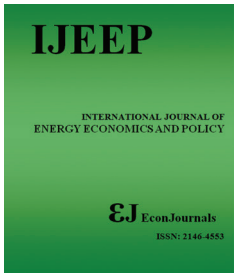

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Green Tech and Human Dynamics: Transforming Indonesia's Waste Industry with VR, AR, and Renewable Energy Innovations

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ABSTRACT

The objective of this study is to assess the impact of implementing virtual reality technology, augmented reality, renewable energy, and green leadership on industrial sustainability in waste management in Indonesia. Additionally, this study aims to examine the role of HR attitudes as a moderating variable in this context. The study focuses on leaders of large and medium-sized companies in Indonesia in 2022. The study examines several variables, including virtual reality, augmented reality, the application of renewable energy, and the application of green leadership. The study also considers exogenous variables such as industrial sustainability in waste management in Indonesia, and moderating variables such as HR behaviour. The data analysis employs SEM analysis using SMART PLS 3.0 software. The study methodology employed entails a quantitative descriptive approach utilising data analysis through the structural equation model (SEM) method. The data processing using the SEM method is conducted with the PLS application. Based on the findings of previous studies, it can be inferred that virtual reality, augmented reality, renewable energy, and green leadership have a partial impact on the sustainability of industrial businesses involved in waste treatment in Indonesia. Additionally, these variables also influence the behaviour of HR in responding to technological changes and the adoption of renewable energy in waste management companies in Indonesia. The variables of virtual reality, augmented reality, renewable energy, and green leadership have a simultaneous impact on the sustainability of industrial businesses involved in waste treatment in Indonesia. This impact is mediated by the HR behaviour in response to changes in technology adoption and the use of renewable energy in waste management companies in Indonesia. By implementing virtual reality and augmented reality technologies, as well as embracing the latest energy solutions and fostering a green leadership mind-set, companies can drive changes in human resource behaviour. This will enable employees to continuously adapt to technological advancements, particularly in smartphone applications, and leverage them to enhance existing businesses and ensure their sustainability. Moreover, the promotion of green energy will induce a shift in human resource practices towards consistently utilising eco-friendly energy sources and embracing sustainable leadership models within each organisation. This will ensure the long-term survival of the organisations and mitigate environmental harm caused by global warming.

Keywords: Virtual Reality, Technology, Augmented Reality, Renewable Energy, HR Behaviour, Business Sustainability
JEL Classifications: B22, F38, H21, G21, G32, G33

1. INTRODUCTION

In order to ensure the long-term viability of a company, it is necessary to introduce an innovative approach. This process involves implementing principles, guidelines, and procedures that pertain to organizational structure, work arrangements, and working conditions. These measures will ultimately contribute to the overall sustainability of the organization and its operations (Subakti et al., 2023). The innovation process for company sustainability is implemented to ensure the company's survival amidst challenging circumstances that restrict its resources for managing existing changes. This necessitates a high level of adaptability, which in turn requires extensive innovation to prevent other parties, particularly competitors, from replicating our business strategy and probing the company's adaptability (Ikhasari and Faturohman 2021). The current adaptation process involves the company's adjustment to technology transfer and innovation in order to mitigate the impact of global warming caused by climate

change. This is not only a concern for Indonesia, but also for the rest of the world. Consequently, a strategic shift is necessary to prevent competitors from adopting technologies that could disrupt the company's operations. Specifically, the company needs to adapt its production processes to reduce carbon emissions and embrace environmentally friendly technologies. This will enable the company to produce goods that contribute to carbon emission reduction and help prevent further global warming caused by climate change (Al-Ghazali and Afsar, 2020).

Companies should now incorporate their technological advancements into eco-friendly technologies, such as the integration of virtual reality technology. This technology is considered a groundbreaking innovation in human-computer interaction. This technology provides users with a more immersive and engaging experience compared to conventional technologies. Consumer-based technologies refer to outdated industrial machinery that certain companies continue to utilize for production. These machines significantly contribute to the rise in carbon emissions, posing harm not only to the company itself but also to its consumer base (Chien et al., 2017). This virtual reality technology facilitates consumers' immersion in a virtual corporate setting, including the advent of virtual marketing distribution channels offering a wide range of environmentally friendly products. This is achieved through the utilization of digital technology devices, such as software and hardware, as well as devices associated with the digital realm, such as those utilizing 4G or 5G technology. These advancements enable companies to streamline tasks and operations, resulting in reduced carbon emissions and mitigating the effects of global warming. This is achieved by phasing out outdated technologies that contribute to climate change and global warming (Nara et al., 2021). Virtual reality encompasses a wide range of digital material, and in recent years, there has been a significant increase in both the quantity and quality of content accessible in VR.

Several companies have made significant investments in the creation of engaging and practical virtual reality (VR) content. Furthermore, virtual reality (VR) technology provides users with an exceptionally remarkable visual and sensory encounter that creates the illusion of being immersed in an environment that is distinctly dissimilar from the physical world (Ullah et al., 2021). A side from Virtual reality (VR) technology, there exists an alternative known as augmented reality (AR) technology. AR is a fusion of the real world and the virtual world, incorporating virtual elements such as images, text, video, 3D, and other advanced components that surpass the capabilities of VR technology. Furthermore, augmented reality technology presents a virtual representation of the physical world through digital devices. This includes various environments such as the company setting, supplier setting, company distributor setting, and marketing link setting, which may include shops, kiosks, and stalls that mimic real-world retail spaces. Additionally, the production environment is digitally connected to the AV programmed, despite existing in the digital realm (Taghizadeh-Hesary et al., 2020). The advancement of VR and AR technology has brought about significant transformations in systems, organizational functions, and work processes that previously relied on manuals. With the progress of digital technology, consumers no longer face difficulties in finding market links for company-produced products. This is because all aspects of the company's operations have become interconnected, fostering unity between different regions and departments. As a result of this innovation, the company is well-positioned to enhance its business and operational sustainability in the future (Junsheng et al., 2020).

In addition to technological adaptation, innovation is also being implemented in product production. The government is actively promoting the use of renewable energy in factory machinery and processing, particularly in the waste processing industry. It is crucial to manage existing waste responsibly to prevent harm to both local communities and the environment. Careless waste management not only exposes people to toxic waste, which can have detrimental effects on health, but also contributes to global warming, a growing concern. Therefore, it is our obligation to protect the environment, as the increasing air temperature poses a threat to personal health and well-being (Rahmayanti et al., 2019). The company utilizes waste processing techniques to transform it into clean energy, which can be harnessed for industrial and community needs. This renewable energy can be used to produce fuel, generate electricity, and serve other beneficial purposes for the community (Masri et al., 2017). Renewable energy, often known as green energy or renewable energy, is energy derived from abundant and sustainable natural resources. Conversely, fossil energy is obtained from limited fossil fuels like coal, gas, and oil. Renewable energy is widely seen as a more sustainable alternative with little environmental repercussions (Stanaya et al., 2022).

Nature offers various renewable energy sources that can be harnessed for human benefit. One such source is solar energy, which can be amplified by utilizing waste processing to generate power for solar plants. Additionally, this processed waste can be used as fuel to power factory machinery and motorized vehicles (Elshaer et al., 2021). Renewable energy, such as water energy, is harnessed to power factory turbine engines and generate electricity. Additionally, wind energy is used to drive turbines and power factory machinery. Geothermal energy, ocean current energy, biomass, and bio thermal energy are also sources of renewable energy. Biomass and bio thermal energy are derived from wood waste, agricultural waste, and river waste, which are processed in an environmentally friendly manner. These renewable energy sources are utilized to benefit the community, reduce carbon emissions, and mitigate global warming (Mathiyazhagan et al., 2021). The rise of technological innovation and the adoption of renewable energy will impact human resource behavior in the utilization of digital applications and renewable energy. Consequently, individuals in the workforce must be receptive to the growing role of digital applications within companies, particularly in the sewage treatment industry. Workers must be willing to adapt to prevailing circumstances in order to enhance company performance and promote the long-term viability of the sewage industry (Burrichter et al., 2022).

By embracing digital applications, companies aim to encourage human resources to actively engage with and explore the use of

digital technologies for enhanced work efficiency. This includes facilitating the transfer of technology to improve the quality and capabilities of the workforce (Guo et al., 2019). Human resources must consistently be responsive and adaptable in enhancing their skills and facilitating the transition from outdated to modern technology within their respective companies. This is particularly crucial in the waste treatment industry, where a seamless adaptation process is necessary for employees to effectively utilize and implement new technologies. It is imperative for these individuals to continuously enhance their capabilities and comprehension of these applications (Loizodou et al., 2021). Human resources that fail to adapt and enhance their capacity to adopt applications will be marginalized. Therefore, it is imperative to possess comprehensive skills and comprehension of application usage, which can yield benefits not only for the individuals themselves but also for the community at large (Kerin and Mairi 2021) (Kerin and Pham 2019). Human resources must maintain a constant awareness of the need for cost-effective, clean energy resources in both the company and community environments. This includes avoiding water, soil, and air pollution, as high pollution levels can negatively impact both health and the long-term sustainability of human life.

Climate change resulting from such pollution can lead to irregular weather patterns, natural disasters, and environmental damage in both the company and household settings (Margallo et al., 2019). The degradation of the environment will profoundly affect human existence and well-being. The escalating release of carbon emissions will lead to the deterioration of the natural environment, resulting in the occurrence of natural disasters caused by ecological imbalances. These events will impose substantial losses on society, while inadequate waste management practices will also harm both companies and the community (Mohammadi and Harjunkoski 2020). In light of the rise of virtual reality and augmented reality applications, as well as the growing importance of renewable energy, it is crucial for company leaders to establish policies that foster innovation in technology transfer and application. These policies should also be responsive to both the business and community environments, thereby necessitating green leadership. This type of leadership is essential for promoting technological innovation and advancing the utilization of renewable energy sources. By doing so, it can help prevent and minimize environmental harm, while also mitigating the effects of global warming (Ali et al., 2020). Indonesia, as a signatory of the climate change agreement, has committed to an annual reduction of carbon emissions by 20% in order to mitigate the effects of climate change and global warming on the planet (Sabokro et al., 2021) stated that This has led to a significant effort from both the government and industry, particularly those in waste management, to decrease reliance on fossil fuels and implement technical advancements in order to achieve a 20% reduction in carbon emissions (Ahmed et al., 2021).

Companies must lessen their reliance on ecologically unfriendly technology by implementing virtual technology that utilizes renewable energy derived from nature, resulting in a 20% decrease in carbon emissions (El Barhoumi et al., 2022). Medium and large enterprises that effectively manage their industrial waste are the ones who actively decrease their carbon emissions. An all-encompassing overview of medium and big industries in Indonesia can be obtained as follows:

In Table 1, it can be observed that the number of large and medium industries in Indonesia has been consistently decreasing over the past 5 years. This decline can be attributed to the influence of digital technology adoption, specifically the lack of utilization of virtual reality and augmented reality in the production department for operating factory machinery. Additionally, there is a lack of awareness regarding the reduction of carbon emissions through the use of renewable energy sources. It is worth noting that 60% of existing industries still rely on fossil energy, particularly coal power, which is detrimental to the environment. The industry's recognition of the need for green energy implementation in company operations is due to a deficiency in green leadership. Some companies or industries have failed to convert waste into useful resources for society. Consequently, the government will impose sanctions, such as licensed revocation, on companies that violate their commitments to reduce emissions and use environmentally unfriendly materials or energy. This is in line with research (Alzahrani and Alfouzan 2022) the current implementation of existing technology is hindered by its high costs. However, not adopting digital technology will negatively affect company performance, as companies now require increased production and capacity to meet demand. The study conducted by (Chams and García-Blandón 2019) indicates that as carbon emissions rise, there is a direct correlation with the increase in global surface temperature. This can lead to a disruption or imbalance in the current environmental conditions. Therefore, it is crucial to be mindful of utilizing energy sources that are environmentally friendly and do not cause destabilization, such as renewable energy.

2. LITERATURE REVIEW

2.1. Virtual Reality Technology

Virtual reality technology refers to the use of computer-generated simulations to create a realistic and immersive experience for users. Virtual reality (VR) technology provides users with a very immersive visual and sensory experience, creating the illusion of being in a completely different environment from the real world (Muisyo and Qin, 2021). Virtual reality (VR) is widely regarded as a momentous advancement in the evolution of human-computer interaction. When compared to traditional interfaces, it generates a more engaging and interactive experience (Reedy, 2023). Moreover, virtual reality exerts a substantial influence on the corporate realm, particularly in the domains of marketing, training, and education. Businesses and institutions utilize virtual reality

Table 1: Number of large and medium industries in Indonesia 2018-2022

Year	Total employment in the printing industry in Indonesia (Person)
2018	569
2019	604
2020	583
2021	570
2022	554

Source: bps.go.id, 2022

(VR) to enhance operational efficiency and enhance consumer involvement (Foo et al., 2023). (Foo et al., 2021) The following aspects and components are the main content or components of VR technology, namely: The main content and components of VR technology include the following aspects: A VR headset is an integral component of VR technology. This headset features a screen positioned in front of the user's eyes and is worn on the head. Consequently, a visually engaging and three-dimensional presentation is generated.

Furthermore, these headsets frequently incorporate motion sensors that track the user's head motions and automatically adapt the display accordingly. In VR, input devices are utilized to enable users to interact with the virtual world. A wide range of input devices are commonly employed for this purpose. These consist of joysticks, hand controllers, and other gadgets that allow users to interact with the virtual world. Virtual environment, when the virtual environment itself is the VR content. This setting can encompass a game, simulation, training facility, or any other interactive environment. These settings, whether they imitate real-world environments or are artificially constructed, are typically generated using VR production tools. The inclusion of 3D audio considerably enhances the VR experience. In order to enhance the realism and immersion of virtual reality, a 3D audio system is employed to generate sounds that appear to originate from certain directions. Motion sensors track the user's physical movements, including walking, running, and turning. Users have the ability to explore and engage with the virtual environment. VR content encompasses many experiences such as simulation, training, education, and entertainment. These encompass virtual reality video games, medical field training, tours, concerts, and other activities. To develop VR experiences and content, specific gear and platforms are necessary, such as high-performance computers, VR headsets, and input devices. Several virtual reality (VR) platforms exist, such as Oculus Rift, HTC Vive, PlayStation VR, and various more.

The creation and advancement of VR technology is the primary focus of numerous developers and technology businesses. These corporations encompass HTC, Sony, Oculus (now a division of Meta, previously known as Facebook), and numerous more technology companies. (Grigg, 2021) one of the indicators of the growing advancement of VR technology in these organizations is the increase in research and development (R&D) spending, since more companies are investing in VR-related research and development. This entails establishing dedicated research and development laboratories and devoting more funding to virtual reality activities. Industry collaboration involves the joint creation of virtual reality (VR) technologies, with technology companies frequently forming partnerships and collaborating with other businesses. The integration of Internet of Things (IoT), artificial intelligence (AI), and other related technologies can be included in these collaborations. These partnerships have played a crucial role in advancing VR standards, with numerous businesses making substantial contributions to the development of industry-wide VR standards and protocols. Examples of this include cooperation among members of the virtual reality community and advocacy for the adoption of open source standards. The sales and acceptability of VR products are important market indicators. The rise in sales of virtual reality (VR) equipment indicates a growing inclination among consumers towards this technology (Maddikunta et al., 2021).

2.2. Augmented Reality Technology

Augmented reality (AR) technology merges tangible parts of the physical environment with virtual or digital components to generate immersive experiences (Priyadarshini et al., 2020). *Smartphones*, tablets, AR glasses, and other gadgets that can project digital images or information onto the real world are used to perform this technique (Cremiato et al., 2018) Augmented reality technology is continuously developing and has the capacity to profoundly transform our interactions with the surrounding world, be it in entertainment, education, business, or other domains. Furthermore, AR is often regarded as a technology that facilitates the expansion of the Internet of Things (IoT) and mobile computing (Marks-Bielska et al., 2020). Augmented reality technology encompasses several crucial components, including the integration of virtual elements that enhance the real world. On the screen of an AR device, these can be photographs, text, movies, 3D models, or other elements. Augmented reality (AR) users interact with the real world by viewing it on their device screen. AR things, despite being presented on a device, retain the ability to interact with objects and individuals in their physical surroundings. AR commonly employs technology to identify and comprehend real-world objects and environments, facilitating interaction.

Consequently, augmented reality (AR) has the ability to precisely position virtual objects into their real-world environment. AR technology offers a wide range of applications across several disciplines. These topics encompass AR gaming, advertising, planning and design, education (interactive training, visual learning), healthcare (medical monitoring, surgical training), and other domains. AR experiences that are exclusive to particular AR devices, such as Microsoft HoloLens or Google Glass, are only available on specialized devices. Nevertheless, numerous augmented reality (AR) applications are compatible with commonly utilized devices like smartphones and tablets. AR is also employed in the realm of commerce and advertising, where it generates interactive advertisements that materialize when the user directs their smartphone camera towards a certain advertisement (Lee et al., 2020). The signs of implementing augmented reality in a firm include the development of customized AR applications, where companies either construct or utilize tailor-made AR applications to meet their specific business requirements. These applications can encompass customer experience, product visualization, maintenance enhancement, or training. AR can enhance business operations by improving employee training, equipment maintenance, product assembly, and supply chain management. Additionally, AR can be utilized to enhance customer service by offering visual instructions, integrating AR into in-store purchases, and providing remote technical assistance. AR can be utilized in marketing and promotion to enhance marketing campaigns, promote products, and facilitate consumer contact. Illustrations encompass location-based augmented reality marketing or augmented reality applications that enable

consumers to virtually experience products or services (Roscoe et al., 2019).

2.3. Renewable Energy

Renewable energy, also known as green energy, is derived from inexhaustible and sustainable natural resources. On the other hand, fossil energy is derived from limited fossil fuels like coal, gas, and oil (Nižetić et al., 2019). Sustainable energy sources are those that can be replenished naturally and indefinitely. Renewable energy sources, such as solar, wind, hydro, geothermal, and biomass, can be harnessed naturally and indefinitely, ensuring a continuous supply (Singh et al., 2020). When comparing conventional energy, which is obtained from fossil fuels, to renewable energy, it is commonly concluded that renewable energy has a lower environmental impact (Sinaga and Sitorus, 2023). Employing renewable energy sources can effectively mitigate environmental contaminants and greenhouse gas emissions (Syed Shaharuddin et al., 2021). Presented below are few illustrations of contemporary alternative energy sources: Solar Energy (Solar Power), wherein the sun supplies solar energy that can then be harnessed by solar panels to produce electricity (Agustina et al., 2023; Napitupulu et al., 2023). Solar power systems can be utilized for power generation in both commercial and residential settings. Wind turbines harness wind energy to generate power. While large-scale wind power facilities are prevalent, smaller wind turbines can also be employed to produce electricity for residential use. Another form of renewable energy is hydroelectric power generation, which harnesses the kinetic energy of moving water, such as rivers or waterfalls. Examples of dams and water turbines are provided. Geothermal energy is derived from the thermal energy produced by the Earth's heat.

At both local and big levels, it is utilized to produce thermal energy and electrical power. Ocean energy, derived from the motion of waves and ocean currents, is commonly known as ocean energy, wave energy, or ocean current energy. This include ocean current turbines and wave power plants. Biomass refers to organic materials that can be combusted or fermented for energy production, such as wood, food waste, and agricultural waste. The composition of this energy source includes biogas and solid biomass, specifically firewood. Micro hydro energy, a type of water energy, is derived from rivers or streams in a small-scale form. It is frequently employed in a limited manner, particularly in rural regions (Hartini et al., 2021). The indicators for renewable energy are as follows: Contribution to energy supply, which quantifies the extent to which renewable energy affects the overall energy supply of a country or region. Market share measures the proportion of renewable energy in the total energy consumed in a specific industry, such as transportation or electricity (Aniqoh et al., 2022; Napitupulu et al., 2023). Energy security is improved by diversifying energy sources and reducing reliance on fossil fuels. Increased energy efficiency reflects the enhanced effective (Widjajanto et al., 2020).

2.4. Green Leadership

Green leadership prioritizes social and environmental responsibility while making choices and taking action. Green leaders focus on implementing projects that minimize negative effects on society and the environment, while also promoting sustainability in organizational and corporate practices (Jamal et al., 2021). Adopting green leadership is a crucial strategy for tackling the growing urgency of environmental and social problems. It encompasses not only making environmentally responsible corporate decisions, but also fostering cultural transformation and promoting more sustainable behaviors. Adopting this strategy is crucial for addressing climate change, preserving natural resources, and promoting sustainable societies (Awan et al., 2020). Environmental leaders must possess a profound care for the environment and possess extensive knowledge about environmental challenges. They should possess the ability to identify opportunities for promoting sustainability and identify potential dangers that pose a threat to the environment (Song and Yu 2018). Green leadership promotes sustainable company practices, including the adoption of renewable energy, waste reduction, and the utilization of environmentally friendly goods. Green leaders drive the development of eco-friendly technologies and other innovations that promote sustainable behavior.

Advocacy for environmental regulations, in which environmentally conscious leadership promotes the necessity of stringent and aggressive environmental laws and disseminates information to all pertinent stakeholders regarding the significance of adhering to these policies. Environmental performance measurement is a practice in which environmental leaders share information to ensure accountability and assess their environmental performance (Bayar et al., 2021). The indicators of green leadership include the utilization of renewable energy, which measures the extent to which a business or organization relies on renewable energy sources. This score incorporates energy-saving measures and programs, such as enhancing the energy efficiency of buildings and transportation. Utilize Eco-Friendly Raw Materials by monitoring the quantity of recycled and environmentally sustainable raw materials employed in the manufacturing process (Napitupulu et al., 2023). Evaluating an organization's dedication to creating and executing innovative strategies that promote sustainable practices (Dwivedi et al., 2022).

2.5. HR Behavior

Human resource behavior refers to the actions, thoughts, and responses of individuals inside the workplace. HR practices play a crucial role in the management of human resources in business, since they have the potential to impact employee satisfaction, productivity, and overall success (Wismantoro et al., 2023). The role of Human Resources (HR) is crucial in ensuring the successful and efficient implementation of new technologies through the transfer of digital technology. Several crucial behaviors in digital technology transfer include Openness to Change, which is regarded as one of the most significant behaviors (Sitorus et al., 2022). HR must demonstrate receptiveness to change and a willingness to adapt when new technology supplants current systems or practices. Flexibility refers to the ability to adapt and adjust to changes in tasks and duties that come with the transfer of digital technologies. HR must possess the ability to adapt in order to establish new positions in response to emerging technologies. HR must possess the capacity to utilize digital technology while sticking to established best practices. In order to accomplish the

objectives of the organization, it is necessary to embrace the implementation of optimal methods and procedures.

The utilization of innovative and creative human resources can facilitate the discovery of novel approaches to implementing digital technology, hence fostering creativity and innovation. They have the potential to enhance company procedures or devise more efficient solutions (Jamal et al., 2021). Human Resources (HR) must demonstrate sustainable and responsible behavior in diverse settings, ranging from individual residences to major enterprises, by adopting renewable energy sources. Actions pertaining to the utilization of renewable energy encompass acquiring knowledge of renewable energy sources, such as biomass, solar, wind, and hydroelectric energy, which is essential for HR personnel to possess. It is imperative that they comprehend the advantages to the environment and the inexhaustible abundance of resources. HR should priorities the adoption of renewable energy sources and gradually eliminates or integrate traditional energy sources into daily operations. Options for transitioning to sustainable energy sources include installing solar panels on your residence, procuring renewable energy from your utility provider, or utilizing an electric vehicle for transportation. Encouraging investment in renewable energy technology is necessary for corporations and organizations to promote the use of sustainable energy sources. This entails the installation of sustainable energy systems, such as solar panels, wind turbines, and other similar technologies, within their commercial enterprises. Environmental consciousness is necessary for human resources employed in the renewable energy industry to better understand the effects of environmental change. They should be educated on programs aimed at mitigating greenhouse gas emissions and preserving the global ecology (Grigg, 2021).

The indicators of HR behavior in the effective acceptance of new technologies and the use of renewable energy are as follows: Learning and adaptability, which is measured by the ability of communities and groups to embrace and adjust to new concepts in renewable energy and technology. Having the ability and eagerness to acquire new skills and comprehend technologies is crucial. The importance of maintaining a positive attitude towards change. Individuals that possess a willingness to embrace novel concepts and sustainable energy alternatives are more inclined to endorse and back their execution. Innovation and creativity are crucial factors in generating novel ideas and utilizing technology and renewable energy in imaginative ways. Embracing new technologies and renewable energy sources while being conscious of social and environmental responsibilities is highly advantageous (Lee et al., 2020).

2.6. Business Sustainability

Business sustainability refers to a company's ability to operate and expand in the long run, considering economic, environmental, and social aspects (Kim et al., 2019). The concept posits that a company's sustainability is determined not just by its financial performance, but also by its impact on the environment and society. The three primary principles of business sustainability are as follows: Economic sustainability refers to a business's ability to fulfil stakeholder requirements, provide enduring economic worth, and sustain profitability in the long run. Examples include the generating of profit, enhanced operational efficiency, and financial investment in product development and innovation. The company strives to achieve environmental sustainability by actively minimizing its negative influence on the environment. This includes the mitigation of greenhouse gas emissions, the sustainable use of natural resources, effective waste management, and the promotion of eco-friendly conduct. Social sustainability pertains to the company's interactions with society and its workforce. This encompasses the guarantee of social equity, protection of human rights, promotion of diversity, maintenance of workplace safety, and the company's constructive impact on the local community (Margallo et al., 2019). The indicators that determine the sustainability of a business through the implementation of technology and the utilisation of renewable energy are as follows: The reduction of greenhouse gas emissions by quantifying the decrease in emissions resulting from the company's operations. Energy efficiency involves assessing the efficiency of energy utilisation and implementing measures to decrease usage. The company seeks to establish partnerships and collaborations with other entities, including producers of eco-friendly raw materials, to enhance cooperation and promote sustainable practices. Evaluating environmental performance through frequent measurement and reporting, which includes data on emissions, waste, and resource utilization (Fatimah et al., 2020).

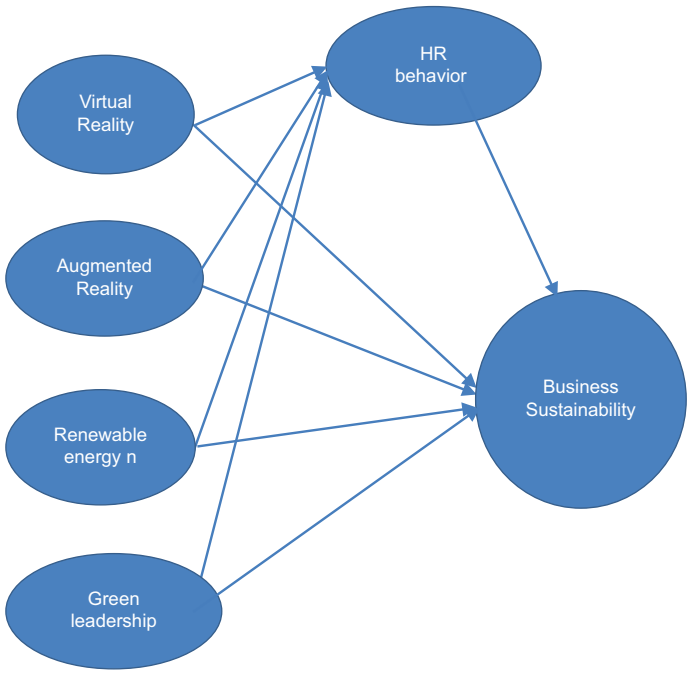
2.7. Conceptual Framework

The conceptual framework can be seen in Figure 1 below:

2.8. Hypothesis

1. *Virtual reality* affects the business sustainability of waste management companies in Indonesia
2. *Augmented reality* affects the business sustainability of companies that manage waste in Indonesia

Figure 1: The conseptual framework



3. Renewable energy affects the business sustainability of waste management companies in Indonesia
4. Green leadership affects the business sustainability of companies that manage waste in Indonesia
5. Virtual *reality* affects HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia.
6. *Augmented reality* affects HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia.
7. Renewable energy affects the behavior of human resources in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia.
8. Green leadership affects HR behavior in responding to changes in technology options and the use of renewable energy in waste management companies in Indonesia.
9. HR behavior in responding to changes in technology adoption and the use of renewable energy in waste management companies in Indonesia moderates the positive relationship between *virtual reality* and business sustainability of waste management companies in Indonesia.
10. HR behavior in responding to changes in technology adoption and the use of renewable energy in waste management companies in Indonesia moderates the positive relationship between *aumanted reality and* business sustainability of waste management companies in Indonesia.
11. HR behavior in responding to changes in technology adoption and the use of renewable energy in waste management companies in Indonesia moderates the positive relationship between renewable energy and business sustainability of waste management companies in Indonesia.
12. HR behavior in addressing changes in technology adoption and renewable energy use in waste management companies in Indonesia moderates the positive relationship between green leadership and business sustainability of waste management companies in Indonesia.

3. RESEARCH METHODS

The research employs a quantitative descriptive approach, utilizing data analysis through the structural equation model (SEM) method. The data processing using the SEM method is conducted using the PLS programme. (Ramli et al., 2018) utilized a quantitative descriptive method with the Structural Equation Modelling (SEM) technique. This approach allowed for the examination of multiple variables and their intricate interrelationships. This enables the undertaking of research in diverse scientific disciplines, encompassing natural sciences, social sciences, and economics. The data gathering methods employed in this study encompassed observation studies, documentation studies, and the distribution of questionnaires. The study population consists of leaders from 554 large and medium-sized companies in Indonesia who consistently demonstrate proper waste management. The sampling method employed is accidental sampling, which involves selecting samples based on the researcher;s interest in investigating a specific problem within the study. The sample can be conducted using the Slovin formula, which yields the following calculation results: $n = N/(1 + N e^2) = 554/(1 + 554 \times 0.05^2) = 399.28 = 399$ leaders of large and medium-sized firms in Indonesia who are proficient in waste management. The sample size consists of 399 executives from prominent and mid-sized enterprises in Indonesia who consistently demonstrate effective waste management practices. The study involves conducting various data analysis techniques, including descriptive analysis, convergent validity analysis, AVE analysis, R Square test, and hypothesis testing.

4. RESEARCH RESULTS

4.1. Descriptive analysis

4.1.1. Virtual reality variables

Based on the Table 2, the distribution of data that most respondents answered for question 1 was agreed as many as 155 respondents (38.84%), for question 2 the most respondents answered agreed as many as 160 respondents (40.10%), for question 3 many respondents answered agreed as many as 158 respondents (39.60%), and for question 4 respondents who answered agreed as many as 161 respondents (40.3%).

4.1.2. Augmented reality variables

Based on Table 3, the distribution of data that most respondents answered for question 1 was agreed as many as 158 respondents (39.60%), for question 2 the most respondents answered agreed as many as 157 respondents (39.35%), for question 3 many respondents answered agreed as many as 161 respondents (40.3%), and for question 4 respondents who answered agreed as many as 155 respondents (38.84%).

4.1.3. Renewable energy variables

According to Table 4, the majority of respondents answered question 1 with agreement, with a total of 157 respondents (39.35%). Similarly, for question 2, the highest number of respondents answered with agreement, with 155 respondents (38.84%). Question 3 also had a significant number of respondents answering with agreement, with 153 respondents (38.34%). Finally, for question 4, there were 161 respondents (40.3%) who answered with agreement.

4.1.4. Green leadership variable

Based on The Table 5, the majority of respondents answered question 1 with agreement, with a total of 153 respondents (38.34%). Similarly, for question 2, the highest number of respondents answered with agreement, with a total of 161 respondents (40.3%). Question 3 also had a significant number of respondents answering with agreement, with a total of 157 respondents (39.35%). Lastly, for question 4, there were 160 respondents (40.10%) who answered with agreement

4.1.5. HR behavior variables

Based on Table 6, the distribution of data that most respondents answered for question 1 was agreed as many as 157 respondents (39.35%), for question 2 the most respondents answered agreed as many as 160 respondents (40.10%), for question 3 many respondents answered agreed as many as 158 respondents

Table 2: Descriptive analysis of virtual reality variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	147	35.84	155	38.84	84	21.05	13	3.26	-	-
Q2	145	36.34	160	40.10	87	21.80	7	1.75	-	-
Q3	142	35.59	158	39.60	82	20.55	17	4.26	-	-
Q4	144	36.09	161	40.3	84	21.05	10	2.51	-	-

Source: Processed with primary data, 2023

Table 3: Descriptive analysis of augmented reality variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	142	35.59	158	39.60	82	20.55	17	4.26	-	-
Q2	146	36.59	157	39.35	88	22.05	8	2	-	-
Q3	144	36.09	161	40.3	84	21.05	10	2.51	-	-
Q4	147	35.84	155	38.84	84	21.05	13	3.26	-	-

Source: Processed with primary data, 2023

Table 4: Descriptive analysis of renewable energy variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	146	36.59	157	39.35	88	22.05	8	2	-	-
Q2	147	35.84	155	38.84	84	21.05	13	3.26	-	-
Q3	143	35.84	153	38.34	85	21.30	18	4.51	-	-
Q4	144	36.09	161	40.3	84	21.05	10	2.51	-	-

Source: Processed with Primary Data, 2023

Table 5: Descriptive analysis of green leadership variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	143	35.84	153	38.34	85	21.30	18	4.51	-	-
Q2	144	36.09	161	40.3	84	21.05	10	2.51	-	-
Q3	146	36.59	157	39.35	88	22.05	8	2	-	-
Q4	145	36.34	160	40.10	87	21.80	7	1.75	-	-

Source: Processed with primary data, 2023

Table 6: Descriptive analysis of HR behavior variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	146	36.59	157	39.35	88	22.05	8	2	-	-
Q2	145	36.34	160	40.10	87	21.80	7	1.75	-	-
Q3	142	35.59	158	39.60	82	20.55	17	4.26	-	-
Q4	147	35.84	155	38.84	84	21.05	13	3.26	-	-

Source: Processed with primary data, 2023

(39.60%), and for question 4 respondents who answered agreed as many as 155 respondents (38.84%).

4.1.6. Business sustainability variables

Based on Table 7, the distribution of data that most respondents answered for question 1 was agreed as many as 160 respondents (40.10%), for question 2 the most respondents answered agreed as many as 157 respondents (39.35%), for question 3 many respondents answered agreed as many as 160 respondents (40.10%), and for question 4 respondents who answered agreed as many as 158 respondents (39.60%).

The output results of the SEM test can be seen from the following Bootstraping diagram (Figure 2):

Table 7: Descriptive analysis of business sustainability variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	145	36.34	160	40.10	87	21.80	7	1.75	-	-
Q2	146	36.59	157	39.35	88	22.05	8	2	-	-
Q3	145	36.34	160	40.10	87	21.80	7	1.75	-	-
Q4	142	35.59	158	39.60	82	20.55	17	4.26	-	-

Source: Processed with primary data, 2023

4.2. Convergent Validity Analysis

(Sohaib et al., 2017) stated that the convergent validity test in the SEM PLS test is a data test the aims to increase the validity value of the data, so that data adjustments appear to be used in further testing, this convergent validity analysis is carried out by looking at the outer loading value.

Based on Table 8, it can be explained that the test results of the outer loading value of several variables listed, namely virtual reality variables, augmented reality variables, renewable energy variables, green leadership variables, HR behavior variables and business sustainability variables have valid data distribution and are suitable for hypothesis testing.

4.3. Average Variant Extracted (AVE) Analysis

(Ramli et al., 2018) stated that this AVE test aims to describe whether the data in each variable is valid or suitable for regression and hypothesis testing. The results of the Average Variant Extracted (AVE) test can be seen in Table 9 below

The Table 9, the output results for the Average Variant Extracted (AVE) test of virtual reality variables, augmented reality variables, renewable energy variables, green leadership variables, HR behavior variables and business sustainability variables are greater than the significance value of 0.5, where all existing and scattered data are very valid and suitable for testing regression hypotheses.

4.3.1. Composite reliability test

(Ramli et al., 2018) Composite Reliability test is carried out to describe matters relating to the reliability results of the distribution of data in each variable, where this data analysis can be seen in the following table:

Based on Table 10, the output results of the composite reliability test of the virtual reality variable, augmented reality variable, renewable energy variable, green leadership variable, HR behavior variable and business sustainability variable are greater than the significance of 0.6, where the data distribution of several variables is appropriate and suitable for other tests.

4.3.2. Path coefficient test

As for the *path coefficient* (R Square) test of each variable can be seen in Tables 11-16 below:

Based on Table 11, it states that the R Square value of the virtual reality variable in several large and medium industries in Indonesia is 0.852, where the percentage of the emergence of virtual reality in several large and medium industries in Indonesia of 85.2% can be explained by the variable sustainability of industrial businesses that carry out waste treatment in Indonesia and the rest will be explained by other variables that are not included in the object studied by researchers by 14.8%.

Table 8: Convergent validity test

Variables	Indicator	Outer loading
Virtual Reality $(X)_1$	VR 1	0,855
	VR 2	0,765
	VR 3	0,875
	VR 4	0,805
Augmented Reality $(X)_2$	AR 1	0,845
	AR 2	0,735
	AR 3	0,844
	AR 4	0,850
Renewable Energy $(X)_3$	ET 1	0,754
	ET 2	0,802
	ET 3	0,768
	ET 4	0,822
Green Leadership $(X)_4$	KH 1	0,875
	KH 2	0,857
	KH 3	0,847
	KH 4	0,877
HR Behavior (Z)	PS 1	0,837
Business Sustainability (Y)	PS 2	0,793
	PS 3	0,737
	PS 4	0,805
	KU 1	0,725
	KU 2	0,827
	KU 3	0,726
	KU 4	0,730

Source: Results of Data, 2023

Table 9: AVE test

Variables	AVE
Virtual Reality $(X)_1$	0.803
Augmented Reality $(X)_2$	0.779
Renewable Energy $(X)_3$	0.855
Green Leadership $(X)_4$	0.865
HR Behavior (Z)	0.730
Business Sustainability (Y)	0.770

Source: Results of Data, 2023

Based on Table 12, it states that the R Square value of the augmented reality variable in several large and medium industries in Indonesia is 0.866, where the percentage of the emergence of augmented reality in several large and medium industries in Indonesia of 86.6% can be explained by the variable sustainability of industrial businesses that carry out waste treatment in Indonesia and the rest will be explained by other variables that are not included in the object studied by researchers by 13.4%.

Table 10: Composite reliability test

Variables	Composite reliability
Virtual Reality $(X)_1$	0.784
Augmented Reality $(X)_2$	0.820
Renewable Energy $(X)_3$	0.745
Green Leadership $(X)_4$	0.754
HR Behavior (Z)	0.855
Business Sustainability (Y)	0.825

Source: Results of data, 2023

Table 11: R square test

Variables	R-square
Virtual Reality $(X)_1$	0.852
Business Sustainability (Y)	0.707

Source: Results of data, 2023

Table 12: R-square test

Variables	R-square
Augmented Reality $(X)_2$	0.866
Business Sustainability (Y)	0.709

Source: Results of data, 2023

Based on Table 13, the R Square value for the renewable energy variable in various large and medium industries in Indonesia is 0.853. This means that 85.3% of the increase in renewable energy usage in these industries can be explained by the sustainability of industrial businesses that implement waste treatment in Indonesia. The remaining 14.7% is attributed to other variables not included in the study.

The data in Table 14 indicates that the R-square value for the green leadership variable in various large and medium industries in Indonesia is 0.805. This means that 80.5% of the occurrence of green leadership in these industries can be explained by the sustainability of industrial businesses that implement waste treatment in Indonesia. The remaining 19.5% is attributed to other variables not included in the study.

Based on Table 15, the R Square value for the virtual reality variable in various large and medium industries in Indonesia is 0.707. This means that 70.7% of the occurrence of virtual reality in these industries can be explained by the HR behavior variable, which refers to how employees respond to technology adoption and the use of renewable energy in waste management companies in Indonesia. The remaining 29.3% is attributed to other variables that were not included in the researchers' study.

Based on Table 16, it states that the R Square value of the augmented reality variable in several large and medium industries in Indonesia is 0.741, where the percentage of the emergence of augmented reality in several large and medium industries in Indonesia of 74.1% can be explained by the HR behavior variable in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia and the rest will be explained by other variables that are not included in the object studied by researchers by 25.9%.

Table 13: R-square test

Variables	R-square
Renewable energy $(X)_3$	0.853
Business sustainability (Y)	0.721

Source: Results of data, 2023

Table 14: R-square test

Variables	R-square
Green leadership $(X)_4$	0.805
Business sustainability (Y)	0.712

Source: Results of data, 2023

Table 15: R-square test

Variables	R-square
Virtual Reality $(X)_1$	0.707
HR Behavior (Z)	0.602

Source: Results of data, 2023

Table 15: R-square test

Variables	R-square
Virtual Reality $(X)_1$	0.707
HR Behavior (Z)	0.602

Source: Results of data, 2023

Table 16: R-square test

Variables	R-square
Augmented reality $(X)_2$	0.741
HR behavior (Z)	0.633

Source: Results of DATA, 2023

Based on Table 17, it states that the R Square value of the renewable energy variable used in several large and medium industries in Indonesia is 0.747, where the percentage of the emergence of renewable energy used in several large and medium industries in Indonesia of 74.7% can be explained by the HR behavior variable in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia and the rest will be explained by other variables that do not enter the object studied by researchers by 25.3%.

Based on Table 18, it states that the R Square value of the green leadership variable in several large and medium industries in Indonesia is 0.800, where the percentage of the emergence of green leadership in several large and medium industries in Indonesia of 80% can be explained by the HR behavior variable in addressing changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia and the rest will be explained by other variables that are not included in the object studied by researchers by 20%.

4.3.3. Hypothesis test

The results of the hypothesis test Table 19 below:

Based on Table 19, that the variables of virtual reality, augmented reality, renewable energy, and green leadership have a partial impact on the sustainability of industrial businesses engaged in

waste treatment in Indonesia. Additionally, these variables also influence the behavior of HR in addressing technological changes and the adoption of renewable energy in waste management companies in Indonesia. The sustainability of industrial businesses in Indonesia that handle waste treatment is influenced by several factors, including virtual reality, augmented reality, renewable energy, and green leadership. These variables impact the behavior of human resources in responding to technological changes and the adoption of renewable energy in waste management companies. Additionally, the use of renewable energy acts as a moderating variable in this context.

5. DISCUSSION

The study findings indicate that virtual reality factors have an impact on the long-term viability of industrial enterprises engaged in waste treatment in Indonesia (Muisyo and Qin, 2021) This technology has the potential to enhance the capacity to simulate real-life company environments, thereby fostering a sense of proximity between consumers and businesses. Consequently, consumers are more likely to consistently utilise these products to enhance their skills, thereby ensuring the sustainability of their enterprises. The findings indicate that augmented reality factors have an impact on the sustainability of industrial enterprises engaged in waste treatment in Indonesia. (Priyadarshini et al., 2020) This technology enhances the real-time visualization of product capabilities and quality, instilling a sense of comfort and safety among consumers. By incorporating this technology, businesses aim to bolster the longevity of their operations. The study found that renewable energy factors have an impact on the sustainability of industrial businesses engaged in waste treatment in Indonesia (Nižetić et al., 2019).The adoption of renewable energy sources can enable companies to reduce their reliance on environmentally damaging waste and mitigate the risks associated with their operations. This, in turn, enhances the long-term viability of the businesses and reduces the likelihood of closure. The findings indicate that green leadership factors have an impact on the sustainability of industrial enterprises engaged in waste treatment in Indonesia (Jamal et al., 2021). (Jamal et al., 2021) Employing leadership that embraces ecologically sustainable energy options would enable enterprises to mitigate the risk of escalating carbon emissions, so safeguarding their survival and ensuring the long-term viability of their commercial operations. The findings indicate that virtual reality factors influence the behavior of HR personnel in their response to the adoption of new technology and the utilization of renewable energy in waste management companies in Indonesia. (Reedy, 2023) this type of technology has the potential to completely transform workers' behavior, leading to wholehearted acceptance of its implementation to enhance business growth and HR performance. The study findings indicate that augmented reality factors influence the behavior of HR in responding to changes in technology

Table 17: R-square test

Variables	R-square
Renewable Energy $(X)_3$	0.747
HR Behavior (Z)	0.622

Source: Results of data, 2023

Table 18: R-square test

Variables	R-square
Green Leadership $(X)_4$	0.800
HR Behavior (Z)	0.727

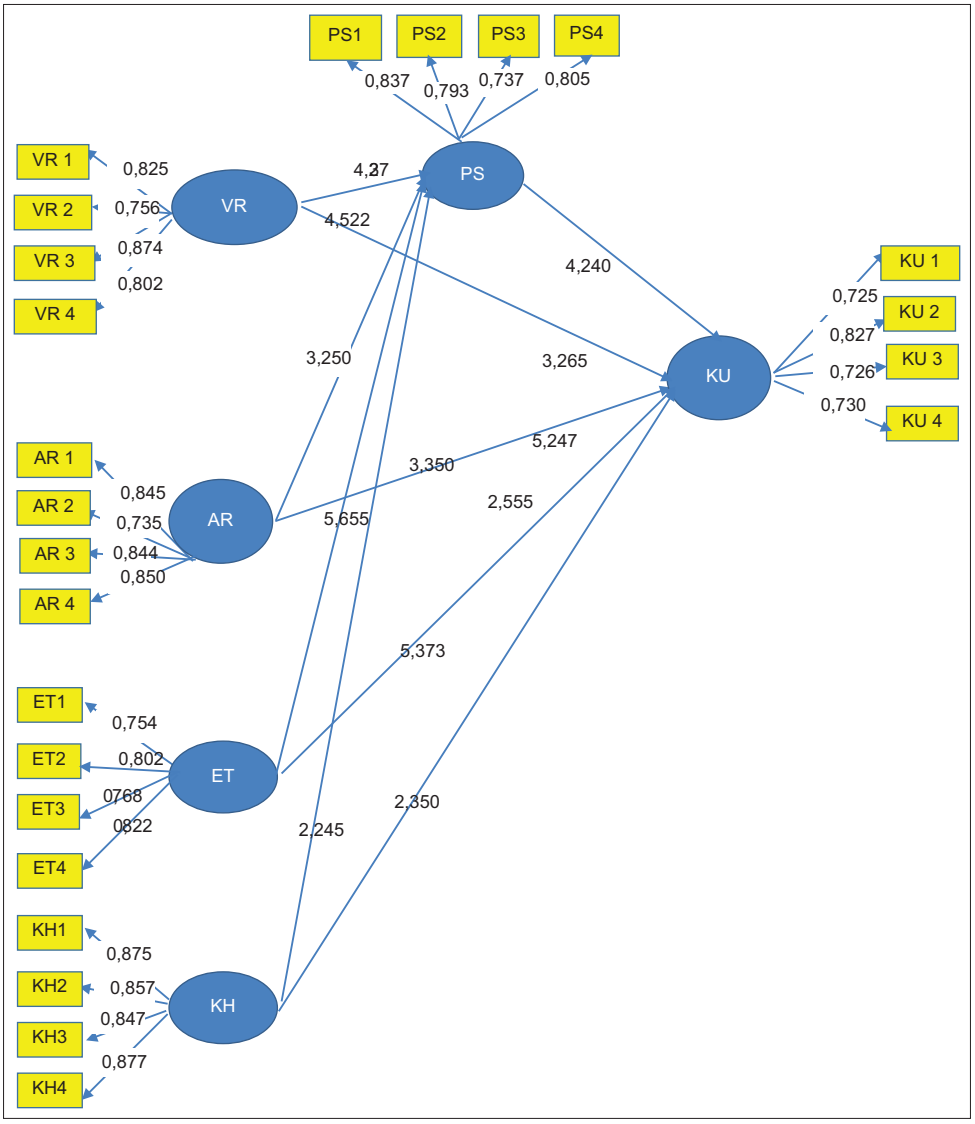
Source: Results of data, 2022

Table 19: Hypothesis test

Hypothesis	Influence	T-statistics	P-value	Results
H1	Virtual reality on the business sustainability of waste treatment industries in Indonesia	4.522	0.001	Accepted
H2	Augmented reality on the sustainability of industrial businesses that carry out waste treatment in Indonesia	3.250	0.016	Accepted
H3	Renewable energy on business sustainability of waste treatment industries in Indonesia	5.655	0.006	Accepted
H4	Green leadership on business sustainability of waste treatment industries in Indonesia	2.245	0.000	Accepted
H5	Virtual reality on HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia	4.237	0.018	Accepted
H6	Augmented reality on HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia	3.350	0.003	Accepted
H7	Renewable energy on HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia.	5.373	0.001	Accepted
H8	Green leadership on HR behavior in response to changes in technology adoption and renewable energy use in waste management companies in Indonesia	2.350	0.000	Accepted
H9	Virtual reality on the sustainability of industrial businesses that carry out waste treatment in Indonesia through HR behavior in addressing changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia as a moderating variable	4.240	0.001	Accepted
H10	Augmented reality on the sustainability of industrial businesses that carry out waste treatment in Indonesia through HR behavior in addressing changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia as a moderating variable.	3.265	0.022	Accepted
H11	Renewable energy on the sustainability of industrial businesses that carry out waste treatment in Indonesia through HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia as a moderating variable.	5.427	0.000	Accepted
H12	Green leadership on the sustainability of industrial businesses that carry out waste treatment in Indonesia through HR behavior in addressing changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia as a moderating variable	2.555	0.000	Accepted

Source: Results of Data Processing with PLS 3.0, 2023

Figure 2: Bootsraping Diagram



adoption and the use of renewable energy in waste management companies in Indonesia. The implementation of this technology is expected to enhance HR skills and knowledge, facilitating technology transfer and improving HR performance. The study findings indicate that the adoption of renewable energy and its use in waste management companies in Indonesia have an impact on the behavior of human resources (HR) in response to technological changes. The study suggests that the implementation of renewable energy, aligned with community expectations of environmental preservation, can influence HR's mindset towards continuous self-improvement and the use of environmentally friendly energy sources. This shift in thinking aims to minimize environmental damage caused by global warming. The study findings indicate that green leadership has an impact on HR behavior on the management of technological advances and the use of renewable energy in waste management enterprises in Indonesia (Singh et al., 2020) renewable energy and in accordance with what the community expects not to damage the environment will change the thinking of human resources who work to always increase their self-knowledge to always use energy that does not damage the environment in order to minimize environmental damage due to global warming. Propose that leadership focused on enhancing environmental circumstances will impact the current workforce by fostering a commitment to environmental protection, hence reducing environmental harm and mitigating climate change-induced natural disasters and global warming.

The study findings indicate that virtual reality factors influence the long-term viability of industrial enterprises engaged in waste management in Indonesia. This influence is mediated by the behavior of human resources in adapting to technological advancements and the incorporation of renewable energy sources (Song and Yu, 2018). (Song and Yu, 2018) leadership based on increasing improvements to environmental conditions will have an influence on existing human resources to always protect the environment in order to minimize environmental damage and natural disasters due to climate change, as well as global warming. this technology has been found to enhance the willingness of HR departments to adopt technological solutions. This increased interest in investing in the company leads to various benefits and ensures the company's continued existence, ultimately improving its performance. The study findings indicate

that augmented reality factors have an impact on the long-term viability of industrial enterprises engaged in waste management in Indonesia. This impact is mediated by the behavior of human resources in adapting to technological advancements and the incorporation of renewable energy sources in waste management operations. (Foo et al., 2021) which states that this technology will increase the openness of HR to use technology like a real situation that makes HR interested in spending in the company which will make the company benefit and continue to exist to improve its performance. The results of the study describe that augmented reality variables affect the sustainability of industrial businesses that carry out waste treatment in Indonesia through HR behavior in responding to changes in technology adoption and the use of renewable energy in companies that manage waste in Indonesia as a moderating variable (Marks-Bielska et al., 2020) enhancing the expertise in this particular technology will facilitate the utilization of products and services that integrate the physical and virtual realms. This, in turn, will enhance the presence of businesses, enabling them to reach a wider audience across various locations.

The study findings indicate that renewable energy factors have an impact on the sustainability of industrial enterprises engaged in waste treatment in Indonesia. This impact is mediated by the behavior of human resources in response to changes in technology adoption and the utilization of renewable energy (Hartini et al., 2021) the adoption of renewable energy will lead to a shift in people's behavior, encouraging them to consistently utilize this energy source in order to safeguard the planet and the environment. Additionally, this transition will promote the growth of companies involved in waste management, enabling them to generate clean energy that can be utilized by others without causing environmental pollution. The study findings indicate that green leadership factors have an impact on the sustainability of industrial enterprises engaged in waste treatment in Indonesia. This impact is mediated by the behavior of human resources in adapting to technological changes and utilizing renewable energy. Additionally, the study identifies waste management as a moderating variable in this relationship (Kim et al., 2019) implementing green leadership practices can influence employees to adopt a mindset of environmental love and respect. This is crucial for the long-term survival of companies, as those that embrace this leadership approach are more likely to benefit from increased trade with external parties.

6. CONCLUSION

The study concludes that virtual reality, augmented reality, renewable energy, and green leadership partially impact the sustainability of industrial businesses engaged in waste treatment in Indonesia. Additionally, these variables also influence HR behavior in addressing technological changes and the adoption of renewable energy in waste management companies in Indonesia. The sustainability of industrial businesses in Indonesia that handle waste treatment is influenced by several factors, including virtual reality, augmented reality, renewable energy, and green leadership. These variables impact the behavior of human resources in responding to technological changes and the adoption of renewable energy in waste management companies. Additionally, the use of renewable energy acts as a moderating variable in this context.

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