Technical Education and Skills Development Authority

LABOR MARKET INTELLIGENCE REPORT

ISSUE NO. 1 | SERIES OF 2021

LABOR MARKET
INTELLIGENCE REPORT

SUSTAINING THE FUTURE

Powering Individuals and Communities Through Renewable Energy

Issue no. 1 | Series of 2021
Technical Education and Skills
Development Authority (TESDA)

I. Executive Summary

The transition to renewable energy (RE) from carbon-intensive energies became a vital component of several environmental protection and conservation policies. In the Philippines, the Biofuels Act of 2006 and the Renewable Energy Act of 2008 mainly support the said shift for a more sustainable energy solution.

Initially, the target is to increase the RE-based capacity of the country to 15,304 by 2030. But the updated National Renewable Energy Plan 2020-2040 now targets at least 20,000 megawatts of RE capacity by 2040. This is expected to further strengthen investments in RE projects with the following RE technologies: geothermal, hydropower, biomass, solar, wind, and ocean.

Over the years, the rise in solar and wind energy became noticeable, specifically in Luzon and Visayas. The country is also the third-largest producer of geothermal energy in the world. This growth in RE investments is expected to increase the demand in terms of RE-related employment opportunities.

However, as much as there is work to do in sustaining RE investments to boost more jobs, much is left to do with the training and education. Training education and skills development pose both an opportunity and challenge in the RE sector.

While considering the current status of RE in the country and the projected future, several recommendations had been made to avoid skills and labor supply shortages.

II. Background

Over the last century, the world witnessed the rise of greenhouse gas (GHG) emissions. One big factor is the various human and economic activities such as the continued burning of fossil fuels for energy generation. For the scientists, the pressing environmental concerns on climate change and global warming began to be "observed since the mid-20th century to the human expansion of greenhouse effect" (NASA Global Climate Change, n.d).

In efforts to further prevent the environmental impact, "countries pledged to reduce carbon dioxide (CO2) and other greenhouse gas emissions" through the signing of the Paris Agreement (International Renewable Energy Agency, 2020). The Philippines, as part of the said commitment, submitted its Intended Nationally Determined Contributions

(INDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) in October 2015 (Intended Nationally Determined Contributions, 2015).
The country's INDC included the Biofuels Act of 2006 and the Renewable Energy Act of 2008 as one of the comprehensive climate change policy agendas. However, despite the steps towards cleaner and greener energy generation and consumption, data shows GHG emissions remain high in the energy sector.

Of the approximately 50 billion tons of global GHG gases emitted each year, 73.2% come from the energy sector in 2016 (Ritchie, 2020). The same is true in the Philippines, where the "energy sector is the leading emitter of greenhouse gases" (REECS, 2010 as cited in Aquino & Abeleda, 2014).

In response, the Philippines is slowly shifting to renewable energy (RE) sources as a more "sustainable… clean, non-polluting energy" (Delos Santos, 2011). Many government and private initiatives aim to fast-track the utilization of RE technologies, with the Department of Energy (DOE) acting as the lead agency.

Besides a more sustainable environment, moving to renewable energy will provide other benefits including low electricity costs, "increased energy access", and the "account of employment opportunities" (World Wildlife Fund - Philippines, 2017; Department of Energy, n.d).

III. Relevant Policies

A. Biofuels Act of 2006

RA 9367 or the "Biofuels Act of 2006" mandates the development and utilization of "indigenous renewable and sustainably-sourced clean energy source" as an additive to the fuel mix in the transportation sector. This is to "reduce the dependence on imported oil, to mitigate toxic and greenhouse gas emissions, to increase rural employment and income, and to ensure availability of renewable energy without any detriment to the natural ecosystem, biodiversity and food reserves of the country" (Republic Act 9367, 2006).

In compliance with the law, a minimum of five percent (5%) bioethanol by volume shall be blended with gasoline and diesel until 2009, the second year from its effectivity. Likewise, three months after the effectivity of the act (April 2007), all diesel engine fuels sold in the country shall have a minimum of one percent (1%) biodiesel by volume. The bioethanol blend and biodiesel blend must conform with the Philippine National Standards consistent with Section 26 of RA 8749 or the Philippine Clean Air Act of 1999. All companies are only allowed to import if there is a shortage as determined by NBB.

Two years thereafter, the National Biofuels Board (NBB) is authorized to determine the feasibility of increasing 10% by volume and 2% by volume the bioethanol and biodiesel in the fuel mix of motors and engines, respectively. To date, this is the minimum bioethanol and biodiesel blend in the country (Department of Energy, 2021).

In the recently concluded 39th Japan Cooperation Center Petroleum (JCCP) International Symposium, the Department of Energy discussed the Phillippine DOE's Biofuels Roadmap 2018-2040. The roadmap aims to increase the biodiesel requirement from the current 2% to 5% and reach up to 20% by 2040 (Department of Energy, 2021).

Fiscal incentives such as specific tax exemption, value-added tax exemption, the exemption from wastewater charges, and financial assistance are offered to encourage investments (Republic Act 9367, 2006).

B. Renewable Energy Act of 2008

RA 9513 or the "Renewable Energy Act of 2008" provides a framework that would develop, utilize, and commercialize renewable energy sources. Renewable energy resources, as defined in Section 4 of this act, are those resources that can be replenished regularly and are available indefinitely. Biomass, solar, wind, geothermal, ocean energy, hydropower, and other emerging renewable energy technologies are among them (Republic Act 9513, 2008).

This act envisions the nation to be energy self-sufficient through sustainable energy development strategies in the exploration and development of renewable energy resources. The country's reliance on fossil fuels will be reduced as a result, minimizing the country's vulnerability to international market price fluctuations. It is also the policy of the state to encourage the development and utilization of renewable energy sources to prevent harmful emissions (Republic Act 9513, 2008).

Moreover, to accelerate the development of the country's renewable energy resources, and the participation of the private sector, the state provides fiscal and non-fiscal incentives, also acting as policy mechanisms, to private sector investors and equipment manufacturers/suppliers (Republic Act 9513, 2008).

Fiscal incentives available under the law, include, but is not limited to, income tax holiday, low-income tax rate, duty-free importation of RE machinery, equipment, and materials, tax rebate for the purchase of RE components, and Net Operating Loss Carry-Over (NOLCO)(Republic Act 9513, 2008).

Whereas non-fiscal incentives include green energy program, renewable portfolio standard, feed-in tariff, and net metering for RE, wherein even end-users can benefit from

some of these. Figure 1 and Figure 2 show the incentives available for each stakeholder (National Renewable Energy Board, 2012).

Incentives	RE Developers	RE Commercialization
7-Year Income Tax Holiday	Yes	Yes
Duty-free Importation	Yes	Yes
VAT-free Importation	No. Tax Credit	Yes
Special Realty Tax Rate <= 1.5 %	Yes	
Net Operating Loss Carryover	Yes	Yes
10% Corporate Tax Rate after ITH	Yes	
Accelerated Depreciation	Yes	Yes
Zero Percent VAT on RE Sales & Purchases	Yes	Yes
Cash Incentive = 50% of UC for Missionary Electrification	Yes	
Tax Exemption on Carbon Credits	Yes	
Tax Credit on Domestic Capital Equipment & Services	Yes	Yes

Figure 1. Summary of Incentives for RE Developers and RE commercialization. Source: National Renewable Energy Board Presentation during the Fair FIT Workshop, National Renewable Energy Board. 2012, Retrieved March 22, 2021, from https://pdf.wri.org/wri_fair_fit_workshop_presentation_philippines_nreb.pdf.

Incentives	RE Developers	Electricity Suppliers	End -users
Renewable Portfolio Standards	Yes		
Feed-In Tariff on Emerging Technologies	Yes	Yes	
Renewable Energy Market & Certificates		Yes	
Green Energy Options			Yes
Net Metering			Yes
Government waives share of proceeds on RE micro-scale Projects <= 100 kW	Yes		
Exemption from Universal Charge	Yes		
Payment of Transmission & Wheeling Charge = Average kWh rate	Yes		
Tax Rebate for RE Components	Yes		
Financial Assistance Program	Yes		
Incentives for Host Communities			Yes

Figure 2. Incentives for RE Developers, suppliers, and end-users. Source: National Renewable Energy Board Presentation during the Fair FIT Workshop, National Renewable Energy Board. 2012, Retrieved March 22, 2021, from https://pdf.wri.org/wri_fair_fit_workshop_presentation_philippines_nreb.pdf.

- National Renewable Energy Plan 2011-2030

The Department of Energy (DOE), as the lead agency in the implementation of RA 9513, approved the National Renewable Energy Program (NREP) 2011-2030 which outlines the policy of this act. NREP 2011-2030 plans to "increase the geothermal capacity by 75%, increase hydropower capacity by 160 percent; deliver additional 277 MW biomass power capacities, attain wind power grid parity with the commissioning of 2,345 MW additional capacities, mainstream an additional 284 MW solar power capacities and pursue the achievement of the 1,528 MW aspirational target; and develop the first ocean energy facility for the country". Figure 3 ("Renewable Energy Plans", n.d.) presents these goals with their corresponding target year. Initially, the goal is to increase the RE-based capacity of the country to an estimated 15, 304 MW by the year 2030, almost triple its 2010 level of 5,438 MW (see Figure 4).

Sector	Target indicative capacity addition achieved by	Others
Geothermal	2027	Low-Enthalpy Geothermal Resource Assessment completed by 2015
Hydro	2023	Construction of Sea Water Pumped Storage Demo Facility by 2030
Biomass	2015	Mandatory E10 blend for all gasoline vehicles by 2012
Wind	2022	Grid parity by 2025
Solar	2030	Smart Grid and Concentrated Solar Thermal Power Demo completed by 2015; Grid parity by 2020
Ocean	2025	1st Ocean Energy Facility operational by 2018

Figure 3. Consolidated Renewable Energy Roadmap.
Source: Adapted from "Renewable Energy Plans: 2011-2030", n.d., Retrieved March 23, 2020, from https://policy.asiapacificenergy.org/sites/default/files/NREP_red.pdf

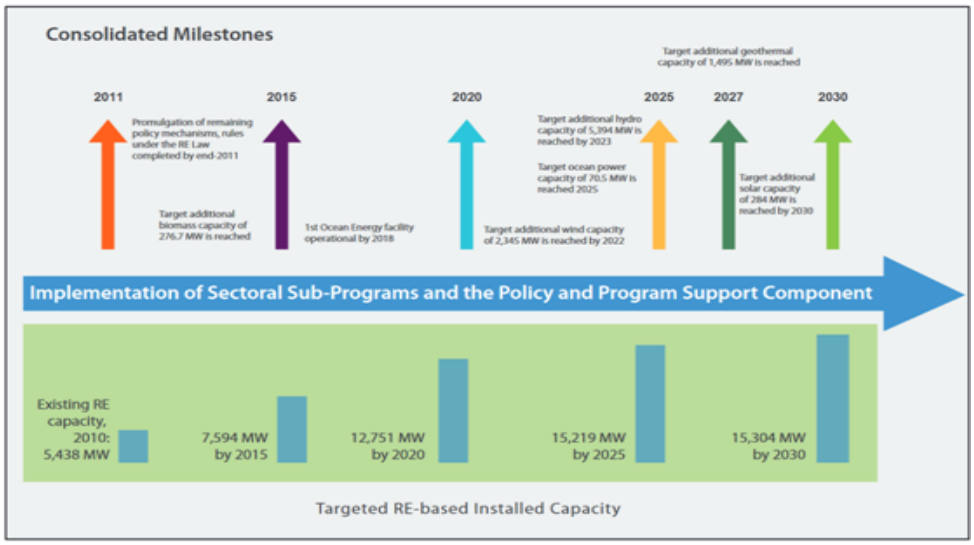


Figure 4. National Renewable Energy Program 2011-2030 Milestones.
Source: Adapted from "Renewable Energy Plans: 2011-2030", n.d., Retrieved March 24, 2020, https://policy.asiapacificenergy.org/sites/default/files/NREP_red.pdf

- National Renewable Energy Program 2020-2040

The National Renewable Energy Board drafted a new NREP for the years 2020 to 2040, with a goal of at least 20,000 megawatts of renewable energy capacity by 2040, up from the initial target of 15,304 megawatts by 2030 (Department of Energy, n.d.)

Among renewable energy resources, hydropower has the largest capacity target (Figure 5). Whereas, the first ocean energy plant in the Philippines has yet to be built.

Figure 5. Renewable Energy Capacity target in the National Renewable Energy Program 2020-2040.

Source: Adapted from "Philippine Energy Plan 2018-2040", Department of Energy, n.d., from https://www.doe.gov.ph/sites/default/files/pdf/pep/PEP%202018-2040%20Complete.pdf

C. Other Relevant Policies

- Electric Power Industry Reform Act of 2001

One of the policies declared in RA 9136 or the "Electric Power Industry Reform Act of 2001" is the "utilization of indigenous and new renewable energy resources in power generation" to minimize the country's dependence on imported energy (Republic Act 9136, 2001).

- Guidelines for the Policy on Maintaining the Share of RE in the Country

Department Circular DC No. 2015-07-0014 or "Guidelines for the Policy of Maintaining the Share of RE in the Country" set a minimum of 30% share of RE in the total power generation capacity of the country by implementing the FIT System and other provisions of RE Act of 2008 (DC No 2015-07-0014, 2015).

- Guidelines for the Operationalization of the Renewable Energy Trust Fund (RETF)

Department Circular DC No. 2018-10-0018 or the "Guidelines for the Operationalization of the Renewable Energy Trust Fund (RETF)" set RETF as fund

source for activities related to the realization of the objectives of RA 9513 (DC No. 2018-10-0018, 2018).

- Philippines Green Jobs Act of 2016

  Republic Act No. 10771 or the "Philippines Green Jobs Act of 2016" mandates the state to "identify needed skills, develop training programs, and train and certify workers for jobs in a range of industries that produce goods and render services for the benefit of the environment, conserve natural resources for the future generation, and ensure the sustainable development of the country and its transition into a green economy." Incentives shall be given to encourage the participation of individuals and business enterprises (Republic Act 10771, 2016).

- Establishment and Development of Competitive Renewable Energy Zones in the Country

  DOE issued Department Circular DC No. 2018-09-0027 or the "Establishment and Development of Competitive Renewable Energy Zones in the Country", which includes the expansion and upgrading of "transmission facilities through policy initiatives that shall enable the optimal use of indigenous RE resources in the country." This is for the enhancement of the planning process and strengthening the Philippine Energy Plan (PEP), Power Development Plan (PDP), Transmission Development Plan (TDP), and National Renewable Energy Program (NREP) (DC No. 2018-09-0027, 2018).

IV. Renewable Energy in Other Countries

- Global Renewable Energy Statistics

From 1998 to 2019, the global consumption of renewables exponentially increased from 2.7 exajoules to about 29 exajoules, with China and the United States as the leading consumers of renewable energy (Jaganmohan, 2021).

Based on the International Energy Agency's market report "Renewables 2017: An analysis and projections to 2022", during the next five years, the growth of renewable generation will surpass gas and coal combined. Besides, between 2016 and 2022, the share of renewable energy in power generation will rise from 26% to 30%. In 2022, Denmark is regarded as the likely global leader with 70% of its electricity generation coming from variable renewables (International Energy Agency, 2017).

Within that five years' projection of the International Energy Agency, the Covid-19 pandemic affected the energy systems around the world due to restrictions on social

and economic activity. Although the greenhouse gas emissions were reduced due to the outbreak, the energy demand significantly decreased too. As a result, critical problems in the renewable energy sector such as "delays in the supply chain, difficulties in tax stock markets and the risk of not being able to benefit from government incentives ending this year" were experienced (Eroğlu, 2020).

- Significant Programs, Success Stories, Case Studies/Report

  - Iceland's Sustainable Energy Success Story

    Iceland is one of the most tectonically active places on earth and 11% of the country is covered by glaciers. Its geographical and geological feature creates an abundant source of hydropower and geothermal power (Davidsdotti, n.d.).

    Iceland's renewable developments started from local farmers and later developed into larger projects (Logadóttir, n.d.). The Icelandic Energy System has undergone three transitions: peat to coal, coal to oil, and fossil fuels to renewable fuels. Investments in renewable energy sources drastically increased in the 20th century due to the financial incentives offered by the national government to individuals and municipalities (Davidsdotti, n.d.).

    Logadóttir (n.d.), however, noted that the drive to push for this transition was not due to climate change mitigations, but due to the country's vulnerability to the price fluctuations affecting world energy markets and the need for energy security. The "local empowerment and public engagement" made the "green transition" possible.

    Today, almost 100 percent of the electricity consumed in Iceland with a population of 330,000 comes from renewable energy. Additionally, 90% of Icelandic households are heated directly with geothermal energy. These green energies from hydro and geothermal sources power intensive industries.

    However, Iceland still relies on non-renewable fossil fuels for the transportation sector, which accounts for about 27% of all the primary energy consumption (Davidsdotti, n.d.). This may be the case, but Iceland is "closer to sustainability" and has lower "import dependency" compared to other countries.

  - Paraguay's Hydropower for Sustainable Development

    Paraguay has the highest level of sustainable development among the 11 South American countries (Toumi, Gallo & Rejeb, 2017, as cited in Silvero, Rodrigues &

Montelpare, 2020) and has the "highest per capita hydroelectric power generation in the world" despite being a developing country.

Hydropower accounts for nearly all of the electricity produced at 99.7% and 67% of the domestic primary energy supply, while biomass accounts for 33% (Pappis et.al, 2021). Also, 85% of Paraguay's produced electricity is exported, making it the largest net electricity exporter in South America and one of the world's largest.

Ironically, the country has the second-lowest electricity consumption per capita in South America, with nearly 1563 kWh in 2014. The level of satisfaction with energy services is extremely low, and one-third of the population lives in extreme poverty. The country's transmission (4%) and distribution (17%) networks have high losses due to the country's low electricity tariffs (Pappis et.al, 2021).

- Costa Rica's 100% Renewable Energy

Similar to the geographical features of Iceland, Costa Rica's abundance of rivers, dams, volcanoes, and favorable rainfall levels enable it to produce large amounts of renewable energy, particularly hydropower (International Hydropower Association, 2017).

Costa Rica has relied heavily on hydropower for electricity generation, accounting for 72% of total generation in 2017-2018. To cut back dependencies on hydropower throughout dry seasons, the country began to diversify its electricity mix with other renewable energy sources. From 4% in 2011, wind power made up 15% of the electricity mix by 2018.

Costa Rica, with a 98% renewables share in its electricity matrix, is well on its way to becoming a green powerhouse. For the last four years (until 2018), they are one of only a few countries that operate on 100% renewable energy for the majority of the year. (Van riet et.al, 2020).

However, petroleum derivatives constitute more than 60% of the country's energy consumption. Costa Rica's transportation is still highly dependent on fossil fuels like Iceland. Thus, in line with the Paris Climate Change Agreement's goals, the country has approved the National Decarbonization Plan in February 2019. It intends to make the country a net-zero emissions economy by 2050 and a public transport powered by electricity – 70 % in 2035 and 85% in 2050 (Van riet et.al, 2020).

- China

China is a world leader in different sectors of renewable energy (International Energy Agency, 2017). With nearly 165 gigatonnes (GW) coming online, renewables accounted for nearly two-thirds of net new power capacity globally.

Global new solar PV capacity increased by 50%, reaching over 74 GW, with China contributing to nearly half of this growth (International Energy Agency, 2017). China now accounts for half of the global solar PV demand, while Chinese firms account for about 60% of total annual solar cell manufacturing capacity worldwide (International Energy Agency, 2017).

The country is also responsible for more than 40% of worldwide renewable capacity growth, which is primarily driven by air pollution issues and capacity targets outlined in the country's 13th five-year plan for 2020.

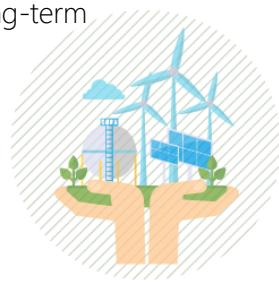
The 13th Five Year Plan (FYP) outlines the capacity additions for different renewable energy technology. Gosen et. al (2017), however, noted that such capacity additions alone would not be sufficient to ensure China's continued transition to renewable energy. Efforts to improve grid interconnectedness, the versatility of generating capacity and the grid, market mechanisms to reduce and spread electricity demand to boost competition, and increase the level of consumption of the renewable power generated are crucial.

- United States

According to the International Renewable Energy Agency, the United States has some of the largest wind, solar, geothermal, hydro, and biomass resources in the world. Hence, the U.S. stands as a potential world leader in the global transition to renewable energy.

The country remains as "the second-largest growth market for renewable energy" despite policy uncertainty (International Energy Agency, 2017). Given the right policies and support, coupled with the current technologies, "the share of renewables in the U.S energy mix (total final energy consumption, TFEC) could more than triple by 2030, from 7.5% in 2010 to 27%" (International Renewable Energy Agency, 2015).

There are several motivators for expanding renewable energy deployment in the United States. Among these are the desires to significantly reduce GHG emissions from the power and transportation industries, identify more sustainable, long-term



energy sources, and create employment/ "green jobs" (National Academy of Engineering and National Research Council, 2010).

- Germany

Traditionally, Germany's energy mix was based on hard coal and lignite as they are among the largest producers of these in the world. Since domestic petroleum-based fossil fuel resources are extremely limited, the country is also highly dependent on gas and petroleum imports for the last thirty years. The importation rate is ranging from 95% to 97% from 65% in the 1960s (Kuittinen & Velte, 2018; Amelang, 2016 as cited in Kuittinen & Velte, 2018).

Under the Kyoto Protocol, Germany vowed to reduce its GHG emissions by 21% between 1990 and 2008. In 2010, Germany adopted Energiekonzept, "a long-term energy strategy calling for a renewable-based economy by 2050", serving as the guiding strategy for Energiewende (The Federal Ministry for Technology and Economy and The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2010; as cited in Kuittinen & Velte, 2018).

Energiewende "energy transition" is Germany's national long-term plan for developing a low-carbon energy system based on renewable energy and energy efficiency. As a result of the citizens' strong opposition to nuclear power, the energy transition aims to close Germany's nuclear power plants by the end of 2022 and to transition the energy system to be heavily dependent on renewable energy resources by the year 2050 (International Renewable Energy Agency, 2015).

Currently, Germany is leading the use of renewable energy. Figure 6 shows the important policies and historical events from 1970 to 2025. It can be seen from the graph that the electricity production of Germany has shifted to renewable energy and an ongoing effort to phase out nuclear.

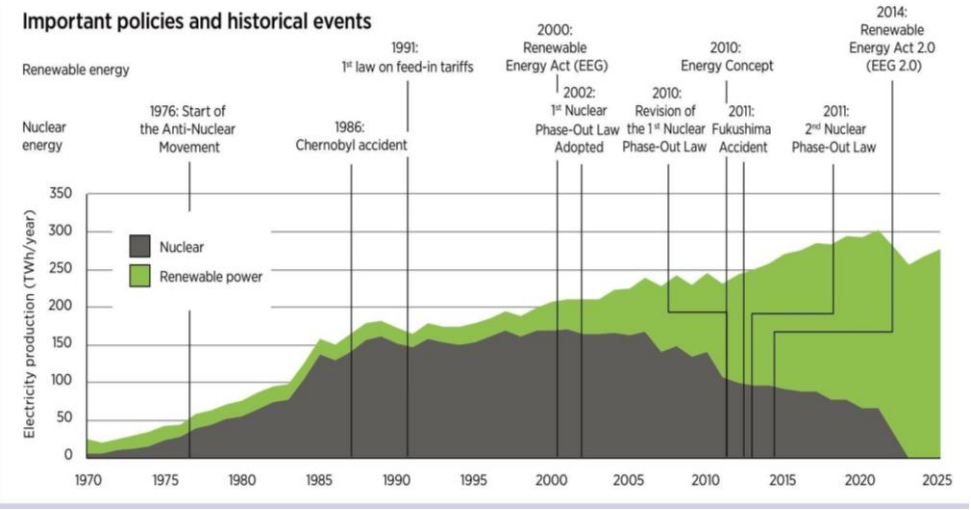


Figure 6. Nuclear and renewable electricity generation and major events, 1970- 2025.

Source: Adapted from "Renewable Energy Prospects: Germany" by the International Renewable Energy Agency, 2015, p. 15, Retrieved March 24, 2021, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_REmap_Germany_report_2015-(1).pdf

- Brazil

The energy sector of Brazil is one of the world's least carbon-intensive in the world (International Energy Agency, 2021). The country is also recognized by the World Bank and the United Nations as one of the fast-moving countries on the path to 'Sustainable Energy for All' (SE4ALL, 2013) (Newborne & Welham, 2014).

Historically, the use of ethanol in Brazil dates back to 1923 (Amorim & Lopes, 2005). But when the relatively lower-priced oil fields were discovered, the energy demand favored the use of petroleum-based fuels.

In 1975, the Brazilian Government launched the National Alcohol Program (Proálcool) which aims to reduce external dependence on fuel and save foreign exchange (Lopes et. al, 2016; Stolf & de Oliveira, 2020). Brazil began to explore the use of sugarcane-derived ethanol. But Brazil experienced a long period of continuous shifting of energy demands between ethanol and petroleum.

To date, Proálcool is the largest bioenergy program in the world which lets Brazil achieve energy stability and sustainability. Sustained leadership, responsive legislation, public and private investment in R&D, and government programs to provide affordable electricity as part of larger poverty-reduction efforts, as well as coherent investment in the growth of national skills and capacity, are critical to the success (Newborne & Welham, 2014)

Aside from renewable energy derived from sugar canes, hydroelectricity is one of Brazil's main energy sources. Hydropower accounts for two-thirds of Brazilian electricity capacity and more than three-quarters of worldwide electricity demand (International Hydropower Association, n.d.). The country also considered diversifying its energy mix by using other renewable energy sources such as solar, wind, and biomass to deal with intense rain seasonality (Dias et.al, 2018).

V. Renewable Energy in the Philippines

A. Current Situation

As the Philippines' dependence on imported fossil fuels exposes the country to high electricity rates in Asia, trade deficit, and possible energy scarcity, shifting to renewable energy sources seems to be the best solution (World Wildlife Fund - Philippines, 2017; Ahmed, 2020; Department of Energy, 2019).

Thus, with the guidance and leadership of DOE, the National Renewable Energy Program (NREP) laid the foundation for RE sector planning, RE resources and technologies development, and RE investments (Department of Energy, n.d).

Under Energy Secretary Alfonso Cusi's leadership, the Department's 2020 accomplishment report introduced a paradigm shift by RE systems in the updated NREP 2020-2040 roadmap. The shift focused on three main baskets: (Quinones, 2020)

- Consumer + RE Systems: this will encourage the development of RE Systems to be utilized by consumers in the agriculture and fisheries, health, and education sectors. This basket aims to maximize the integration of the battery, as well as other energy storage systems and information communication technology.
- Consumer + RE Systems + Distribution Utility: this aims to promote investment in the Net Metering Program, other demand-side participation schemes, and distributed energy systems through various innovative, technical, and commercial approaches.
- Consumer + RE Systems + Distribution Utility + System and Market Operations: this will facilitate increased investments in large-scale RE projects, and hasten compliance with the Renewable Portfolio Standards, the Green Energy Auction Policy, Renewable Energy Market Rules, the Green Energy Option Program, and the Smart Grid Policy, among other systems and policies.

NREP 2020-2040 foresees an additional 20,000 MW mainstreamed capacity on top of the existing RE capacity. The program also expects to develop the first ocean energy facility in the Philippines (Department of Energy, n.d). While most of the ocean energy projects are

still in the pre-development stage, the "rise of solar and wind energy" is specifically growing in Luzon and Visayas.

Additionally, Luzon sources natural gas in the Malampaya fields while geothermal energy is also dominant in the Visayas, particularly in Leyte and Negros. Mindanao, on the other hand, has "highly seasonal hydro-based generation" as its dominant feature (Asian Development Bank, 2018). These reflect current data on the energy supply mix showing that the country generates electricity from diverse supplies "mainly natural gas, some coal, and varied renewable energy resources" (Asian Development Bank, 2018).

As a result of the government's effort, Table 1 lists the number of commercially operating RE facilities as of 2018, with data on Megawatt capacity. "This represents 30.3 percent of the country's total generating capacity", where a "bulk of these capacities were produced from hydro and geothermal resources" (Department of Energy, n.d).

Table 1. List of commercially operating RE facilities (as of 2018)

RE Technology	Capacity (MW)	Number of Projects
Geothermal	1,944.00	11
Hydro	3,700.90	70
Wind	426.9	7
Biomass	258.5	18
Solar	896.1	42
TOTAL	**7,226.40**	**148**

Source: Department of Energy as cited from "Philippine Energy Plan 2018-2040", Retrieved March 17, 2021, from https://www.doe.gov.ph/sites/default/files/pdf/pep/PEP%202018-2040%20Complete.pdf

In 2019, a Philippine News Agency article boasts about the 32.8% share of renewable energy in the supply mix (Crismundo, 2020). This makes the country "have the highest RE generation mix within the Southeast Asian region" (Quinones, 2020).

According to a Philippine Electricity Market Corporation (PEMC) report, the "RE industry has saved PhP 4.04 billion of energy costs for the Philippines" (Department of Energy, 2019). Whereas, the World Wide Fund for Nature (WWF-Philippines) said that these investments are "simultaneously generating more local jobs and reducing the country's share of carbon emissions by an impressive 2.8 million tons" (World Wildlife Fund – Philippines, 2017).

Figure 7 shows a summary of the RE projects under the Renewable Energy Act of 2008 as of September 2020.

RESOURCES	NO. of RE PROJECTS		POTENTIAL CAPACITY MW		INSTALLED CAPACITY MW		ESTIMATED ENERGY GENERATION (MWh)
	Commercial	Own-Use	Commercial	Own-Use	Commercial	Own-Use	
Hydropower*	554	2	12,871.43	1.56	1,435.78	-	5,911,385.18
Ocean Energy	8	-	24.00	-	-	-	
Geothermal**	32	-	475.00	-	1,937.56	-	14,427,071.76
Wind	78	1	4,093.58		442.90	0.01	1,066,946.10
Solar	290	30	12,973.87	1.36	1,058.89	6.43	1,484,139.48
Biomass	63	21	159.43	-	627.30	204.43	3,956,475.02
SUB -TOTAL	**1025**	**54**	**30,597.31**	**2.92**	**5,502.42**	**210.87**	**26,846,017.55**

* - excluding 52 installed projects with 2,641.73MW capacity under RA 7156, CA 120, PD 1645, RA 3601 & Own-Use
** - excluding 1 potential project with 20MW capacity under PD 1442

Figure 7. Summary of renewable energy (RE) projects under the RE Act of 2008
Source: Adapted from "Summary of Department of renewable energy (RE) projects under the RE Act of 2008", Department of Energy, Retrieved March 10, 2021, from https://www.doe.gov.ph/sites/default/files/pdf/renewable_energy/summary-re-applications-2020-september-30.pdf)

DOE said that from 2019 to June 2020 alone, "133 certificates of energy projects of national significance were issued with investments amounting to PHP 386.86 billion" (Crismundo, 2020). An additional 13,419 RE-related jobs are expected to result from these projects once operationalized.

B. Other Relevant Projects/Programs

- Green Energy Option Program: Section 9 of the Renewable Energy Act of 2008, mandates DOE to "establish a Green Energy Option program which provides end-users the option to choose RE sources as their sources of energy" (Republic Act 9513, 2008). As of December 2020, six RE suppliers were listed under the Green Energy Option Program namely: Bacman Geothermal, Inc., First Gen Energy Solutions, Inc., SN Aboitiz Power-Magat, Inc., SN Aboitiz Power-Res, Inc., AC Energy Philippines, Inc., and Sparc-Solar Powered Agri-Rural Communities Corporation (Department of Energy, 2020).

- Access to Sustainable Energy Programme (ASEP): In 2015, the program was launched in partnership with the European Union (EU) "to help the Philippines secure sustainable energy supplies, increase energy efficiency, and expand access to electrification in underserved households" (Crismundo, 2020). Sitio New Mabuhay in Malita, Davao Occidental became one of the beneficiaries of the program's solar home systems, where "3,017 out of the targeted 4,671 Solar Home Systems (SHS) were installed" (Department of Energy, 2018).

- Development for Renewable Energy Applications Mainstreaming and Market Sustainability (DREAMS) Project: DREAMS Project is supported by the United

Nations Development Programme (UNDP), although DOE has the sole ownership through the Renewable Energy Management Bureau (REMB). The primary goal of the project is "to promote and facilitate the commercialization of the renewable energy (RE) markets through the removal of barriers to increase investments in RE based power generation projects'' (Department of Energy, 2020). Besides conducting public consultations, training, and Information, Education, and Communication campaigns, "a program policy document on the 'Balik Probinsiya program' was submitted to DOE'' to encourage "developers to use generate local employment in areas where RE facilities are being built" (Department of Energy, 2020).

- Clean Development Mechanism (CDM): The Philippines "ratified the Kyoto Protocol in 2003" in support of CDM, "one of the three (3) flexibility mechanisms" intending to assist developed countries in meeting their emission reduction targets while helping "developing countries achieve their sustainable development goals and objectives" (Environmental Management Bureau, 2018). Following this, Figure 8 shows 10 CDM project activities issued in 2018, which facilitated livelihood and employment opportunities generation and "free education, training, and skills development among the youth" (Environmental Management Bureau, 2018).

Title of Project Activity	Total CERs
Bataan 2020 12.5 MW Power Rice Hull Cogeneration Project (2015)	118,174
San Carlos Renewable Energy Project (2012)	21,442
Northwind Bangui Bay Project (2017)	444,312
Quezon City Controlled Disposal Facility Biogas Emission Reduction Project (2018)	808,538
Philippine Sinter Corporation Sinter Cooler Waste Heat Recovery Power Generation Project (2017)	122,675
Hedcor Sibulan 42.5 MW Hydroelectric Power Project (2016)	979,577
Wastewater Treatment using a Thermophilic Anaerobic Digestor at an Ethanol Plant in the Philippines (2014)	94,990
Ambuklao Hydro Electric Power Plant (AHEPP) Rehabilitation Project (2018)	494,318
Superior Hog Farms Methane Recovery (2014)	5,437
Joliza Farms Inc. Methane Recovery (2013)	5,637
10 Projects	**3,095,100**

Figure 8. CDM Project Activities Issued CY 2018
Source: Adapted from "Annual Report CY 2018", Department of Environment and Natural Resources- Environmental Management Bureau, Retrieved March 12, 2021, from https://emb.gov.ph/wp-content/uploads/2019/04/EMB-ANNUAL-REPORT-FOR-CY-2018.pdf)

VI. Opportunities in Renewable Energy

Besides the potential to reach more people off-grid and provide lower-cost energy, various socio-economic opportunities can result from the RE sector including investments, training and education, and employment.

A. Investments

To further boost investments, Republic Act 9513 or the RE Act of 2008 includes a specific section to incentivize investments: Section 21, Incentives for RE Commercialization. This includes, among others, fiscal incentives such as income tax holiday and duty-free importation of RE machinery, equipment, and materials (Republic Act 9513, 2008).

Towards the end of 2018, 277 Renewable Energy Service Contract (RESC) was awarded, which are expected to produce "additional green energy projects and jobs" (Department of Energy 2020).

According to the Philippine Energy Plan 2018-2040 report, the biggest contribution to new investment has been made in hydropower (PHP 2,040 billion), geothermal (PHP 16.7 billion), solar (PHP 5.2 billion). The Philippines, for instance, ranks third as the largest geothermal energy producer in the world "with a total installed capacity of 1,918 MW, following the lead of US and Indonesia, respectively" (Quinones, 2020).

There are also several opportunities for the development and emergence of the Ocean Renewable Energy (ORE) sector in Southeast Asia. "ORE is also relatively more stable than its other counterparts, like oil and gas, when it comes to the price of energy. As such, long-term employment and job security can be foreseen once the sector is developed in the region" (Quirapas, and Taeihagh, 2020).

Several companies are also leading the Philippines in investing in renewable energy. Two Lopez-led power firms, First Gen and its subsidiary, EDC, are two of the largest clean and renewable energy producers in the country. EDC is also "one of the world's largest geothermal producers" (Rivera, 2019). Both even entered the Carbon Clean 200, a list ranking the companies according to their revenue size from clean energy sources (Rivera, 2019).

B. Employment

Consequently, investments could result in "substantial employment associated with project development, construction and installation for all renewable energy technologies" (International Labour Organization, 2011). The transition from carbon-intensive energy to a more sustainable source gives rise to a new demand for labor.

"These green investments as they are called are expected to create measurable impact on employment as these now become the source of new green jobs" (Cruz, 2009). Green jobs are defined in the National Green Jobs Human Resource Development (HRD) Plan 2020-2030 as "employment that contributes to preserving or restoring the quality of the environment" under the notion that these should be "decent jobs" as well (Department of Labor and Employment, 2020).

In response to a post-COVID-19 economy, the National Green Jobs HRD plan attempts the promotion of green jobs as a means to revert the country's safe and healthy economy. Similar to the RE Act of 2008, Republic Act 10771 or the Green Jobs Act of 2016 also encourages establishments to generate green jobs by providing them with fiscal and non-fiscal incentives such as special tax deduction and duty-free capital equipment importation (Department of Labor and Employment, 2020).

Viloria said in a press release that "up to 50,000 jobs over the next 20 years" can be produced "if the Renewable Energy (RE) Law will be fully implemented without delay" (Renewable Energy: caring for the environment, creating green jobs, n.d). However, the crucial assumption is that other emerging technologies like biomass, wind, and solar should be developed as well.

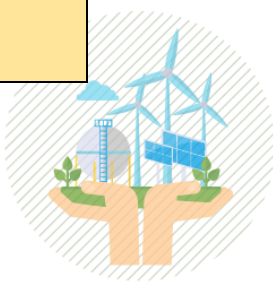
C. Training and education

In support of the RE investment projects, there is also a need to build a strong and equipped workforce. New technologies might mean "new skills and a digital mindset" (General Electric, 2017). At the same time, General Electric (GE) (2017) continues that "encouraging and supporting the growth of skills in younger workers will be crucial". There is the opportunity to involve the younger groups in RE-related training and education, thus making them ready once RE projects are fully operational and demand for workers increases.

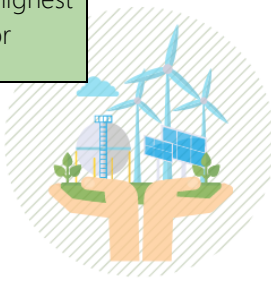
RE infrastructures being built in communities, such as in the case of solar energy technologies, could also explore partnerships with the locality. The goal will then be centered around training community residents hosting the projects as this will "help them acquire the needed skills and qualifications for employment" (Renewable Energy: caring for the environment, creating green jobs, n.d).

Table 2. Renewable Energy Value Chain.

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
Equipment manufacture and distribution	Wind	R&D engineers (computer, electrical, environmental, mechanical, wind power design) (H)	Equipment manufacturers and distributors supply "substantial investment in capital equipment", which are all necessary in all the RE technologies
		Software engineers (H,M)	
		Modellers (prototype testing) (H,M)	
		Industrial mechanics (M)	
		Manufacturing engineers (H)	
		Manufacturing technicians (M)	
		Manufacturing operators (L)	
		Manufacturing quality assurance experts (H,M)	
		Certifiers (H)	
		Logistics professionals (H,M)	
		Logistics operators (L)	
		Equipment transporters (L)	
		Procurement professionals (H,M)	
		Marketing specialists (H,M)	
		Sales personnel (H,M)	
	Solar	Researchers (chemists, physicists, engineers with specialization in electrical, mechanical, chemical, materials, system design or process engineering) (H)	
		Chemical laboratory technicians and assistants (M)	
		Software engineers (H,M)	
		Modellers (H)	
		Manufacturing engineers (H)	
		Manufacturing technicians (H,M)	
		Manufacturing operators (M,L)	
		Building systems specialists (H)	
		Manufacturing quality assurance experts (H,M)	
		Logistics professionals (H,M)	
		Logistics operators (L)	
		Equipment transporters (L)	
		Procurement professionals (H,M)	
		Marketing specialists (M,H)	
		Sales personnel (M,H)	
	Hydropower	Design engineers (civil, mechanical, electrical, hydropower) (H)	
		Modellers (H/M)	
		Software developers (H)	

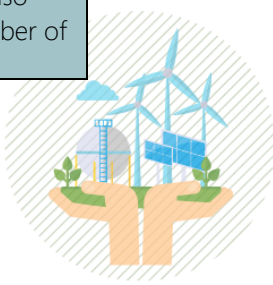


Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		Manufacturing engineers (H)	
		Manufacturing technicians (M)	
		Manufacturing operators (L)	
		Quality assurance specialists (H,M)	
		Marketing specialists (H,M)	
		Sales personnel (H,M)	
	Geothermal	Designers (H)	
		Electrical engineers (H)	
		Mechanical engineers (H)	
		Software developers (H)	
		Machinists (M)	
		Welder (M)	
		Sales personnel (H,M)	
	Bioenergy	Biochemists and microbiologists (H)	
		Agricultural biological, chemical and physical scientists (H)	
		Chemical, biological, mechanical and electrical engineers (H)	
		Material scientists in R&D (H)	
		Software engineers (H)	
		Manufacturing engineers (H)	
		Manufacturing quality assurance specialists (H,M)	
		Manufacturing technicians (H,M)	
		Quality assurance specialists (H,M)	
		Logistics professionals (H,M)	
		Logistics operators (L)	
		Equipment transporters (L)	
		Procurement professionals (H,M)	
		Marketing specialist (H,M)	
		Sales personnel (H,M)	
Project development	Wind	Project designers (engineers) (H)	The project development process includes jobs related to the design, planning, and processing of regulatory permissions with the authorities and in consultation with community members, especially on community-based RE projects. This is also "one of the highest levels of employment for
		Environmental impact assessment specialists (H,M)	
		Economic/financial /risk specialists (H)	
		Atmospheric scientists (H)	
		Social impact specialists (H)	
		Lawyers (feed-in contract, grid connection and financing contract, construction permit, power purchase agreement) (H)	
		Planners (permit monitoring, amendment and application) (H)	

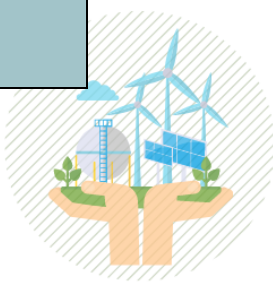


Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		Land development advisor (H)	hydropower".
		Land use negotiator (H)	
		Lobbyist (H)	
		Mediator (H)	
		Environmental and social NGO representatives (H,M)	
		Public relations officers (H)	
		Procurement professionals (H,M)	
		Wind resource assessment specialist (H)	
		Geographers (H)	
	Solar	Project designers (engineers) (H)	
		Architects (H) (small projects)	
		Atmospheric scientists and meteorologists (H)	
		Resource assessment specialists and site evaluators (H)	
		Environmental consultant (H)	
		Lawyers, government program	
		Debt financier representatives (H)	
		Developers/ facilitators (H,M)	
		Land development advisor (H)	
		Land use negotiator (H)	
		Lobbyist (H)	
		Mediator (H)	
		Environmental and social NGO representatives (H,M)	
		Public relations officer (H)	
		Procurement professionals (H,M)	
		Resource assessment specialists (H)	
	Hydropower	Project designers (engineers) (H)	
		Environmental engineers (H)	
		Sustainability specialists (natural resource/ environmental planners, social scientists, cultural consultants) (H)	
		Economic/finance/ risk specialists (H)	
		Physical and environmental scientists (hydrologists, geologists, ecologists) (H)	
		Market analysts (H)	
		Natural resource / environmental lawyers (H)	
		Commercial lawyers (H)	
		Debt financier representatives (H)	
		Land development advisor (H)	

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		Land use negotiator (H)	
		Communications specialists (H)	
		Procurement specialists (H)	
		Archaeologists (H)	
		Lobbyist (H)	
		Mediator (H)	
		Environmental and social NGO representatives (H,M)	
		Public relations officer (H)	
		Procurement professionals (H,M)	
	Geothermal	Hydrologists, hydrogeologists (H)	
		Geologists (H)	
		Geophysicists (H)	
		Project designers (engineers) (H)	
		Permit planners (H)	
		Debt financier representatives (H)	
		Land use negotiator (H)	
		Lobbyist (H)	
		Mediator (H)	
		Environmental and social NGO representatives (H,M)	
		Public relations officer (H)	
		Procurement professionals (H,M)	
	Bioenergy	Resource assessment specialists (H)	
		Project designers (engineers and scientists) (H)	
		Sustainability specialists (H)	
		Debt financier representatives (H)	
		Society and trade administrators (H,M)	
		Land use negotiators (H)	
		Communications specialists (H)	
		Lobbyists (H)	
		Mediators (H)	
		Environmental and social NGO representatives (H,M)	
		Public relations officer (H)	
		Procurement professionals (H,M)	
Construction and installation	Wind	Project managers (H)	This value chain focuses on "site preparation, installation, and commissioning of the facility". Most projects also employ the largest number of
		Electrical,civil and marine engineers (H)	
		Small wind turbine installers (M)	
		Construction electricians (M)	
		Power line technician (M)	

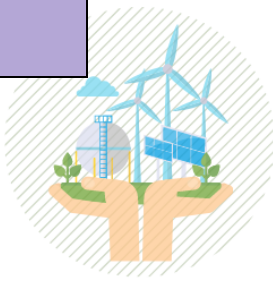


Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		Construction worker (M,L)	people at this particular value chain, especially in hydropower.
		Quality control inspectors (M)	
		Instrumentation and control technicians (M)	
		Business developers (H)	
		Commissioning engineer (electrical) (H)	
		Transportation workers (L)	
		Marine engineers (consultancy for offshore wind)	
	Solar	**Solar Thermal (ST)**	
		System designer (H,M)	
		Plumbers specializing in solar (M)	
		Small Photovoltaic	
		System designer (electrical engineers or technologists) (H,M)	
		Electricians specializing in solar(M)	
		Small Photovoltaic, ST	
		Roofers specializing in solar (M)	
		Large Photovoltaic	
		System designers (electrical/ mechanical/ structural engineers)	
		Installers (M)	
		Concentrated Solar (CSP)	
		Welders (M)	
		Pipe fitters (M)	
		Small Photovoltaic, Large Photovoltaic, ST, CSP	
		Electricians specializing in solar (M)	
		Project designers and managers (H)	
		Project and installation evaluators (H,M)	
		Construction professionals (H)	
		Installers (M)	
		Software engineers (H,M)	
		Quality assurance specialists (H,M)	
		Business developers (H)	
		Commissioning engineer (electrical) (H)	
		Transportation workers (L)	
	Hydropower	Engineers (civil, mechanical, electrical) (H)	
		Technicians (civil, mechanical, electrical) (M)	
		Project managers (H)	
		Skilled construction workers (heavy machinery operators, welders, pipe fitters	



Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		etc.) (M)	
		Construction labourers (L)	
		Business developers (H)	
		Commissioning engineer (electrical) (H)	
		Transportation workers (L)	
	Geothermal	Hydrologists, hydrogeologists (H)	
		Geologists (H),	
		Geophysicists (H)	
		Geothermal engineers (H)	
		Geochemists (H)	
		Chemical laboratory technicians and assistants (M)	
		Drilling and structural engineers (H)	
		Architects (H)	
		Surveyors (H)	
		Designers (H)	
		HVAC technicians	
		Drilling technicians and operatives (roughnecks) (M)	
		Welders (M)	
		Pipe fitters (M)	
		Plumbers (M)	
		Construction equipment operator (M)	
		Drilling equipment operator (M)	
		Excavators (L)	
		Measurement and control engineers (H)	
		Business developers (H)	
		Commissioning engineer (Electrical) (H)	
		Transportation workers (L)	
	Bioenergy	Biochemists and microbiologists (H)	
		Environmental engineers (H)	
		Laboratory technicians and assistants (M)	
		Chemical, biological mechanical and electrical engineers (H)	
		Project designers and managers (H)	
		Software engineers (H)	
		Construction professionals (H)	
		General electricians, plumbers, roofers (M)	
		General construction workers (L)	
		Business developers (H)	
		Commissioning engineer (electrical) (H)	

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		Transportation workers (L)	
Operations and maintenance	Wind	Windsmith/ millwright/mechanical technician or fitter/wind service mechatronics technician (M, some H)	Compared to the construction and installation phase, few people are employed for the operations and maintenance phase. For the solar energy systems, most jobs "are local in nature and therefore mostly occur in the country where the capacity is installed".
		Operations and maintenance specialists (M)	
		Power line technician (M)	
		Field electricians (M)	
	Solar	Photovoltaic maintenance specialists (electricians specializing in solar) (M)	
		ST maintenance specialists (Plumbers specializing in solar) (M)	
		CSP maintenance specialists (M)	
		Inspectors (M, L)	
		Recycling specialists (H)	
	Hydropower	Engineers (civil, mechanical, electrical) (H)	
		Operations and maintenance technicians (M)	
		Physical and environmental scientists (hydrologists, ecologists) (H)	
		Tradespersons (M)	
	Geothermal	Plant managers (H)	
		Measurement and control engineers (H)	
		Welders (M)	
		Pipe Fitters (M)	
		Plumbers (M)	
		Machinists (M)	
		Electricians (M)	
		Construction equipment operator (M)	
		HVAC technicians (M)	
	Bioenergy	Biochemists and microbiologists (H)	
		Laboratory technicians and assistants (M)	
		Operations and maintenance specialists (M, L)	
Biomass production	Wind		Biomass production is the fifth value chain stage in the bioenergy subsector. Generally, it employs "substantial numbers of people" except "where the main source of biomass is some form of waste".
	Solar		
	Hydropower		
	Geothermal		
	Bioenergy	Agricultural scientists (H)	
		Biomass production managers (H, M)	
		Plant breeders and foresters (H, M)	
		Agricultural/forestry workers (L)	
		Transportation workers (L)	



Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
Cross-cutting/ enabling activities	Wind	Policy-makers and government office workers (H, M)	
		Trade association and professional society staff (H, M, L)	
		Educators and trainers (H)	
		Management (H, M)	
		Administration (H, M, L)	
		Publishers and science writers (H, M)	
		Insurer representatives (H, M)	
		IT professionals (H, M)	
		Human resources professionals (H)	
		Other financial professionals (accountants, auditors, and financiers) (H)	
		Health and safety consultants (H, M)	
	Solar	Policy-makers and government office workers (H, M)	
		Trade association and professional society staff (H, M, L)	
		Educators and trainers (H)	
		Management (H, M, L)	
		Administration (H, M, L)	
		Publishers and science writers (H, M)	
		Insurer representatives (H, M)	
		IT professionals (H, M)	
		Human resources professionals (H)	
		Other financial professionals (accountants, auditors, and financiers) (H)	
		Health and safety consultants (H,M)	
	Hydropower	Policy-makers and government office workers (H, M)	
		Trade association and professional society staff (H, M, L)	
		Educators and trainers (H)	
		Management (H, M, L)	
		Administration (H, M, L)	
		Publishers and science writers (H, M)	
	Geothermal	Policy-makers and government office workers (H, M)	
		Trade association and professional society staff (H, M, L)	
		Educators and trainers (H)	
		Management (H, M, L)	
		Administration (H, M, L)	

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Remarks
		Publishers and science writers (H, M)	
	Bioenergy	Policy-makers and government office workers (H, M)	
		Trade association and professional society staff (H, M, L)	
		Educators and trainers (H)	
		Management (H, M, L)	
		Administration (H, M, L)	
		Publishers and science writers (H, M)	
		Insurer representatives (H, M)	

Source: International Labour Organization as cited from "Skills and occupational needs in renewable energy", Retrieved March 5, 2021, from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.467.6383&rep=rep1&type=pdf

The International Labour Organization (ILO) (2011) categorized the RE sector's value chain into four namely: equipment manufacture and distribution, project development, construction and installation, and operations and maintenance. Another category is added for the bioenergy subsector: biomass production, which involves "growth, transport, and processing of biomass".

Jobs were then determined in consideration of these categories where the skills level of occupations were identified as the following:

- H: High skilled (Professional/Managerial)
- M: Medium skilled (Technician/Skilled Crafts/Supervisory)
- L: Low skilled (Semi-skilled and Unskilled)

Additionally, as reflected in Table 2, some jobs are recurring in the value chain. This is because there are certain jobs that although found in the same value chain, can cut across several RE technologies. In the same way, some jobs may not be limited in a single value chain, thus, dedicating a separate section on cross-cutting/enabling activities.

Among the list of RE occupations, the following are some of the fastest-growing jobs within the renewable energy sector based on Bureau of Labor Statistics data (Kiersz and Akhtar, 2019):

1. Civil engineers
2. Financial analysts
3. Roofers
4. Environmental scientists, specialists, and engineering technicians

5. Construction managers
6. Systems software developers
7. Operating engineers and other construction equipment operators
8. Structural iron and steelworkers
9. Electrical powerline installers and repairers
10. Wind turbine service technicians

VII. Issues and Challenges

Although generally, the RE sector is expected to produce various employment opportunities, some jobs may also be at risk as a result of migrating to RE technologies. The International Labour Organization (2011) expects that this "will cause fossil-based energy industries to shrink", thus affecting economic activities and job creation.

Moreover, the need and duration of employment are not the same for every RE technology given various value chains. For instance, work in the construction and installation phase might be more labor-intensive than in the maintenance phase.

Additionally, "work is project-based, and so continuity of employment depends on a fairly steady flow of projects" International Labour Organization (2011). In a presentation on Status, Challenges and Forecast of the Philippines Wind Industry during the Clean Energy Forum 2016, Mr. Marasigan, OIC Assistant Secretary of the Renewable Energy Management Bureau cited the following challenges in the wind energy sector (Marasigan, 2016):

- High upfront and technology costs
- Non-competitiveness
- Non-viable markets
- Inaccessible financial packages
- Social acceptability

Due to several factors, other projects also take time before they become fully operational. One example is the state of the country's ocean energy. "While scholars working on ORE [Ocean Renewable Energy] in the SEA region agree that there is potential for it to be fully utilized as a renewable energy source, its development has been slower compared to other renewables" (Quirapas, & Taeihagh, 2021).

The difficulty in developing and maintaining investment projects in RE hampers not only the RE industry but job creation as well. Add this to the need to master certain skills and competencies while enhancing general knowledge to make it possible to jump from one work to another, when a project end.

In this regard, another issue is reflected: training and education. The lack of training programs and training providers in the RE sector is both a global and national problem. According to the International Labour Organization (2011), "most developing countries are less well provided with high quality providers of training and education than developed countries, making it more difficult for them to respond to skills needs through either initial or continuing training and education".

As the main agency mandated to provide quality technical education and skills development in the country, TESDA has a crucial role in ensuring that a sufficient qualified labor force for the renewable energy industry will be produced.

It is particularly important to highlight the need to produce technicians, engineers, and other technical workers. The International Renewable Energy Alliance (REN Alliance) (2011) as cited in the International Labour Organization (2011) found out that there are skill shortages, especially technicians and engineers, across all parts of the RE industry. The report further noted that there is a broader trend of students moving away from engineering studies.

As a result of these stated challenges, Table 3 shows a list of hard-to-fill occupations in the different RE energy sub-sectors (REN Alliance Survey, date as cited in International Labour Organization, 2011).

Table 3. Hard-to-fill occupations in the renewable energy sector

Sub-sector	Occupations
Wind energy	project developers; service technicians; data analysts; electrical, computer, mechanical, and construction engineers
Solar energy	photovoltaic and solar thermal system installers and maintainers; building inspectors
Hydropower energy	electrical and operations and maintenance engineers; technicians; tradespersons; sustainability specialists
Geothermal energy	trainers; geothermal engineers
Bioenergy	R&D and design engineers; service technician; trainers

Source: REN Alliance Survey as cited from "Investment in renewable energy generates jobs.Supply of skilled workforce needs to catch up", International Labour Office, Retrieved March 17, 2021, from https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_168354.pdf

Gender issues are also common as women remain underrepresented in RE employment. Some tasks may be regarded by others as too heavy and technical to allow a woman to engage in such activities. A sample study conducted in the Philippines revealed that although women have a share of work in the consultation and planning stage, most revolved around administrative jobs (Lumampao, Lopez, & Go, 2004).

For instance, "in terms of operation and maintenance, men are involved in the technical troubleshooting and repairs, while the women take care of administrative matters such as bookkeeping and payment collection" (Lumampao et.al, 2004). Furthermore, the study explained that less opportunity is given to women to participate "in any of the related technical training programmes", thus giving them "very limited knowledge of the technical workings of the micro-hydro project" (Lumampao et.al, 2004).

VIII. Skills Needed

Based on Table 2, the specific training regulations associated with the jobs needed for each RE value chain were determined. The jobs which are classified as high skilled (professional/managerial) roles were not included in Table 4 as these roles would need higher education training and certifications.

Table 4. Training Regulations in the Renewable Energy Sector.

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
Equipment manufacture and distribution	Wind	Software engineers (M)	
		Modellers (prototype testing) (M)	
		Industrial mechanics (M)	CNC Milling Machine Operation NC II CNC Milling Machine Operation NC III CNC Lathe Machine Operation NC II CNC Lathe Machine Operation NC III
		Manufacturing technicians (M)	Instrumentation and Control Servicing NC II Instrumentation and Control Servicing NC III Instrumentation and Control Servicing NC IV Mechatronics Servicing NC II Mechatronics Servicing NC III Mechatronics Servicing NC IV
		Manufacturing operators (L)	CNC Lathe Machine Operation NC II CNC Lathe Machine Operation NC III Machining NC I Machining NC II Machining NC III
		Manufacturing quality assurance experts (M)	Laboratory and Metrology/ Calibration Services NC II Laboratory and Metrology/ Calibration Services NC III
		Logistics professionals (M)	Warehousing Services NC III Warehousing Services NC IV
		Logistics operators (L)	Warehousing Services NC II

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
		Equipment transporters (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
		Procurement professionals (M)	
		Marketing specialists (M)	
		Sales personnel (M)	Contact Center Services NC II Customer Services NC II
	Solar	Chemical laboratory technicians and assistants (M)	
		Software engineers (M)	
		Manufacturing technicians (M)	Instrumentation and Control Servicing NC II Instrumentation and Control Servicing NC III Instrumentation and Control Servicing NC IV Mechatronics Servicing NC II Mechatronics Servicing NC III Mechatronics Servicing NC IV
		Manufacturing operators (M,L)	CNC Lathe Machine Operation NC II CNC Lathe Machine Operation NC III Machining NC I Machining NC II Machining NC III
		Manufacturing quality assurance experts (M)	Laboratory and Metrology/ Calibration Services NC II Laboratory and Metrology/ Calibration Services NC III
		Logistics professionals (M)	Warehousing Services NC III Warehousing Services NC IV
		Logistics operators (L)	Warehousing Services NC II
		Equipment transporters (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
		Procurement professionals (M)	
		Marketing specialists (M)	
		Sales personnel (M)	Contact Center Services NC II Customer Services NC II
	Hydropower	Modellers (M)	
		Manufacturing technicians (M)	Instrumentation and Control Servicing NC II Instrumentation and Control Servicing NC III Instrumentation and Control Servicing NC IV

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
			Mechatronics Servicing NC II Mechatronics Servicing NC III
		Manufacturing operators (L)	CNC Lathe Machine Operation NC II CNC Lathe Machine Operation NC III Machining NC I Machining NC II Machining NC III
		Quality assurance specialists (M)	
		Marketing specialists (M)	
		Sales personnel (M)	Contact Center Services NC II Customer Services NC II
	Geothermal	Machinists (M)	Machining NC I Machining NC II Machining NC III
		Welder (M)	Flux Cored Arc Welding (FCAW) NC I Flux Cored Arc Welding (FCAW) NC II Flux Cored Arc Welding (FCAW) NC III Gas Metal Arc Welding (GMAW) NC I Gas Metal Arc Welding (GMAW) NC II Gas Metal Arc Welding (GMAW) NC III Gas Welding NC I Gas Welding NC II Gas Tungsten Arc Welding (GTAW) NC II Gas Tungsten Arc Welding (GTAW) NC IV Shielded Metal Arc Welding NC I Shielded Metal Arc Welding NC II Shielded Metal Arc Welding NC III Shielded Metal Arc Welding NC IV Submerged Arc Welding (SAW) NC I Submerged Arc Welding (SAW) NC II
		Sales personnel (M)	Contact Center Services NC II Customer Services NC II
	Bioenergy	Manufacturing quality assurance specialists (M)	Laboratory and Metrology/ Calibration Services NC II Laboratory and Metrology/ Calibration Services NC III
		Manufacturing technicians (M)	Instrumentation and Control Servicing NC II Instrumentation and Control Servicing NC III Instrumentation and Control Servicing NC IV Mechatronics Servicing NC II Mechatronics Servicing NC III Mechatronics Servicing NC IV
		Quality assurance specialists (M)	
		Logistics professionals (M)	Warehousing Services NC III

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
			Warehousing Services NC IV
		Logistics operators (L)	Warehousing Services NC II
		Equipment transporters (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
		Procurement professionals (M)	
		Marketing specialist (M)	
		Sales personnel (M)	Contact Center Services NC II Customer Services NC II
Project development	Wind	Environmental impact assessment specialists (M)	
		Environmental and social NGO representatives (M)	
		Procurement professionals (M)	
	Solar	Developers/ facilitators (M)	PV System Design NC III
		Environmental and social NGO representatives (M)	
		Procurement professionals (M)	
	Hydropower	Environmental and social NGO representatives (M)	
		Procurement professionals (M)	
	Geothermal	Environmental and social NGO representatives (M)	
		Procurement professionals (M)	
	Bioenergy	Society and trade administrators (M)	
		Environmental and social NGO representatives (M)	
		Procurement professionals (M)	
Construction and installation	Wind	Small wind turbine installers (M)	
		Construction electricians (M)	Electrical Installation and Maintenance NC II Electrical Installation and Maintenance NC III Electrical Installation and Maintenance NC IV
		Power line technician (M)	Transmission Line Installation and Maintenance NC II Transmission Line Installation and Maintenance NC III Transmission Line Installation and Maintenance NC IV Electric Power Distribution Line Construction NC II Electric Power Distribution Line

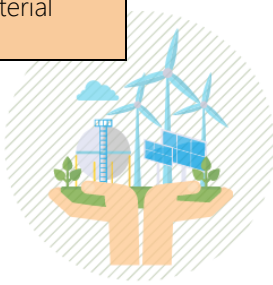
Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
			Construction NC III Electric Power Distribution Line Construction NC IV
		Construction worker (M,L)	Carpentry NC II Carpentry NC III Masonry NC I Masonry NC II Masonry NC III Reinforcing Steel Works NC II Scaffolding Works NC II (Supported Type Scaffold) System Formwork Installation NC II Structural Erection NC II HEO (various NC)
		Quality control inspectors (M)	
		Instrumentation and control technicians (M)	Instrumentation and Control Servicing NC II Instrumentation and Control Servicing NC III Instrumentation and Control Servicing NC IV
		Transportation workers (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
	Solar	**Solar Thermal (ST)**	
		System designer (M)	PV System Design NC III
		Plumbers specializing in solar (M)	
		Small Photovoltaic	
		System designer (electrical engineers or technologists) (M)	
		Electricians specializing in solar(M)	
		Small Photovoltaic, ST	
		Roofers specializing in solar (M)	PV Systems Installation NC II
		Large Photovoltaic	
		Installers (M)	PV Systems Installation NC II
		Concentrated Solar (CSP)	
		Welders (M)	Flux Cored Arc Welding (FCAW) NC I Flux Cored Arc Welding (FCAW) NC II Flux Cored Arc Welding (FCAW) NC III Gas Metal Arc Welding (GMAW) NC I Gas Metal Arc Welding (GMAW) NC II Gas Metal Arc Welding (GMAW) NC III Gas Welding NC I Gas Welding NC II

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
			Gas Tungsten Arc Welding (GTAW) NC II Gas Tungsten Arc Welding (GTAW) NC IV Shielded Metal Arc Welding NC I Shielded Metal Arc Welding NC II Shielded Metal Arc Welding NC III Shielded Metal Arc Welding NC IV Submerged Arc Welding (SAW) NC I Submerged Arc Welding (SAW) NC II
		Pipe fitters (M)	Pipefitting (Metallic) NC II
		Small Photovoltaic, Large Photovoltaic, ST, CSP	
		Electricians specializing in solar (M)	
		Project and installation evaluators (M)	
		Installers (M)	PV Systems Installation NC II
		Software engineers (M)	
		Quality assurance specialists (M)	
		Transportation workers (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
	Hydropower	Technicians (civil, mechanical, electrical) (M)	Electrical Installation and Maintenance NC III Electrical Installation and Maintenance NC IV
		Skilled construction workers (heavy machinery operators, welders, pipe fitters etc.) (M)	Rigging NC I HEO (Various NC) Heavy Equipment Servicing (Mechanical) NC II Gas Metal Arc Welding (GMAW) NC I Gas Metal Arc Welding (GMAW) NC II Gas Metal Arc Welding (GMAW) NC III Gas Welding NC I Gas Welding NC II Flux Cored Arc Welding (FCAW) NC I Flux Cored Arc Welding (FCAW) NC II Flux Cored Arc Welding (FCAW) NC III Masonry NC I Masonry NC II Masonry NC III Reinforcing Steel Works NC II Shielded Metal Arc Welding NC I Shielded Metal Arc Welding NC II Shielded Metal Arc Welding NC III Shielded Metal Arc Welding NC IV Submerged Arc Welding (SAW) NC I

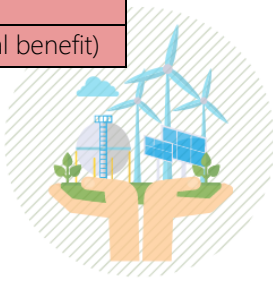
Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
			Submerged Arc Welding (SAW) NC II Pipefitting (Metallic) NC II Construction Lift Passenger/Material Elevator Operation NC II Structural Erection NC II
		Transportation workers (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
	Geothermal	Chemical laboratory technicians and assistants (M)	
		Drilling technicians and operatives (roughnecks) (M)	
		Welders (M)	Flux Cored Arc Welding (FCAW) NC I Flux Cored Arc Welding (FCAW) NC II Flux Cored Arc Welding (FCAW) NC III Gas Metal Arc Welding (GMAW) NC I Gas Metal Arc Welding (GMAW) NC II Gas Metal Arc Welding (GMAW) NC III Gas Welding NC I Gas Welding NC II Gas Tungsten Arc Welding (GTAW) NC II Gas Tungsten Arc Welding (GTAW) NC IV Shielded Metal Arc Welding NC I Shielded Metal Arc Welding NC II Shielded Metal Arc Welding NC III Shielded Metal Arc Welding NC IV Submerged Arc Welding (SAW) NC I Submerged Arc Welding (SAW) NC II
		Pipe fitters (M)	Pipefitting (Metallic) NC II
		Plumbers (M)	Plumbing NC I Plumbing NC II Plumbing NC III
		Construction equipment operator (M)	HEO (various NC) Construction Lift Passenger/Material Elevator Operation NC II
		Drilling equipment operator (M)	
		Excavators (L)	HEO (Hydraulic Excavator) NC II
		Transportation workers (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
	Bioenergy	Laboratory technicians and assistants (M)	Laboratory and Metrology/ Calibration Services NC II Laboratory and Metrology/ Calibration Services NC III
		General electricians, plumbers,	Plumbing NC I

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
		roofers (M)	Plumbing NC II Plumbing NC III Electrical Installation and Maintenance NC II Electrical Installation and Maintenance NC III Electrical Installation and Maintenance NC IV Biogas Plant Installation NC III
		General construction workers (L)	Carpentry NC II Carpentry NC III Masonry NC I Masonry II Masonry III Reinforcing Steel Works NC II Scaffolding Works NC II (Supported Type Scaffold) Structural Erection NC II
		Transportation workers (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
Operations and maintenance	Wind	Windsmith/ millwright/mechanical technician or fitter/wind service mechatronics technician (M)	CNC Milling Machine Operation NC II CNC Milling Machine Operation NC III Pipefitting (Metallic) NC II Mechatronics Servicing NC II Mechatronics Servicing NC III Mechatronics Servicing NC IV
		Operations and maintenance specialists (M)	
		Power line technician (M)	Transmission Line Installation and Maintenance NC II Transmission Line Installation and Maintenance NC III Transmission Line Installation and Maintenance NC IV Electric Power Distribution Line Construction NC II Electric Power Distribution Line Construction NC III Electric Power Distribution Line Construction NC IV
		Field electricians (M)	Electrical Installation and Maintenance NC II Electrical Installation and Maintenance NC III Electrical Installation and Maintenance NC IV

Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
	Solar	Photovoltaic maintenance specialists (electricians specializing in solar) (M)	PV System Design NC III PV Systems Installation NC II PV Systems Servicing NC III
		ST maintenance specialists (Plumbers specializing in solar) (M)	
		CSP maintenance specialists (M)	PV System Design NC III PV Systems Installation NC II PV Systems Servicing NC III
		Inspectors (M, L)	PV System Design NC III PV Systems Installation NC II PV Systems Servicing NC III
	Hydropower	Operations and maintenance technicians (M)	
		Tradespersons (M)	
	Geothermal	Welders (M)	Flux Cored Arc Welding (FCAW) NC I Flux Cored Arc Welding (FCAW) NC II Flux Cored Arc Welding (FCAW) NC III Gas Metal Arc Welding (GMAW) NC I Gas Metal Arc Welding (GMAW) NC II Gas Metal Arc Welding (GMAW) NC III Gas Welding NC I Gas Welding NC II Gas Tungsten Arc Welding (GTAW) NC II Gas Tungsten Arc WElding (GTAW) NC IV Shielded Metal Arc Welding NC I Shielded Metal Arc Welding NC II Shielded Metal Arc Welding NC III Shielded Metal Arc Welding NC IV Submerged Arc Welding (SAW) NC I Submerged Arc Welding (SAW) NC II
		Pipe Fitters (M)	Pipefitting (Metallic) NC II
		Plumbers (M)	Plumbing NC I Plumbing NC II Plumbing NC III
		Machinists (M)	Machining NC I Machining NC II Machining NC III
		Electricians (M)	Electrical Installation and Maintenance NC II Electrical Installation and Maintenance NC III Electrical Installation and Maintenance NC IV
		Construction equipment operator (M)	HEO (various NC) Construction Lift Passenger/Material Elevator Operation NC II



Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
		HVAC technicians (M)	Air Duct Servicing NC II RAC (PACU-CRE) Servicing NC III
	Bioenergy	Laboratory technicians and assistants (M)	Laboratory and Metrology/ Calibration Services NC II Laboratory and Metrology/ Calibration Services NC III
		Operations and maintenance specialists (M, L)	
Biomass production	Wind		
	Solar		
	Hydropower		
	Geothermal		
	Bioenergy	Biomass production managers (M)	
		Plant breeders and foresters (M)	
		Agricultural/forestry workers (L)	Agricultural Crops Production NC I Agricultural Crops Production NC III
		Transportation workers (L)	Driving NC II Driving (Articulated Vehicle) NC III Driving (Passenger Bus/Straight Truck) NC III
Cross-cutting/ enabling activities	Wind	Policy-makers and government office workers (M)	
		Trade association and professional society staff (M, L)	
		Management (M)	
		Administration (M, L)	
		Publishers and science writers (M)	
		Insurer representatives (M)	Microinsurance Services (Mutual benefit) NC II
		IT professionals (M)	Computer Systems Servicing NC II Web Development NC III Programming (.Net Technology) NC III Programming (Oracle Database) NC III Programming (Java) NC III
		Human resources professionals (H)	
		Health and safety consultants (M)	
	Solar	Policy-makers and government office workers (M)	
		Trade association and professional society staff (M, L)	
		Management (M, L)	
		Administration (M, L)	
		Publishers and science writers (M)	
		Insurer representatives (M)	Microinsurance Services (Mutual benefit)



Renewable Energy Value Chain	Renewable Energy Technology	Jobs Needed	Training Regulations
			NC II
		IT professionals (M)	Computer Systems Servicing NC II Web development NC III Programming (.Net Technology) NC III Programming (Oracle Database) NC III Programming (Java) NC III
		Health and safety consultants (M)	
	Hydropower	Policy-makers and government office workers (M)	
		Trade association and professional society staff (M, L)	
		Management (M, L)	
		Administration (M, L)	
		Publishers and science writers (M)	
	Geothermal	Policy-makers and government office workers (M)	
		Trade association and professional society staff (M, L)	
		Management (M, L)	
		Administration (M, L)	
		Publishers and science writers (M)	
	Bioenergy	Policy-makers and government office workers (M)	
		Trade association and professional society staff (M, L)	
		Management (M, L)	
		Administration (M, L)	
		Publishers and science writers (M)	
		Insurer representatives (M)	Microinsurance Services (Mutual benefit) NC II

Following the formulated National Green Jobs Human Resource Development Plan 2020-2030, the document emphasized how "the shift to green economy does not only require technical skills but also core skills for employability that are relevant such as competencies in literacy, numeracy, decision-making, teamwork, communication, etc." (Department of Labor and Employment, 2020).

As mentioned, one of the challenges in RE is the project-based nature of some occupations. Thus, being well-equipped with both technical and soft skills can increase an individual's occupational mobility. Strieska-Ilina, et.al, (2011) as cited in the Department of Labor and Employment (2020) explained that "innovation and new markets require

entrepreneurship, risk assessment, management, design, planning and leadership skills which are indispensable as economies move to greener solutions".

IX. TVET Capacity

For the TVET Capacity, all the data regarding the qualifications were solely based on WTR and WTR-Cluster as TR status.

Table 5 below shows the total number of enrolled and graduated by qualification (WTR) that are relevant to the renewable energy sector. Some of the Training Regulations (HEO (Backhoe Loader) II, HEO (Bulldozer) II, Masonry III, HEO (Crawler Crane) II, Rigging I) have enrollees but no graduates. There are also those with graduates but no enrollees (Programming IV, Gas Metal Arc Welding (GMAW) I, Gas Welding II, Gas Metal Arc Welding (GMAW) III).

Based on the table, the TRs with the most number of enrollees and graduates for the year 2020 include: Driving II, Shielded Metal Arc Welding (SMAW) II, Electrical Installation and Maintenance II, Shielded Metal Arc Welding (SMAW) I, Contact Center Services II, Computer Systems Servicing II, Agricultural Crops Production II, Carpentry II, Masonry II, and Agricultural Crops Production I.

Table 5. Total Number of Enrolled, Graduated by Qualification (WTR, WTR-Cluster), by Sex 2020.

Qualifications (WTR, WTR-Cluster)	Enrolled			Graduated		
	Male	Female	Total	Male	Female	Total
Shielded Metal Arc Welding (SMAW) II	15,211	1,872	17,083	13,800	1,525	15,325
Driving II	14,510	5,678	20,188	11,030	4,034	15,064
Electrical Installation and Maintenance II	13,704	1,784	15,488	12,451	1,523	13,974
Shielded Metal Arc Welding (SMAW) I	11,475	1,583	13,058	12,319	1,434	13,753
Computer Systems Servicing II	4,428	5,174	9,602	4,295	4,568	8,863
Contact Center Services II	2,344	5,310	7,654	2,496	4,859	7,355
Carpentry II	4,753	558	5,311	5,893	693	6,586
Agricultural Crops Production II	3,555	3,447	7,002	2,888	2,977	5,865
Masonry II	3,662	495	4,157	3,291	486	3,777
Agricultural Crops Production I	1,081	1,405	2,486	963	1,220	2,183
Agricultural Crops Production III	1,011	1,247	2,258	866	1,072	1,938
Plumbing II	1,282	266	1,548	1,358	303	1,661
Pipefitting II	455	31	486	1,162	87	1,249
Masonry I	945	235	1,180	983	243	1,226
HEO (Wheel Loader) II	1,211	56	1,267	993	40	1,033
Gas Tungsten Arc Welding (GTAW) II	728	63	791	904	84	988

Qualifications (WTR, WTR-Cluster)	Enrolled			Graduated		
	Male	Female	Total	Male	Female	Total
Electrical Installation and Maintenance III	793	52	845	708	48	756
Gas Metal Arc Welding (GMAW) II	604	75	679	583	60	643
PV Systems Installation II	779	254	1,033	503	134	637
HEO (Forklift) II	1,069	68	1,137	602	28	630
Plumbing I	594	149	743	513	80	593
Shielded Metal Arc Welding (SMAW) III	580	93	673	518	60	578
Machining II	500	21	521	512	55	567
HEO (Rigid On-Highway Dump Truck) II	631	15	646	505	13	518
HEO (Hydraulic Excavator) II	1,225	29	1,254	453	4	457
Scaffolding Works (Supported Type Scaffold) II	334	5	339	243	3	246
RAC Servicing (PACU-CRE) III	111	0	111	206	4	210
Mechatronics Servicing II	197	77	274	142	50	192
HEO (Motor Grader) II	165	2	167	178	0	178
Shielded Metal Arc Welding (SMAW) IV	147	11	158	135	10	145
Driving (Passenger Bus/Straight Truck) III	225	11	236	118	12	130
Customer Services II	4	9	13	26	84	110
CNC Lathe Machine Operation II	43	4	47	84	8	92
Instrumentation and Control Servicing II	217	38	255	82	10	92
PV Systems Servicing III	56	3	59	81	3	84
Mechatronics Servicing III	72	8	80	64	8	72
HEO (Road Roller) II	28	2	30	51	2	53
Flux Cored Arc Welding (FCAW) II	25	0	25	43	5	48
HEO (Truck Mounted Crane) II	20	0	20	43	1	44
Programming IV				22	18	40
Carpentry III	20	0	20	39	0	39
Driving (Articulated Vehicle) III	25	0	25	25	0	25
Gas Metal Arc Welding (GMAW) I				24	1	25
Machining I	10	0	10	25	0	25
Programming (Java) III	51	24	75	19	6	25
CNC Milling Machine Operation II	18	2	20	18	0	18
Instrumentation and Control Servicing III	31	7	38	15	3	18
Pipefitting (Metallic) II	111	15	126	15	2	17
Gas Welding II				9	0	9
Gas Metal Arc Welding (GMAW) III				7	1	8
HEO (Backhoe Loader) II	1,310	57	1,367			
HEO (Bulldozer) II	486	13	499			
Masonry III	25	0	25			
HEO (Crawler Crane) II	24	0	24			
Rigging I	20	0	20			

Legend: Grayscale means no available data.

Source: 2020 Consolidated Data of Enrolled and Graduated Output from TESDA.

Meanwhile, Table 6 lists the following Training Regulations relevant to the RE sector that do not have enrollees and graduates for the year 2020.

Table 6. Training Regulations in Renewable Energy Sector with no available data for both enrolled and graduated, 2020.

List of Training Regulations with No Available Data For Enrolled and Graduated, 2020.
Air Duct Servicing NC II
Biogas Plant Installation NC III
CNC Lathe Machine Operation NC III
Construction Lift Passenger/Material Elevator Operation NC II
Electric Power Distribution Line Construction NC II
Electric Power Distribution Line Construction NC III
Electric Power Distribution Line Construction NC IV
Electrical Installation and Maintenance NC IV
Flux Cored Arc Welding (FCAW) NC I
Flux Cored Arc Welding (FCAW) NC III
Gas Tungsten Arc Welding (GTAW) NC IV
Gas Welding NC I
Heavy Equipment Servicing (Mechanical) NC II
HEO (Rigid Off-Highway Dump Truck) NC II
HEO (Articulated Off-highway dump truck) NC II
HEO (Concrete Pump) NC II
HEO (Container Stacker) NC II
HEO (Overhead and Gantry Crane) NC III
HEO (Paver) NC II
HEO (Rough Terrain Crane) NC III
HEO (Screed) NC I
HEO (Tower Crane) NC III
HEO (Transit Mixer) NC II
Laboratory and Metrology/ Calibration Services NC II
Laboratory and Metrology/ Calibration Services NC III
Machining NC III
Mechatronics Servicing NC IV
Microinsurance Services (Mutual benefit) NC II
Programming (.Net Technology) NC III
Programming (Oracle Database) NC III
PV System Design NC III
Reinforcing Steel Works NC II
Structural Erection NC II
Submerged Arc Welding (SAW) NC I

List of Training Regulations with No Available Data For Enrolled and Graduated, 2020.
Submerged Arc Welding (SAW) NC II
System Formwork Installation NC II
Transmission Line Installation and Maintenance NC II
Transmission Line Installation and Maintenance NC III
Transmission Line Installation and Maintenance NC IV
Warehousing Services NC II
Warehousing Services NC III
Warehousing Services NC IV
Web Development NC III

Table 7 lists the top 20 Training Regulations in 2020 in terms of the total number of graduates produced with Shielded Metal Arc Welding (SMAW) II ranking first. However, Computer Systems Servicing II ranks first in terms of the qualification with the most number of graduates who have been assessed and certified.

Contact Center Services II is the top six graduate producers, but there is no available data for the assessments and certifications.

It can also be deduced from Table 7 that there is a comparable difference in the number of males and females who were enrolled, graduated, assessed, and certified. For all 16 of the 20 Qualifications cited in Table 7, the majority of enrollees and graduates are male. Only Computer Systems Servicing II, Contact Center Services II, Agricultural Crops Production I and Agricultural Crops Production III are dominated by females in the number of enrolled and graduated. For Agricultural Crops Production II, there are more male than female in the number of enrolled, but more female than male in the number of graduates.

Table 7. Total Number of Enrolled, Graduated, Assessed and Certified by Qualification (WTR, WTR-Cluster), by Sex, 2020 (Top 20).

Qualification (WTR)	Enrolled			Graduated			Assessed			Certified		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Shielded Metal Arc Welding (SMAW) II	15,211	1,872	17,083	13800	1525	15325	20,082	2,113	22,195	18,983	1,987	20,970
Driving II	14510	5678	20188	11030	4034	15064	22941	5424	28365	21616	5041	26657
Electrical Installation and Maintenance II	13704	1784	15488	12451	1523	13974	23541	2184	25725	21734	2021	23755
Shielded Metal Arc Welding (SMAW) I	11,475	1,583	13,058	12319	1434	13753	14,677	1,763	16,440	13,718	k1,642	15,360
Computer Systems Servicing II	4428	5174	9602	4295	4568	8863	19,634	17,844	37,478	17,439	15,731	33,170
Contact Center Services II	2344	5310	7654	2496	4859	7355						
Carpentry II	4088	528	4616	5893	693	6586	6,146	630	6,776	5,807	592	6,399

Qualification (WTR)	Enrolled			Graduated			Assessed			Certified		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Agricultural Crops Production II	3555	3447	7002	2888	2977	5865	4,295	3,946	8,241	4,103	3,767	7,870
Masonry II	3662	495	4157	3291	486	3777	3309	399	3708	3184	385	3569
Agricultural Crops Production I	1081	1405	2486	963	1220	2183	1,391	1,371	2,762	1,311	1,321	2,632
Agricultural Crops Production III	1011	1247	2258	866	1072	1938	1,284	1,192	2,476	1,200	1,113	2,313
Plumbing II	1282	266	1548	1358	303	1661	1619	269	1888	1555	255	1810
Pipefitting II	455	31	486	1162	87	1249	1188	74	1262	1141	74	1215
Masonry I	945	235	1180	983	243	1226	898	228	1126	883	224	1107
HEO (Wheel Loader) II	1211	56	1267	993	40	1033	1,485	25	1,510	1,459	24	1,483
Gas Tungsten Arc Welding (GTAW) II	728	63	791	904	84	988	995	77	1,072	951	75	1,026
Electrical Installation and Maintenance III	793	52	845	708	48	756	819	35	854	750	33	783
Gas Metal Arc Welding (GMAW) II	604	75	679	583	60	643	557	43	600	543	43	586
PV Systems Installation II	779	254	1033	503	134	637	586	163	749	574	160	734
HEO (Forklift) II	1069	68	1137	602	28	630	3329	53	3382	3137	53	3190

Legend: Grayscale means no available data.

Source: 2020 Consolidated Data of Enrolled, Graduated, Assessed, and Certified from TESDA.

X. TESDA Initiatives

A. Greening the TVET System Framework

TESDA adopted the Greening the TVET System Framework in collaboration with ILO under the Just Transition to a Green Economy Project. Thereby, issuing TESDA Circular No. 58 Series of 2018 on Implementing Guidelines for Greening the TVET System. This Framework aims to:

1. support the implementation of the Philippine Green Jobs Act through training and retraining of workers in jobs that are sustainable and decent;
2. establish common understanding and appreciation of laws, policies, and concepts of greening the TVET system;
3. integrate environmental sustainability in the Training Regulations, competency standards, and curricula applying research philosophies;
4. guide employees, trainees, and other TVET clients and partners to implement sustainability practices within TVET institutions and/or offices;
5. partner with "green" enterprises in implementing sustainability practices in the TVET sector; and

6. support in ensuring a just transition towards a greening economy and society through skills development.

B. Greened Training Regulations

Based on the LMIR Issue No. 1, Series of 2018 "Green Skills for Green Jobs: Preparing the Filipino Workforce for the Green Economy", there are only 20 Training Regulations with green competencies. One out of the 20 Qualifications relates to the Renewable Energy sector.

Figure 9 shows the Qualifications with Green Competencies, Enrolled, Graduates, Assessed and Certified, 2016 and 2017.

Sector	Qualifications Title	2017					2016				
		E	G	A	C	Certification Rate	E	G	A	C	Certification Rate
Construction	PV Systems Design NC III										
	PV Systems Installation NC II	429	387	219	208	94.98%	42	57	170	146	85.88%
	PV Systems Servicing NC III	24	21	41	41	100.00%			3	3	100.00%
HVAC and Refrigeration	RAC-PACU/CRE Servicing NC II	1	1								
	RAC-PACU/CRE Servicing NC III	747	617	726	622	85.67%	295	313	952	861	90.44%
	RAC (Window AC/Domestic Refrigeration) Servicing NC I	35	26				282	212	70	70	100.00%
	RAC (Window AC/Domestic Refrigeration Servicing) NC II	4,209	2,899	6,415	5,775	90.02%	4,764	4,225	7,874	7,133	90.59%
	Ice Plant Refrigeration Servicing NC III	2	5								
	Transport RAC Servicing NC II	110	68	102	102	100.00%	18	18	232	224	96.55%
Agriculture and Fishery	Pest Management (Vegetables) NC II	56	145	250	223	89.20%	504	474	495	493	99.60%
	Landscape Installation and Maintenance (Softscape) NC II	68	45	136	136	100.00%	152	122	136	131	96.32%
	Bamboo Production NC II										
	Organic Agriculture Production NC II	7,373	5,765	13,595	12,824	94.33%	1627	1334	4078	3893	95.46%
Automotive and Land Transportation	Automotive Servicing NC I	20,070	14,969	32,052	29,624	92.42%	18,887	17,262	31,202	28,260	90.57%
	Automotive Servicing NC II	20,538	15,386	28,928	26,460	91.47%	20,255	19,212	25,212	22,338	88.60%
	Automotive Servicing NC III	1163	1038	541	498	92.05%	945	895	550	471	85.64%
	Automotive Servicing NC IV	1,228	1,223	518	447	86.29%	1,077	962	51	51	100.00%
Utilities	Garbage Collection NC I										
	Sanitary Landfill Operations NC II										
	Sanitary Landfill Operations NC III										

Figure 9. Qualifications with Green Competencies, Enrolled, Graduated, Assessed and Certified, 2016 and 2017.

Source: Adapted from "Green Skills for Green Jobs: Preparing the Filipino Workforce for the Green Economy." Technical Education and Skills Development Authority, LMIR Issue No. 1 Series of 2018, Retrieved March 22, 2021

C. Solar PV Rooftop Projects Portfolio

The Philippine National Oil Company Renewables Corporation (PNOC RC) proactively partners with several government institutions, including TESDA, "to explore the untapped potential of the country's clean energy resources" (Department of Energy, 2018). One of the company's accomplishments is the inclusion of TESDA "as partner agencies in its Solar PV Rooftop Projects portfolio" (Department of Energy, 2018). Additionally, TESDA signed a Memorandum of Agreement with PNOC RC for the development and implementation of RE and EE projects.

D. Industry Consultations

As part of the skills prioritization process and training regulations (TR) development, TESDA is currently having industry consultations with the wind energy sector, specifically for wind turbines. Based on the feedback report on the meeting with DOE and the UNDP-DREAMS project in February 2021, a TR for windmill/wind turbine operations and maintenance is being proposed. The said meeting focused on the validation of skills among wind farm owners. Further discussions and consultations will be made regarding the said initiative.

E. Establishment of Green Technology Center (GTC)

In response to the emerging green industry personnel needs, TESDA decided to establish and dedicate the Green Technology Center (GTC) in the offering of "various green skills training courses…integrated into the technical-vocational curriculum" (Department of Labor and Employment, 2020). "GTC is involved in the greening of TRs; assessment and certification; and training of trainers on green technologies such as renewable energy, efficient energy use, and management, water and wastewater treatment, waste management recovery and recycling and environmental consultancy, and green ICT" ((Department of Labor and Employment, 2020).

XI. Way Forward

The Philippines has been taking initiatives to transition into RE technologies and boost the development of green jobs as lead by the Department of Energy and Department of Labor and Employment, respectively. However, the analysis of the country's status in terms of RE training and education, and employment proved that there is still a need to ensure that the current and future demand in RE employment will be met by a skilled and competent workforce.

To increase responsiveness in the RE sector, prepare labor supply, and avoid skill shortages, the following are the recommended action steps for TESDA:

- Training regulations may be re-evaluated. Provided that some energy-related jobs might be obsolete due to the emerging RE technologies, initiatives should be made to retrain those who might be displaced. Additionally, since even other RE-related jobs are short-term, "education and training courses should therefore be built around a core qualification that will be useful in a broader range of sectors" (International Labour Organization, 2011).

- Since few existing training regulations relate to RE, there is the opportunity to identify the priority skills and competencies and further formulate new TVET programs that can be used to addressed the skills gaps, Table 8 shows a summary of the jobs that are relevant in the RE sector according to the International Labour Organization (2011), but do not have existing or related TRs.

Table 8. Jobs Needed in Renewable Energy Sector With No Corresponding Training Regulations.

Jobs Needed Without Training Regulations
Software engineers (M)
Modellers (prototype testing) (M)
Procurement professionals (M)
Marketing specialists (M)
Chemical laboratory technicians and assistants (M)
Quality assurance specialists (M)
Environmental impact assessment specialists (M)
Environmental and social NGO representatives (M)
Society and trade administrators (M)
Small wind turbine installers (M)
Quality control inspectors (M)
Plumbers specializing in solar (M)
Electricians specializing in solar(M)
Project and installation evaluators (M)
Drilling technicians and operatives (roughnecks) (M)
Drilling equipment operator (M)
Operations and maintenance specialists (M, L)
ST maintenance specialists (Plumbers specializing in solar) (M)
Tradespersons (M)
Biomass production managers (M)
Plant breeders and foresters (M)
Policy-makers and government office workers (M)
Trade association and professional society staff (M, L)
Management (M)
Administration (M, L)

Publishers and science writers (M)
Human resources professionals (H)
Health and safety consultants (M)

- One of the main reasons why the Philippines RE sector progresses slowly is the lack of trained and well-equipped workers. TESDA has the capacity-building platform to promote renewable energy and train the future RE workers of this country. In light of this, TESDA has to increase its capacity on specifically on skills requirements with corresponding TR/TVET programs. This includes the registration of programs, assessment centers, assessors and trainers.

Table 9. Summary of the Number of Assessment Centers, Competency Assessors, Registered Programs, and National TVET Trainers Certification Holder by Qualification, as of 2020.

QUALIFICATION	NO. OF ASSESSMENT CENTERS	NO. OF COMPETENCY ASSESSORS	REGISTERED PROGRAMS	TRAINERS
CNC Lathe Machine Operation NC II	4	6	3	14
CNC Lathe Machine Operation NC III	1	1	1	4
CNC Milling Machine Operation NC II	4	5	3	12
Gas Welding NC II	3	1	4	3
CNC Milling Machine Operation NC III	1	1	1	6
HEO (Articulated Off-highway dump truck) NC II	2	1	2	1
HEO (Tower Crane) NC III	2	6	2	10
Machining NC III	2	0	5	13
Mechatronics Servicing NC IV	1	3	3	9
PV System Design NC III	1	1	1	4
HEO (Crawler Crane) NC III	6	7	1	11
Reinforcing Steel Works NC II	2	8	1	11
Web Development NC III	8	5	0	11
Electric Power Distribution Line Construction NC III	2	4		1
Electric Power Distribution Line Construction NC IV	2	3		1
Flux Cored Arc Welding (FCAW) NC I	4	1	6	
Flux Cored Arc Welding (FCAW) NC III	2	0		1
Gas Tungsten Arc Welding (GTAW) NC IV		1		
Gas Welding NC I	1	0	1	
Submerged Arc Welding (SAW) NC I		2		
System Formwork Installation NC II	1	4		
Warehousing Services NC II	1	2		1
HEO (Paver) NC II	1	2		1
HEO (Transit Mixer) NC II	5	5		5
Instrumentation and Control Servicing NC IV			1	
Agricultural Crops Production NC II	96	198	158	606

QUALIFICATION	NO. OF ASSESSMENT CENTERS	NO. OF COMPETENCY ASSESSORS	REGISTERED PROGRAMS	TRAINERS
Agricultural Crops Production NC III	41	95	72	533
Carpentry NC II	109	209	159	575
Computer Systems Servicing NC II	249	505	514	2309
Driving (Passenger Bus/Straight Truck) NC III	57	104	21	162
Driving NC II	265	514	467	1408
Electrical Installation and Maintenance NC II	209	596	349	1551
Electrical Installation and Maintenance NC III	47	103	45	391
Gas Metal Arc Welding (GMAW) NC II	44	75	57	353
Gas Tungsten Arc Welding (GTAW) NC II	46	82	65	328
HEO (Bulldozer) NC II	29	39	37	93
HEO (Forklift) NC II	58	84	59	204
HEO (Hydraulic Excavator) NC II	60	87	63	198
HEO (Motor Grader) NC II	24	28	19	66
HEO (Wheel Loader) NC II	64	75	70	199
Machining NC II	24	41	38	134
Masonry NC II	108	154	139	447
Mechatronics Servicing NC II	15	35	31	108
Plumbing NC II	47	89	73	261
PV Systems Installation NC II	27	37	36	116
RAC (PACU-CRE) Servicing NC III	21	21	19	77
Scaffolding Works NC II (Supported Type Scaffold)	34	30	15	75
Shielded Metal Arc Welding NC II	330	708	665	2226
Shielded Metal Arc Welding NC III	38	60	49	334
Agricultural Crops Production NC I	48	70	69	
Masonry NC I	41	55	41	
Plumbing NC I	17	28	34	
Shielded Metal Arc Welding NC I	255	438	438	
Electric Power Distribution Line Construction NC II	7	7	2	27
Electrical Installation and Maintenance NC IV	1	4	3	30
Gas Metal Arc Welding (GMAW) NC III	4	4	3	19
Heavy Equipment Servicing (Mechanical) NC II	5	11	2	25
HEO (Rough Terrain Crane) NC III	8	8	5	24
HEO (Rigid Off-Highway Dump Truck) NC II	3	6	2	16
Instrumentation and Control Servicing NC III	4	7	5	26
Mechatronics Servicing NC III	5	7	10	33
Pipefitting (Metallic) NC II	2	3	4	25
Plumbing NC III	2	1	1	19
PV Systems Servicing NC III	4	11	6	30
Shielded Metal Arc Welding NC IV	5	11	3	57

QUALIFICATION	NO. OF ASSESSMENT CENTERS	NO. OF COMPETENCY ASSESSORS	REGISTERED PROGRAMS	TRAINERS
Carpentry NC III	12	29	4	69
Customer Services NC II	11	24	11	93
Flux Cored Arc Welding (FCAW) NC II	11	21	15	123
HEO (Truck Mounted Crane) NC III	12	18	4	30
Instrumentation and Control Servicing NC II	7	23	14	69
Masonry NC III	9	23	5	63
Pipefitting NC II	12	41	21	122
Rigging NC I	13	19	4	25
HEO (Backhoe Loader) NC II	3	42	56	101
HEO (Rigid On-Highway Dump Truck) NC II	53	5	40	118
HEO (Road Roller) NC II	21	17	11	33
Driving (Articulated Vehicle) NC III	26	31	5	46
Gas Metal Arc Welding (GMAW) NC I	12	11	17	
Machining NC I	13	18	15	

Legend: Yellow means low values/least number, Green means high values/most number. Grayscale means no available data.

Source: 2020 TVET Statistics from TESDA.

Table 10. List of Training Regulations with No Available Data for Competency Assessors, Assessment Centers, Registered Programs, and Trainers, 2020.

List of Training Regulations with No Available Data For Competency Assessors, Assessment Centers, Registered Programs, and Trainers, 2020.
Air Duct Servicing NC II
Biogas Plant Installation NC III
Construction Lift Passenger/Material Elevator Operation NC II
HEO (Concrete Pump) NC II
HEO (Container Stacker) NC II
HEO (Overhead and Gantry Crane) NC III
HEO (Screed) NC I
Laboratory and Metrology/ Calibration Services NC II
Laboratory and Metrology/ Calibration Services NC III
Microinsurance Services (Mutual benefit) NC II
Structural Erection NC II
Submerged Arc Welding (SAW) NC II
Transmission Line Installation and Maintenance NC II
Transmission Line Installation and Maintenance NC III
Transmission Line Installation and Maintenance NC IV
Warehousing Services NC III
Warehousing Services NC IV

- Skill and labor shortages may also be solved through targeting gender issues. Although TVET statistics show that several women have access to TESDA's education and training programs, more effort should be made to attract and empower them to take STEM courses. Table 7 reflects this comparable difference in the number of males and females who were enrolled, graduated, assessed, and certified.

- TESDA should ensure that employment opportunities will not be overestimated provided that several RE projects are still in the pre-development stage. Thus, strong coordination with other stakeholders including other government agencies and industry, will be crucial.

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