

Vocational high school as a part of Indonesian photovoltaics supply chain

R Budiarto^{1,*}, N Effendy¹, F Aliyah¹, D Novitasari², I A Mubarak², R K Arruzi³, Z A Fikriyadi⁴, T P Handayani⁵ and H H Adudu⁵

¹Department of Nuclear Engineering and Engineering Physics, Universitas Gadjah Mada, Indonesia

²Department of Electrical and Information Engineering, Universitas Gadjah Mada, Indonesia

³Center for Energy studies, Universitas Gadjah Mada, Indonesia

⁴The Agency for the Assessment and Application of Technology (BPPT), Jakarta, Indonesia

⁵Universitas Muhammadiyah Gorontalo, Indonesia

*E-mail: rachmawan@ugm.ac.id

Abstract. As a part of its national policy, Indonesia significantly increases its photovoltaics (PV) role in its energy mix. As investment in PV grows significantly, there is also demand to increase benefits in new jobs creation. Meanwhile, the dependence on imported components and support for the operation and maintenance of the system is still a big challenge. There is a strong demand in increasing capacity of the national industry to provide support in various aspects. This capability in all parts of the Indonesian PV supply chain needs to be improved. This study explored the opportunity to more intensively integrate the vocational education system into the PV supply chain to answer the problem related to the PV application in Indonesia. The research was focused on the Vocational High School (VHS). The analysis is conducted on various data of the VHS: its number, its spatial distribution, and its program to develop the student's expertise. The study shows that VHS has opportunities to play a significant role in developing the PV industry in Indonesia. It can be realized systemically not merely for skilled labor provision but also to increase the production capacity of various PV system components.

1. Introduction

Indonesia implements a new and renewable energy (NRE) target in the primary energy mix as outlined in the National Energy General Plan (Rencana Umum Energi Nasional - RUEN) of 23% by 2025 and 31% by 2050 [1]. The share of NRE only increased from 4.40% in 2015 to 9.15% in 2019. It is below the Indonesian national target from 9.82% to 12.20% [2]. Meanwhile, based on Indonesia's national goals in the SDGs, Goals 7-Clean and Affordable Energy, the achievement also did not reach the target at about 10%-16%. In 2019, the primary energy mix was still dominated by oil (33.58%) and coal (37.15%) [2].

By 2017, at least Indonesia installed 616 photovoltaics (PV) powerplant used for rural electrification. To meet the target, PV contributes 6,500 MWp in 2025 and 45,000 MWp in 2050. In 2050, the capacity of PV should be the largest compared to other NRE technologies such as hydropower, geothermal, wind, and bioenergy powerplant [1,3].



The PV market in Indonesia is predicted to grow continuously. One analysis state that the value of PV projects in Indonesia by 2025 could reach at least USD 769.3 million [4]. Indonesia is growing as a bigger and more attractive PV market. Some schools already used PV energy resources [5].

In 2019, global employment in the renewable energy sector reached around 11.5 million, increasing compared to 2018 going 11 million. From this figure, the PV industry continues to be the largest employer providing approximately 3.8 million jobs (33%). In 2019, 87% of employment in the PV industry was concentrated in the ten countries leading PV production and installation. As a leading country for PV production and utilization, China was a significant provider of employment, reaching 2.2 million jobs (more than half of the world's total) [6]. Although growing as a big market of PV, Indonesia is not in the top 10.

Furthermore, there were many problems in operational and maintenance (O&M) faced by PV systems in rural areas. Many PV powerplants, for example, in Bali, Daerah Istimewa Yogyakarta, and West Timor [7], did not operate or faced severe problems due to component breakdown. Most of the damages occurred due to technical factors or overload. Further exploration showed that the problem occurred due to the incapability of the PV management to understand how to manage PV powerplants properly. In some cases, PV consumers assume that the PV electricity from the government is free. Therefore, there was no awareness of paying electricity fees to maintain the sustainability of the system. The ability of the system to deliver electricity and generated benefits (benefit sustainability) is still an essential issue in the PV applications in Indonesia.

One of three pillars in the energy trilemma is each country's energy security demand ability to fulfill its energy need in any circumstances. It includes the power of the country to diversify the energy supply in its energy mix and minimize its dependence on energy imports. However, currently, one of the challenges still faced by Indonesia is the relatively low ability of the national industry to meet the need for renewable energy technology. The import component of renewable technology is still high. Therefore, it is necessary to carry out a comprehensive systematic effort to prevent the transition from dependency on oil import to dependence on importing renewable energy.

This study explored the opportunity to integrate the vocational education system more intensively into the PV supply chain to answer the problem related to the PV application in Indonesia. The research was focused on the Vocational High School (VHS).

2. Method

The initial process is problem identification related to PV development in Indonesia. Furthermore, literature studies were conducted to find the root which causes the problem and options to solve it, which is a relatively new approach. This approach includes exploring an opportunity to integrate the vocational education system into the PV supply chain more intensively.

The research is focused on the VHS. The data to be explored includes the number of the VHS and its spatial distribution and its focus on student competence building. The data was collected online through various credible sources, such as related ministries. The collected data and associated references were elaborated to formulate a solution to the problem.

3. Results

To overcome this problem, it is necessary to increase the capacity of the national renewable energy industry. This capability needs to be improved in all parts of the renewable energy supply chain, which is the PV supply chain in the context of this paper.

Renewable energy development can create more jobs compared to that provided by fossil powerplant development [8]. For instance, the PV system offers jobs for around 7 to 11 people per MW power installed. Meanwhile, the coal and natural gas power plants require an average of one appointment per MW.

Figure 1 shows an overview of the renewable energy supply chain, including PV. The whole supply chain is divided into four parts, 1) supply, 2) manufacturing, 3) distribution, and 4) use [9]. The number of jobs provided by renewable energy development will partly determine by an ability to play an active

role in each component of the supply chain. The service business, which will primarily fill the needs in the distribution and demand sides, can offer design, sale and purchase, installation, and maintenance services.

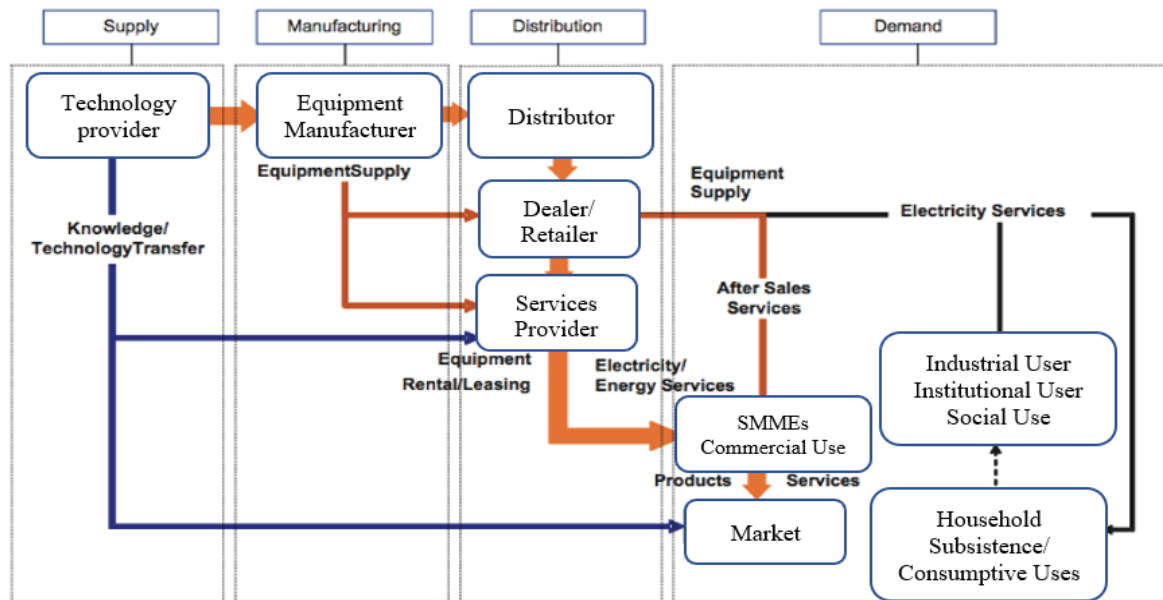


Figure 1. Renewable Energy's Supply Chain [7]

Meanwhile, education that trains and educates individuals as skilled workers to be employed in the industrial, commercial, and service sectors is said to be the goal of vocational-technical education (VTE) [10]. VTE students are also said to have the potential to become excellent individuals with the skills they have through training that has been taught at schools [11]. Moreover, evidence showed a correlation between a country's vocational education level and its economic growth [12, 13]. Countries with better levels of vocational education have been shown to have better economic growth.

In Indonesia, VHS provides a formal vocational education focused on various expertise programs such as mechanical engineering, electrical engineering, automotive, and others [14]. The further direct study of VHS students at the higher education level is a polytechnic and diploma program.

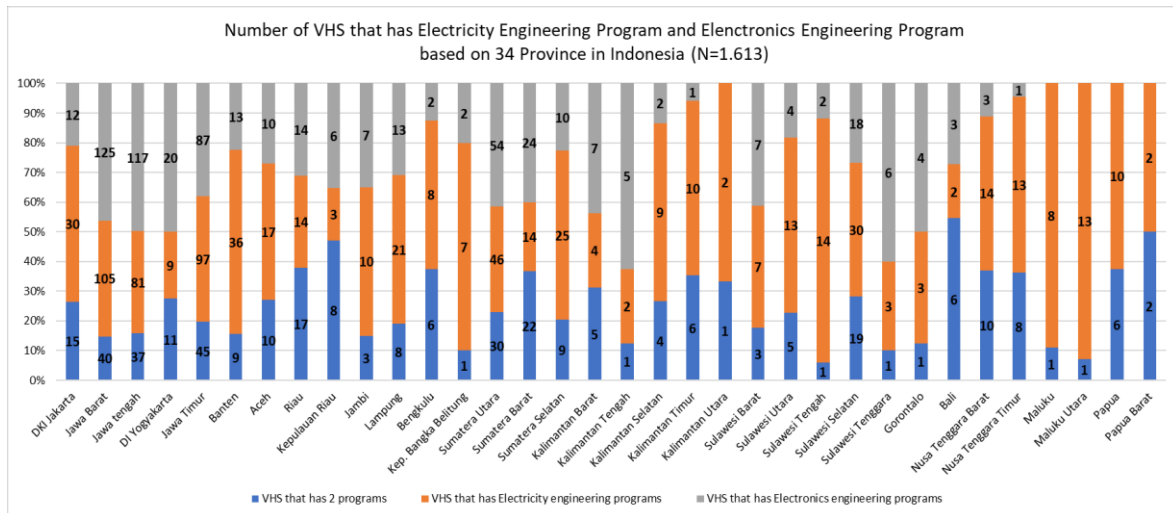
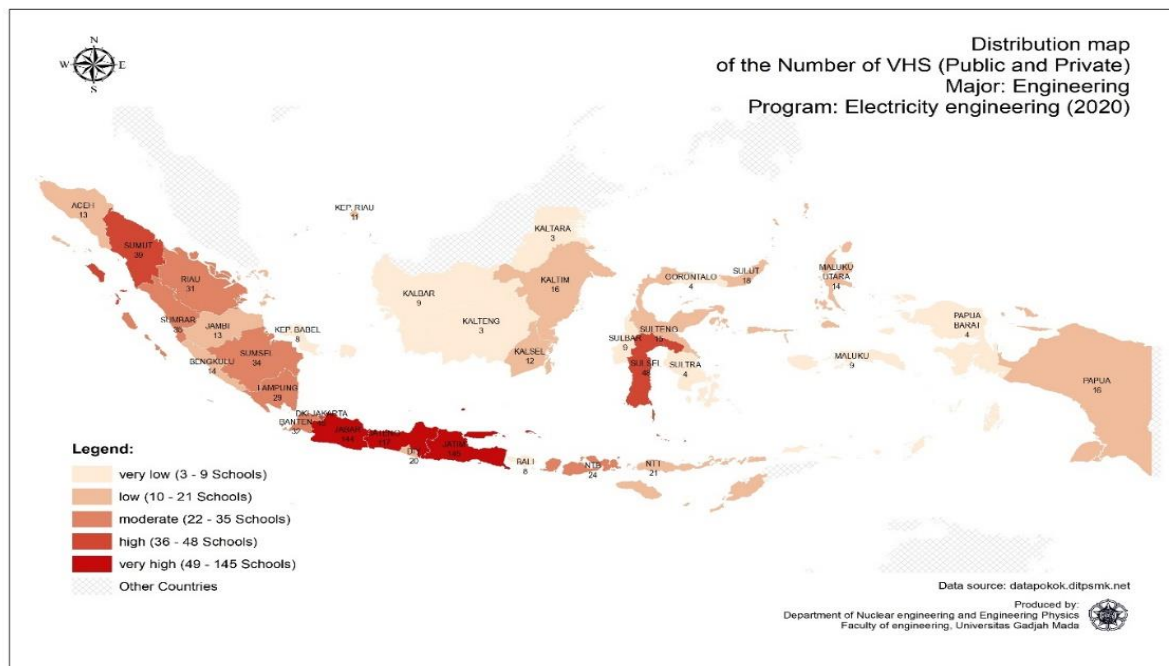
Based on datapokok.ditpsmk.net, there are 146 majors in VHS in Indonesia. This research focused on electronics engineering and electrical engineering majors suitable for integrating into the PV supply chain in Indonesia. There are 1613 VHSs in these two majors. There are 55 more private VHSs (51.70%) in these two majors than public VHSs (48.30%). More detailed information on the number of VHSs in these majors is shown in Table 1. The Table shows the VHSs, which provide electrical engineering, electronics engineering, or both of them.

VHSs with one or two of these programs are spatially distributed throughout Indonesia, as shown in Figure 2. The highest number of VHSs are in the West Java Province. The number of VHSs with the Electricity Engineering program in West Java is 105 schools, followed by East Java with 97 schools and Central Java with 81 schools. The three top provinces which have the highest number of VHSs managing the Electronics Engineering program are West Java (125 schools), Central Java (117 schools), and East Java (87 schools).

The highest number of VHS with these two programs is found in West Java with 270, followed by Central Java with 235 schools and East Java with 229 schools. The distribution of schools in these two majors in Indonesia is shown in Figure 3 and Figure 4.

Table 1. Number of VHS that has electrical engineering and electronics engineering.

No	Variable	Number of VHS
1.	VHS has an electrical engineering program	1034
2.	VHS has an electronics engineering program	931
3.	VHS has electricity and electronics engineering program	352

**Figure 2.** Number of VHS that has Electricity engineering and Electronics engineering Programs**Figure 3.** Distribution of VHS for Electricity engineering program in Indonesia

The VHS program in the two majors run departments that develop renewable energy expertise, including PV. It can be seen that the curriculum of VHS provides a solid foundation for accelerating the provision of reliable human resources in the department of the PV industry.

4. Discussion

Various data clearly show an increasing trend in the role of renewable energy, including PV systems. It needs to be planned and appropriately implemented to invest in the renewable energy sector, a vital enabler in generating continuously new green jobs. The mass scale of green jobs can increasingly appear in any part of the supply chain of the renewable energy system.

Various innovations, even business model disruptions, continue to develop in line with the increase in PV utilization with different technical configurations. Big businesses that have promising opportunities to grow include business on maintenance services. It is a bright prospect for skilled labor to fill this opportunity.

Table 2. Expertise in VHS.

No	Code	Department
1	1165	Power generation engineering
2	1814	Electrical Installation of Power Engineering
3	1823	Electrical Network of Power Engineering
4	1903	Hydropower plant
6	1912	Solar and wind power plant
7	1929	Biomass power plant

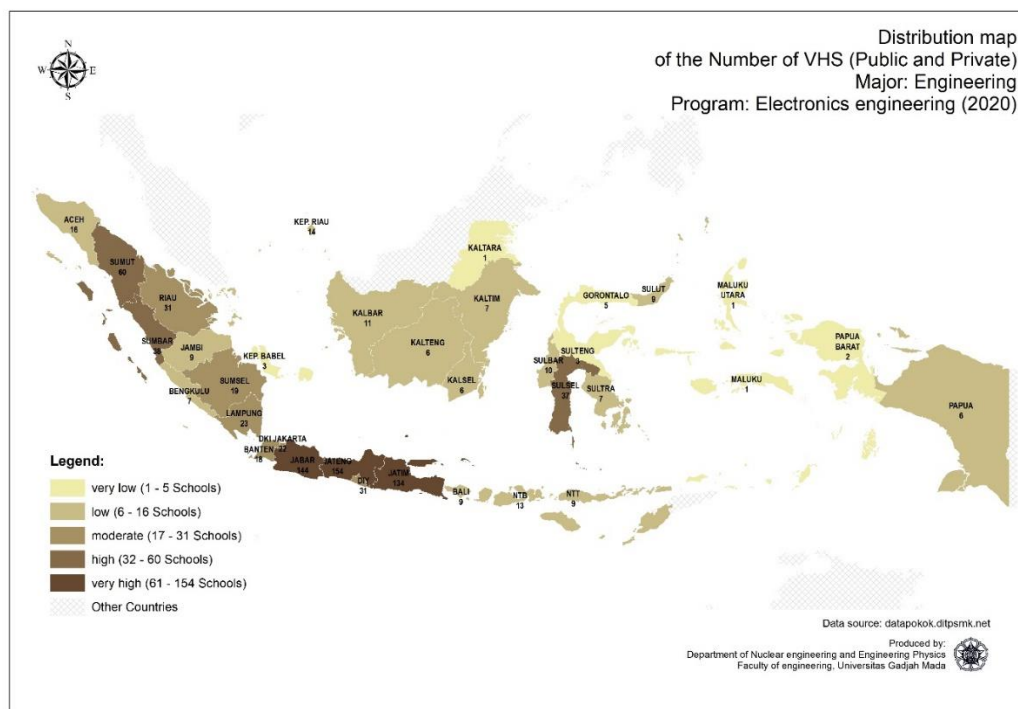


Figure 4. Distribution of VHS for Electronics engineering program in Indonesia

Meanwhile, currently, the PV component manufacturing industry is still concentrated in a few countries. However, through appropriate policy support, specific components and assembly activities can become an integral part of the decentralized local industry. Many countries, including Indonesia, can enjoy the broad benefits of PV utilization in job creation: manufacturing, project development, sales, distribution, construction, installation, operation, and maintenance.

As a part of the Indonesian education system, the VHS has opportunities to play a significant role in developing the PV industry in Indonesia. VHS can contribute in various sides, including the solar panel assembly industry, producing some components of the system, construction work, and service providers in operation and maintenance.

Affirmation for VHS students and graduates needs to be provided to strengthen the national PV industry further. It can be realized systemically not limited to skilled labor provision but also to increase the production capacity of various PV system components. Many VHSs already have laboratory/workshop facilities that are suitable for teaching/ training. These multiple facilities can be upgraded in capacity and management to become centers for repairing and producing various PV components. Production can be started with, for example, inverters and controllers of a specific size. This could be developed as production unit which is integrated with the business line of the state-owned enterprise. Furthermore, the VHS-based business unit could also play interesting role in accelerating renewable energy development and its related business activities in province level.

The systemic affirmation could be provided by well-orchestrated policy and implementing programs of, for at least four Indonesian ministers: 1) Ministry of Education, Culture, Research and Technology; 2) Ministry of Manpower; 3) Ministry of Industry as well as 4) Ministry of State-Owned Enterprise. The support could be provided by private and banking sectors. The local government has also capability in developing support for the VHS-based renewable energy business schemes.

5. Conclusion

VHS has opportunity to play a significant role in the PV industry in Indonesia. Among the existing programs in HVS that can be basis for the development include power generation engineering, Electrical installation of Power Engineering, Electrical Network of Power Engineering, and Solar Power Plant. It can be realized systematically for skilled labour provision and production of various PV system components. A well-coordinated development of policies and it implemented from various ministers and other related stakeholder could provide strong enabling environments for realizing this opportunity of VHS.

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