Collect and analyze performance data, identify inefficiencies, and propose solutions to optimize energy production. • Work on substations, power distribution systems, and communication networks to maintain operational reliability. • Prepare detailed monthly operational reports, including maintenance logs and recommendations for improvements. • Manage tools and inventory, handle assigned tasks and adapt to dynamic work conditions with a proactive approach.	• College, intermediate degree or above in Electrical Engineering, Power Systems, Renewable Energy, or Automation Control. • Proficient in using design and office software for documentation and reporting. • Knowledge of PV system monitoring software and familiarity with inverter and battery management systems. • Hardworking, with a positive attitude, high independence, and a proactive mindset. • Strong communication and teamwork skills. • Ability to work under high-pressure conditions. • English proficiency in reading and listening.
Shift Supervisor	• Be responsible for operating the plant in accordance with relevant processes and regulations. • Organise, manage, supervise, and operate all human resources on duty, ensuring safe and effective operation. • Coordinate with all levels of national load dispatch centers (national: A0, regional: A2), and other relevant units to ensure safe and reliable operation of the wind power plant. • Coordinate with relevant units to quickly handle incident situations and prioritise incidents that have serious impacts on the grid system.	• Bachelor's degree in Power systems, electrical engineering, or automation control engineering. • 2-3 years of experience. • Operation certificate by National Load Dispatch Center (A0) • Proficient in using design and office software computer software. • Creative skills. • Strong communication skills. • Team organisation/teamwork skills. • English listening and reading skills.
Operation Technician	• Coordinate with all levels of dispatch (A0, A2), and relevant units at the request of the shift supervisor to ensure safe and reliable operation of the plant.	• College/ University bachelor's degree in Power systems, electrical engineering, or automation control engineering. • At least 1 year of experience.

Positions	Responsibilities	Qualifications
	• Responsible for the operation of closing/switching off high-voltage equipment at the substation following the procedures and regulations under the supervision of the chief operator. • Fully record the operation status of electrical equipment, support handling and investigation when incidents occur at the plant.	• Proficient in using design and office software computer software. • Creative skills. • Strong communication skills. • Motivational skills and self-control, ability to self-manage work. • Team organisation/teamwork skills.

Source: *Author's Own Compilation*

CHAPTER IV - TRAINING CAPACITY IN THE RENEWABLE ENERGY SECTOR

4.1 OVERVIEW OF THE TRAINING PROGRAMS OFFERED BY UNIVERSITIES, TVET INSTITUTIONS, AND OTHER TRAINING PROVIDERS IN THE REGIONS

The Central and Central Highlands regions, renowned for their abundant solar and wind energy potential, have become focal points for renewable energy development in Vietnam. This surge in renewable energy initiatives has consequently driven an increased demand for skilled professionals in the field. Recognizing this growing need, numerous training institutions, including TVET institutes, have been actively developing training programs to equip individuals with the necessary skills and knowledge. The following analysis provides an overview of the training majors related to renewable energy, categorized by training level, that are offered by TVET institutes in these regions:

University level

To understand university-industry collaboration, the consultant team reviewed the university websites, related documents. When possible, we also conduct telephone interviews with key personnel. At university level, the following institutions provide bacherlor / engineer and higher degrees in the field:

Table 13: Universities that offer courses and majors in RE

Regions	Name of the university	Description
Northern region	Hanoi Bach Khoa University	Hanoi University of Science and Technology (HUST) offers a variety of training programs and research activities related to RE, such as: Power Systems and Renewable Energy (Advanced Program), and Energy Management. HUST has participated in the project "Strengthening Research Capacity and Knowledge Transfer on RE Integration into the Power Grid" with European partners (2020-2021). The Institute of Energy Technology under HUST focuses on research and development of technological solutions in the energy sector, including RE.
	Electricity Power University	EPU offers specialized programs and research opportunities in RE, particularly through its Faculty of Energy Technology. Under academic programs there are Undergraduate program in Energy Technology and Master's and Doctoral Programs on energy engineering.

Regions	Name of the university	Description
		Under research programs EPU collaborates with international institutions to enhance its research capabilities in RE and conducts research on photovoltaic (PV) integrated charging stations in Vietnam.
	University of Engineering and Technology - Vietnam National University, Hanoi (VNU-UET)	VNU-UET offers a program in Energy Engineering, focusing on RE and related technologies. While specific degree programs dedicated solely to RE are not explicitly listed, UET's engineering curriculum encompasses courses and research opportunities that address various aspects of renewable energy technologies.
	Vietnam-France University (USTH)	The University offers a bachelor programme on electrical engineering, and RE which provides technical knowledge of production, transmission, distribution, and use of electricity. Students will be equipped with knowledge of smart grid, renewable energy technologies such as photovoltaic systems, wind power, hydropower, biofuels, fuel cells, energy efficiency, and management.
	Hanoi University of Industry (HaUI)	HaUI offers an undergraduate program in Renewable Energy Engineering Technology, which trains engineers with expertise in RE technologies, including solar, wind, hydro, and biomass energy systems.
Central region	Ho Chi Minh City Nong Lam University - Ninh Thuan Branch	The University branch offers training programs in Renewable Energy Engineering Technology, besides other programs and research opportunities related to renewable energy.
	Da Nang University of Technology – Da Nang University (DUT)	The University offers the Bachelor programme in energy and environmental engineering with RE courses. In addition, DUT also has a Center for Alternative Energy Application Research, focusing on research and development of sustainable energy solutions. Students of the Faculty of Civil and Industrial Engineering have carried out projects such as "Solar panel support structure", demonstrating their interest in the application of renewable energy in construction.
Southern Region	Ho Chi Minh City Nong Lam University (NLU)	NLU offers a training program in Renewable Energy Engineering Technology, equipping students with knowledge and skills in renewable energy systems such as solar, wind, biomass and hydropower. Program objectives: Provide basic and in-depth knowledge of renewable energy; Develop skills in designing, operating and maintaining renewable energy systems; Enhance

Regions	Name of the university	Description
		creative thinking, analysis and problem solving in the energy sector.
	Ho Chi Minh City University of Technical Education (HCMUTE)	HCMUTE offers a program in Renewable Energy, equipping students with knowledge and skills related to renewable energy systems such as solar, wind, biomass, hydroelectric power, energy management, energy auditing, etc.
	Ho Chi Minh City Bach Khoa University (HCMUT)	HCMUT offers training programs in RE at both undergraduate and postgraduate levels. The undergraduate program "Renewable Energy" provides basic knowledge about renewable energy forms such as solar, wind, biomass, geothermal, tidal and ocean, hydropower. The postgraduate program "Renewable Energy and Energy Storage" focuses on energy storage systems and the role of renewable energy in the global energy landscape. In addition, HCMUT participates in the ECO-RED project, which aims to develop European-standard RE modules, providing students with the opportunity to study and receive international certification.
	Ho Chi Minh City University of Technology (HUTECH)	HUTECH offers a training program in Electrical Engineering with a major in Renewable Energy and Energy Management. The program provides knowledge about RE systems such as solar, wind, biomass and hydropower; develops skills in designing, operating and maintaining RE systems; and improves the ability to manage and optimize energy use in organizations and businesses.
	Can Tho University (CTU)	CTU integrates renewable energy courses into its curriculum. Within the framework of the ECO-RED project, the school organized courses such as: RE Sources and Management, Biomass and Bio-fuels, Application of Wind and Solar Energy, Integration of RE based generation system into power systems, Power Conversion Interfaces for Renewable Energy System).

Source: *Author's Own Compilation*

Table 13 illustrates that the training programs offered by universities cover a wide range of RE technologies. Key subjects in these programs include:

- Solar Energy: Students delve into the intricacies of solar power systems, learning about their components, installation techniques, operation, maintenance, and troubleshooting.

- Wind Energy: The curriculum explores the principles of wind energy conversion, wind turbine design, site selection, installation, and maintenance.
- Hydropower: Students gain knowledge of hydropower systems, including dam design, water flow management, turbine technologies, and environmental impact assessment.
- Bioenergy: This area covers the production of biofuels from biomass sources like agricultural residues, municipal waste, and energy crops.
- Geothermal Energy: The program introduces the principles of geothermal energy, exploration techniques, well drilling, power plant design, and environmental considerations.
- Energy Storage: The students explore various energy storage technologies, such as batteries, pumped hydro storage, and compressed air energy storage, to ensure a reliable and efficient energy supply.
- Energy Management: Students study energy efficiency measures, demand-side management, and the integration of RE sources into smart grid systems.
- Waste-to-Energy: The subject covers waste classification, treatment, and conversion into energy, including technologies like incineration and anaerobic digestion.
- Green and Sustainable Energy: Students explore emerging technologies and innovative solutions for sustainable energy production and consumption, with a focus on environmental impact assessment and mitigation strategies.

Other universities and colleges in major cities such as Hue, Da Nang, Nha Trang, and Ho Chi Minh City offer a variety of renewable energy-related programs. These institutions often have specialized faculties in energy, electricity, and automation that offer specialized training in areas such as power systems, electrical engineering, and control systems, which are essential for working in the renewable energy sector.

Specialized centers

There are a few specialized centers which provide certified trainings to those who work (recently or expectedly) in the RE sector. These specialized training centers are often established by government agencies (e.g. Vietnam Electricity Corporation (EVN,), and the National Load Dispatch Center – NLDC, now called National Power System and Market Operator Company Limited (NSMO)[24]) and a number of industry players companies, provide focused training in specific areas of RE. They have strong industry linkages and can offer hands-on training using real-world equipment, such as solar panels, wind

[24] Starting from August 01, 2024, NLDC has become the National Electricity System and Market Operation Company Limited (NSMO), as stipulated by the Prime Minister issued Decision No. 753/QD-TTg.

turbines, energy storage systems and power system management. This practical experience is invaluable for students, as it allows them to develop the skills and knowledge needed to work in the field.

The NSMO in Vietnam is responsible for managing and operating the power system. Within the scope of power plant operations, NLDC often requires, and issues certificates related to power system operation and management to employees. NSMO conducts training, testing and issuance of Certificates for positions directly involved in dispatching, operating the power system and the electricity market, such as:

- Power plant operation certificate.
- Power system dispatcher certificate.
- Power system maintenance and repair certificate.
- Renewable energy training certificate (Operation and maintenance of RE system; Integration of RE systems into the national grid; Regulations and technical standards of the NSMO system).
- Certificate of participation in special training programs[25].

Wind Power Training Centers: As discussed in previous chapters, while working in the solar power plants often requires regular certificates, working in wind power plants requires special ones, including working at height, first aid, fire awareness, manual handling, rope access, and sea survival (for offshore wind plants). In addition to NSMO, there are several specialized training centers that provide essential certifications for worker in the wind energy industry. These centers often collaborate with or recognized by international organizations to ensure high-quality training in safety and technical skills. In Viet Nam, there are following some notable training centers:

- Global Wind Academy Vietnam (in collaboration with VIVABLAST)[26]: Established through a partnership between Global Wind Academy Denmark and VIVABLAST, this center provides GWO-certified training programs, including safety and technical courses tailored for the wind turbine industry. It should be noted that while primarily focused on the wind energy industry, some of the safety training covered in the GWO's Basic Safety Training (BST), such as working at heights and first aid, can be relevant to solar energy plant workers as well.
- PVD Training (Công ty CP Đào tạo Kỹ thuật PVD)[27], under PetroVietnam, offers GWO courses including Basic Safety Training (BST), Basic Technical Training (BTT),

[25] Decision No. 752/QD-TTg dated August 1, 2024 by the Prime Minister; Decision No. 69/QD-DTDL dated September 28, 2018 by the Electricity Regulatory Authority of Viet Nam.
[26] https://www.globalwindacademy.com/vn/on-site-traening?scroll-to-class=vmcms-navigation-container-default-584
[27] https://pvdtraining.com.vn

and Advanced Rescue Training (ART). Their facilities are equipped to international standards, providing comprehensive training for the wind power industry.

- SafeTech Training Centre (SRE Company Limited)[28]: offers a range of GWO-certified courses, such as Basic Safety Training (BST) and Advanced Rescue Training (ART). Their indoor facilities simulate real-life scenarios, enhancing the practical training experience. SRE is also a Vietnamese company that provides training and certificates for rope access, namely Industrial Rope Access Trade Association (IRATA) in Viet Nam, together with two other companies (SB Rope Access Specialist, headquartered in Singapore, and Protection Rigging Access Services Sdn. Bhd., headquartered in Malaysia).
- JCD Training Vietnam Company Ltd.[29] provides GWO and other international certification programs, focusing on safety and technical training for the wind energy sector. Having its headquarters and training center in Vung Tau city, they are among the first service providers in Viet Nam to offer such programs.
- TST Education[30] offers a variety of courses, including those in renewable energy. They provide GWO certified training programs, including Onshore and Offshore BST, Working at Height, and Sea Survival training.

These centers are recognized for their commitment to delivering high-quality training that meets international standards, supporting the growth and safety of Vietnam's wind energy industry. However, their training programs may be expensive, and the certificates often have as they often involve specialized equipment and expert trainers. Additionally, some certificates have a limited validity period and may require recertification after a certain time.

TVET institutes

College and intermediate level TVET training institutions

The consultant team gathers information from various sources, including TVET Institute websites, in-depth interviews with key personnel, surveys conducted with stakeholders, and training documents provided by the Institutes. The training majors and modules offered by TVET institutions in Vietnam encompass a variety of RE-related technologies. A significant number of these colleges are concentrated in the Central region, suggesting a regional focus on RE training. While no specific major solely focuses on RE, many programs provide essential foundations for entering the energy sector, including RE. These foundational majors equip students with the necessary knowledge and skills to later specialize in RE technologies.

[28] https://gwo-training.vn/vi/
[29] https://jcdtraining.com.vn
[30] https://www.ccp.edu.vn/collections/gwo

Table 14: Selected TVET institutions that offer courses and majors related to RE

Regions	Name of the TVET institutes	Description
Northern region	Hanoi High-Tech Vocational College	HHT focuses on training related technical majors such as Industrial Electricity and Industrial Electronics, providing the necessary knowledge and skills for jobs in the energy sector, including renewable energy.
	Northern Electricity Power College	NEPC offers training programs related to the electricity sector, including: Power Systems (for Intermediate level), and Hydropower Plant Operation (College and Intermediate levels), both are related to RE.
	FPT Polytechnic College	The school offers related majors such as Control and Automation Engineering Technology and Electrical and Electronic Engineering Technology, which includes subjects in renewable energy.
Central region	Vietnam – Korea Industrial Technical College (VKC)	VKC offers training majors of Industrial Electronics, Mechatronics, Industrial Electricity, Electrical Installation and Control Engineering in Industry (Automation Electricity), Air Conditioning and Refrigeration Engineering (Refrigeration). These programs are trained at College, Intermediate and Elementary levels, meeting international standards.
	Quang Binh Industrial – Agricultural Technical Colledg (QBIATC)	The school offers training programs related to the field of engineering and industry, including Industrial electricity; Electrical and electronic engineering technology; and Mechanical engineering technology. These programs provide knowledge and skills foundation for the students to participate in the energy sector, including RE.
	Central Region Electricity Power College (CEPC)	CEPC provides training programs related to the electricity sector, including: Substation operation management; Electrical safety. In addition, CEPC also organizes short-term training courses and cooperates with businesses in the electricity sector to improve skills and knowledge for students.
	Quang Nam Vocational College	From 2021, Quang Nam College was merged from 6 schools. The school offers training programs related to the field of renewable energy, including: Electrical and Electronic Engineering Technology; Mechanical Engineering Technology.

Regions	Name of the TVET institutes	Description
	Quy Nhon College of Engineering and Technology (QCET)	The school offers training programs related to the field of RE, including: Industrial Electricity; Mechatronics; Information Technology (Software Applications).
	Nha Trang College of Technology	The college offers courses related to RE, such as Solar Power System Installation and Maintenance, which instructs students on how to install, operate and maintain solar power systems, knowledge about the structure, operating principles of solar power systems, installation procedures, system inspection and maintenance.
	Da Nang Vocational Training College (DANAVTC)	DANAVTC offers training courses related to the field of RE, including Mechatronics; Industrial Electricity; Industrial Automation.
	Dak Lak College	The college offers courses related to renewable energy, such as: Industrial Electricity; Information Technology (Software Applications); Civil Electricity; Industrial Electronics; Mechatronics; Construction Engineering; Refrigeration and Air Conditioning Engineering.
	Ninh Thuan Vocational Colledge (NTVC)	NTVC offers related training majors such as Industrial Electronics and Industrial Electricity. Industrial Electronics: Provides students with the ability to design, install, maintain solar power systems, wind power systems, smart home systems and program control of industrial production lines. Faculty of Electricity - Electronics provides majors such as Industrial Electricity, Industrial Electronics and Rooftop Solar Power Installation, focusing on professional quality in practical skills, regularly updating new knowledge and technology to provide learners with knowledge, skills, autonomy and responsibility so that they have a solid foundation for their careers. The faculty has been equiped with a total of 11 modern workshops, of which 6 workshops have been supported by the GIZ. Wind Energy Technology Training Course: On August 1, 2022, NTVC opened an advanced training course on "Fundamentals of Wind Energy Technology". The course provides basic knowledge of wind energy technology, contributing to improving students' capacity and meeting human resource needs in the field of RE.

Regions	Name of the TVET institutes	Description
	Trường Cao đẳng Điện lực TPHCM (HEPC)	HEPC has specialized training programs in solar power, including maintenance and installation of solar power systems, with practical classes equipped with basic systems, and regularly cooperates with businesses to improve students' practical skills.
	College of Mechanery and Irrigation (VCMI)	VCMI participates in the project "Technical education and vocational training reform program - Center for high-quality green technical education and vocational training" (Green vocational training) funded by the Federal Republic of Germany. Within the framework of the project, the school trains in occupations such as "Electronics and Building Energy Technology" and "Mechanical, Heating and Air Conditioning Technology". VCMI's has also sent teaching staff participated in training courses on "Renewable Energy" in the Germany, aiming to improve their knowledge and skills in this field. Module on environmental protection and energy efficiency: Since 2019, VCMI has integrated the module "Environmental protection, efficient use of energy and resources" into the training program of all occupations, aiming to raise awareness and skills for students on sustainable energy use.

Source: *Author's Own Compilation*

A diverse range of training programs offered by TVET institutes are relevant to the RE sector, particularly wind and solar power. Despite the lack of dedicated RE majors, several programs provide foundational knowledge and skills crucial for working in this field. The following occupational training programs, provided by most of the interviewed TVET institutes, are considered highly relevant to the solar and wind energy sector. The ones with the (*) mark are those that are provided by most of the interviewed TVET institutes and noted by them of the connectivity to the sector (check Annex 4 for a full lisy of occupational training programs provided by Universities and TVET Institutes):

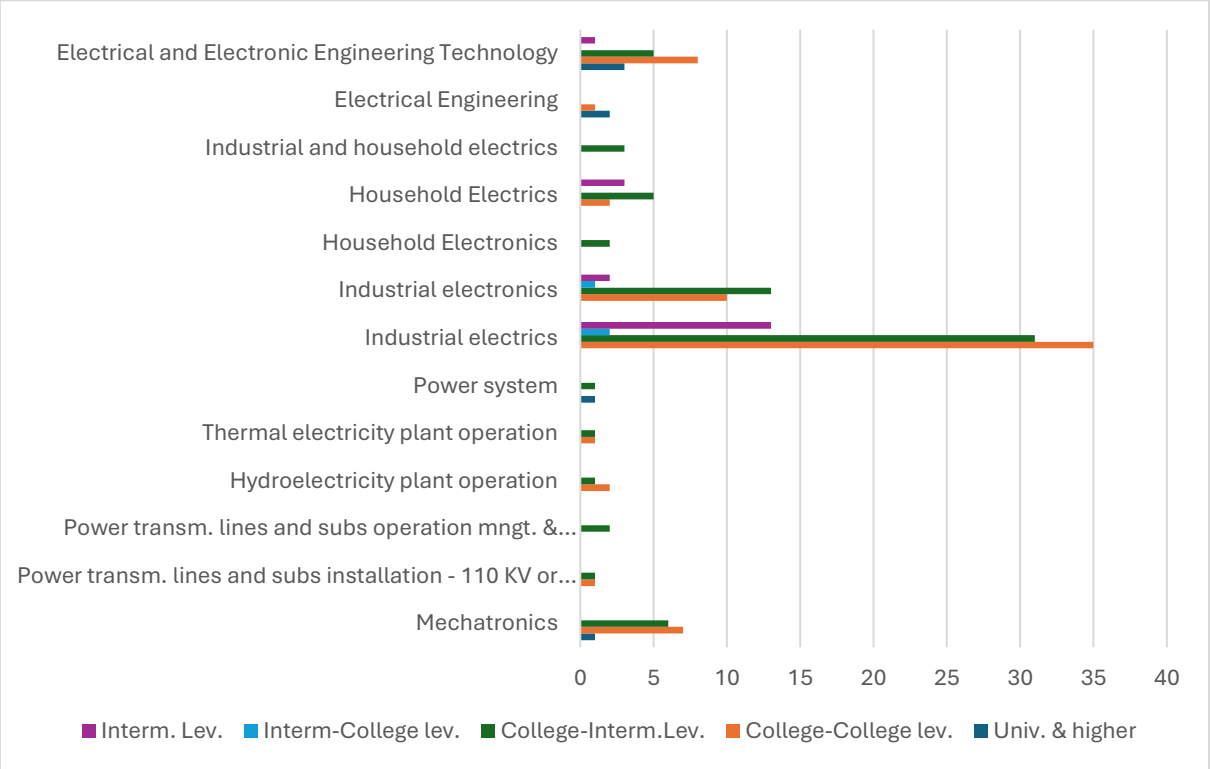
- **Industrial electrics***: This occupational training focuses on the generation, transmission, distribution, and utilization of electrical energy in industrial settings. This discipline plays a crucial role in the renewable energy sector, as it involves the design, installation, and maintenance of the electrical infrastructure required to harness and distribute renewable energy sources.
- **Industrial electronics***: This discipline combines electrical engineering and electronics to design and implement control and automation systems for industrial processes. In the context of renewable energy, industrial electronics

plays a vital role in the efficient operation and control of renewable energy systems.

- **Mechatronics*:** The major includes mechanical engineering, electrical engineering, control engineering, and computer science. It focuses on designing, developing, and maintaining systems that integrate these engineering disciplines. Mechatronic systems are integral to the efficient operation and maintenance of various renewable energy technologies, including solar and wind energy, hydropower, and energy storage systems.
- **Electrical and electronic engineering technology*:** This training provides a strong foundation in electrical engineering principles, enabling graduates to design, install, operate, and maintain solar and wind power systems. Specific modules may include power system analysis, electrical machines, power electronics, and renewable energy systems, which are crucial for ensuring the successful deployment and management of RE technologies.
- **Electronics and building energy***: a multidisciplinary field that combines electrical engineering, electronics, and building science. It focuses on the design, installation, and maintenance of electrical systems within buildings, including residential, commercial, and industrial structures.
- **Power transmission lines and substations of 110 KV or lower operation management and repair*:** This major equips students with the necessary knowledge and skills toOperate and maintain power systems; Repair and troubleshoot; Manage power systems; Ensure safety. It is vital for ensuring the stability and reliability of the electrical infrastructure that supports renewable energy distribution.
- **Mechatronic engineering, heating and air conditioning** *: This program equips students with knowledge and skills to perform tasks of processing and manufacturing mechanical equipment; installation, maintenance, repair and operation of: Water supply and drainage systems, ventilation and air conditioning systems, heating systems for factories and in civil works, ensuring technical standards, labor safety and hygiene, environmental protection, efficient use of energy and resources. All of which are essential in maintaining energy-efficient system within RE applications.

The Figure 8 illustrates the subjects and majors related to RE sector, offered by the selected 60 technical universities and TVET institutions. It can be seen clearly that Industrial electronics, Industrial electrics, Mechatronics, and Electrical and electronic engineering technology are among the most commonly taught programs across these institutions.

Figure 8: Number of universities and TVET institutions that provide RE-related majors and occupational training



Source: *Author's Own Compilation*

Besides, RE is often integrated into other relevant occupational training. While not always a standalone major, RE modules are frequently incorporated into electrical engineering, industrial electronics, and other related programs. Students enrolling in the following majors, provided by the TVET institutions, can also work in RE-related projects:

- Control and automation engineering technology
- Electrical systems
- Construction and repair of operating power grids with voltage levels of 22kV
- Refrigeration and air conditioning engineering
- Thermal engineering technology
- Manufacturing of mechanical equipment
- Operating foundation construction machines.

In addition to college-level programs, TVET institutes also offer intermediate and elementary vocational training as well as a range of short-term, advanced training courses to upskill professionals working in the power industry. The intermediate programs typically focus on the operation and repair of power lines and transformer stations, while elementary programs cover the construction and repair of operating

power grids. These skills can be applied to both traditional and RE infrastructure, equipping individuals to work effectively in the RE sector. The relevant majors include:

- Electrical Installation: This program trains individuals in the practical skills required for installing solar PV systems, wiring electrical components in wind power systems, and connecting these systems to the grid. Students learn about electrical safety practices, cable installation, wiring techniques, and testing procedures.
- Electrical Repair: This program focuses on the maintenance and repair of electrical equipment used in renewable energy systems, ensuring their optimal performance and safety. Students acquire skills in troubleshooting techniques, fault diagnosis, component replacement, and preventive maintenance practices.
- Machine Operation: This program prepares individuals to operate machinery and equipment used in renewable energy production, such as pumps, generators, and control systems. Students gain knowledge about the principles of operation, safety procedures, maintenance practices, and troubleshooting techniques.

These training programs prioritize practical electrical engineering skills, including circuit analysis, power systems, and electrical machinery. These fundamentals are crucial for students pursuing careers in RE technologies. Although the specific programs and modules offered by TVET institutions are tailored to local industry needs, these core areas consistently form a strong foundation for RE careers.

Main contents of the wind power modules provided by the TVET institutes

For wind power, TVET institutes have incorporated various modules into their programs to provide students with a solid foundation in the industry. These modules typically cover a range of topics, including wind power technology fundamentals, occupational safety practices, environmental protection measures, wind power system operation, lifting technology, and cable technology. By integrating these modules into existing programs, schools aim to equip students with the necessary knowledge and skills to work in the wind energy industry.

The below admission notices of a TVET institute, i.e. the NTVC, clearly indicates the relevance of the mechatronics major to the wind power technology, as well as indicating the majors that are trained following international (German, Australian, Japanese, etc.) standards. These majors have been supported by different technical assistance by the corresponding donors, e.g. Industrial Electronics, Building electronics and energy technology, and Mechanical heating and air conditioning technology are the majors that follow Germany standards.

Figure 9: Admission notice for the year 2024 of Ninh Thuan Vocational College

Source: *Ninh Thuan Vocational College, 2024*

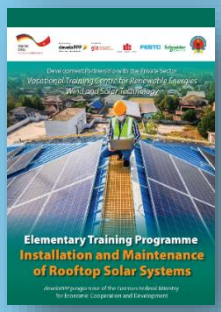
Nonetheless, while these modules provide a valuable introduction to wind power, students who aspire to work in specific roles within wind power plants will likely need to obtain additional certifications from recognized organizations i.e. the Global Wind Organization. These certifications are essential for ensuring safety and competence in various tasks, such as working at heights, electrical safety, and first aid.

To facilitate the acquisition of these certifications, TVET institutes can collaborate with accredited training providers to offer on-site courses. This approach allows students to conveniently obtain the necessary certifications without having to travel to external training centers. However, it is important to note that these certifications are typically mandatory for specific job roles, and students may need to pursue additional training and certifications based on their career aspirations.

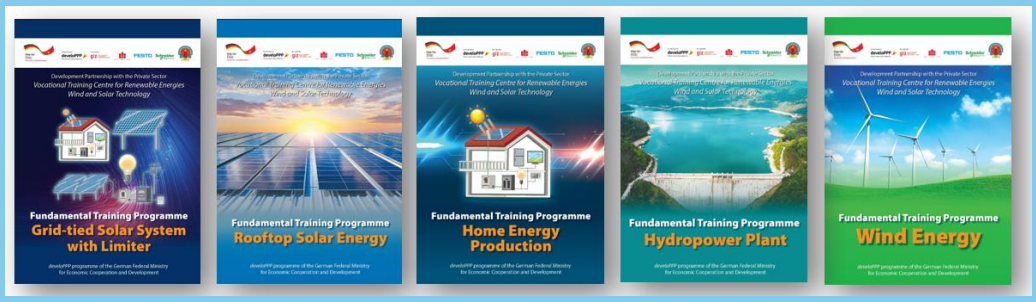
Box 1: Example of training courses provided by NTVC

Ninh Thuan Vocational College (NTVC) has successfully developed and implemented an elementary training program on "Roof Top Solar Installation and Maintenance". A formal training program on "Wind Energy Plant Service Technician" based on German and international standards and aligned with Vietnamese regulations, has been drafted in collaboration with the wind industry and was set as one module to integrate into formal training programmes such as Mechatronics, Industrial Electronics, etc. since 2024.

NTVC also support capacity building for 17 trainers on rooftop solar power system installation through the training which was conducted by German Renewable Academy (RENAC). In addition, NTVC offers five further training courses (short-term training courses) for TVET teachers and renewable energy technicians which provide the necessary theoretical knowledge and practical skills in several RE topics. The main contents include:



- Fundamental Training Programme on Home Energy Production: Knowledge on Home Energy Production from Renewable Energy (grid-connected and stand-alone), wind power systems and limited grid-connected solar power systems.
- Fundamental Training Programme on Wind Energy: General introduction to wind energy and its applications; Wind power systems (grid-connected and stand-alone); Nacelle wind power training system; Application of wind power systems.
- Fundamental Training Programme on Grid-tied Solar System with Limiter: Overview of Grid-tied Solar Systems with Limiter; Solar PV modules; Inverter Installation, testing, operation, and maintenance.
- Fundamental Training Programme on Rooftop Solar Energy: Overview of solar energy and its applications; Installation of Photovoltaic Cells and PV Module, etc.
- Fundamental Training Programme on Hydropower Plant.



These programs share the common goal of providing learners with the knowledge and practical skills to work in the field of renewable energy, especially in solar and wind power. The documents emphasize compliance with safety regulations, the use of measuring equipment and control software, as well as the ability to work in teams and solve problems.

Source: *Training curricula, Ninh Thuan Vocational College, 2024*

Orientations of the TVET institutes to ensure the relevance and effectiveness of RE training programmes

TVET institutes are actively working to ensure the relevance and effectiveness of RE training programs to meet the evolving needs of the sectors. To achieve this, these institutions are implementing a range of strategies that focus on offering diverse programs, integraying RE knowledge into traditional curricula, and fostering industry collaboration.

Offering diverse and specialized Training programs

One key approach is to offer diverse training programs that tailored to the dynamic demands of the RE sector. TVET institutes are developing new courses and updating existing training programs to better align with industry requirements. This includes programs in industrial electricity, solar power, and wind power. For instance, one college in Hue, and a well-known college in Dong Nai noted in interviews and discussions that the colleges have recently developed the specialized course on Renewable Energy System Installation and Maintenance. So far, the subject is available only at the two other colleges, one in the Central region, and one in Ho Chi Minh City. By offering such specialized training, these institutions are ensuring that their graduates are prepared for diverse roles in the RE sector, from installation to maintenance.

Integrating RE modules into Existed Formal Occupational Training Programmes

TVET institutes are integrating RE modules into their core existing electrical engineering programs. Example is the integration of “Design, installation, maintenance, repair and operation of electrical systems derived from renewable energy” into the Electrical and electronic engineering technology major at a college in Ho Chi Minh City. This approach allows students to acquire a comprehensive skill set, combining traditional electrical engineering knowledge with specialized expertise in RE technologies. By incorporating these modules, the TVET Institutes are ensuring that graduates are well-equipped to address the challenges and opportunities presented by the transition to renewable energy.

Leveraging International Collaboration for Curriculum Enhancement

Cooperating with international support projects presents a valuable opportunity for the TVET institutes to enhance their training programs. By leveraging partnership with international organizations, TVET institutes can update their curriculum, improve teaching methods and strengthen the capacity of their staff and lecturers through study abroad opportunities. For instance, the Green TVET Initiative (funded by BMZ and the state of Hessen) has provided training opportunities for the teaching and management

staff of the Vietnam College of Machinery and Irrigation's (VCMI) in the areas related to their mission of becoming a Center of Excellence in Green TVET. Many VCMI staff and teachers have participated in study programs and exchange experiences to deepen their knowledge and skills in RE. This exposure enables them to bring back valuable insights to share with their students, ensuring that that the training programs reflect global best practices and lastest development in the field.

Implementing Dual / Cooperative Training

The concept of Dual/Coopoerative Training is increasingly recognized by TVET Institutes as an effective model for ensuring the relevance of training programmes. This training model fosters strong connections between educational institutions and relevant businesses throughout the training and employment processes. It combines theoretical instruction in a school or college with practical, hand-on training in a workplace setting[31]. By blending academic knowledge with real-world skills specific to a particular occupation, this model highlights the social responsibility of businesses to actively engage in training workers while they are still in school. Integrating industry involvement into training programs helps develop a workforce that is well-equipped to meet the demands of the rapidly growing renewable energy sector.

Capacity building for TVET teachers with Modern Pedagogical Methods

TVET institutes recognize that skilled and knowledgeable TVET teachers are essential to the success of RE training programs. To improve the quality of instruction, these institutions are equipping their faculty with modern pedagogical methods and ensuring that teachers stay updated on the latest industry trends and technologies. By enhancing teaching methods and fostering continuous professional development for instructors, TVET institutes are improving the overall quality of education in the RE sector.

Strengthening Industry Collaboration for Practical Training

TVET institutes are increasingly recognizing the important role of direct industry collaboration, particularly in providing practical training opportunities for students. This is especially important in the wind energy sector, where practical, hands-on experience is vital for developing the specialized skills needed for operation and maintenance. Schools are planning to strengthen partnerships with businesses to facilitate on-site training, ensuring that students are exposed to real-world challenges and equipped with the skills needed to succeed in the field. Such collaborations are expected to become more prominent in the coming years, with the goal of aligning training content with

[31] Make in in Germany, official website for qualified professionals working in Germany.

industry needs and providing students with the practical experience required to transition seamlessly into the workforce.

Soft skills development and English language proficiency in training programmes by the TVET institutes

TVET institutes are increasingly recognizing the importance of soft skills and English language proficiency for success in the RE sector. To address these needs, TVET Institutes are implementing various strategies to ensure that students are not only technically proficient but also equipped with the communication and interpersonal skills necessary to thrive in a globalized and fast-evolving industry.

Enhancing English Language Proficiency

While conversational English is encouraged, the primary focus is on technical English, which is essential for effective communication in professional environments. This includes the ability to understand technical manuals, participate in technical discussions, and write technical reports. One approach is to integrate English language training directly into technical modules. For example, wind power course may include practical English language exercises that focus on technical terminology and reading comprehension of industry documents. This approach enables students to improve both their language skills and subject-specific knowledge simultaneously.

In addition to these internal efforts, international cooperation has also been another key strategy for improving English proficiency of the students. For instance, an outstanding TVET Institute in the southern part of the Central Region has several collaboration projects with international donors, one of which is dedicated specifically to English language learning for students. These partnerships provide students with additional opportunities to immerse themselves in English-languague environments and further refine their communication abilities.

Developing Soft Skills

To ensure that students become well-rounded professionals, TVET Institutes are increasingly prioritizing the development of soft skills, such as being careful, meticulous and accurate, Serious learning attitude and sense of responsibility, Scientific and creative thinking (analyzing problems, finding solutions and improving work processes), Teamwork, Autonomy and Responsible, Problem-solving abilities, Communication and reporting skills, Awareness of labor safety, etc. These skills not only help students complete practical exercises well but also serve as an important foundation for future career development, helping them become competent and responsible technicians. Additionally, TVET Institutes are shifting towards a more flexible approach. Instead of

dedicating separate courses, soft skills training has moved to an online self-study platform to optimize classroom time. This allows students to learn at their own pace, earn certifications, and free up valuable classroom time for developing core technical skills.

Furthermore, TVET teachers are being encouraged to incorporate soft skills development into project-based learning activities. These projects provide students with hands-on expereience to teamwork, collaboration, communication, problem-solving, critical thinking which are skills that are highly valued by employers in the RE sector. Through this approach, students are not only gaining technical expertise but are also learning how to work effectively in teams, clearly communicate their ideas, and think critically to tackle complex challenges in renewable energy.

4.2. ADDRESSING BUSINESS DEMANDS FOR HUMAN RESOURCE DEVELOPMENT FOR RE SECTOR AND THE NEEDS FOR COLLABORATION WITH TVET INSTITUTES

Training situations in the wind and solar energy sector

In the early stages of the solar energy industry, businesses often relied on internal training to upskill existing workforce, particularly electrical and mechatronic engineers. This approach allowed them to adapt their workforce to the specific requirements of solar energy projects. However, as industry has matured and scaled, there has been a growing demand for skilled workers with specialized knowledge and experience in renewable energy technologies.

One of the primary challenges faced by RE businesses is the difficulty in finding candidates who are immediately ready for renewable energy job positions. Unlike traditional industries, the renewable energy sector often requires specific technical expertise and familiarity with unique technologies that are not typically covered in standard engineering programs. This has led many RE businesses to invest in internal training programs to ensure that their employees have the necessary skills and knowledge to perform their tasks safely and efficiently and in line with industry standards.

For example, several businesses with research and development departments have taken the initiative to develop their own training programs, tailored to their specific needs and focus on the operations and maintenance of renewable energy assets, including both *solar* and *wind power*. In at least two of the interviewed businesses, since they have been managing several power plants, both solar, wind, and hydro power, they often send their newly recruited staff to the power plants for practical and hands-on training. Through such training, their staff will be equipped with both theoretical and practical knowledge, regulations, standards, procedures, and more importantly, the operational principles

and workflows for the power plants that they will be working at after the training. By fostering such tailored training, these RE businesses are able to cultivate a highly skilled workforce and maintain a competitive edge in a rapidly growing industry.

While formal requests for a specific number of trained workers in RE have not been explicitly stated, collaborations between TVET institutes and companies, particularly those involved in wind energy, highlight a clear demand for skilled technicians and engineers. Wind farm operators and maintenance providers require workers with expertise in areas such as wind turbine maintenance, electrical systems, and SCADA (Supervisory Control and Data Acquisition) systems. This growing demand underscores the importance of providing high-quality training programs that equip graduates with the practical skills required to enter the labour market and gain successful careers in the renewable energy sector.

The situation requires a need to strengthen partnerships between TVET institutes and industry to ensure that training programs are aligned with industry standards and that graduates possess the necessary skills to meet the specific requirements of employers. By fostering closer collaboration, TVET institutes can bridge the gap between academia and industry, leading to more effective and relevant training programs.

Furthermore, TVET institutes should explore opportunities to offer specialized training programs in niche areas of wind energy, such as offshore wind and floating wind technologies. As these emerging technologies gain traction, there will be a growing demand for skilled workers with expertise in these areas.

Current collaboration between businesses and TVET institutes

Short-term training plans for businesses by the TVET institutes

Some TVET institutes have recognized the immediate needs of businesses in the RE sector and have begun offer short-term training programs to businesses. Those programs have tailored and focused on specific knowledge and skills gaps in areas of rooftop solar systems, basic principles of wind energy technologies, production of RE electricity, solar power system for self-use, etc. These short-term courses are designed to equip individuals with essential knowledge and skills to individuals involved in the installation, operation and maintenance of these RE systems.

However, the demand for short-term solar training has been relatively low. This can be attributed to several factors, including the simplicity of rooftop solar systems and the ability of companies to train their own staff internally. *Looking ahead, TVET institutes are planning to offer training modules focused on the maintenance and repair of aging solar systems. As solar systems reach the end of their lifespan, there will be a growing need for skilled technicians to perform refurbishment and replacement work. By offering these*

specialized training programs, TVET institutes can help to extend the life of existing solar systems and reduce the environmental impact of decommissioning.

To address the growing demand for skilled workers in the wind energy sector, a few TVET institutes are collaborating with industry partners to develop specialized training programs for wind maintenance technicians. These programs equip individuals with necessary skills to maintain and repair wind turbines, ensuring the reliable operation of wind farms.

Nonetheless, there is still room for improvement. While these programs provide a solid foundation, additional efforts are needed to address the evolving needs of the industry. For example, as wind turbine technology advances, there is a growing demand for technicians with expertise in advanced diagnostics, predictive maintenance, and digitalization. TVET institutes should consider incorporating these emerging technologies into their training programs to ensure that graduates are well-prepared for future challenges.

Forms of collaboration between the TVET Vietnam and businesses to enhance RE training in Vietnam

The partnership between TVET Vietnam and businesses has been instrumental in developing high-quality training programs and providing practical skills to students and industry professionals. Here are some of the key following forms they've collaborated:

Curriculum Development:

- Businesses have played a key role in developing training curricula for RE courses, ensuring alignment with the latest industry standards and global best practices. To foster this collaboration, a mechanism so called “Industry Advisory Boards” has been established and operated in some TVET Institutes. This platform facilitates businesses’ involvement in various aspects from developing training content to assessing student performance and supporting job placement.
- The curricula incorporate practical, hands-on training using businesses’ state-of-the-art training equipment, such as pneumatic and hydraulic training systems, which simulate real-world industrial processes.

Teacher Training:

- Businesses have provided comprehensive training to TVET teachers on the latest RE technologies, teaching methodologies, and industry best practices.
- This equips teachers with the necessary skills to deliver effective and up-to-date training to students, ensuring that they are well-prepared for the demands of the industry.

Infrastructure Development:

- Businesses have supported the establishment of modern training facilities at TVET institutions, including well-equipped laboratories and workshops.
- These facilities are equipped with advanced training equipment, such as Festo's Didactic Systems, which provide a realistic and engaging learning environment for students.

Industry Partnerships:

- Businesses have facilitated partnerships between TVET institutions and industry players in the RE sector.
- This collaboration ensures that training programs are aligned with industry needs and that graduates possess the skills and knowledge required for successful employment.

Student Training:

- Businesses' training equipment and methodologies are used to provide students with hands-on experience in RE technologies.
- This practical training enhances students' skills, problem-solving abilities, and critical thinking skills, preparing them for successful careers in the industry.
- Students can gain practical experience in areas such as automation, control systems, and energy efficiency, which are crucial for the RE sector.

The relevance of training equipment provided by the businesses to the skills required for working in real wind farms is significant, but it's essential to acknowledge the limitations of such simulated environments.

Equipment at businesses offers a valuable tool for understanding the fundamental principles of wind turbine operation. By providing a scaled-down model, students can visualize the various components, observe their interactions, and collect data using a control system similar to those found in real-world wind farms. This hands-on experience helps to solidify theoretical knowledge and build a strong foundation for further learning.

However, it's important to recognize that these models lack the scale and complexity of actual wind turbines. For instance, the adjustment mechanisms for wind turbine blades are often intricate and require specific skills to operate and maintain. While the equipment can provide a basic understanding of these mechanisms, practical experience at real wind farms is necessary to develop the proficiency required for GWO certification and on-site work.

Figure 10: Companies like JA Solar are trying to help Vietnamese students with RE trainings.[32]

Source: *PV Tech, 2024*

Therefore, while equipment is a valuable tool for initial training, it should be complemented with practical training at real wind farms. This practical experience allows students to develop the necessary skills for working at height, performing maintenance tasks, and troubleshooting issues.

Several businesses have a strong collaboration focused on enhancing RE training in Vietnam, significantly impacting the development of skilled professionals in the RE sector.

Box 2: Example of benefits from collaboration between businesses and TVET institutes

In addition to collaborations with global giants like Festo and Schneider Electric Việt Nam, TVET institutes in Vietnam have also forged partnerships with numerous other companies to enhance their training programs. These partnerships often involve joint training programs, internships, and industry visits. For instance, collaborations with Bosch Vietnam, Mercedes-Benz Vietnam, Schaeffler Vietnam, WARD Shipbuilding, QHPLUS, and ISHISKEI have allowed institutions like LILAMA2 International Technology College to receive production orders, providing students with invaluable opportunities to work on real-world projects. This hands-on experience enables students to gain practical skills, learn from industry experts, and stay updated with the latest industry standards and technologies.

Source: *Author's Own Compilation*

By fostering close ties with businesses, TVET institutes can ensure that their training programs are aligned with industry needs and that graduates are well-prepared for employment. Additionally, organizing visits to industrial facilities allows students to

[32] https://www.pv-tech.org/industry-updates/ja-solar-empowers-talent-development-with-practical-training-program-in-vietnam

observe real-world operations, interact with industry professionals, and gain a deeper understanding of the practical applications of their studies. These experiences can inspire students and motivate them to pursue careers in the relevant fields.

4.3. CHALLENGES AND SHORTCOMINGS

Challenges in the RE labor market

Recent policy changes in the self-consumption solar power sector have had a significant impact on the demand for trained workers in installation and maintenance. As a result, the immediate need for newly trained workers has decreased. This presents a challenge for TVET institutes, as their training programs are designed to prepare students for immediate employment upon graduation.

However, it is important to note that this reduced demand is likely to be temporary. As existing solar power systems age, there will be an increasing need for skilled technicians to perform maintenance, testing, and component replacement. Additionally, the growth of large-scale solar power projects and the integration of renewable energy into the grid will create new job opportunities for trained professionals.

Although short-term fluctuations in the demand for RE workers are inevitable, the long-term outlook remains positive. To adapt these changning market conditions, TVET institutes should focus on training programs that equip students with a broad range of skills, including troubleshooting, system optimization, and data analysis. These versatile skills will be valuable across different stages of renewable energy projects and throughout the lifecycle of RE systems.

Another challenge is the language barrier, particularly with International standard certifications, such as GWO's and IRATA's, which are often required for RE sector jobs. These certifications require proficiency in English, both written and spoken as technical manuals, operation guidelines, and safety protocols are often published in English only. This can be a significant hurdle for Vietnamese students who may not have strong English language skills.

Additionally, TVET Institutes recognize that some students require improvement in self-learning skills, occupational safety compliance, and soft skills such as communication and teamwork. The ability to **communicate effectively in English** is also essential for meeting the job requirements of the RE sector, where international collaboration and adherence to global best practices are critical.

Challenges in student enrollment and skills development for wind and solar energy careers

TVET institutes face challenges in recruiting students for programs in electronics and mechatronics, which are crucial for the RE sector. While there is a high demand for electrical engineering graduates as well as number of institutions that offer such majors, the **interest** in these specialized fields remains relatively low. Several factors that contribute to low interest, including:

- Lack of awareness: Students and their families may not fully understand the potential of careers in RE or advanced technical fields.
- Limited access to information and guidance: Students may not have access to adequate information and guidance on career paths in the RE sector.
- Preference for other fields: Students may prefer other career paths, such as those in more traditional industries.

Despite these challenges, graduates in electronics and mechatronics are highly sought after by renewable energy power plants. The **demand** for these skilled professionals remains strongs, leading to rapid absorption into the workforce. This highlights the importance of these programs in meeting the industry's needs.

However, TVET institutes encounter obstacles in providing optimal training, particularly in the area of **wind energy**. The lack of suitable practical **equipment** makes it difficult to offer in-depth training and develop practical skills. While basic systems are available for solar power, the limitations in wind energy training hinder the development of a well-rounded skill set. Most of the interviewed institutes expressed that regarding equipment for teaching solar power, they are quite sufficient, both for experiments and training in installation, operation and maintenance. For wind power training, many institutes still lack equipment, only small model turbines, mainly for experiments and understanding principles, not yet used for practical training.

TVET graduates in Vietnam face several challenges in obtaining **internationally recognized certificates**, especially for wind energy, such as those offered by GWO and IRATA. One significant challenge is the cost of these certifications, which can be prohibitive for many individuals, particularly those from disadvantaged backgrounds. Additionally, the availability of accredited training centers and instructors in Vietnam may be limited. This creates a barrier for students who wish to pursue internationally recognized qualifications that are essential for working in the global renewable energy market.

To address these issues, TVET institutes and industry partners should explore ways to reduce the cost of certification programs, improve access to accredited training centers,

and expand the availability of specialized training equipment. By overcoming these barriers, Vietnam can better prepare its workforce for the growing demands of the renewable energy sector.

Limited access to proprietary technology in wind turbines affect training and employment prospects

A significant challenge in wind energy training is limited access to proprietary technology and software. While companies often provide training to operate and maintain their specific turbine models, they typically restrict access to proprietary information, such as programming codes and system modifications.

This limitation can hinder the depth of knowledge and skills that technicians can acquire. Training programs often focus on fault diagnosis, component replacement, and operation within predefined parameters set by the manufacturer. While these skills are essential for maintaining turbine performance, they do not provide a comprehensive understanding of the underlying systems.

As a result, technicians may have limited opportunities to develop expertise in areas such as programming, system optimization, and troubleshooting complex issues. This can impact their career advancement prospects and limit their ability to adapt to emerging technologies and industry trends.

While protecting intellectual property and ensuring system integrity is important, it is crucial to strike a balance between safeguarding proprietary information and providing technicians with the necessary knowledge and skills to advance their careers. By fostering collaboration between industry and academia, it may be possible to develop training programs that provide a more comprehensive understanding of wind turbine technology without compromising intellectual property rights.

Obtaining industry-required certificates for the jobs

One of the major challenges faced by TVET graduates seeking employment in the wind energy sector, particularly offshore wind, is the requirement for specific industry certifications, most notably those provided by GWO and IRATA (for those working at heights in the wind energy sector).

While the specific GWO certifications required can differ depending on the wind industry role, **all** onshore sites require the wokers to have up-to-date training for *Working at Height*, *Fire Awareness*, *Manual Handling* and *First Aid* as a minimum. These courses together are often known as the *Onshore Basic Safety Training* bundle and are essential

for anyone looking to work on wind turbines. While these certifications ensure high safety standards, they can pose a significant financial burden for individuals and institutions.

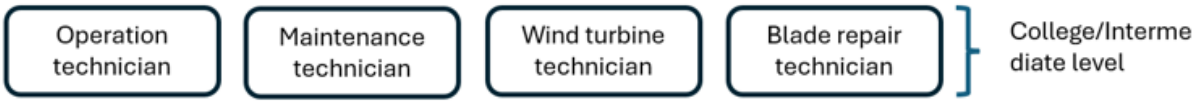
The cost of GWO certification, combined with the need for regular refresher training, can be prohibitive for many TVET graduates, particularly those from disadvantaged backgrounds. This can limit their career opportunities and hinder the growth of the domestic workforce in the renewable energy sector.

To address this challenge, it is crucial to explore strategies to reduce the cost of GWO certification, such as offering subsidized training programs or collaborating with international organizations to secure financial support. Additionally, TVET institutions should work closely with industry partners to develop training programs that align with GWO standards and provide students with the necessary skills and certifications to meet the demands of the global wind energy market.

In addition, many wind power companies have their own specific training and certification requirements for the newly recruited staff, in addition to industry standards. They include training on the company's unique wind turbine models, proprietary software and systems for work orders, maintenance procedures, emergency response plans, and safety protocols.

CHAPTER V - GAP ANALYSIS

5.1 GAPS IN TECHNICAL SKILLS FOR WIND POWER INDUSTRY BETWEEN VIETAM'S STANDARDS AND INTERNATIONAL STANDARDS



In Chapter III, it is highlighted that in Viet Nam's wind farms, the operational, maintenance, turbine and blade repair technicians are the positions that TVET Institutes' graduates can pursue. Based on the discussions with business and job description observations, it is evident that currently wind farms in Viet Nam primarily hire employees with background in Power System, Industrial Electrics and Mechatronics (occupational training program code 55202665, 6520227, 6520263 according to Decree No.26/2020 of MOLISA) programs to fill their technical roles. Businesses generally express sastification with the skills provided by electric-related programs and are willing to offer additional training or send employees for further certifications to ensure they are capable of handling job responsibilities.

Since candidates with a background in Power System typically work at substation and these tasks are well covered by Viet Nam education system and legal standards, this analysis will focus on graduates from Industrial Electrics and Mechatronics prorams. Among the four positions above, the Operation Technician roles largely align with the skills offered by Viet Nam TVET Institutes, so the analysis will center on the maintenance, wind turbine and blade repair technicians.

The maintenance role, as described in the job descriptions, includes responsibilities for both substations and turbines. As such, this analysis will focus specifically on wind turbine and blade repair technicans. Blade repair technicians required special skill sets relating to composite material which are not yet covered in Viet Nam's technical training programs. As a result, most individuals working in this field will likely receive trainig from blade manufactures/suppliers or obtain certification from organizations like GWO.

The following section will analyse the gap between the skills of Vietnamese graduates in Industrial Electrics and Mechatronics programs and the skills standards for wind turbine technician in the USA.

Table 15: Gaps between Vietnam's industrial electrics and mechatronics and USA's wind turbine technician

Criteria	Skill Standards for Industrial Electric (MoLISA)[33]	Skill Standards for Mechatronics (MoLISA)[34]	Skill Standards for Wind Turbine Technician (USA)[35,36]
Focus Area	Installation, maintenance, and repair of industrial electrical systems.	Design, installation, operation, and maintenance of mechatronic systems.	Operation, maintenance, and repair of wind turbine generators.
Core Skills	- Use of electrical measurement tools and testing equipment. - Installation and connection of electrical systems in industrial settings. - Ability to read and interpret technical drawings and electrical schematics. - Troubleshooting and repairing electrical faults in industrial equipment. - Electrical safety procedures.	- Mechanical and electronic system design and integration. - Use of programming for controlling mechatronic systems. - Maintenance and troubleshooting of mechatronic components. - Safety practices in mechatronic environments.	- Mechanical, hydraulic, and electrical component service on wind turbines. - Troubleshooting and diagnosing complex system failures. - Performing repairs in high-altitude and challenging outdoor environments. - Routine and preventive maintenance of turbine systems. - Safety procedures for working at heights and in harsh weather conditions.
Knowledge Areas	- Electrical theory and principles. - Understanding of industrial electrical components and systems. - Familiarity with national electrical codes and regulations.	- Mechanical engineering principles. - Electronic and electrical systems. - Control systems and automation. - Knowledge of programming and software for system control.	- Advanced AC/DC electrical systems, hydraulics, and mechanical systems. - Understanding of wind energy principles and turbine operation. - Basic meteorology and environmental stewardship. - Familiarity with industry-specific tools and equipment (e.g., torque wrenches, oscilloscopes).

[33] https://cpa.haui.edu.vn/media/30/uffile-upload-no-title30131.pdf
[34] https://cpa.haui.edu.vn/media/30/uffile-upload-no-title30272.pdf
[35] Urban Institute, Competency-based occupational framework for wind turbine technician, 2019
[36] Washington State University, Skills standards for wind turbine technician, 2009

Criteria	Skill Standards for Industrial Electric (MoLISA)[33]	Skill Standards for Mechatronics (MoLISA)[34]	Skill Standards for Wind Turbine Technician (USA)[35,36]
Working Environment	- Primarily indoor, industrial environments (factories, plants). - Less emphasis on working at heights or in harsh weather conditions.	- Industrial settings including automated production lines and robotic systems. - Requires hands-on work with both mechanical and electronic components.	- High-altitude work (up to 260+ feet above the ground). - Outdoor environments with exposure to extreme weather.
Certifications	National certifications related to industrial electricity.	National certifications related to mechatronics.	- Safety certifications like GWO (Global Wind Organization) for wind energy. - Specialized training for high-voltage electrical systems.

***Source**: Author's Own Compilation*

Vietnam and U.S. standards align in foundational knowledge of electrical and mechanical systems, safety norms, and industrial focus, providing a solid base for technical competencies. However, Vietnam's curricula fall short in several key areas. They lack specialization in wind energy principles, training for challenging environments, advanced technical skills like hydraulics and control systems. Additionally, globally recognized certifications, such as those from GWO, which are emphasized in U.S. standards, are not covered in Viet Nam's current training programs.

These gaps highlight the need for updates to Viet Nam's curricula to better prepare the workforce for renewable energy sectors, particularly wind energy. The following tables highlight the key areas where additional focus is needed and the necessary additions for Vietnam's graduates in Industrial Electric and Mechatronics to meet global standards and be competitive in the wind energy.

Table 16: Comparison of areas that have strong alignment vs. those that require updates

Areas of Strong Alignment	Areas Requiring Updates
• Both U.S. and Vietnam standards emphasize foundational knowledge in electrical and mechanical systems, ensuring graduates have baseline technical competencies. • Vietnam's focus on industrial electrical systems and mechatronics is aligned with the mechanical and electrical core skills needed in renewable energy sectors, particularly in wind turbine maintenance. • Safety procedures, such as electrical safety and handling hazardous materials, are integral to both systems, reflecting universal industrial safety norms.	• **Specificity to Wind Energy**: U.S. standards include specialized knowledge in wind energy principles, aerodynamics, and turbine-specific operations, which are largely absent in Vietnam's training programs. • **Work Environment Adaptation**: U.S. standards incorporate training for challenging environments, including high-altitude work and harsh weather, which are critical for wind projects but less emphasized in Vietnam. • **Advanced Technical Skills**: The integration of hydraulics, advanced control systems, and renewable energy-specific tools in U.S. standards highlights a gap in Vietnam's curricula. • **Certification Focus**: International certifications like GWO are prioritized in the U.S., whereas Vietnam lacks standardized certification mechanisms recognized globally.

***Source**: Author's Own Compilation*

Points that need to be supplemented:

Table 17: Specific needs for different skills and knowledge

Improvement Area	Specific Needs
1. Knowledge of Wind Turbine Systems	Industrial Electricity graduates need additional training on the principles of operation, structure, and functioning of mechanical, electrical, and automatic control systems in wind turbines.
2. Skills for Working at Heights	Training on high-altitude safety and rescue is essential, as working on wind turbines often involves operating at significant heights (typically over 60 meters).
3. Knowledge of Hydraulics and Mechanics	Additional knowledge is needed for hydraulic and mechanical systems within wind turbines, including maintenance and repair of components like gearboxes, braking, and pitch control systems.

4. Technical Documentation Comprehension Skills	Ability to read and understand complex technical documentation, often in English, which includes specialized terminology related to wind turbines.
5. Specialized Safety and Maintenance Certifications	Certifications like GWO for wind turbine safety and maintenance are required for industry readiness.

***Source**: Author's Own Compilation*

From our analysis and observation of the Vietnam's wind industry, graduates of the Industrial Electricity and Mechatronic programs in Vietnam have a solid foundation to become Wind Turbine Technicians, but they need to supplement their knowledge and skills in wind turbine technology and complete the relevant safety certifications and to be hold the better position in system.

5.2 GAPS IN TECHNICAL SKILLS FOR SOLAR POWER INDUSTRY BETWEEN VIETNAM'S STANDARDS AND INTERNATIONAL STANDARDS

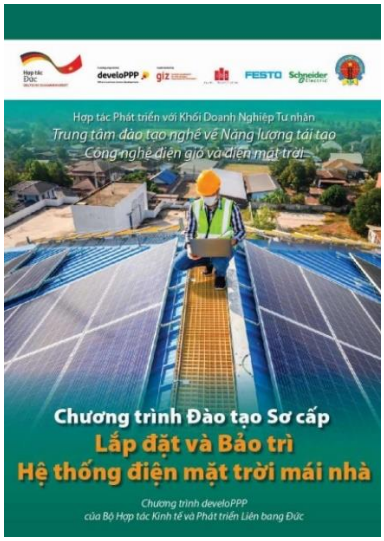
During our interviews, it is found that Vietnamese businesses are generally satisfied with the engineering skill sets of the local workforce for solar farm. While they express a desire for improvement, they often struggle to identify specific skill gaps, unlike the wind energy industry. To address this question, we analyzed the training programs offered by vocational schools in Viet Nam.

We specifically examined two short-course solar PV programs: one offered by NTVC, which was recently developed with GIZ's support, and the Renewable Energy program from the University of Technology and Education (UTE). NTVC's program, although newly designed and not yet recruited students yet, is the only detailed Solar PV program available for review. We selected UTE's university program for consideration since it's a new program and the fact that its graduates are beginning to enter the workforce.

Additionally, we compared these programs with the NABCEP (North American Board of Certified Energy Practitioners), a globally recognized professional certification

organization that establishes industry standards for RE professionals, particularly in the solar energy sector. Once again, we will just focus on maintenance positions since other positions are well coverd by the education system.

Figure 11: Basic Training Program in Installation and Maintenance of Rooftop Solar PV System of NTVC



***Source**: Ninh Thuan Vocational College, 2024*

Table 18: Gaps in training contents in solar PV between training programmes

Criteria	NTVC's solar program's graduates[37]	University of Technology and Education's graduates[38]	NABCEP Certification Holders[39]
Technical Knowledge	Basic knowledge focused on rooftop solar systems, installation procedures, and common local setups.	Comprehensive engineering knowledge, including renewable energy systems, electrical design, and system optimization.	Strong understanding of PV system design, components, NEC standards, grid integration, and advanced troubleshooting.
Practical Skills	Strong practical skills in installation, wiring, and local system troubleshooting.	Moderate practical exposure through labs and internships; more theoretical	Extensive fieldwork experience with hands-on installation, commissioning, and maintenance.

[37] https://www.tvet-vietnam.org/vi/thu-vien-dien-tu
[38] HCMUTE, Ngành Năng Lượng Tái Tạo, 2023
[39] https://www.solarenergy.org/nabcep/

Criteria	NTVC's solar program's graduates[37]	University of Technology and Education's graduates[38]	NABCEP Certification Holders[39]
		than vocational graduates.	
Standards Compliance	Knowledge of Vietnamese regulations and localized safety practices but limited exposure to international standards.	Some familiarity with national and international standards but may lack in-depth focus on compliance during training.	Proficient in international standards (e.g., NEC, OSHA safety regulations, global best practices).
Problem-Solving Ability	Good at solving common issues in rooftop installations; limited exposure to larger, complex solar farm systems.	Strong analytical skills but may lack practical problem-solving experience in real-world solar PV projects.	Experienced in identifying and resolving complex technical issues in PV systems.
Safety Knowledge	Knowledge of local safety regulations; practical experience in safety practices for rooftop installations.	Familiarity with general safety protocols but less focus on hands-on application in solar-specific contexts.	Extensive training in workplace and electrical safety, including OSHA standards.
Advanced Engineering Skills	Limited to basic system sizing and design for rooftop setups; not suited for advanced engineering tasks.	Capable of designing and optimizing solar systems but may lack practical experience in complex projects.	Proficient in advanced design, optimization, and performance analysis for large-scale systems like solar farms.
Soft Skills	Basic communication and teamwork skills, often suitable for small teams or local projects.	Better teamwork and leadership skills, with the potential for project management but less focus on customer interaction.	Strong communication and project management skills due to NABCEP's emphasis on customer interaction and professionalism.

***Source**: Author's Own Compilation*

Based on this analysis, graduates from NTVC's training program are well trained in practical skills while those from UTE are more geared for system design. Together, these 2 training programs are comparable to NABCEP certification which provides a more comprehensive skillset emcompassing design, installation, operation and maintenance.

To achieve gloablly recognized learning outcomes, Vietnamese training programs should concentrate on the areas currently lacking, depending on industry needs. Currently, there is no significant dissatisfaction from businesses regarding Viet Nam's solar PV workforce. However, as the country shifts towards increased solar rooftop adoption, developing a highly skilled workfroce that aligns with international standards, especailly in areas such as design, optimization and performance analysis could be essential for the industry's future growth.

Table 19: Improvement areas for different skills and knowledge

Improvement Area	Specific Needs
1. Technical Knowledge	- **International Standards**: Training in NEC, OSHA safety standards, and other international codes for working on global-scale solar farms.
	- **Advanced Design Skills**: Deeper understanding of system optimization, shading analysis, and grid integration for higher-level design and engineering roles.
2. Practical Experience	- **Fieldwork**: Gain more hands-on experience in installation and troubleshooting.
	- **Large-Scale Solar Farms**: Exposure to complexities of solar farm setups, including DC/AC integration, energy storage, and performance monitoring.
3. Problem-Solving and Troubleshooting	Enhanced training in diagnosing and resolving complex system issues, especially in large-scale installations.
4. Safety Practices	- **OSHA Training**: Incorporating global safety standards into curricula for diverse working environments.
	- **Emergency Protocols**: Training in advanced safety protocols for high-voltage systems.
5. Soft Skills	- **Customer Interaction**: Improve client-facing skills to handle customer concerns and system handovers.
	- **Leadership Training**: University graduates should be trained in leadership for project and team management roles.
6. Certifications	Encourage Vietnamese graduates to pursue globally recognized certifications like NABCEP to increase employability and credibility.

***Source**: Author's Own Compilation*

5.3 SKILLS GAPS BETWEEN VIETNAM'S GRADUATES AND INDUSTRY EXPECTATION IN RE SECTOR

The rapid growth of the RE sector in Vietnam has driven a significant demand for specialized skills in areas such as wind turbine maintenance, solar PV system installation, and energy storage. However, the current workforce often lacks the required technical expertise to meet these demands. In discussions with the TVET institutes as well as different businesses, several skills deficiencies in TVET students have been identified, including, but not limited to the following, starting with the most concerned ones:

- **Insufficient English Proficiency**: In today's globalized economy, proficiency in English is essential for success in many industries. RE sector, being new andhighly technical, relies heavily on English-language materials. Many Vietnamese businesses also have foreign managers, and technical workforce must be able to communicate in English on daily basis. Our observation is that employees with basic English skills, even if rudimentary, tend to thrive in businesses more easily. However, many TVET students currently struggle with English language skills, which limits their ability to access and understand technical materials, communicate effectively with international colleagues and experts, and pursue international job opportunities.
- **Safety and Compliance**: Another concern is the lack of awareness and adherence to safety and compliance standards among some TVET students. One local manager stressed "There is not second chance for any mistake in the electrics industry". Mistakes can lead to accidents, injuries, and damage to equipment. It is crucial to instill a strong safety culture in TVET institutions and provide students with comprehensive training on safety protocols, hazard identification, and risk assessment. The safety cultue must be integrated into training modules for lasting effects.
- **Lack of Practical Skills**: A significant challenge in TVET education is the insufficient emphasis on practical skills, due to both infrastructure limitations and limited opportunities for practicing. While theoretical knowledge is important, hands-on experience is essential for developing the skills needed for success in the workforce. During our visits to vocational colleges and universities, we found that, except for a few institutions with strong active collaboration with international and industry partners, many institutions still lack modern facilities and equipments to equip their students with practical skills required in the RE sector.
- **Limited Self-directed Learning and Active Self-learning**: Both interviewed businesses and TVET institutes have raised concern about students limited self-directed learning and active self-learning skills. Many students tend to rely heavily

on teacher-led instruction and expect clear and step-by-step guidance at every stage. This reliance restricts their ability to take initiative, solve problems independently, and to continue learning beyond the classroom.

- **Communication Skills**: Effective communication is a cornerstone of professional success. Many RE businesses highlight the need for technical workforce to be proactive in their communication in professional settings to exchange ideas and learn from colleagues. Communication is also essential for further training both internally and externally. However, many TVET students struggle with both verbal and written communication skills. This deficiency can hinder their ability to collaborate with colleagues, present ideas clearly, and solve problems effectively. Poor communication skills can lead to misunderstandings, delays, and errors in the workplace.

Figure 12: Solar/Wind Energy Training System at NTVC

***Source**: Author's Own Compilation*

- **Problem-solving Skills**: Critical thinking and problem-solving skills are essential for success in any field, including technical trade. Unfortunately, many TVET students rely heavily on rote learning and memorization, rather than developing the ability to analyze problems, identify potential solutions, and implement effective strategies. This can limit their ability to adapt to new challenges and innovate.
- **Time Management and Organization**: Effective time management and organizational skills are essential for success. However, some TVET students struggle with these skills, leading to poor time management, procrastination, and missed deadlines.

- **Adaptability and Flexibility**: some TVET students may be resistant to change and have difficulty adapting to new situations and technologies. This can hinder their ability to learn new skills and keep up with industry trends.

Besides, there are issues with learning manners that need to be addressed, according to the schools and the businesses. They include:

- **Deep Understanding of Concepts and Principles**: A common issue among TVET students is their lack of a deep understanding of the core priciples, as many rely heavily on rote learning and memorization. Instead of focusing on understanding the underlying concepts and principles, many students simply memorize facts and figures without fully comprehending their meaning. This approach can struggle their ability to apply theoretical knowledge in practical situations, such as troubleshooting equipment or innovating within the renewable energy sector, where problem-solving and adaptability are key.

5.4 REASONS FOR DEMAND OF NEW SKILLS IN THE RE INDUSTRY

The rapid growth of the RE sector in Vietnam has created a significant demand for specialized skills in areas such as wind turbine maintenance, solar PV system installation, and energy storage. However, the current workforce often lacks the necessary technical expertise to meet these demands. This skills gap can be attributed to several factors. As new technologies emerge, such as advanced energy storage systems, artificial intelligence, and the Internet of Things, the skills required to design, install, and maintain these systems also evolve. However, many training institutions struggle to keep pace with these advancements, leading to a mismatch between the skills taught in training programs and the actual needs of the industry. This mismatch can hinder the growth of the RE sector and limit Vietnam's ability to capitalize on the full potential of RE. This skills gap can be attributed to several factors, including:

- **Rapid Technological Advancements**: The RE sector is characterized by rapid technological advancements such as advanced energy storage systems, artificial intelligence, and the Internet of Things. As these new technologies emerge, there is an increasing demand for workers with specialized skills to operate and maintain these complex systems.[40]
- **Policy and Regulatory Changes**: Government incentives and policy adjustments have further accelerated the demand for skilled workers in the renewable energy sector.[41] Changes in environmental regulations, for example, may necessitate

[40] https://www.weforum.org/stories/2018/10/skills-gap-jeopardizing-efforts-end-energy-poverty-power-for-all
[41] https://en.vneconomy.vn/renewable-energy-key-to-greenhouse-gas-emission-reduction.htm

new skills in areas like environmental compliance and sustainable practices. Furthermore, Government's initiatives in promoting Industry 4.0, such as digitalization and automation, may create a mismatch between the skills of the existing workforce and the demands of the evolving industrial landscape.

- **Emerging Trends and Specializations**: The emergence of new trends and niche specializations, such as offshore wind energy and energy storage systems, demands specific expertise that currently falls short in the workforce. [42] Moreover, the rapid evolution of technology and the rise of new industries create novel job roles and specializations that existing TVET programs may not adequately address. To thrive in this dynamic environment, many modern jobs necessitate interdisciplinary skills, requiring individuals to seamlessly integrate technical expertise with critical thinking, communication, and teamwork.
- **Environmental and Social Considerations**: The growing emphasis on sustainability and social responsibility in energy projects necessitates a skilled workforce that aligns with these values. Increased concerns about environmental sustainability are driving demand for expertise in renewable energy technologies, green building practices, and environmental management. Concurrently, there's a rising emphasis on social responsibility, ethical considerations, and community engagement within the energy sector. This requires professionals with strong ethical frameworks, a deep understanding of social impacts, and the ability to engage with local communities effectively.[43]
- **Global Market Dynamics**: The global energy market is becoming increasingly competitive. The integration of Vietnamese energy companies into the global RE market necessitates skills that meet international standards and practices.[44]
- **Economic Growth and Investment**: Rapid economic growth, a shift towards a more knowledge-based economy, and increased investment in RE projects have amplified the demand for a highly trained workforce. Investments in Industry 4.0 technologies, such as robotics and automation, may create a demand for workers with specialized skills in areas like data analysis, AI, and robotics maintenance.[45]
- **Energy Transition Goals**: Ambitious energy transition targets, including the PDP VIII and Just Energy Transition Partnership (JETP) requirements, underline the need for skilled professionals to meet these goals.[46]

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[42] Cobenefit, Future skills and job creation through renewable energy in Vietnam, 2019
[43] Asialink, Green skills for Vietnam's climate transistion, 2024
[44] https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/putting-renewable-energy-within-reach-vietnams-high-stakes-pivot?utm_source=chatgpt.com
[45] https://www.rmit.edu.vn/news/all-news/2023/aug/energy-and-digital-competency-needed-now-for-vietnams-future
[46] https://www.rmit.edu.vn/news/all-news/2024/mar/making-the-renewable-technology-goals-achievable-for-vietnam

5.5 ROOT CAUSES OF SKILLS GAPS FROM TVET

TVET institutions in Vietnam face significant challenges in keeping up with the above industry shifts, resulting in a persistent skills mismatch between graduates and labor market demands.

- **Limited Training Programs**: Many training institutions, including TVET schools and universities, may not offer comprehensive training programs in RE technologies. This can lead to a shortage of skilled workers, particularly in niche areas like offshore wind and solar PV systems.[42]
- **Limited Access to Modern Equipment**: Many TVET institutions lack the resources to provide students with hands-on experience using state-of-the-art equipment like solar panels, wind turbines, and energy storage systems. This gap prevents students from acquiring the practical knowledge necessary for immediate contribution in the workplace.
- **Insufficient Practical Training Hours**: A noteworthy shortcoming in TVET training for RE is the insufficient emphasis on practical skills. While theoretical knowledge is crucial, hands-on experience is paramount for developing the competencies required in the sector. However, many curricula prioritize theory over practical application, resulting in inadequate training hours dedicated to hands-on learning. This limits student exposure to real-world scenarios, leaving them underprepared for the demands of the renewable energy industry.
- **Weak Industry Partnerships**: Effective partnerships between TVET institutions and industry players are crucial for aligning training with market needs. These collaborations can facilitate internships, work placements, and project-based learning opportunities. Unfortunately, in Vietnam, such partnerships remain underdeveloped, particularly in regions outside major urban centers, limiting students' access to practical experience and professional networks.
- **Lack of Awareness of Career Opportunities**: A critical issue hindering the growth of skilled talent in the RE sector is the lack of awareness among students, and even their parents, about the diverse career paths available. Misconceptions about the sector or limited exposure to its potential opportunities—such as roles in engineering, technical services, and project management—result in a smaller talent pool pursuing relevant training. Raising awareness through targeted campaigns, career fairs, and industry outreach can help address this problem.
- **Infrastructure Deficiencies in TVET Institutions**: High-quality training in renewable energy technologies requires access to specialized infrastructure, including laboratories, workshops, and advanced software tools. Unfortunately, many TVET institutions in Vietnam lack these essential facilities. Without proper infrastructure, students are unable to fully develop the technical and practical competencies required for employment in the sector.

5.6 POTENTIAL IMPACTS OF SKILLS GAPS ON THE TVET INSTITUTES

The skills gap in Vietnam's renewable energy sector not only affects the workforce but also poses significant challenges for TVET institutions. As the demand for specialized skills in wind turbine maintenance, solar PV system installation, and energy storage increases, the pressure on educational institutions to provide relevant training intensifies. TVET institutes, often relying on outdated curricula and limited resources, struggle to align their programs with the evolving needs of the industry. This misalignment can have long-term consequences for both the institutions and their graduates. As businesses increasingly seek highly skilled workers proficient in emerging technologies, the inability of TVET institutes to adapt to these changes can lead to a number of negative impacts.

- **Outdated Curricula**: Many TVET programs fail to adapt to rapid technological advancements in the renewable energy sector, resulting in outdated training content. As businesses increasingly demand expertise in cutting-edge technologies such as advanced energy storage, AI, and IoT, TVET graduates often lack the relevant skills, making their education less valuable to employers.
- **Graduate Employability**: The misalignment between TVET training and industry needs directly affects graduate employability. Employers often report that TVET graduates lack the technical and practical competencies necessary for immediate integration into the workforce. This disconnect undermines the reputation of TVET institutions and erodes trust from both students and businesses.
- **Competition from Universities and Private Providers**: TVET institutions face mounting competition from universities and private training providers. Universities often attract students with more comprehensive programs and better resources, while private providers offer flexible, industry-specific courses that are more aligned with market demands. As a result, TVET institutions struggle to remain competitive, further diminishing their appeal.
- **Decline in Industry Partnerships**: Industry partnerships are critical for providing students with real-world experience and for ensuring that training programs meet labor market needs. However, the skill gap mismatch reduces businesses' willingness to invest in collaboration with TVET institutions. Companies may instead partner with private training providers or universities, leaving TVET institutions with fewer opportunities for joint projects, internships, or resource-sharing initiatives.
- **Reduced Investment in Training Programs**: A lack of confidence in TVET institutions' ability to deliver skilled graduates results in reduced investment from both the government and the private sector. This financial constraint exacerbates

existing challenges, such as outdated equipment and insufficient training facilities, creating a vicious cycle of declining quality and relevance.

- **Decreasing Student Enrollment**: The perception of TVET institutions as being less effective compared to universities and private service providers discourages potential students from enrolling. Parents and students often prefer academic pathways that they perceive as offering better career prospects, leading to a decline in enrollment numbers and further straining institutional resources.

5.7 POTENTIAL IMPACTS OF SKILLS GAPS ON THE RE SECTOR

The skills gaps identified in the renewable energy sector can have far-reaching consequences for businesses operating in this space. With the rapid growth and evolving nature of the industry, the ability of companies to recruit, train, and retain skilled workers is critical for maintaining competitiveness and ensuring the smooth execution of projects. As new technologies and regulatory standards emerge, businesses face increasing pressure to upskill their workforce to meet these demands. However, the challenges posed by skills gaps can affect the efficiency, safety, and financial viability of renewable energy projects. The following are some of the potential impacts these skills gaps could have on businesses in the renewable energy sector.

- **Delayed Project Implementation**: A shortage of skilled workers can significantly delay the implementation of renewable energy projects. This can lead to missed opportunities to generate clean energy, reduce greenhouse gas emissions, and achieve national energy targets. Moreover, delays in project implementation can increase costs due to financing charges, inflation, and other factors.
- **Increased Costs**: The lack of skilled workers can lead to increased project costs. To address this issue, companies may need to hire foreign experts or invest heavily in training programs for their existing workforce. Both options can be costly and time-consuming. Additionally, a lack of skilled workers can lead to operational inefficiencies, which can also increase costs.
- **Reduced Efficiency**: A shortage of skilled workers can negatively impact on the efficiency of renewable energy systems. For example, poorly trained technicians may be unable to identify and address technical issues promptly, leading to system downtime and reduced energy output. Furthermore, a lack of skilled workers can hinder the adoption of advanced technologies and innovative solutions, limiting the potential for improving system performance and reducing costs.
- **Increase Safety Risks**: A lack of proper training and certification can increase safety risks in the renewable energy sector. This can lead to accidents, injuries,

and fatalities, as well as damage to equipment and infrastructure. To mitigate these risks, it is essential to invest in comprehensive training programs that cover safety procedures, hazard identification, and emergency response. Additionally, strict adherence to safety regulations and standards is crucial to ensure a safe working environment for all personnel involved in renewable energy projects.

CHAPTER VI – RECOMMENDATIONS

6.1 RECOMMENDATIONS FOR TVET INSTITUTES:

To equip TVET graduates with skills necessary for success in the RE sector, it is crucial to focus on both technical skills and soft skills. Belows are recommendations for TVET Institutes:

Technical Skills:

- **Strenthening Core Electrical Engineering Knowledge:** A strong foundation in core electrical engineering principles, including circuit analysis, power systems, and electrical machines, is essential. TVET institutes should continue to prioritize these subjects in their curricula.

- **Specialized Renewable Energy Modules and integrate in existed formal training programme:** Incorporating specialized modules in renewable energy technologies, such as solar PV, wind power, and energy storage, will equip students with the specific knowledge and skills required for the industry.

- **Review and update the training program to align with international standards:** Incorporate the recommended knowledge and skills from Tables 17 and 19 (Chapter 5) to enhance training programs, including capacity building for TVET teachers. Additionally, invest in facilities and foster collaborations with businesses to improve practical training opportunities for students.

- **Offer short-term training courses to businesses:** Tailored short-term training programs should be offered to businesses, focusing on addressing specific knowledge and skill gaps in areas such as rooftop solar systems, basic wind energy technologies, renewable energy (RE) electricity production, solar power systems for self-use, and component replacement, etc. These courses are designed to equip individuals with the essential knowledge and skills required for the installation, operation, and maintenance of RE systems in the short and long term.

- **Facilitating access to international certifications:** Explore strategies like government subsidies, partnerships with international organizations, and local training centers to offer affordable certification programs. Focus on reducing the cost of GWO certifications (e.g., Working at Height, Fire Awareness, Manual Handling, and First Aid) through subsidized training or financial support. TVET institutions should collaborate with industry partners to develop GWO-aligned programs, equipping students with necessary skills for the global wind energy

market. Additionally, build capacity for TVET teachers and in-company trainers with international certifications to enhance training quality.

Soft Skills:

- **Enhancing English Language Proficiency:** Proficiency in English is essential for accessing technical information—such as manuals, operation guidelines, and safety protocols—communicating with international colleagues, obtaining globally recognized certifications (e.g., GWO, IRATA, and brand certifications), and pursuing global career opportunities. To better prepare students for these demands, TVET institutes should prioritize English language training and seamlessly integrate it into their curriculum. This will ensure graduates are equipped with the language skills necessary to thrive in a globalized and increasingly interconnected professional environment

- **Emphasizing Occupational Safety and Compliance:** Ensuring the safety of students and future workers is paramount. TVET institutes should emphasize safety training, including hazard identification, risk assessment, and emergency procedures.

- **Improving essential working skills:** such as self-learning, communication, problem-solving, adaptability, and time management, should be prioritized and integrated into training programs. These skills are critical for success in any professional setting, enabling individuals to work efficiently, collaborate effectively, and adapt to changing circumstances. During training implementation, practical exercises, real-life scenarios, and interactive activities can be used to enhance these skills. For example, incorporating team-based projects can foster communication and problem-solving, while time management workshops can teach effective prioritization and organization. By embedding these competencies into training, individuals will be better prepared to navigate the challenges of the modern workforce, ensuring they possess not only technical expertise but also the soft skills needed to thrive in dynamic, fast-paced environments.

Industry Collaboration and Curriculum Alignment:

- **Fostering Industry Partnerships:** Strong collaborations with industry partners can help TVET institutes align their training programs with the latest industry trends and standards. Cooperative training approaches, multi-stakeholder collaboration through Industry Advisory Board model are valuable to engage businesses in shapping and delivering training curriculum. These partnerships also play a crucial role in assessing graduate performance and supporting job placement, ensuring that students are well-prepared for success in the workforce.

- **Providing Practical Training Opportunities:** In order to enhance the development of hands-on skills, it is essential to offer ample practical training opportunities, such as internships, apprenticeships, and industry projects. Investing in modern training facilities, laboratories and workshops, advanced simulation equipment or promoting in-company training can significantly improve these opportunities. By providing scaled-down or simulation systems, students can visualize the various components, observe their interactions, and gather data using a control system similar to those found in real-world RE farms. In addition, the collaboration with businesses for in-company training allows students to work with real equipment and offer valuable insights into on-site operations. These practical experiences not only reinforce theoretical knowledge but also provide a strong foundation for further learning and professional growth as well as improve necessary skills for real life working such as system optimization, working at height, performing maintenance tasks and troubleshooting issues. Additionally, promoting in-company trainers and coordinators is essential, with recognition from the TVET system to ensure active business involvement in training. This requires collaboration with government authorities overseeing the TVET system in Vietnam.

- **Regular Curriculum Review and Updates:** To ensure training programs stay relevant and align with industry advancements and international standards, regular curriculum reviews and updates are essential. While the current programs provide solid foundation, it is important to make on-going improvements to address the industry's evolving needs. TVET Institutes should explore partnerships with businesses to incorporate emerging technologies (advanced diagnostic, predictive maintenance, digitalization, etc.) into their training programs. This will help to ensure that graduates are well-prepared with the skill needed to navigate future challenges and thrive in the dynamic workforce.

6.2 RECOMMENDATIONS FOR STATE MANAGEMENT AGENCIES

State management agencies play a crucial role in fostering effective TVET training for the wind and solar energy sectors. To ensure the effective development of a skilled workforce, the following recommendations should be considered:

- **Incentivizing Industry Collaboration**: Policies that encourage collaboration between TVET Institutes and businesses can strengthen the relationship between education and industry. These incentives could include tax breaks, subsidies, or grants or non-financial support mechanism for businesses that partner with TVET institutions to provide on-the-job training, internships, and contribute to curriculum development. This fosters a symbiotic relationship where businesses

gain access to a skilled workforce, while TVET institutions receive valuable industry insights and resources.

- **Establishing Clear Accreditation and Workforce development Standards**: Establishing clear accreditation standards and workforce development programs tailored to the RE sector is paramount. These standards should outline the knowledge, skills, and competencies required for various roles in the wind and solar energy industry, ensuring that graduates possess the necessary qualifications to meet industry demands. The development of sector-specific workforce development programs, including upskilling and reskilling initiatives, is crucial to address the evolving needs of the renewable energy sector and ensure that the Vietnamese workforce remains competitive. By implementing these recommendations, state management agencies can significantly enhance the quality and relevance of TVET training, contributing to the successful development of Vietnam's renewable energy sector and a sustainable energy future.
- **Improve skills development in the renewable energy sector, the government should establish and facilitate a robust and reliable Labour Market Information System (LMIS) specifically tailored to this sector.** This system would provide continuous and real-time analysis of skills demand, helping training institutes stay updated on emerging trends and industry needs. By regularly assessing the skills required by the renewable energy industry, the LMIS can ensure that training programs are aligned with current market demands, allowing institutions to adapt and enhance their curricula accordingly. Furthermore, the system could provide valuable data on workforce gaps, allowing both public and private stakeholders to address skill shortages through targeted training initiatives. This collaboration between government, industry, and training institutes will help create a dynamic and responsive skills development framework, ensuring that the workforce remains equipped with the necessary competencies to meet the evolving needs of the renewable energy sector. Additionally, the LMIS can support job placement services, providing industry insights that help graduates transition into meaningful employment while ensuring employers find qualified workers with the specific skills they need.
- **Promoting Sustainable Power Transmission Solutions**: To support the growth of the renewable energy (RE) sector in Vietnam while addressing challenges in power transmission, it is essential to align human resource development with the sector's evolving needs. As Vietnam accelerates RE projects to reduce greenhouse gas emissions and ensure energy security, the pressure on the power transmission system has intensified, including increased transmission demand, the dispersion of power sources, and volatility in power generation. To effectively address these challenges and ensure seamless integration of RE projects in line with the Power Development Plan 8 (PDP 8), the government, through the Ministry of Industry and

Trade and EVN together with the Ministry of Education and Training, should focus on the following:

- **Investing in the Transmission Grid:** Significant investment in grid expansion and modernization is crucial, incorporating smart grid technologies to enhance reliability and efficiency. Alongside physical infrastructure, developing a skilled workforce to operate and maintain these advanced systems is essential to meet the growing demand for expertise in grid management.
- **Strengthening Policy Mechanisms:** The legal and regulatory framework should be reviewed and updated to support the integration of RE, with specific focus on mechanisms for auctioning connection rights, streamlining administrative processes, and providing incentives for private sector investment. Equally important is the development of policies that encourage investment in human resources and the upskilling of the workforce to keep pace with technological advancements in the sector.
- **Developing the Support Service Market:** Building a robust support service market is vital for the long-term success of the renewable energy sector. Encouraging the development of services such as operations, maintenance, and consultancy—alongside an efficient information system—will boost efficiency in the sector and create additional opportunities for skilled professionals. This will also contribute to the growth of a sustainable workforce that can support RE projects over their entire lifecycle.
- **Improving Human Resource Capacity:** Targeted training programs and international collaboration are essential to equip Vietnam's workforce with the specialized skills required for the renewable energy sector. Strengthening human resource capacity through continuous education, certification, and skills development will ensure that Vietnam’s workforce can meet the demands of the rapidly growing RE sector, particularly in specialized fields such as smart grid technology, system integration, and maintenance.
- **Developing a Long-Term Power Transmission Plan:** A long-term power transmission development strategy, aligned with national energy goals, will help ensure that the transmission system can accommodate the growing RE capacity. Regular evaluations and adjustments to this plan will ensure that both infrastructure and human resources are developed in tandem to support sustainable growth in the sector.

- **Improve the legal framework on skills development and promote lifelong learning in the sector**
  - Strengthen the effectiveness and execution of policies that promote training, particularly in essential skills that improve the renewable energy

(RE) sector's supply chain. Encourage lifelong learning to ensure the workforce remains adaptable to industry changes.
    - Develop strategies to increase productivity, raise salaries, improve working conditions, and establish clear career progression paths within the renewable energy sector. These measures will help boost attractive workforce retainment.
    - Elevate the image of the renewable energy sector and raise public awareness through targeted communication about the sector's potential for economic growth and its critical role in Vietnam's economy. This will help attract students and job seekers.
    - Invest in upgrading training facilities and equipment at Technical and Vocational Education and Training (TVET) institutions and universities. Build capacity for educators and update training programs in collaboration with businesses to ensure they meet industry standards.
- **Enhance Budget Allocation for Skills Development and Training Based on Sector-Specific Needs**
    - Targeted Funding for Sector Demands: Increase the budget for skills development and training tailored to the specific needs of the renewable energy sector. Draw lessons from successful funding models used by educational and TVET institutions to address resource limitations in infrastructure and training, particularly with the involvement of SMEs and small businesses.
    - Establish a Skills Development Fund: Create a dedicated Skills Development Fund for the sector, supported by contributions from businesses, the government, and other legal entities. This fund would help sustain and expand training programs, ensuring long-term investment in workforce development.

6.3 RECOMMENDATIONS FOR BUSINESS SECTOR

The recommendations for the business sector include:

- **Address and Bridge the Skills Gap:** Wind and solar energy businesses should actively bridge the skills gap in renewable energy sector by investing in training and upskilling programs tailored to the industry's need. The following actionable suggestions should be added into consideration
    - Partnership with TVET Institutes and other Training Providers to view and update training programme or module related to renewable energy or develop specific curricula for renewable energy.

- Collaborate with Governments to create incentives for businesses that invest in local talent and skills development, such as tax rebates or grants for training programs.
- Implement industry-specific On-the-job Training initiatives or together with school conduct cooperative training where students and employees can gain hands-on experience while learning from experts, especially in technical roles such as turbine maintenance, system design, installation or operation. The building of pool of in-company trainers is also essential for these initiatives and enhance business engagement in TVET and educational system

- **Empower the Local Workforce:** Promote the empowerment of the local workforce by collaborating with educational institutions to enhance the quality and quantity of skilled labour which reduces reliance on foreign expertise. Some actionable suggested for this recommendation are:
  - Curriculum Development: Collaborate with local training providers, especially TVET Institutes, to co-design, develop, implement and certify programs that align with the needs of industry
  - Develop formal internship and apprenticeships programs with TVET Institutes and offer student real world experience
  - Assess performance and provide job placement support for graduates of RE training programs including career counseling, mentorship and networking opportunities
- **Foster Sustainable Growth:** Businesses should foster sustainable growth by developing customized training programs that ensure graduates and employees possess industry-relevant skills, leading to sustainable employment and long-term business success in the Vietnamese renewable energy sector in strong collaboration with training providers. The following actionable suggestions are highly recommended:
  - Invest in supprt TVET Institutes' training facility equipment or industry-specific training centers focused on RE technologies which providing hands on experience with the latest equipments and system used in wind and solar energy.
  - In collaboration and discussion with local governments and educational institutions, especially TVET Institutes to create workforce development roadmap for long and short-term, ensuring continuos supply of skills labour that meets future needs. The idea of a labour market information system specificly for the sector is critical and businesses will play the leading role in providing continuous and real-time analysis of skills demand, helping training institutes stay updated on emerging trends and industry needs.
  - Implement continuos professional development programs that allow workers to stay current with technological advancements in RE sector,

such as emerging trends in energy storage, grid integration, energy efficiency.

- **Invest in Human Capital:** Business should invest in employee upskilling and career development programs to enhance employee motivation, retention and productivity which will contribute to the overall success of the business. Businesses should offer training provided by TVET Institutes or other training providers to create opportunities for the staff to up-skill or re-train on technical skills and knowledge. The TVET Institutes who certified by recognized certification bodies (GWO, NSMO, IRATA, etc.) in the sector will have more advancetage in collaboration with businesses.
- **Address specific training and certification requirement in the sector**: Wind businesses should provide specialized training and certifications programs that align with their unique operational and safety requirements in addition to adhearing to industry standards. They include training on the businesses' unique wind turbine models, proprietary software and systems for work orders, maintenance procedures, emergency response plans, and safety protocols.
- **Promote Collaboration and Knowledge Exchange**: It is encouraged to establish collaboration between businesses, educational institutions and government agencies to create a shared knowledge base and improve the overal training ecosystem. The tripartile mechanism or skills council mechanism at different levels should considered as solution to create the RE knowledge hubs, develop national standards for training, certification, providing LMIS for the sector, etc. which ensuring that Vietnamese RE workforce meets international standards.

6.4 RECOMMENDATIONS FOR GIZ'S TVET PROGRAMME:

To bridge the gap between the needs of businesses and the qualifications of graduates, there are the following suggestions for TVET Programme:

- **Provide Technical Support and Share Expertise**: Offer technical guidance and share industry experience to assist TVET Institutes in aligning their training programs with global standards and industry certifications (e.g., GWO, IRAT, etc.). This includes advising on curriculum design to ensure training modules reflect the latest industry practices and meet certification requirements.
- **Foster Collaboration Between Industry and TVET Institutes**: Encourage stronger partnerships between industry and TVET Institutes to develop training programs that are both technically sound and industry relevant. Promote active business involvement in training development and real-world training experiences through cooperative programs. Additionally, facilitate regular industry advisory boards dialougue with businesses, industry experts, and educational leaders to ensure continuous communication and alignment with the workforce's evolving needs.

- **Leverage and Scale Successful models**: Identify successful existing TVET programs, particularly in the renewable energy sector, and share best practices, lessons learned, and experiences. Recommend scaling or adapting these successful models for broader use. Activities may include organizing knowledge-sharing events, conferences, webinars, and study tours, where TVET Institutes can learn from collaborations with NTVC, VCMI, and other advanced renewable energy training models.
- **Provide technical input for Policy**: Collaborate with government agencies, industry leaders, and TVET Institutes to deliver evidence-based policy recommendations aimed at strengthening the legal and regulatory framework for skills development in the renewable energy sector. Contribute to policy discussions and studies, producing technical reports that emphasize the need for effective policies to ensure long-term sector growth, workforce development, and enhanced business engagement in the TVET system.
- **Share International Best Practices**: Support educational and training institutions, as well as businesses, by sharing international practical experiences that prepare graduates for the global renewable energy market. This will help ensure that the workforce is equipped with skills that meet international standards and meet market demands.
- **Facilitate Access to Advanced Learning Opportunities**: Build partnerships with leading renewable energy companies to provide TVET students with access to the latest technologies and hands-on learning experiences with state-of-the-art solutions. This will enhance their practical skills and prepare them for cutting-edge developments in the renewable energy field.

CHAPTER VII – CONCLUSIONS

This report highlights a significant skills gap within the Renewable Energy sector, particularly in wind and solar power, in the Central and Central Highlands regions of Vietnam. The current workforce lacks advanced technical skills, specialized certifications, and practical experience required for the O&M of RE systems.

Furthermore, existing training programs within TVET institutions face several challenges. These include outdated equipment, a lack of industry-relevant curricula, limited access to proprietary technologies, and insufficient collaboration with businesses. This often results in a disconnect between training programs and the actual needs of the RE industry, with graduates lacking the necessary practical skills.

The rapid development of technology within the RE sector, including advancements in energy storage systems, artificial intelligence, and the Internet of Things, is further exacerbating this skills gap. The emergence of new technologies, such as offshore wind power and advanced energy storage systems, demands a highly specialized workforce. Additionally, Vietnam's ambitious energy transition goals necessitate a significant increase in the number of skilled human resources within the sector.

The root causes of this skills gap are multifaceted. Training programs have not kept pace with the rapid technological advancements in the RE sector. Limited access to modern equipment and practical training programs within TVETs further hinders the development of a skilled workforce. In-sufficient cooperation between educational institutions and businesses restricts internship and practical work opportunities for students. Moreover, a lack of awareness regarding career opportunities within the RE sector discourages students from pursuing relevant majors.

Addressing these challenges requires a multi-pronged approach. TVET schools must prioritize both technical and soft skills development, with a particular focus on English proficiency. Strengthening collaboration between training institutions and businesses is crucial to ensure that training programs align with the actual needs of the industry. The development and implementation of industry-specific certification standards and workforce development programs are also essential.

Finally, government agencies, particularly the Ministry of Education and Training, Department of TVET and Continuing Training, Ministry of Industry and Trade (MOIT) and Electricity of Vietnam (EVN), must play a crucial role in facilitating cooperation between training institutions and businesses. This can be achieved through the development and implementation of supportive policies that encourage collaboration and incentivize industry involvement in workforce development initiatives.

LIMITATIONS OF THE STUDY

The study faced significant limitations due to a low response rate from both TVET institutions and companies through survey. The low response rate raises concerns about the representativeness of the data and the potential for significant sampling bias. Though we have tried to utilize the information provided by the in-depth interviews with the TVET institutions and businesses, plus additional studying of the remaining ones via internet search, the findings may not fully reflect the perspectives and experiences of the broader TVET sector and the RE industry in Vietnam.

Furthermore, the study primarily focused on the Central and Central Highlands regions, limiting the generalizability of the findings to other regions in Vietnam. The renewable energy landscape and the associated skills needs may vary across different regions due to factors such as resource availability, economic development, and existing infrastructure. Therefore, the findings may not be fully applicable to other regions with different characteristics and priorities.

Finally, the study encountered limitations due to data gaps. Access to consistent and comprehensive data on existing training programs, employment outcomes, and industry trends was limited.

APPENDICES

Annex 1: List of TVET institutions interviewed, surveyed and desk research

#	Name
1	Trường Cao đẳng Kỹ thuật Việt Đức Hà Tĩnh
2	Trường Cao đẳng Cơ giới và Thuỷ lợi
3	Trường Cao đẳng công nghiệp Huế
4	Trường Cao đẳng Huế
5	Trường Cao Đẳng Kỹ Nghệ II
6	Trường Cao đẳng nghề Ninh Thuận
7	Trường Cao đẳng Kỹ thuật Quảng Trị
8	Đại học điện lực
9	Cao đẳng công nghệ cao Hà Nội
10	Hanoi University of Science and Technology HUST
11	Vietnam France University USTH
12	Trường ĐH Bách khoa - ĐH Đà Nẵng
13	Học viện công nghệ Bưu chính Viễn thông
14	Trường Cao đẳng Công nghiệp Thanh Hóa
15	Trường Cao đẳng Nông nghiệp Thanh Hóa
16	Trường Cao đẳng Kinh tế - Kỹ thuật Công thương
17	Trường Cao Đẳng Nghề Nghi Sơn
18	Trường Cao đẳng Việt - Đức Nghệ An
19	Trường Cao đẳng Kỹ thuật Công nghiệp Việt Nam - Hàn Quốc
20	Trường Cao đẳng nghề số 4 - BQP (Nghệ An)
21	Trường Cao đẳng Kinh tế kỹ thuật số 1 Nghệ An
22	Trường Cao đẳng Giao thông vận tải Trung ương IV (Vinh, NA)
23	Trường Cao đẳng Công nghệ Hà Tĩnh
24	Trường Cao đẳng nghề Quảng Bình
25	Trường Cao đẳng Kỹ thuật Công Nông nghiệp Quảng Bình
26	Trường Cao đẳng Kỹ thuật Quảng Trị
27	Trường Cao đẳng Nguyễn Văn Trỗi (Đà Nẵng)
28	Trường Cao đẳng Giao thông vận tải Trung ương V (Đà Nẵng)
29	Trường Cao đẳng Bách khoa Đà Nẵng
30	Trường Cao đẳng Đại Việt Đà Nẵng
31	Trường Cao đẳng FPT Polytechnic (Hà Nội)
32	Trường Cao đẳng THACO (Quảng Nam)

#	Name
33	Trường Cao đẳng Điện lực miền Trung (Quảng Nam)
34	Trường Cao đẳng Quảng Nam
35	Trường Cao đẳng Miền Trung
36	Trường Cao đẳng Kỹ nghệ Dung Quất (Quảng Ngãi)
37	Trường Cao đẳng Cơ giới (Huyện Tư Nghĩa, Tỉnh Quảng Ngãi)
38	Trường Cao đẳng Việt Nam - Hàn Quốc Quảng Ngãi
39	Trường Cao đẳng Kỹ thuật Công nghệ Quy Nhơn
40	Trường Cao đẳng Cơ điện - Xây dựng và Nông Lâm Trung Bộ (Bình Định)
41	Trường Cao đẳng nghề Phú Yên
42	Trường Cao đẳng Công Thương miền Trung (Tuy Hòa, Phú Yên)
43	Trường Cao đẳng Kỹ thuật Công nghệ Nha Trang
44	Trường Cao đẳng Gia Lai
45	Trường Cao đẳng Đà Lạt
46	Trường Cao đẳng Công nghệ và Kinh tế Bảo Lộc (Lâm Đồng)
47	Trường Trung cấp kinh tế - kỹ thuật Bắc Nghệ An
48	Trường Trung cấp Kinh tế - Kỹ thuật Hồng Lam
49	Trường Trung cấp Kỹ thuật - Nghiệp vụ Vinh
50	Trường Trung cấp nghề Hà Tĩnh
51	Trường Trung cấp Du lịch – Công nghệ số 9 (Quảng Bình)
52	Trường Trung cấp Mai Lĩnh Quảng Trị
53	Trường Trung cấp ASEAN (Tam Kỳ, Quảng Nam)
54	Trường Trung cấp nghề tỉnh Quảng Ngãi
55	Trường Trung Cấp Công Nghệ Việt Mỹ
56	Trường Trung cấp nghề Ninh Hòa (Khánh Hòa)
57	Trường Trung cấp nghề Cam Ranh
58	Trường Trung cấp nghề Cam Lâm
59	Trường Trung cấp nghề Diên Khánh (Khánh Hoà)
60	Trường Trung cấp nghề Đắk Nông
61	Trường Trung cấp nghề Bảo Lộc
62	Trường Trung cấp nghề Tân Tiến (Lâm Đồng)
63	Cao đẳng nghề Đà Nẵng
64	Đại học Quốc tế Miền Đông
65	Trường Cao đẳng nghề Đăk Lăk/Trường Cao đẳng Đăk Lăk (?)
66	Cao đẳng nghề KonTum
67	Trường Cao đẳng Điện lực miền Bắc

***Source**: Author's Own Compilation*.

Annex 2: List of businesses interviewed and surveyed

#	Name
1	Thuan Binh Wind Power JSC, Wind and Solar Power Association
2	RE Department, BIM Group
3	BIM Group
4	Song Hung Thuan Company
5	Thuan Hai Renewable Energy
6	Dam Nai Wind Power, Scatec Solar
7	Festo Viet Nam
8	Trung Nam group
9	Công ty Cổ phần Tư vấn xây dựng điện 3 PECC3
10	Vu Phong Energy Group JSC
11	IBS Viet Nam
12	Technical Department, IBS Viet Nam
13	Bosch Việt Nam
14	PRIM Consultancy Energy Company
15	Vivablast Vietnam Co. Ltd
16	GEC Điện Gia Lai
17	Schaeffler Viet Nam Co., Ltd
18	Enercorn Viet Nam Company Limited
19	SP Energy Viet Nam
20	PC1
21	New Atlantic International Trading JSC
22	Công ty Phú Điền
23	Tập đoàn Thái Bình Dương (Pacific Corporation)
24	Tập đoàn Thái Bình Dương (Pacific Corporation)
25	Công ty tư vấn Năng lượng Vatec
26	La Gan Wind - Copenhagen Offshore Partners
27	INS Engineering
28	Systech Highvoltage Company
29	Công ty TNHH Nhất Nước
30	Cty Năng lượng mặt trời tiêu điểm
31	DEAHAN E&C
32	Tâm Giao
33	Công ty Cổ phần năng lượng Focus Solar
34	Pacific Company Ltd Company, Binh Thuan

#	Name
35	Sembcorp
36	Siemens Gamesa
37	Indefol Solar
38	Schneider Electric
39	Solar EV
40	Phong Huy Wind Power company

***Source**: Author's Own Compilation*.

Annex 3: Survey questionnaires for TVET institutes and businesses, and interview guides for businesses

Guiding questions for businesses (for KII)

Guiding Question for Businesses - VNM.doc

Questionnaires for businesses (for survey)

Biz Questionnaires ENGVNM.xlsx

TVET questionnaires (for survey and KII)

TVET Questionnaires ENGVNM.xlsx

Annex 4: List of occupational training programs that are suitable for works at wind or solar PV farms

Program	Code (starting with 5 for intermediate, 6 for college and 7 for university)
Mechatronic engineering	5510304, 6510304
Mechatronics	5520263, 6520263
Electromechanical equipment maintenance	5520149, 6520149
Power transmission lines and substations of 220 KV or higher installation	5520243, 6520243
Power transmission lines and substations of 110 KV or lower installation	5520244, 6520244
Power transmission lines and substations of 220 KV or higher operation management and repair	5520256, 6520256
Power transmission lines and substations of 110 KV or lower operation management and repair	5520257, 6520257
Electricity operation in electricity power plant	5520245, 6520245
Hydroelectricity plant operation	5520246, 6520246
Thermal electricity plant operation	5520247, 6520247
Electricity operation in hydroelectricity power plant	5520251, 6520251
Power system	5520265
Industrial electrics	5520227, 620227
Industrial electronics	5520225, 6520225
Household Electronics	5520224, 6520224
Household Electrics	5520226, 6520226
Industrial and household electrics	5520223
Industrial and Household Electronics	5520222
Electronics and building energy engieering	5510314, 6510314
Mechatronic engineering, heating and air conditioning	5510315, 6510315
Set up and maintenance renewable energy systems	5520270, 6520270
Wind and solar energy plant operation	5520271, 6520271
Solar energy system engineering	5510313, 6510313

Electrical Engineering	7520201
Electrical and Electronic Engineering Technology	7510301
Renewable Energy Engineering Technology	7519007

***Source**: Author's Own Compilation*.

Annex 5: List of positions in offshore wind farm [47]

Title	Design & Development	Construction	Operations & Maintenance	Degree Required
Chief Executive Officer (CEO)	X	X		University
Chief Commercial Officer	X	X	X	University
Commercial Manager	X	X		University
Chief Finance Officer	X	X	X	University
Finance Manager	X	X	X	University
Project Development Manager	X	X		University
Government Relation Director/Manager	X	X		University
Communication Manager	X	X	X	University
Community Affairs Officer	X	X		University
Procurement Director/Manager	X	X	X	University
Localization Manager	X	X	X	University
Project Management Officer (PMO)	X	X	X	University
Planning Manager	X	X	X	University
Document Control Manager	X	X	X	University
Environment and Consent Manager	X	X	X	University
Legal Counsel	X	X	X	University
EPC Director	X	X	X	University

[47] CIP, Offshore wind workforce, 2024

Title	Design & Development	Construction	Operations & Maintenance	Degree Required
Project Engineer	X	X	X	University
Geophysical & Geotechnical Survey Lead	X	X	X	University
Foundation Package Manager	X	X	X	University
Foundation T&I Package Manager	X	X	X	University
Offshore Substation Package Manager	X	X	X	University
Onshore Substation Package Manager	X	X	X	University
Grid Manager	X	X	X	University
WTG Package Manager	X	X	X	University
WTG T&I Package Manager	X	X	X	University
SCADA Engineer	X	X	X	University
Interface Manager	X	X	X	University
HSE Manager	X	X	X	University
Quality Manager	X	X		University
Risk Manager	X	X	X	University
Human Resources Manager	X	X	X	University
Office Manager	X	X		University
Construction Manager	X	X	X	University
Site Manager	X	X	X	University
Fabrication Supervisor/Manager	X	X	X	College
Heavy Lift Supervisor	X	X	X	College
Rigger Foreperson			X	College
Client Representative (Installation)		X		University
Site Administrator			X	College/ Intermediate or above

Title	Design & Development	Construction	Operations & Maintenance	Degree Required
Marine Coordinator		X		College/ Intermediate or above
Installation Technician		X		College/ Intermediate or above
Cable Installation Manager		X		College/ Intermediate or above
Carousel Engineer		X		College/ Intermediate or above
Tension Operator		X		College/ Intermediate or above
Commissioning Engineer		X		College/ Intermediate or above
Captain		X	X	College/ Intermediate or above
Chief Engineer		X	X	College/ Intermediate or above
Chief Integrated Rating		X		College/ Intermediate or above
Control Room Technician		X	X	College/ Intermediate or above
Radio Operator		X	X	College/ Intermediate or above
Deck Supervisor		X	X	College/ Intermediate or above

Title	Design & Development	Construction	Operations & Maintenance	Degree Required
Deck Cadet		X		College/ Intermediate or above
Marine Steward		X	X	College/ Intermediate or above
Electrical Technician/Supervisor		X	X	College/ Intermediate or above
Mechanical/Hydraulics Technician		X		College/ Intermediate or above
Crane Inspection Engineer		X		College/ Intermediate or above
Crane Operator		X		College/ Intermediate or above
Coating Inspector		X		College/ Intermediate or above
Painter/Rope Access Technician		X		College/ Intermediate or above
Rope Access Manager		X		College/ Intermediate or above
Diver		X	X	College/ Intermediate or above
Remote Operated Vehicle Technician		X	X	College/ Intermediate or above
Warehouse Stores Assistant		X		College/ Intermediate or above

Title	Design & Development	Construction	Operations & Maintenance	Degree Required
Wind Turbine Technician		X	X	College/ Intermediate or above
Blade Repair Technician		X	X	College/ Intermediate or above
Master Crew Transfer Vessel		X		College/ Intermediate or above
Deckhand/Mate Crew Transfer Vessel		X		College/ Intermediate or above
Engineer Crew Transfer Vessel		X		College/ Intermediate or above
Approvals Compliance Manager		X		College/ Intermediate or above
Asset Integrity Manager		X		College/ Intermediate or above
Operation & Maintenance Manager			X	College/ Intermediate or above
Wind Yield Performance Analyst	X	X	X	College/ Intermediate or above

***Source**: Author's Own Compilation*.

Annex 6: List of Solar PV and wind plants in Central and Central Highland Areas of Viet Nam (COD after 31 October 2021)

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
1	BT1 Gia Ninh	Wind	109.2		Jul-21
2	BT2 Ngư Thủy Bắc - GĐ1	Wind	100.8		Nov-21
3	Amaccao Quảng Trị 1	Wind	50		Nov-21
4	Gelex 1,2,3	Wind	90		Nov-21
5	Hải Anh	Wind	40		Nov-21
6	Hoàng Hải	Wind	50		2021
7	Hướng Hiệp 1	Wind	30	126	Dec-20
8	Hướng Linh 1,2	Wind	60	244,68	May-17
9	Hướng Linh 3	Wind	30		Dec-20
10	Hướng Linh 4	Wind	30	100	2021
11	Hướng Linh 5	Wind	30		2021
12	Hướng Linh 7	Wind	30		2021
13	Hướng Linh 8	Wind	25.2		2021
14	Hướng Phùng 1	Wind	30	81,1	2020
15	Hướng Phùng 2	Wind	20	77,5	2021
16	Hướng Phùng 3	Wind	30	116,3	2021
17	Hướng Tân	Wind	48		2021
18	Liên Lập	Wind	48	158,8	Oct-21
19	Phong Huy	Wind	48	133,7	Oct-21
20	Phong Liệu	Wind	48	133,7	Oct-21
21	Phong Nguyên	Wind	48	133,7	Oct-21
22	Tài Tâm	Wind	48		2021
23	Tân Linh	Wind	48		2021
24	Fujiwara Bình Định	Wind	50		Feb-20
25	Phương Mai 3	Wind	20.79	50	Jan-20
26	Nhơn Hội 1	Wind	30		Sep-21
28	Phương Mai 1	Wind	26.4		Oct-21
29	Tân Tấn Nhật - Đăk Glei	Wind	50		Nov-21
30	Chế Biến Tây Nguyên	Wind	50	160	2021
31	Chơ Long	Wind	155		Nov-21
32	Cửu An	Wind	46.2		2021

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
33	HBRE Chư Prông	Wind	50	160	Nov-21
34	Hưng Hải Gia Lai	Wind	100		2021
35	Ia Bang 1	Wind	50		2021
36	Ia Boòng - Chư Prông	Wind	50		2021
37	Ia Le 1	Wind	100	320,7	Oct-21
38	Ia Pếch 1	Wind	50		2021
40	Ia Pết - Đak Đoa 1	Wind	99	550	Oct-21
41	Ia Pết - Đak Đoa 2	Wind	99	550	Oct-21
42	Ia Pết 1	Wind	100	550	Oct-21
43	Ia Pết 2	Wind	100	550	Oct-21
44	Nhơn Hòa 1	Wind	50		Oct-21
45	Nhơn Hòa 2	Wind	50		2021
46	Phát Triển Miền Núi	Wind	50	160	2021
47	Song An	Wind	46.2		2021
48	Yang Trung	Wind	145		Nov-21
49	Cư Né 1	Wind	50		2021
50	Cư Né 2	Wind	50		2021
51	Ea Nam	Wind	400	1173	Dec-21
52	Krông Búk 1	Wind	50		2021
53	Krông Búk 2	Wind	50		2021
54	Ea H'leo	Wind	57		2021
55	Đăk Hòa	Wind	50		2021
56	Đăk N'Drung 2	Wind	100		2021
57	Đăk N'Drung 3	Wind	100		2021
58	Nam Bình 1	Wind	30		Oct-21
59	7A Thuận Nam	Wind	50		Oct-21
60	BIM Thuận Nam	Wind	88	306,9	Nov-21
61	Công Hải 1 GD1	Wind	3		2020
63	Đầm Nại	Wind	40	110	Nov-18
64	Hanbaram	Wind	115.6		2021
65	Lợi Hải 2	Wind	30		Nov-21
66	Mũi Dinh	Wind	37.6	105	Nov-18
68	Phước Minh	Wind	27.2		2021
69	Số 5 Ninh Thuận	Wind	46.2	136,3	Sep-21
70	Trung Nam Ninh Thuận	Wind	152	426	Apr-19

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
71	Win Energy Chính Thắng	Wind	50		Mar-21
74	Hồng Phong 1	Wind	40		Oct-21
75	Phong Điện 1 - Bình Thuận GĐ1	Wind	30	85	2017
76	Phong Điện 1 - Bình Thuận GĐ2	Wind	30	85	Oct-21
77	Phú Lạc	Wind	24	59	Sep-16
78	Phú Lạc GĐ 2	Wind	25.2	84,7	2021
79	Phú Quý	Wind	6	25,4	Aug-12
80	Thái Hòa	Wind	90	225	2021
81	Thuận Bình	Wind	24		Sep-16
82	Thuận Nam (Hàm Cường 2)	Wind	20		2021
83	Thuận Nhiên Phong	Wind	30.4		2021
84	Tuy Phong	Wind	30	85	Apr-12
85	Cầu Đất	Wind	60	150	Nov-21
86	Côn Đảo	Wind	4		2015
88	Tân Phú Đông 2	Wind	50		2021
89	Bình Đại	Wind	30		Jun-21
91	Nexif Energy GĐ1 (80M)	Wind	30		2021
92	Số 5 - Thạnh Hải 1	Wind	30		2021
96	Số 5 Thạnh Hải	Wind	120		Oct-21
97	Số 7 Ba Tri	Wind	110		Oct-21
98	Sunpro Bến Tre	Wind	30		Oct-21
99	Thanh Phong	Wind	30		Oct-21
100	VPL Bến Tre	Wind	60		Oct-21
101	Đông Hải 1 (V1-7)	Wind	100		Oct-21
102	Hàn Quốc - Trà Vinh	Wind	48	173	Oct-21
104	Hiệp Thạnh	Wind	77.3	300	Oct-21
105	Trà Vinh V1-1	Wind	48		Oct-21
106	Trà Vinh V1-2	Wind	48	163	Oct-21
107	Trà Vinh V1-3	Wind	48	163	Oct-21
108	Công Lý Sóc Trăng	Wind	30	84	Apr-20
109	Hòa Đông	Wind	30	109,3	Oct-21
111	Lạc Hòa - GĐ1	Wind	30	93	2021
112	Lạc Hòa (Số 5 ST)	Wind	30		Oct-21
117	Số 7 Sóc Trăng	Wind	30	108	Oct-21
118	Bạc Liêu	Wind	99	320	Oct-12

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
120	Đông Hải 1	Wind	100	365	Aug-21
121	Hòa Bình 1	Wind	50		Jun-21
122	Hòa Bình 1 - GĐ2	Wind	50	200	2021
123	Hòa Bình 2	Wind	50	200	2021
124	Hòa Bình 5 - GĐ1	Wind	80	280	2021
125	KOSY Bạc Liêu	Wind	400		2023
126	Tân Ân 1 - GĐ1	Wind	25		Oct-21
128	Tân Thuận	Wind	75	220	2021
129	Viên An	Wind	50		2021
130	Yên Định	Solar	30		Dec-18
131	Cẩm Hòa	Solar	50		Jun-19
132	Cẩm Hưng	Solar	29		2020
133	Sơn Quang	Solar	29		2020
134	Dohwa Lệ Thủy	Solar	47.6	65,81	Dec-20
135	Gio Thành 1&2	Solar	100	127,2	Dec-19
136	LIG Quảng Trị	Solar	49.5	67,6	Jun-19
137	Phong Điền 2	Solar	50	68	Dec-20
138	TTC Phong Điền	Solar	35	61,6	Oct-18
139	Bình Nguyên	Solar	50	73,7	Jun-19
140	Mộ Đức	Solar	19.2	35	Apr-19
141	Cát Hiệp	Solar	49.5	75	May-19
142	Đầm Trà Ổ	Solar	50	78	Dec-20
143	Sê San 4	Solar	49	72,4	Nov-20
144	Fujiwara Bình Định	Solar	50		Feb-19
145	Mỹ Hiệp	Solar	50	82	Dec-20
146	Phù Mỹ	Solar	216		Dec-20
147	Krông Pa 2	Solar	49	103	Dec-18
148	LIG Chư Ngọc	Solar	15		May-19
149	TTC Krông Pa	Solar	49	103	Dec-18
150	Europlast Phú Yên	Solar	44.7		Jun-19
151	Hòa Hội	Solar	214	334	Jun-19
152	Thành Long Phú Yên	Solar	50		Dec-20
153	Thịnh Long AAA Phú Yên	Solar	50		Sep-19
154	Xuân Thọ 1	Solar	45.9	76	Jun-19
155	Xuân Thọ 2	Solar	45.9	76	Jun-19

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
156	BMT Đắk Lắk	Solar	30	44	Apr-19
157	Buôn Mê Thuột	Solar	30		May-19
158	Ia Lốp 1	Solar	50		2019
159	Jang Pong GĐ1	Solar	8.6	17,5	May-19
160	Long Thành	Solar	10	20	May-19
161	Long Thành 1	Solar	50		Jun-19
162	Quang Minh	Solar	50		Mar-19
163	Srêpôk 1	Solar	100		Mar-19
164	Xuân Thiện Ea Súp	Solar	831	1500	Nov-20
165	AMI Khánh Hòa	Solar	47.5	74	May-19
166	Cam Lâm	Solar	100	158	Jul-19
167	KN Vạn Ninh	Solar	86.7	162	Dec-20
168	Cam Lâm VN	Solar	45	79	Jul-19
169	Điện lực Miền Trung	Solar	8.5		Jun-19
170	KN Cam Lâm	Solar	45	79	Jul-19
171	Long Sơn	Solar	170		Dec-19
172	Sông Giang	Solar	50	80	May-19
173	Trung Sơn	Solar	35		Dec-20
174	Tuấn Ân	Solar	9.6		Dec-20
175	Cư Jút	Solar	50	94,7	Apr-19
176	Trúc Sơn	Solar	36.5	80	Jun-19
177	Bàu Ngứ	Solar	50	100	Jul-19
178	Bàu Zôn	Solar	25		2020
179	BIM 1,2,3 Ninh Thuận	Solar	330	545	Apr-19
180	BP Solar 1	Solar	45	74	Jan-19
181	CMX Renewable Việt Nam	Solar	168		Jun-19
182	Gelex Ninh Thuận	Solar	50	82	Jun-19
183	Hà Đô Ninh Phước	Solar	40		Sep-20
184	Hacom Solar	Solar	50	75	Oct-19
185	Mỹ Sơn 1	Solar	50		Dec-18
186	Mỹ Sơn 2	Solar	50		Dec-19
187	Mỹ Sơn Hoàn Lộc Việt	Solar	50		Dec-18
188	Nhị Hà - Bitexco	Solar	50	80	Sep-19
189	Nhị Hà - Thuận Nam 13	Solar	50	80	Jul-19
190	Ninh Phước 6.1	Solar	58.3		Jun-19

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
191	Ninh Phước 6.2	Solar	50		2019
192	Phước Hữu - Điện lực 1	Solar	30		Jul-19
193	Phước Hữu - Vịnh Nha Trang	Solar	50		Jun-19
194	Phước Minh	Solar	49.8		May-20
195	Phước Ninh	Solar	45	75	Jun-20
196	Phước Thái 1	Solar	50	81	Jul-20
197	Phước Thái 2,3	Solar	150		Dec-21
198	Sinenergy Ninh Thuận 1	Solar	50	78,25	Oct-19
199	Solar farm Nhơn Hải	Solar	35	59	Jun-20
200	SP-Infra 1	Solar	50		Jun-19
201	Thiên Tân 1.2	Solar	100		Jan-21
202	Thiên Tân 1.3	Solar	50		Jan-21
203	Thiên Tân Solar Ninh Thuận	Solar	50		Mar-20
204	Thuận Nam 19	Solar	49		May-19
205	Thuận Nam Đức Long	Solar	50		Dec-19
206	Trung Nam NT	Solar	204	450	Apr-19
207	Trung Nam Thuận Nam	Solar	450		Oct-20
208	Xuân Thành	Solar	30		2020
209	Xuân Thiện Thuận Bắc	Solar	256	500	Feb-20
210	Bình An	Solar	50		Jun-19
211	Đa Mi	Solar	47.5	70	Jun-19
212	Eco Seido Tuy Phong	Solar	40		Jun-19
213	Hàm Kiệm	Solar	49		2019
215	Hồng Liêm 3	Solar	50		Jan-21
216	Hồng Phong 1A	Solar	150	284,43	Jul-19
217	Hồng Phong 1B	Solar	100	194,6	Jul-19
218	Hồng Phong 4	Solar	48	92	Jun-19
219	Mũi Né	Solar	40	68	Jun-19
220	Phan Lâm 1	Solar	36.72		Jun-19
221	Phan Lâm 2	Solar	49		Jun-19
222	Phong Phú	Solar	42	67	Apr-19
223	Sơn Mỹ 3.1	Solar	50		Jun-19
224	Sông Bình 1	Solar	50		2019
226	Sông Lũy 1	Solar	39	80	May-19
227	Thuận Minh 2	Solar	50		Sep-19

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
228	TTC Hàm Phú 2	Solar	49		May-19
229	Tuy Phong	Solar	30	63	Jun-19
230	Vĩnh Hảo	Solar	30		Jun-19
231	Vĩnh Hảo 4	Solar	39		Jun-19
232	Vĩnh Hảo 6	Solar	50	83	Jun-19
233	Vĩnh Tân 1,2	Solar	49	79	Jun-19
234	VSP Bình Thuận 2	Solar	30	63	Jun-19
235	Lộc Ninh 1,2,3	Solar	550	881,67	Dec-20
236	Lộc Ninh 4	Solar	162		Dec-20
237	Lộc Ninh 5	Solar	40		Dec-20
238	Thác Mơ	Solar	50	78	Dec-20
239	Bách Khoa Á Châu 1	Solar	30		Jul-19
240	Dầu Tiếng 1, 2	Solar	420	688	Jun-19
241	Dầu Tiếng 3	Solar	150	110	Nov-20
242	HCG&HTG	Solar	100		Jun-19
243	Hoàng Thái Gia	Solar	50	110	Dec-18
244	Tân Châu 1	Solar	50		Oct-20
245	Trí Việt 1	Solar	30		Jul-19
246	TTC An Hòa 1&2	Solar	118.8	184	Jun-19
247	BCG Băng Dương	Solar	40.6	60	Jun-19
248	Europlast Long An	Solar	50		Jun-19
249	Solar Park 1	Solar	50		Sep-19
250	Solar Park 2	Solar	50		Jun-19
251	Solar Park 3	Solar	50		Jul-20
252	Solar Park 4	Solar	50		Aug-20
253	TTC Đức Huệ 1	Solar	49		May-19
254	TTC Đức Huệ 2	Solar	49		2020
255	Đá Bạc 1	Solar	48	95,97	2019
256	Đá Bạc 2	Solar	48		2019
257	Đá Bạc 3	Solar	42		2019
258	Đá Bạc 4	Solar	42		2019
259	Hồ Gia Hoét 1	Solar	35		Aug-20
260	Hồ Tầm Bó	Solar	35		Aug-20
261	KCN Châu Đức	Solar	70		2019
262	Bình Hòa	Solar	10		Jun-19

#	Name of plants	Type	Installed capacity (MW)	Production (mil. kWh/yr)	COD
263	Sao Mai Solar PV1	Solar	210	302	Jul-19
264	Văn Giáo 1	Solar	50	69	Jun-19
265	Văn Giáo 2	Solar	50	69	Jun-19
266	VNECO	Solar	50		Dec-20
267	Hậu Giang	Solar	29		Dec-20
268	Trung Nam Trà Vinh	Solar	165	250	Dec-19
269	Cà Mau	Solar	50	73,9	Jun-19

***Source**: Author's Own Compilation*.

Annex 7: Capacity of onshore wind power projects (on land and near shore) by localities by 2030

TT	Project	Capacity (MW)	Year of Operation	Note
	Dien Bien Province	**300**		
1	BCG Dien Bien 1 Wind Power Plant	175	2026-2030	
2	Envision Nam Po Wind Power Plant	125	2026-2030	
	Bac Kan Province	**400**		
1	Cho Moi 2 Wind Power Plant	130	2026-2030	
2	Ngan Son Wind Power Plant	150	2026-2030	
3	Thien Long Cho Moi Wind Power Plant	120	2026-2030	
	Yen Bai Province	**200**		
1	Nam Bung Wind Power Plant	200	2026-2030	
	Bac Giang Province	**500**		
1	Bac Giang 1 Wind Power Plant	55	2026-2030	
2	Bac Giang 2 Wind Power Plant	55	2026-2030	
3	Cam Ly Wind Power Plant	55	2026-2030	
4	Tan Son Wind Power Plant	50	2026-2030	
5	Luc Ngan Wind Power Plant	30	2026-2030	
6	SD Son Dong Wind Power Plant	105	2026-2030	
7	Yen Dung Wind Power Plant	150	2026-2030	
	Lang Son Province	**1.444**		
1	Ai Quoc Wind Power Plant	100	2026-2030	
2	Binh Gia Wind Power Plant	80	2026-2030	
3	Cao Loc Wind Power Plant	55	2026-2030	
4	Cao Loc 3 Wind Power Plant	69	2026-2030	
5	Chi Lang Wind Power Plant	100	2026-2030	
6	Cao Loc 1 Wind Power Plant	50	2026-2030	
7	Cao Loc 1.1 Wind Power Plant	50	2026-2030	
8	Dinh Lap Wind Power Plant	100	2026-2030	
9	Dinh Lap 1 Wind Power Plant	50	2026-2030	
10	Dinh Lap Wind Power Plant 1.1	50	2026-2030	
11	Dinh Lap 4 Wind Power Plant	90	2026-2030	
12	Dinh Lap 5 Wind Power Plant	100	2026-2030	
13	Van Quan 1 Wind Power Plant	50	2026-2030	
14	Huu Kien Wind Power Plant	90	2026-2030	
15	Loc Binh Wind Power Plant	60	2026-2030	

TT	Project	Capacity (MW)	Year of Operation	Note
16	Loc Binh Wind Power Plant - Pharbaco	50	2026-2030	
17	Loc Binh 1 Wind Power Plant	50	2026-2030	
18	Loc Binh 3 Wind Power Plant	60	2026-2030	
19	Mau Son Wind Power Plant	30	2026-2030	
20	Thang Long 3 Wind Power Plant	50	2026-2030	
21	Van Lang 1 Wind Power Plant	80	2026-2030	
22	Van Quan Wind Power Plant	30	2026-2030	
	Thai Binh Province	**70**		
1	Tien Hai Wind Power Plant - Thai Binh	70	2026-2030	
	Thanh Hoa Province	**300**		
1	Bac Phuong - Nghi Son Wind Power Plant	100	2026-2030	
2	Muong Lat Wind Power Plant	200	2026-2030	
	Nghe An Province	**70**		
1	Nam Dan Wind Power Plant	70	2026-2030	
	Ha Tinh Province	**350**		
1	HBRE Ha Tinh Wind Farm	120	2023-2025	
2	Cam Xuyen 1 Wind Power Plant	70	2024-2025	
3	Ky Khang Wind Power Plant - Phase 1	60	2026-2030	
4	Cam Xuyen 2 Wind Power Plant	100	2026-2030	
	Dak Lak Province	**870**		
1	Cu Ne 1 Wind Power Plant	50	2023-2025	18 wind turbines have been deployed, expected to operate in 2024
2	Cu Ne 2 Wind Power Plant	50	2023-2025	Expected operation 2025
3	Krong Buk 1 Wind Power Plant	50	2023-2025	18 wind turbines have been deployed, expected to operate in 2024
4	Krong Buk 2 Wind Power Plant	50	2023-2025	18 wind turbines have been deployed, expected to operate in 2024
5	Buon Ho 1 Wind Power Plant	20	2023-2025	
6	Buon Ho 2 Wind Power Plant	20	2023-2025	
7	Buon Ho 3 Wind Power Plant	15	2023-2025	

TT	Project	Capacity (MW)	Year of Operation	Note
8	Cu M'Gar 2 Wind Power Plant	10	2023-2025	
9	Ea H'Leo 3 Wind Power Plant (Cu M'Gar)	10	2023-2025	
10	Ea H'Leo 4 Wind Power Plant (Cu M'Gar - Buon Ho)	10	2023-2025	
11	Easin 1 Wind Power Plant	100	2026-2030	
12	Krongbuk 3 Wind Power Plant	100	2026-2030	
13	Thuan Phong Wind Power Plant Dak Lak	100	2026-2030	
14	Tan Lap - Ea Ho Wind Power Plant	50	2026-2030	
15	Cu Pong 1,2 Wind Power Plant	80	2026-2030	
16	Krong Nang Wind Power Plant 1.1; 1.2	80	2026-2030	
17	Wind power plant NT 1; NT 2	75	2026-2030	
	Lam Dong Province	**118,9**		
1	Cau Dat Wind Power Plant	68,9	2023-2025	Completed
2	Duc Trong Wind Power Plant	50	2026-2030	
	Ninh Thuan Province	**553,7**		
1	Phuoc Huu Wind Power Plant	50	2023-2025	
2	Vietnam Power Wind Power Plant No. 1	30	2023-2025	
3	Cong Hai 1 Wind Power Plant - Phase 2	25	2023-2025	
4	Cong Hai 1 Wind Power Plant - Phase 1	3	2023-2025	
5	Phuoc Nam Renewable Energy Power Plant - Enfinity - Ninh Thuan	65	2023-2025	
6	Dam Nai 3 Wind Power Plant	39,4	2023-2025	
7	Dam Nai 4 Wind Power Plant	27,6	2023-2025	
8	BIM Wind Power Plant Phase 2 Expansion	50	2023-2025	
9	Wind Power Plant 7A Phase 2	21	2023-2025	
10	Phuoc Dan Wind Power Plant	45	2023-2025	
11	Bau Ngu Lake Wind Power Plant	25,2	2023-2025	
12	Tri Hai Wind Power Plant	79,5	2023-2025	
13	Part of Hanbaram Wind Power Plant Capacity	93	2026-2030	
	Phu Yen Province	**298**		
1	HBRE An Tho Wind Farm Phase 1	200	2023-2025	
2	Song Cau Green Wind Power Plant Phase 1	50	2023-2025	
3	Green Nam Viet Wind Power Plant	48	2023-2025	
	Binh Dinh Province	**30**		
1	Nhon Hoi Wind Power Plant Phase 2	30	2023-2025	Already in operation

TT	Project	Capacity (MW)	Year of Operation	Note
	Ba Ria - Vung Tau Province	**150**		
1	Xuyen Moc nearshore wind power plant phase 2	47	2026-2030	
2	Cong Ly Wind Power Plant Ba Ria - Vung Tau Phase 1	103	2026-2030	
	Ben Tre Province	**713,5**		
1	VPL Wind Power Plant	4,2	2023-2025	
2	Binh Dai Wind Power Plant	25,8	2023-2025	
3	Binh Dai Wind Power Plant No. 2	49	2023-2025	
4	Binh Dai Wind Power Plant No. 3	49	2023-2025	
5	Thanh Phong Wind Power Plant	29,7	2023-2025	
6	Sunpro Wind Power Plant	30	2023-2025	Completed 07 towers/29.4 MW
7	Wind Power Plant No. 5 Ben Tre Phase 2 (Thanh Hai Wind Power Plant 2,3,4)	85,8	2023-2025	Completed 21 towers/90 MW, connected to the grid 4.25 MW, expected to generate 85.75 MW in 2024
8	VPL Wind Power Plant (Phase 2)	30	2023-2025	Operational progress 2025
9	Nexif Energy Ben Tre Wind Power Plant	30	2023-2025	Investment policy has been granted
10	Nexif Ben Tre Wind Power Plant Phase 2, 3	50	2023-2025	Investment policy has been granted
11	Thien Phu 2 Wind Power Plant	30	2023-2025	Investment policy has been granted
12	Thien Phu Wind Power Plant	30	2023-2025	Investment policy has been granted
13	Thanh Phu Wind Power Plant	120	2023-2025	Investment policy has been granted
14	Bao Thanh Wind Power Plant	50	2023-2025	Investment policy has been granted
15	Wind Power Plant No. 19	50	2023-2025	Investment policy has been granted
16	Wind Power Plant No. 20	50	2023-2025	Investment policy has been granted
	Bac Lieu Province	**741**		

TT	Project	Capacity (MW)	Year of Operation	Note
1	Japan Wind Power Plant - Bac Lieu	50	2023-2025	
2	Bac Lieu Wind Power Plant Phase III	141	2023-2025	
3	Hoa Binh 3 Wind Power Plant	50	2026-2030	
4	Hoa Binh 2-1 Wind Power Plant	50	2026-2030	
5	Hoa Binh 4 Wind Power Plant	50	2026-2030	
6	Hoa Binh 6 Wind Power Plant	40	2026-2030	
7	Hoa Binh 8 Wind Power Plant	50	2026-2030	
8	Hoa Binh Wind Power Plant 5.1	80	2026-2030	
9	Dong Hai 1 Wind Power Plant - Phase 3	50	2026-2030	
10	Dong Hai 13 Wind Power Plant	100	2026-2030	
11	Dong Hai 3 Wind Power Plant - Phase 1	50	2026-2030	
12	Dong Hai 6 Wind Power Plant	30	2026-2030	
	Tien Giang Province	**200**		
1	Tan Thanh Wind Power Plant	100	2026-2030	
2	Tan Phu Dong 1 Wind Power Plant	100	2026-2030	
	Tra Vinh Province	**872,5**		
1	Hiep Thanh Wind Power Plant	64,5	2023-2025	Commercially operational
2	Duyen Hai Wind Power Plant	48	2023-2025	Selecting EPC contractor
3	Dong Thanh 1 Wind Power Plant	80	2023-2025	Under construction
4	Dong Thanh 2 Wind Power Plant	120	2023-2025	Under construction
5	Thang Long Wind Power Plant	96	2023-2025	Investment Policy Granted
4	Dong Hai 3 Wind Power Plant (location V3-3)	48	2026-2030	
8	V1-2 Wind Power Plant Extension	48	2026-2030	
9	Wind Power Plant V1-3 Phase 2	48	2023-2025	
3	Wind power plant V1-5 and V1-6 phase 2	80	2023-2025	
3	Duyen Hai 2 Wind Power Plant	96	2026-2030	
6	Wind Power Plant No. 3 (Location V3-8)	48	2026-2030	
7	Wind Power Plant V 1 -1 Tra Vinh Phase 2	48	2023-2025	
5	Long Vinh Wind Power Plant	48	2026-2030	
	Soc Trang Province	**733,2**		
1	Hoa Dong 2 Wind Power Plant	45,6		Already in operation
2	Lac Hoa 2 Wind Power Plant	123,6		Already in operation
3	Lac Hoa Wind Power Plant - Phase 1	5		Already in operation

TT	Project	Capacity (MW)	Year of Operation	Note
4	Lac Hoa 2 Wind Power Plant	6,4	2024	
5	Lac Hoa Wind Power Plant	30	2024	Construction completed
6	Hoa Dong Wind Power Plant	30	2024	Construction completed
7	Cong Ly Wind Power Plant Phase 1	30	2024	Construction completed
8	Wind Power Plant No. 3	29,4	2024	Construction completed
9	Wind Power Plant No. 2	30	2025	Under construction
10	Wind Power Plant No. 18	22,4	2025	
11	Wind Power Plant No. 7 Phase 2	90	2025	
12	Wind Power Plant No. 11	100,8	2026-2030	
13	Tran De Wind Power Plant	50	2026-2030	
14	Song Hau Wind Power Plant	50	2026-2030	
15	Soc Trang Wind Power Plant 16	40	2026-2030	
16	BCG Soc Trang 1 Wind Power Plant	50	2026-2030	
	An Giang Province	**50**		
1	JR An Giang Wind Power Plant	50	2026-2030	
	Ca Mau Province	**900**		
1	Tan An Wind Power Plant 45 MW	75	2023-2025	45 MW in operation, 30 MW under construction
2	Vien An Wind Power Plant	50	2023-2025	25 MW in operation, 25 MW under construction
3	Ca Mau 1A Wind Power Plant	88	2023-2025	Under construction
4	Ca Mau 1B Wind Power Plant	88	2023-2025	Under construction
5	Wind Power Plant Khai Long Tourist Area - Ca Mau Phase 1	100	2023-2025	
6	Tan Thuan Wind Power Plant Phase 3	25	2023-2025	
7	An Dong 1 Wind Power Plant	50	2023-2025	
8	Khanh Binh Tay Wind Power Plant	50	2023-2025	
9	Khai Long Wind Power Plant Phase 2	100	2023-2025	
10	Ca Mau 1C Wind Power Plant	88	2026-2030	Appraising design
11	Ca Mau 1D Wind Power Plant	86	2026-2030	Appraising design
12	Khai Long Wind Power Plant Phase 3	100	2026-2030	

TT	Project	Capacity (MW)	Year of Operation	Note
	Hau Giang Province	**100**		
1	Long My 1 Wind Power Plant	100	2023-2025	
	Kien Giang Province	**137**		
1	Hon Dat 1 Wind Power Plant	77	2026-2030	
2	Kien Luong 1 Wind Power Plant	60	2026-2030	

***Source**: Decision No. 292/QD-TTg dated April 01st, 2024*