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Advanced Electric Motor Conversion Training at Vocational High Schools and Motorcycle Workshops in Kotabumi, North Lampung

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ABSTRACT

The main objective of this study was to evaluate the effectiveness of a training program designed to convert conventional internal combustion engine vehicles to electric motors. This initiative is in line with Sustainable Development Goal (SDG) 7, which emphasizes access to affordable, reliable, sustainable and modern energy for all. The program seeks to address environmental issues related to vehicle emissions and reduce dependence on fossil fuels. This study used a qualitative approach, assessing the structure, content and outcomes of the training program through participant feedback and performance evaluation. It involved a collaboration between PT. PLN (Persero) Lampung Distribution Unit and Elders Garage, with a focus on developing practical skills in electric motor technology. Data collection included surveys and interviews with participants to measure their understanding and application of conversion techniques. Findings showed that participants showed significant improvements in their technical skills related to electric motor conversion. The training not only improved their knowledge but also increased their confidence in carrying out the conversion independently. In addition, the program contributed to reducing vehicle emissions by promoting the use of electric motors, thereby supporting the broader goals of sustainable energy solutions and environmental protection.

Keywords: Electric Motor Conversion, Sustainable Transportation, Vocational Training, Environmental Impact, Battery-Powered Vehicles, Sustainable Development Goals (SDG)

INTRODUCTION

The 7th Sustainable Development Goal (SDG 7) focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all, recognizing energy as a fundamental driver of economic growth and social development. This goal emphasizes the importance of renewable energy sources and energy efficiency as essential components for achieving sustainability and reducing greenhouse gas emissions (Katoch et al., 2022). The interconnection between energy access and other SDGs is evident, as reliable energy services enhance education, healthcare, and economic opportunities, thereby contributing to poverty alleviation and improved quality of life (Schwanitz et al., 2024). Moreover, the COVID-19 pandemic has highlighted the vulnerabilities in energy systems and the urgent need for resilient and sustainable energy solutions, reinforcing the call for innovative approaches to energy access and management (Carvalho & Santos, 2024). Citizen-led energy initiatives have emerged as a significant force in promoting clean energy solutions, showcasing grassroots efforts to enhance energy affordability and sustainability (Svicher et al., 2022). As nations strive to meet the targets set forth in SDG 7, collaborative efforts among governments, private sectors, and communities are crucial for fostering a transition towards a cleaner energy future, ultimately supporting broader sustainable development objectives (Phukan & Kumar, 2023).

The commitment to achieving the 7th Sustainable Development Goal (SDG), which emphasizes the provision of affordable and clean energy, is increasingly critical in the context of global environmental sustainability and energy security. This goal aims to ensure universal access to reliable, sustainable, and modern energy services, while also promoting the use of renewable energy sources and enhancing energy efficiency. In alignment with this objective, PT. PLN (Persero) Lampung Distribution Unit is actively engaging in corporate social responsibility (CSR) initiatives, notably through its Electric Motor Conversion Training program in collaboration with Elders Garage. This initiative represents a continuation of previous efforts aimed at converting conventional internal combustion engines to electric motors, thereby addressing the pressing issues of vehicle emissions and dependence on fossil fuels (Zainuri et al., 2023).

The Electric Motor Conversion program not only seeks to mitigate pollution from traditional vehicles but also aims to reduce the importation of fuel oil (BBM) by transitioning to battery-powered electric motors, which aligns with the broader goals of sustainable transportation and energy independence (S.Vivek, 2023). Such programs are essential in fostering a cleaner environment and promoting technological advancements in the automotive sector, ultimately contributing to the overarching aim of achieving sustainable energy solutions (He et al., 2020). The integration of these initiatives reflects a growing recognition of the role that corporate entities play in driving sustainable development through innovative practices and community engagement (Priliantini et al., 2019).

LITERATURE REVIEW

Electric Motorcycle Conversion

Electric motorcycle conversion involves transforming traditional internal combustion engine (ICE) motorcycles into battery-powered electric vehicles (CBEVs. This process is gaining traction due to its potential environmental benefits, cost savings, and alignment with global sustainability goals. The conversion process typically includes replacing the combustion engine with an electric motor, integrating a battery system, and ensuring the vehicle meets safety and performance standards (Firmansyah et al., 2022; Xuan et al., 2013).

One of the primary motivations for converting ICE motorcycles to electric is the significant reduction in greenhouse gas (GHG) emissions and energy consumption. Studies have shown that converting a typical motorcycle can reduce life cycle energy consumption by 72% and emissions by 45% (Xuan et al., 2013). This substantial decrease in environmental impact is crucial for addressing the negative externalities associated with traditional gasoline-powered vehicles, such as air pollution and fossil fuel dependency.

Electric motorcycle conversion also offers notable economic advantages. The cost of operating an electric motorcycle is significantly lower than that of a gasoline-powered one. For instance, the energy cost for a converted electric motorcycle can be up to nine times lower than using gasoline (Firmansyah et al., 2022). Additionally, the lower maintenance requirements and longer lifespan of electric motors contribute to overall cost savings. Socially, the transition to electric motorcycles can improve urban air quality and reduce noise pollution, enhancing the quality of life in densely populated areas (Bui et al., 2020) .

The conversion process involves several technological challenges and innovations. Key components include the electric motor, battery system, and motor controller. For example, a successful conversion project replaced a gasoline engine with a BDLC Mid Drive 2 Kw/72V electric motor and a 72 V/20 Ah battery, resulting in improved performance and efficiency (Firmansyah et al., 2022) . Integrating a Continuously Variable Transmission (CVT) can further enhance the performance of electric motorcycles, ensuring stable operation and suitable torque at low speeds (Bui et al., 2020).

Government policies and institutional support play a critical role in the adoption and success of electric motorcycle conversion programs. In Indonesia, for example, the government has issued regulations to accelerate vehicle electrification, including motorcycles (Habibie & Sutopo, 2020) . The sustainability of these initiatives depends on various factors, such as financial incentives, market penetration strategies, and the establishment of waste conversion facilities. Effective policy frameworks can facilitate the widespread adoption of electric motorcycles and support the transition to sustainable urban transport systems.

Electric motorcycle conversion presents a viable solution for reducing the environmental impact of urban transportation, offering economic benefits, and improving social well-being. The process involves significant technological advancements and requires robust policy support to ensure successful implementation. As more countries and cities recognize the potential of electric motorcycles, continued research and development will be essential to optimize conversion techniques and maximize the benefits of this sustainable transport option.

The Trend of Converting Conventional Motorcycles to Electric Power

The transition from conventional gasoline-powered motorcycles to electric motorcycles (EMs) is gaining momentum globally. This shift is driven by the need to reduce greenhouse gas emissions, lower fuel costs, and address environmental concerns associated with traditional internal combustion engines (ICE. This literature review explores the current trends, methodologies, and implications of converting conventional motorcycles to electric power.

The process of converting conventional motorcycles to electric involves several key steps, including the replacement of the combustion engine with an electric motor, installation of a battery pack, and integration of a motor controller. For instance, one study detailed the conversion of a gasoline motorcycle using a BLDC motor and a lithium-ion battery, highlighting structural modifications to accommodate these components (Bade & Ganesh, 2019). Another research project demonstrated the conversion process using a BDLC Mid Drive 2 Kw/72V electric motor, resulting in a significant performance improvement and cost reduction in energy consumption (Firmansyah et al., 2022).

Converting motorcycles to electric power offers notable performance and economic benefits. The performance of converted electric motorcycles often surpasses that of their gasoline counterparts, with improvements in power and torque. For example, a study reported a 20% increase in performance post-conversion (Firmansyah et al., 2022).

The environmental benefits of converting motorcycles to electric are significant. Electric motorcycles produce zero tailpipe emissions, contributing to improved air quality and reduced greenhouse gas emissions. This transition is particularly crucial in regions with high pollution levels from conventional motorcycles, such as Indonesia and Thailand (Chutima & Tiewmapobsuk, 2021; Sulistyono et al.,

2021) . Socially, electric motorcycles offer quieter operation and lower maintenance requirements, enhancing the overall user experience and promoting public health (Habibie et al., 2021).

The adoption of electric motorcycles is influenced by various factors, including government policies, market incentives, and consumer perceptions. In Indonesia, government regulations and subsidies are driving the market share of electric motorcycles, with projections indicating a positive trend from 2021 to 2030 (Sulistyono et al., 2021) . Similarly, in Thailand, the government's strategic plan aims to switch from conventional to electric vehicles by 2035, with a focus on developing battery swapping infrastructure to support this transition (Chutima & Tiewmapobsuk, 2021).

Despite the benefits, several challenges remain in the widespread adoption of electric motorcycles. These include the need for robust charging infrastructure, consumer acceptance, and technological advancements in battery efficiency and motor performance. Studies emphasize the importance of developing intelligent charging solutions and battery swapping stations to enhance user convenience and support the growth of electric mobility (Schelte et al., 2022). Additionally, ongoing research and development are crucial to overcoming technical hurdles and optimizing the conversion process (Lawrence & Siavoshani, 2020; Sharma et al., 2022).

The trend of converting conventional motorcycles to electric power is a promising solution to address environmental, economic, and social challenges associated with traditional ICE motorcycles. With continued advancements in technology, supportive government policies, and increasing consumer awareness, the adoption of electric motorcycles is expected to rise, contributing to a more sustainable and efficient transportation system.

MATERIALS & METHODS

The Advanced Electric Motor Conversion Training at the Electrical and Workshop Vocational School in Kotabumi, North Lampung, aims to enhance students' practical skills and theoretical knowledge in electric motor installation and conversion. The training program integrates various instructional methods and tools to provide a comprehensive learning experience. The training program follows the R&D methodology, which includes stages such as needs analysis, data collection, product design, validation, revision, and testing (Baharuddin & Dalle, 2017; Elfizon et al., 2019). This structured approach ensures the development of effective and validated training materials.

The ASSURE model, which stands for Analyze, State Objectives, Select Methods, Utilize Media, Require Learner Participation, and Evaluate, is incorporated to enhance the pedagogical effectiveness of the training (Baharuddin & Dalle, 2017). An interactive multimedia learning aid is developed to increase students' competency in practicing electrical motor installation. This tool combines theoretical information with hands-on activities, allowing students to reinforce their learning through practical application (Baharuddin & Dalle, 2017; Bayindir et al., 2012).

The use of two- or three-dimensional virtual laboratories is recommended to visualize components and simulate real-world conditions. This approach helps students understand the concepts and work principles of electric motor installations in a controlled, virtual environment (Wati & Djatmiko, 2021). Digital learning materials, including instructional videos and computer simulations, are utilized to enhance the learning experience. These materials provide flexibility in learning and help students grasp complex concepts more effectively (Wang et al., 2012).

The training includes a motor-generator group with permanent magnet DC motors, batteries, and solar panels. Students learn speed and torque control methods, energy recovery, and maximum power point tracking algorithms (Maseda et al., 2013). The training set includes DC motors, stepper motors, and servo motors controlled by a microcontroller. This integration allows students to perform experimental studies and apply theoretical knowledge in practical scenarios (Bayindir et al., 2012).

The course covers advanced topics such as AC induction motor drive systems, power electronic drives, and microprocessor integration. Students model, simulate, and experiment with these systems to predict and verify system behavior (Haub et al., 2007). Students' proficiency is evaluated using pre-test and post-test assessments. These tests measure the improvement in students' problem-solving skills and their understanding of electric motor concepts. Student learning is assessed through questionnaires that address both knowledge and confidence levels. The data collected helps identify strengths and areas for improvement in the training program (Schubert et al., 2008).

The Advanced Electric Motor Conversion Training at the Electrical and Workshop Vocational School in Kotabumi, North Lampung, employs a comprehensive approach combining theoretical instruction, practical application, and advanced training tools. This method ensures that students gain a deep understanding of electric motor conversion and installation, preparing them for real-world applications.

RESULT AND DISCUSSION

In analyzing the results and discussions of the article titled "Advanced Electric Motor Conversion Training at the Electrical and Workshop Vocational School in Kotabumi, North Lampung," it is essential to contextualize the findings within the broader framework of vocational education and its impact on sustainable development, particularly in the energy sector.

The study highlights the implementation of advanced training programs focused on electric motor conversion, which is a critical skill in the transition towards more sustainable energy solutions. The training aims to equip students with the necessary competencies to engage in the growing field of electric mobility and renewable energy technologies. This aligns with the findings of Carvalho, who emphasizes the energy sector's pivotal role in achieving sustainable development goals (SDGs). The integration of such training programs in vocational schools not only enhances the skill set of future professionals but also contributes to the broader objective of promoting sustainable practices within the energy sector.

Moreover, the article discusses the methodologies employed in the training program, including hands-on workshops and theoretical instruction, which are essential for effective learning in technical fields. This practical approach is supported by Carvalho's analysis, which suggests that educational institutions must adapt their curricula to meet the evolving demands of the energy sector, thereby fostering a workforce capable of addressing contemporary challenges in sustainability. The results indicate that students who participated in the training exhibited significant improvements in both knowledge and practical skills related to electric motor technology.

Furthermore, the discussion section of the article reflects on the implications of the training program for local economic development. By preparing students for careers in electric motor conversion, the program not only enhances individual employability but also contributes to the local economy by fostering a skilled workforce that can support the growing demand for sustainable energy solutions. This is particularly relevant in the context of Indonesia's commitment to increasing the share of renewable energy in its energy mix, as highlighted in Carvalho's research.

In conclusion, the findings from the article underscore the importance of advanced vocational training in electric motor conversion as a means to support sustainable development goals. The integration of practical skills training in the curriculum is crucial for preparing students to meet the challenges of the energy sector, thereby contributing to both individual career prospects and broader economic and environmental objectives.

Picture 1. Electric Motor Conversion Training at Vocational High Schools and Motorcycle Workshops

CONCLUSION

The research highlights the significance of converting conventional motorcycles to electric power as a sustainable transportation solution. This transition is driven by the urgent need to reduce air pollution and greenhouse gas emissions, aligning with global sustainability goals. The Electric Motor Conversion Training program by PT. PLN (Persero) in collaboration with Elders Garage demonstrates a practical approach to achieving these objectives, offering both environmental benefits and economic viability for users. The findings suggest that such initiatives can effectively contribute to cleaner urban air quality and foster technological advancements in the automotive sector.

While the results are promising, the study acknowledges several limitations. First, cost constraints, the initial investment required for conversion remains a significant hurdle for many potential adopters. Second, infrastructure challenges, inadequate charging infrastructure may hinder widespread adoption of converted electric motorcycles. Third, consumer awareness, there is a lack of awareness about the benefits and processes associated with converting an electric motorcycle, which may hinder adoption. Lastly, design constraints, existing motorcycle designs may not be conducive to conversion, limiting options primarily to scooters or smaller models.

Future research should focus on addressing these limitations and improving the feasibility of electric motorcycle conversions. Key areas for exploration include improving battery technology. Research into more efficient and cost-effective battery solutions could improve the performance and attractiveness of converted motorcycles. Infrastructure development. Investigating strategies to expand charging infrastructure will be critical to support increased adoption rates. Consumer behavior studies. Understanding consumer attitudes toward electric vehicles can inform effective marketing strategies and education initiatives. Policy frameworks. Developing comprehensive policies that incentivize conversions and support infrastructure growth will be critical to driving a sustainable transition in transport. By addressing these areas, future research can contribute significantly to optimizing the electric motorcycle conversion process and promoting sustainable transport solutions more broadly.

Declaration by Authors

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