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TECHNOLOGIES ON REDUCING ENVIRONMENTAL FOOTPRINT: A CASE STUDY OF SUSTAINABLE CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

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ABSTRACT

The effect that technologies have on reducing the environmental footprint, with the primary emphasis being placed on a case study of environmentally responsible handling of debris from building deconstruction. As concerns about the environment continue to rise, the construction industry plays an essential part in the introduction of innovative technology that reduces the sector's negative effects on the environment. This is a topic that is gaining growing significance as time goes on. This study explores the incorporation of cutting-edge technology into the processes for the management of waste from building and demolition projects. It demonstrates how these innovations contribute to the attainment of sustainability goals by examining the ways in which these innovations are incorporated into the procedures. Examining how digital technologies, advanced materials, and automated systems function in the actual world is the focus of this research, which analyzes their effectiveness. The effectiveness of recycling should be improved, as well as the usage of all available resources should be optimized to its fullest potential so as to cut down on the amount of waste produced. The findings shed light on the possibility for widespread adoption in the construction industry in order to significantly lessen the industry's impact on the environment. The findings highlight both the good benefits as well as the limits that are associated with these advances. This case study focuses on the important role that technology plays in promoting sustainable practices within the construction industry. It also offers vital insights for policymakers, industry stakeholders, and academics alike.

keywords: *Reducing, environmental, Footprint, Waste Management*

INTRODUCTION

In an increasingly globalized context, the functioning of the economy is increasingly impacted by technical advancement, the intensity of technological innovation, increases in efficiency and productivity, and a substantial relationship exists between the functioning of the economy and the environmental and social elements of business. In order to achieve the goals of sustainable socioeconomic growth as well as the ongoing improvement and sophistication of the quality of production in all areas of economic activity, technical and product innovation is an essential component and instrument. However, environmental technologies and technology for sustainable development do not perform the same duties. While environmental technologies, in terms of production, remediation and maintenance, primarily address the issue of minimising, eliminating and compensating for environmental pollution, sustainable technologies also pursue the broader objectives of not exceeding the ecological recovery capacity and consolidating growing inequalities in the achievement of economic, social and environmental development goals. According to Feola (2015) and Majernik et al. (2017),

the technologies that are now being used for sustainable development are also considered to be the best available technologies (BAT) in terms of the technical performance, economic availability, and environmental excellence that they provide for the industries that are involved. Many precautionary techniques and instruments are employed in order to meet the lofty objectives of global development policies for environmentalization of technology and sustainable development. These instruments are being standardized as ISO standards, improved by research, and coordinated on a worldwide scale. The application of the Fourth Generation Smart Industry Strategy and its intensification within the framework of the development of the Industry 5.0 concept in the greening of the economy are the major methodological methods used today from a technological point of view. Cumulative carbon emissions and projected changes in global temperature are strongly correlated. In reality, since the middle of the 20th century, it is quite likely that greenhouse gas emissions caused by human activity have been the main driver of discernible global warming. An estimated 75% of emissions worldwide are attributed to carbon, with energy generation accounting for the majority of these emissions. Additionally, data shows that throughout 1750, the last 40 years have seen half of all human-caused carbon emissions (OECD, 2016). Two thirds of world emissions are attributed to non-renewable energy usage (OECD, 2016). Additionally, methane and nitrous oxide, two potent greenhouse gases, are produced by agricultural activities. Thus, reducing carbon emissions through a more coordinated plan and investing in technology and innovation are necessary for mitigating global warming. Utilizing innovation and technology more sustainably is essential to lowering carbon emissions and promoting the development of green economies. Burston (2016:1) points out that substantial reductions in waste and emissions have already been attained via the development of renewable energy, electric vehicles, and hybrid technologies. Additional advancements in biofuels, organic photovoltaics, and hydrogen-powered vehicles are also being made. This suggests that increased innovation and technology are expected to provide the greatest opportunities for developing green economies on a global scale. However, implementing such a plan would require both government and corporate support as well as the strategic formulation and implementation of green policies. With an emphasis on OECD nations, this study contributes to the current body of research by analyzing the impact that innovation and technology investments have in improving environmental quality. Aiming to improve scientific, technology, and innovation capability at the national level, the OECD developed the Innovation and Technology Policy (TIP) in 1993. The TIP encourages information exchange and best practices (OECD, 2018b). Additionally, the TIP seeks to strengthen the growth of businesses and industries focused on science and technology, as well as productivity, sustainable economic advancement and development, and the dissemination and application of scientific knowledge. It also seeks to empower public research organizations, generate a pool of highly skilled experts, and empower public research organizations (Papaconstantinou and Polt, 2018, OECD, 2018a). Additionally, the OECD regularly analyzes scientific systems (systems, industrial research, technological advancements, financial assistance to businesses, venture capital, university-industry links), technology and innovation, and policies at the national level (Aubert, 2018). These have shown that the administrative and political climate, the availability of rewards and punishments, and the ease with which policy actions may be transferred to other nations all have an impact on members' potential for innovation and technology (Aubert, 2018). Shelton (2018:15) noted that policies with specific, quantifiable goals—such as encouraging increased R&D spending, increased scientific personnel mobility, increased industry-university collaboration, or increased access to new technologies for small and medium-sized businesses—make the OECD's "... task of evaluation easier."

GREEN TECHNOLOGICAL GROWTH FOR SUSTAINABLE DEVELOPMENT

The UR includes green socioeconomic growth (GE). Green growth is centered on using clean energy and developing green technology to reduce production and consumption. Thus, technological innovation tackles emissions resulting from both production and consumption, and as such, it is seen as a primary force behind industrial development the creation, advancement, and use of clean technologies improve sustainability.

Through an operational policy plan, the scope of green growth is more specifically focused on making tangible, quantifiable progress at the interface of the environment and the economy. Encouraging innovation, investment, and competitiveness to create new sources of economic development in accordance with resilient ecosystems is essential to this. A number of particular social and equality issues must also be addressed in the RoW's strategy and action plans. These might directly result from the economy, both domestically and globally, implementing ecological principles. Thus, strategies must to be put into action concurrently with projects focused on the social pillar of the UR's metrics.

Global players deal with both new and classic development difficulties, such as globalization, climate change, and the energy crisis, as well as issues such as economic stagnation, crises, and ongoing poverty, hunger, and illness. The idea of sustainable development, or "development that lasts," has become a crucial strategy in this sector..

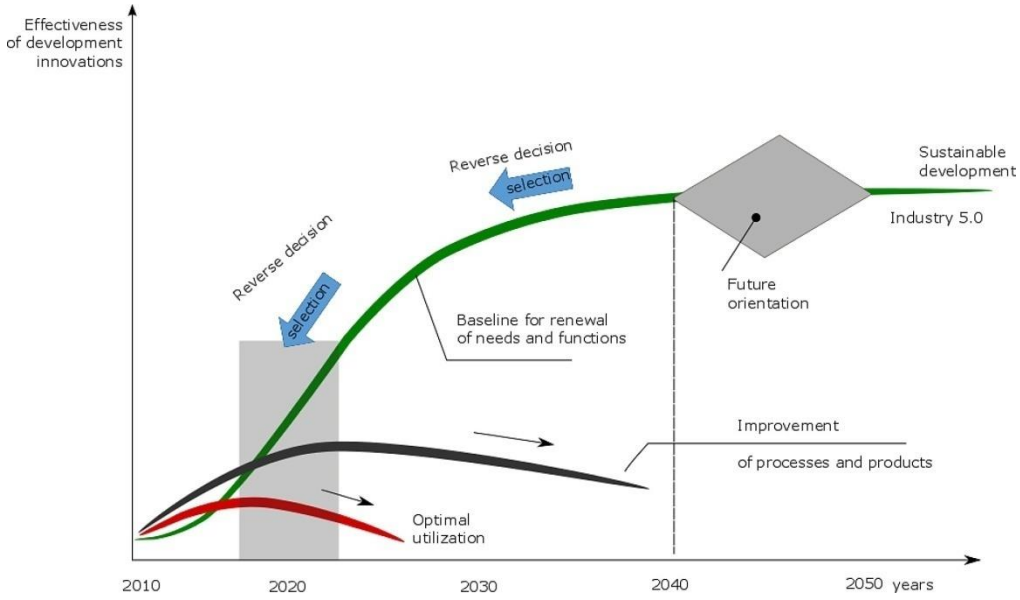
There are several methods to understand and approach sustainability. The idea might be more closed-off and predetermined, or it can be left open to be handled during the process. "Transition management" is one early example, which essentially gives participants the freedom to comprehend sustainability in every given context. The second alternative, which frames sustainability in terms of "boundary conditions" that serve as biophysical constraints that must not be passed, is exemplified by "planetary boundaries" The process of enhancing possibilities that will allow communities and individuals to realize their full potential over extended periods of time while preserving the social, economic, and environmental systems is known as sustainable development.

A more concentrated and pragmatic approach to sustainable development has resulted from this strategy, which defines it as the continuous enhancement of the current standard of living at a reduced resource intensity level, leaving a non-negligible increase in productive assets (i.e., natural, social, and productive capital) for future generations to use for raising standards of living.

SUSTAINABLE TECHNOLOGICAL INNOVATIONS

Though there is frequently room for improvement, optimizing existing technology is crucial to their sustainability.

The backward selection of innovations (Figure 1.) is a methodological approach and



identification of technical innovations that are sustainable and are founded on a study of the socioeconomic demands of the moment. Its goals are to produce terms for long-term innovation and optimization and to reach agreement among stakeholders on renewal and its optionality.

The decision-making and retrospective selection of innovations(Table2) consists in:

- Analyzing an did entifying socio-economic needs;
- Identifying the optimal time for technology improvement;
- Creating general visions for stake holders for the future;
- Developing concepts of progression pathways that lead to the fulfillment of the visions;

LITERATURE OF REVIEW

Jana Chovancova (2023) We examine the critical role that technological innovation plays in attaining sustainable development in this research. Through the integration of environmentally friendly practices into manufacturing processes, technology may help to advance sustainability. To maximize benefits for all parties involved and reduce adverse effects on the environment and society, technology design must balance economic, environmental, and social factors. We offer a methodical summary of the difficulties associated with development throughout time and in relation to the range of social interest. We pinpoint the path forward for a more comprehensive and environmentally friendly approach to innovation, in line with the demands of Smart Industries 4.0 and 5.0. The study also explores the role that cutting-edge instruments such as the Environmental Technologies Action Plan (ETAP), Life Cycle Analysis (LCA), Recycling (R), Pollution Prevention (PP), Cleaner Production (CP), Environmental Accounting (EA), Eco-labelling (EL), and Recycling (R) play in advancing sustainable development as we move toward the Smart Industry. In order to accomplish the objectives of Industry 4.0 and the Smart and Sustainable Industry Generation 5, we also address the timeliness of innovation initiatives through a backward decision-making system and the selection

of innovation instruments. We understand that any technology's economic feasibility must be taken into account for a period of more than 20 years in order to ensure sustainability.

Tayiba Khalid (2023) In the modern period, both developed and developing nations strive for sustainable growth. Regretfully, China is among the nations with a significant ecological footprint—it emits 27% of global carbon emissions in 2021—despite being the greatest developing nation in the world. The good news is that China's economy has grown as a result of technical innovation. Numerous research already conducted have indicated that environmental degradation may be stopped by technological innovation. Thus, from 1985 to 2018, this study investigates whether technological innovation has lessened environmental damage in China. The ecological footprint is used in this study to gauge China's environmental damage. Additionally, this study investigates the effects of population increase, trade openness, and economic expansion on the environment. The ARDL cointegration approach is used to estimate the models, and the results are further verified through the use of Granger causality, CCR, DOLS, and FMOLS procedures. Overall, empirical findings show that China's short- and long-term ecological footprint is severely impacted by technological growth. This makes sense since more innovation produces better technologies with lower resource use and ecological impacts. However, population increase and economic expansion aggravate environmental deterioration, whereas trade openness reduces environmental degradation in China. The study's diagnostic analysis verifies that multicollinearity, heteroscedasticity, and model instability are absent. According to the report, adopting environmentally friendly technology can help cut down on the use of hazardous alternative energy sources. In order to encourage long-term economic growth, carbon emissions must also be taxed and environmentally beneficial technology must be fostered.
Muhamad Apep Mustofa (2023) In the framework of a sustainable environment, this study attempts to examine the link between technical innovation and the supply chain of environmentally friendly construction materials. Technological innovation is crucial in improving sustainability in the construction sector, since there is a growing need for environmentally sensitive construction techniques. The implementation of technical innovation in the supply chain of environmentally friendly construction materials can have a beneficial effect on the sustainable environment, according to a thorough examination of the literature. Improved resource efficiency, less construction waste, and the promotion of eco-friendly building materials are all made possible by technological progress. Furthermore, this study emphasizes how important the supply chain is in mediating the connection between environmental sustainability and technological innovation. The supply chain is essential to the wider acceptance of sustainable solutions, the smooth operation of environmental regulations, and the integration of technological innovation into building processes. Using a quantitative analytic approach, this study collects data from several primary and secondary sources. In terms of a sustainable environment, the analytic results show a favorable association between technical innovation and the supply chain of environmentally friendly construction materials. The research findings have the potential to enhance comprehension of the role that supply chain management and technology innovation play in attaining sustainability in the construction sector.

Norazah Mohd Suki (2021) The environment of the modern industrial period is quickly evolving and heavily dependent on robotic intelligence and technical breakthroughs. Nonetheless, the patterns of worldwide economic evaluations indicated that environmental deterioration is mostly a corollary of progress. Thus, this study examines how technical advancements and renewable energy sources influence Malaysia's carbon dioxide emissions and ecological impact. To achieve this, the study examines the relationship between

environmental degradation proxies using the boot-strapped autoregressive distributed lag (BARDL) model. The results show that using renewable energy can lower the rate of environmental deterioration. Innovation in technology also contributes to a decrease in carbon emissions and environmental impact. Furthermore, the country's inverted U-shaped relationship between economic development and both environmental degradation proxies validates the environmental Kuznets curve (EKC) theory. The results demand policy implications in the form of increased emphasis on the utilization of green energy via renewables, especially in domestic businesses. On the other hand, these findings provide a benchmark for policymakers to encourage both local and foreign investors to invest more in renewable energy production and technology innovation in the Malaysian economy.

Vasantha Shanmugam(2022) Modern industrial environments are changing swiftly and rely significantly on robotic intelligence and technological advancements. However, global economic evaluation trends showed that environmental degradation largely follows development. Thus, this study looks at how Malaysia's carbon dioxide emissions and ecological effect are affected by technological breakthroughs and renewable energy sources. In order to do this, the study uses the boot-strapped autoregressive distributed lag (BARDL) model to investigate the association between environmental degradation proxies. The findings demonstrate that utilizing renewable energy can slow down the rate at which the environment deteriorates. Technology innovation also helps to reduce carbon emissions and its negative effects on the environment. Moreover, the environmental Kuznets curve (EKC) theory is supported by the nation's inverted U-shaped association between economic progress and both environmental deterioration proxies. The findings call for more focus on the use of renewable energy sources to provide green energy, particularly in household companies. However, these results offer a baseline for policymakers to urge international and local investors to increase their investments in technological innovation and renewable energy generation inside the Malaysian economy.

Kashif Iqbal (2023) With time, one of the most significant economic pillars has emerged to be information and communication technology. Information and communication technologies (ICTs) also contribute to environmental damage in addition to economic growth. It's unknown, nevertheless, whether and how ICTs could impact these systems. The new study has examined the effects of ICTs, education, and economic performance on environmental sustainability from 2000 to 2019 across 93 countries classified as low-income, middle-income, and high-income, based on a more thorough measurement of ICTs. In contrast to previous research, this study has achieved more reliable and effective results by utilizing sophisticated econometric approaches to counteract heterogeneities and dependencies in the data. The results from Driscoll and Kraal's standard error approaches and the moment's estimator's bias-corrected method are in agreement. The findings indicate that ICTs have varying effects on environmental sustainability in high-, middle-, and low-income nations. According to other findings, education is crucial for preserving environmental sustainability for middle-class and upper-class individuals, but it does not appear to have the same effect on lower-class individuals. All socioeconomic classes should be included in the policy initiatives to combat climate change, including environmental education.

RESEARCH METHODOLOGY

The phrase "research methodology" is what researchers refer to when they are explaining how they intend to carry out their study. This method takes a rigorous and logical approach to tackling the problems that have been discovered through study. The researchers establish and document their methodology in order to increase the likelihood that their study will produce trustworthy results that are in line with their hypotheses and

expectations. This strategy outlines everything, from the types of data that will be gathered and where they will originate to the methods that will be used to gather the data and analyze it after it has been gathered.

Primary sources: The primary resources, which include a questionnaire and interviews, center their attention primarily on the case study of Carey Developments as their point of departure.

Secondary Sources: Data collecting was carried out for the aim of the literature review so that it would be possible to become familiar with the most recent rules and policies that regulate waste management in India. This was done so that it would be feasible to meet the requirements of the review. The topic of waste management in construction, in addition to the environmental implications of building, has been the focus of a significant lot of written material, including a great number of books, essays, and papers of guidance. This material includes a variety of different formats, such as books, essays, and documents.

DATA ANALYSIS

Systematic literature reviews, which are carried out in accordance with the PRISMA methodology (60), are carried out with the purpose of determining what helpful discoveries have been discovered in the relevant literature that are applicable to a particular research endeavor. The percentage of accepted articles and rejected papers at each stage of the review process and after the selection criteria have been applied, respectively, are depicted in Figure 4.1.

Web of Science, which was developed by Clarivate Analytics, and Scop-us, which was developed by Elsevier, are the two databases that have the most users conducting searches for academic publications. All of the publications that were published on the subject of "applications of RA in the construction sector" between the years 1970 and the present day were collected using this method. The topic of "construction and demolition waste" has been subjected to a comprehensive literature review, which has now been finished. Our investigation was restricted to the "construction industry" and to "recycled aggregates," which refers to the granular material that is rescued from inert waste produced during the construction and destruction of buildings. To be more specific, we focused our search for relevant articles by using the "Article title," "Abstract," and "Key- words" sections that were included in the foreign publications.

The initial search carried out in the data repository yielded a total of 1295 entries after the application of the filters that were described earlier in this section. After that, the documents were loaded into SciMAT, which is software that eliminates duplicate documents, and the process was carried out again. Because Scopus offers a more comprehensive coverage of sources than Web of Science (54, 61), this exclusion had to be performed by hand. The mapping tools that were provided by SciMAT were used to assess and standardize several types of data, including document type, journal title, country, affiliation, keywords, and impact indicators (total citations and h-index). The final number of documents was cut down to 843 (Figure 2) after removing any duplicates, redundant or extraneous data (such as patents and manuscripts), reviews, and methodological studies (given that they may affect the impact (62) and 63).

BIBLIOMETRIC ANALYSIS

The findings of the bibliometric study were combined with the information extracted from the selected papers for the systematic review.

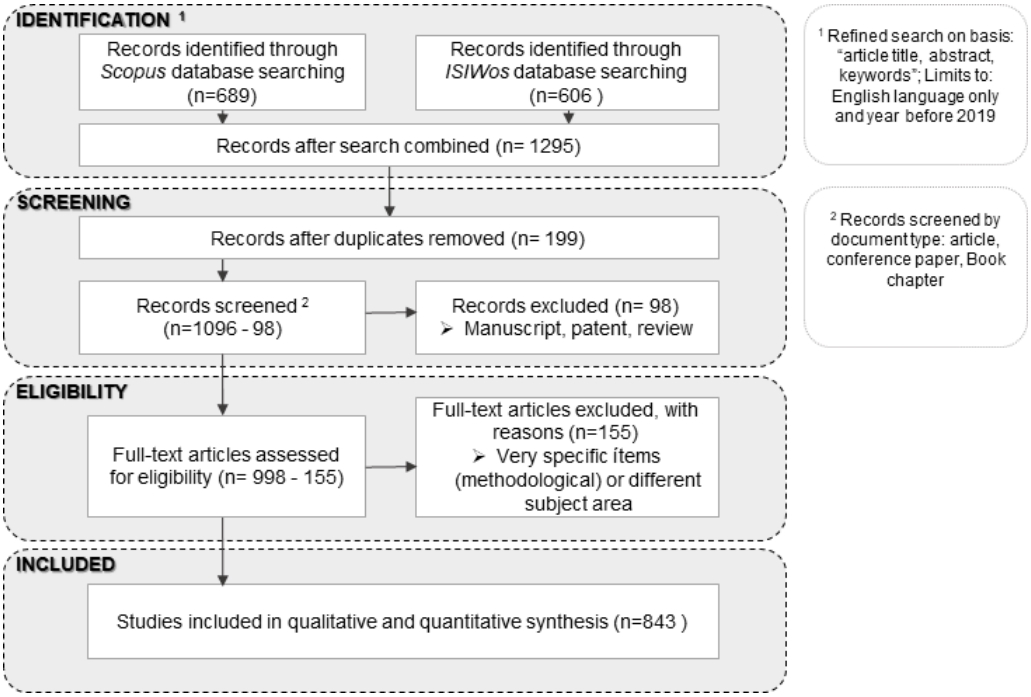


Fig. 2 PRISMA's five stages of data collection and analysis for systematic reviews

In order to conduct an analysis of the material presented in these papers, the bibliometric programs SciMAT and VOSviewer were utilized. As a direct consequence of this, the answers to the following research questions can now be provided:

i. What is the total number of articles and how have they been dispersed throughout time?

ii. Which authors have written the most books?

iii. Which conferences and periodicals have set the standard for this topic?

iv. The most important piece of literature is

v.) Where does this area of study stand right now?

vi. What are the major themes, if any,? also,

vii. What are the cutting-edge areas where more study is needed?

The bibliometric performance study shed light on all four of the queries, and the scientific mapping program that was mentioned was helpful with the last three of the questions.

4.6 EXPERT OPINIONS ON C&D WASTE MANAGEMENT ANALYSIS

Remelting is a process that involves recovering and recycling metals. This process takes place in a boiler and is called remelting. If the timber is in pristine condition, it is possible to reuse the beams, window frames, doors, walls, and other components that are made of timber. This is also the case with any other components that are made of timber. However, in order to reduce the risk of termite infestation, the wood that is used in

construction is often chemically treated. This makes it less likely that termites will be able to colonize the wood. The questionnaire method was used in order to conduct an analysis of the experts' points of view regarding the management of C&D waste. The following responses have been compiled as a result of the survey.

Table 1 a Predetermined Amount Of Time Set Aside For The Development Of A Strategy For The Disposal Of Waste Products.

Response	Frequency	Percentage
Yes	335	67%
No	165	33%
Total	500	100%

The findings of the survey question "Has time been set aside to prepare a waste management plan?" are shown in the table that can be seen above, both in terms of the frequency of the responses and the percentage of those responses. This table may be accessed by clicking here. In the column labeled "Response," the possible responses "Yes" and "No" are displayed. The "Frequency" column displays the number of times each response was provided, while the "Percentage" column displays the percentage of respondents who supplied each response. Both columns are located under the heading "Results."

67% of respondents in this table replied "Yes," indicating that time has been set aside to construct a waste management plan, while 33% of respondents answered "No," suggesting that there has been no time set aside for the preparation of a waste management plan. There were a total of five hundred people who participated in the survey, which is shown in the "Total" row of the dataset.

Table 2The Environmental Impact Of The Building Processes And Materials Has Been Analyzed.

Response	Frequency	Percentage
Yes	250	50%
No	250	50%
Total	500	100%

The responses to the question "Have the construction methods and materials been assessed for the amount of waste they produce?" can be found in the table that can be found above. Additionally, the frequency and percentage of those who answered "yes" to the question are also represented in the table based on the dataset. The "Response" column shows the possible answers, "Yes" or "No". The "Frequency" column shows the number of times each response was given, while the "Percentage" column shows the percentage of respondents who gave each response.

In this table, 50% of respondents answered "Yes", indicating that the construction methods and materials have been assessed for the amount of waste they produce, while the other 50% answered "No", indicating that they have not been assessed. The "Total" row shows the total number of respondents in the dataset, which is 500.

I will assume that you have a dataset with responses to the question "Will materials be ordered with less packaging or packaging that is returnable?" with two possible answers: "Yes" or "No". Here's an table data analysis table:

Table 3 It Is Recommended That Items With Less Packing Or Returnable Packaging Be Ordered

Response	Frequency	Percentage
Yes	400	80%
No	100	20%
Total	500	100%

According to the collected information, the question "Will materials be ordered with less packaging or packaging that is returnable?" was posed to the respondents. The frequency of those who responded "Yes" to this question, as well as the percentage of those who did so, is represented in the table that can be found directly above this one.

In the column labeled "Response," the possible responses "Yes" and "No" are displayed. The "Frequency" column displays the number of times each response was provided, while the "Percentage" column displays the percentage of respondents who supplied each response. Both columns are located under the heading "Results."

CONCLUSION

India is continuously making improvements and setting new standard goals for the implementation of RE in order to reduce ever-increasing carbon emissions, primarily, as well as global warming, and to raise the air flow quality index chart. In addition, India's energy consumption is normally planned to drastically increase in the impending years because the Indian government has got intended to significantly scale back the production of classic cars and improve to take up the use of electrical motor vehicles by the year 2025. This is usually planned to take place by the year 2025. Despite the fact that it is not always truly distributed evenly, India has implemented most initiatives to boost alternative energy generation throughout the country. According to projections made by the International Energy Organization, India would become the second virtually most important factor to the global demand for energy by the year 2035. It is clear, based on the results of load forecasting, that the demand for 90000 MW needs to be satisfied in order to meet the essential electrical requirements in 2035. Solar cells, while still in their early stages of development, tend to be more expensive and produce results that are less effective when compared to other types of energy that are not renewable.

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