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Developing a Web-Based Visualization Tool for Solar Energy Awareness in Malaysia

Naufal Aniq Khairol Amali[1], Norziana Yahya[2*], Mohd Azahani Md Taib[3], Gloria Jennis Tan[4], Ernie Mazuin Mohd Yusof[5]

[1]*Toulouse Business School Education, 20 Bd Lascrosses, 31000, Toulouse, France*
[2]*College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Perlis Branch, Arau Campus, Perlis, Malaysia*
[3]*Richtech-Synergy Sdn Bhd, Menara Maxis, Jalan Ampang, Kuala Lumpur, Malaysia*
[4]*College of Computing, Informatics and Mathematics, Universiti Teknologi MARA Terengganu Branch, Kuala Terengganu, Terengganu, Malaysia*
[5]*Malaysian Institute of Industrial Technology (UniKL MITEC), Bandar Seri Alam, 81750 Masai, Johor, Malaysia*

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ABSTRACT

The aim of this paper is to develop an informative website to address the lack of accessible information and awareness about solar energy usage in Malaysia. The system aims to equip users with knowledge, awareness, and information about solar energy. Additionally, the website incorporates a data visualization feature that demonstrates Malaysia's electrical consumption, enabling users to observe the potential cost savings of utilizing solar energy. The project has three objectives, which are to obtain system requirements for displaying information on solar energy usage in Malaysia, design a data visualization to evaluate Malaysia's suitability for solar energy, and develop an informative website that allows users to explore solar energy data visualization related to Malaysia. The informative website development utilized the Waterfall Model, which progresses through the phases of requirements analysis, system design, and system testing. User Acceptance Testing was conducted to determine the informative website's perceived usability and perceived user satisfaction. The test results indicate that the informative website is a useful tool for allowing users to explore solar energy data visualization related to Malaysia.

1. INTRODUCTION

Electricity consumption has become an integral part of daily life, pervasive across homes, businesses, and industries, especially in today's globalized era. However, in Malaysia, the escalating costs of electricity have emerged as a pressing concern, exacerbated by a staggering 23% surge in usage during the COVID-19 pandemic, intensifying financial burdens for households. Common appliances like refrigerators, air conditioners, and water purifiers significantly contribute to this consumption, particularly in warm climates.

[2*] Corresponding author. *E-mail address*: norzianayahya@uitm.edu.my
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Notably, Malaysia boasts an average solar radiation of approximately 4500 kWh m-2, signaling immense potential for large-scale solar power implementations.

Solar energy, harnessed through photovoltaic systems that directly convert light into electricity (Aziz et al., 2016) alongside technologies like concentrated solar power, holds promise in electricity generation. Additionally, solar-based heating and cooling systems efficiently capture thermal energy to facilitate hot water and air conditioning (SEIA, 2018). Remarkably, the sun radiates enough energy to sustain global energy needs for a year in just one hour (Vourvoulias A., 2021). However, barriers hinder widespread adoption of solar energy in Malaysia. The prohibitive initial installation costs, encompassing expenses for solar panels, inverters, batteries, wiring, and installation, pose a significant obstacle for potential users. Moreover, a prevalent lack of awareness about solar energy's advantages restricts its uptake. Companies specializing in solar panel installations face challenges in identifying suitable buildings due to insufficient data on electricity usage and available roof space.

To confront these multifaceted challenges, this paper aims to propose the development of an informative website tailored to provide comprehensive information on solar energy usage and relevant insights for Malaysians. The envisioned system intends to empower users by imparting knowledge, enhancing awareness, and furnishing essential information about solar energy. Central to its features, the website will offer insights into Malaysia's solar energy potential, data on solar panel power plant capabilities, and a user-friendly data visualization illustrating the country's electrical consumption. Through this, users can discern the scale of electricity usage in Malaysia and envisage the potential cost savings achievable by transitioning to solar energy.

The research methodology adopts a structured approach involving comprehensive data gathering from reputable sources and stakeholder engagements within the solar energy domain. This includes but is not limited to:

Literature Review: Analyzing existing studies and publications on solar energy adoption, costs, and technological advancements relevant to Malaysia.

Data Collection: Collecting pertinent information on solar energy potential, electrical consumption patterns, and demographic specifics within Malaysia.

Development Phase: Implementing the Waterfall Model to guide the iterative process of website development, encompassing requirements analysis, system design, and testing.

User Testing: Conducting rigorous User Acceptance Testing (UAT) to gauge the website's usability, functionality, and user satisfaction.

The UAT results provide strong evidence that the website successfully achieved its objectives. The UAT findings indicate that users found the website to be a valuable tool for accessing comprehensive information on solar energy usage and relevant insights specific to Malaysia. Feedback from UAT participants highlighted the website's effectiveness in imparting knowledge and enhancing awareness about solar energy, with users reporting increased understanding and interest in solar energy solutions. Additionally, the data visualization features were praised for their clarity and usability, allowing users to easily explore Malaysia's solar energy potential, power plant capabilities, and electrical consumption patterns. These visualizations helped users comprehend the scale of electricity usage and the potential cost savings from adopting solar energy.

This multifaceted approach ensures a robust foundation for the development of the informative website, aligning with the objective of addressing challenges and promoting solar energy adoption in Malaysia.

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2. LITERATURE REVIEW

2.1 Solar Energy in Malaysia

Every hour and a half, the sun radiates enough light onto the Earth's surface to generate sufficient energy to power the planet's energy consumption for an entire year. Solar technologies can harness this energy, utilizing photovoltaic (PV) panels or mirrors that concentrate solar radiation to convert it into electrical form. This energy can either be utilized to generate electricity or stored in batteries or thermal storage (Towler B. F., 2014)). Solar radiation, also referred to as electromagnetic radiation, is provided by the sun and received by all areas on Earth, albeit with varying degrees of energy reception in different regions. Solar technologies capture this radiation and transform it into usable energy.

The Malaysian Building Integrated Photovoltaic Project (MBIPV) was initiated by the Malaysian government in 2005 to incentivize the installation of building integrated photovoltaic systems. Universiti Teknologi MARA (UiTM) was designated as the Photovoltaic System Monitoring Centre (PVSMC) in November 2006 to oversee the performance of BIPV and PV projects for a five-year period until June 2011 (Hussin et al., 2012).

According to (Teoh A.I., 2020), two psychological factors are crucial in meeting the increased demand for renewable energy: awareness of renewable energy and adoption of energy-saving behaviors. While the public fulfilled the first criterion, with a majority having knowledge about renewable energy, they fell short in meeting the second criterion, displaying a lack of energy-saving behaviors. Additionally, respondents exhibited reluctance in installing PV panels due to associated costs, despite expressing a desire to do so. A comprehensive investigation into the level of knowledge and awareness among Malaysians was conducted by Teoh (2020), revealing that while a majority of the public is aware of renewable energy, there is a significant gap in the adoption of energy-saving behaviors. This indicates that an informative website on solar energy, which aims to bridge this gap by providing detailed information, benefits, and potential savings of solar energy, is indeed what Malaysians need.

Malaysia has made strides in utilizing solar energy, with several initiatives and projects aimed at increasing solar energy adoption. The country receives an average solar radiation of approximately 4500 kWh m-2, making it highly suitable for solar energy generation. Despite this potential, solar energy constitutes a relatively small portion of the country's energy mix. For instance, as of 2020, solar energy contributed to only about 2% of Malaysia's total energy capacity (SEDA Malaysia, 2020). A thorough investigation into Malaysia's solar energy providers reveals that companies are actively working to raise awareness about the advantages of solar energy. Companies such as Plus Solar, Ditrolic Solar, and GSPARX have initiated various awareness campaigns, educational programs, and promotional activities to inform the public about the benefits of solar energy. These efforts include community outreach, social media campaigns, and partnerships with educational institutions to enhance public understanding and adoption of solar energy technologies.

In conclusion, although solar energy has been utilized in Malaysia, the absence of knowledge, awareness, and energy-saving behaviors has deterred many from availing its benefits. Companies involved in providing solar energy must prioritize raising awareness about its advantages, especially in regions where it can yield significant benefits.

2.2 Web-based Technology

Web technology is the method through which computers communicate with each other using markup languages and multimedia packages. It encompasses various devices and methods utilized over the internet to facilitate communication between different types of computers.

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A study conducted by (Kuiper et al., 2013) employed a web-based mapping application for solar energy project planning. This system facilitated the storage, management, analysis, and visualization of data and information pertinent to solar energy. By offering visual representations of solar energy-related data and information, this study aimed to assist solar panel companies in identifying optimal locations for successful sales of solar panels to their users and customers.

2.2.1 Web Application

A web application is computer software that executes operations over the Internet through web browsers and web technologies (Gibb R., 2016). It necessitates three components for managing client requests, executing desired actions, and storing information: a web server, an application server, and a database.

On the client side, HTML5, CSS, and JavaScript are utilized, while on the server side, languages such as PHP, Python, or Java are essential for storing and retrieving information. Examples of web apps include Yahoo, Gmail, Google Docs, Google Slides, Google Sheets, as well as applications for photo editing, file conversion, and file scanning.

Utilizing a web application offers several advantages. One of the key benefits is its extensive accessibility, compatible with various browsers like Google Chrome and Mozilla Firefox. Moreover, web applications typically operate faster than traditional desktop applications and boast higher reliability as they remain unaffected by viruses or malware. Additionally, users can access them from anywhere with an Internet connection.

2.2.2 Types of Web Application

Web applications are categorized into five types: static, dynamic, e-commerce, portal, and content management systems. Static applications, the most basic type, are usually built using CSS and HTML without scripting or database connections. They are easier to maintain and update due to having less code compared to dynamic websites, but modifying content within them can be more challenging. Examples of static web applications include online documentations, forms, and newsletter contents.

Dynamic web applications, more intricate than static ones, incorporate databases and the capability to modify existing information. Advanced server technologies such as PHP, JavaScript, or ASP are commonly employed in their development, allowing for easier updates and greater interactivity. Dynamic websites are also more interactive, facilitating engagement with users. Examples of dynamic web applications encompass online stores, forums, and social networks. The distinction between static and dynamic websites is delineated in Table 1.

Table 1. Differences of static and dynamic website

Static Website	Dynamic Website
The content is fixed, programmed solely in HTML and CSS on each page.	The content is dynamic, programmed to vary based on user preferences.
Only HTML is required for development.	PHP, JavaScript, and ASP can be utilized for development.
Errors can occur during updates.	Easier to update.
Has more flexibility and freedom as each page differs.	Users have total control over the design content and may update and change it at any time.

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2.3 Data Visualization

Data visualization involves presenting data in visual formats like graphs, charts, or maps, aiding in better comprehension of complex data sets by revealing patterns, trends, and outliers (Heitzman A., 2019). It is an essential step in the business intelligence process and finds applicability across various business sectors and professions.

By employing data visualization, raw data can be modeled and displayed in formats that facilitate drawing meaningful conclusions. Furthermore, ongoing developments in machine learning algorithms aim to enhance data visualizations, making them more comprehensible and analyzable.

2.3.1 Data Visualization Systems and Techniques

Modern systems face the challenge of managing information overload when processing and visualizing large datasets. Visual scalability plays a crucial role in the success of Big Data visualization. Consequently, many systems utilize an 'approximation technique' called data reduction, computing abstract representations of data (Park Y., 2016).

Hierarchical approaches prove notably effective in visualizing vast datasets, offering users an overview and facilitating specific area identification within the dataset (Bikakis et al., 2017). These approaches also leverage approximation techniques to tackle information overload. In Big Graph Visualization, hierarchical methods are commonly employed to recursively break down a graph into smaller subgraphs, establishing a hierarchy of abstraction layers (Rodrigues, 2013) (refer to Fig. 1).

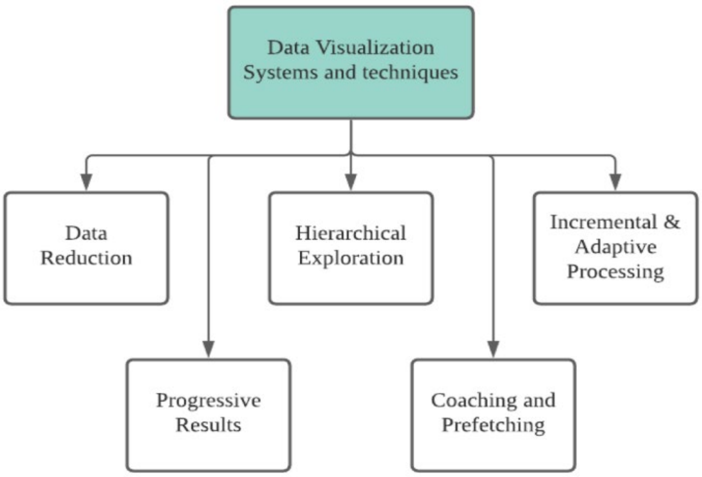

Fig. 1. Data visualization systems and techniques

Source: Bikasis et al. (2017)

Dynamic settings often hinder data preparation, restricting user access to limited input data in exploration settings (Bikakis et al., 2017). To counter this, some systems adopt 'in situ data exploration', enabling users to analyze vast, dynamic datasets on-the-fly without pre-processing the entire dataset. Small data segments are processed incrementally and adaptively using indexing approaches (Olma et al., 2017).

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2.3.2 Data Visualization Tools

Timeline is an open-source program that allows users to create visually appealing and interactive timelines easily, without requiring extensive technical knowledge or special software. The program can be swiftly downloaded and set up using a Google spreadsheet. For a more personalized experience, individuals with a good understanding of JSON may utilize TimelineJS to create their own Timeline project, equipped with the same basic functionalities (Caldarola & Rinaldi, 2017).

Graph-tool is a powerful Python package that equips users with the capability to modify graphs and conduct statistical analyses. The data structures and algorithms necessary for these operations are developed in C++, employing template metaprogramming and the Boost Graph Library. This enables it to be more efficient than many other Python modules with similar capabilities (Peixoto, 2023).

2.3.3 Information Visualization Tools

Tableau is a tool designed for visualizing business big data, offering a wide range of visualizations such as charts, graphs, and maps (Tableau, 2020). It operates as a desktop-based program focusing on visual analytics and charting. Additionally, it provides a server solution allowing users to view reports online and via a mobile app. Customers also have the option of implementing a cloud-hosted service on their own premises (Caldarola & Rinaldi, 2017). An example of data visualization using Tableau is depicted in Fig. 2.

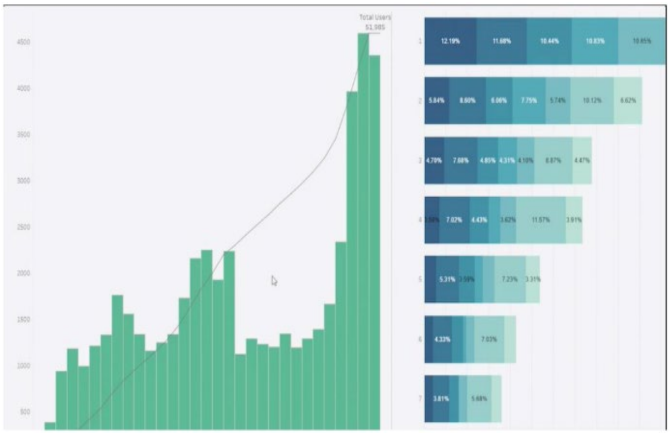

Fig. 2. Example of Tableau

Source: www.tableau.com

Infogram offers a variety of interactive charts and maps to aid users in visually presenting data attractively. Chart objects like column, bar, pie, and word cloud are readily available. It falls under the genre of infographic software, enabling users to include maps in their infographics for creating visually appealing reports. Moreover, Infogram offers team accounts for journalists and media enterprises, branded designs for businesses, and classroom accounts for educational purposes (Caldarola & Rinaldi, 2017). An example of data visualization using Infogram is depicted in Fig 3.

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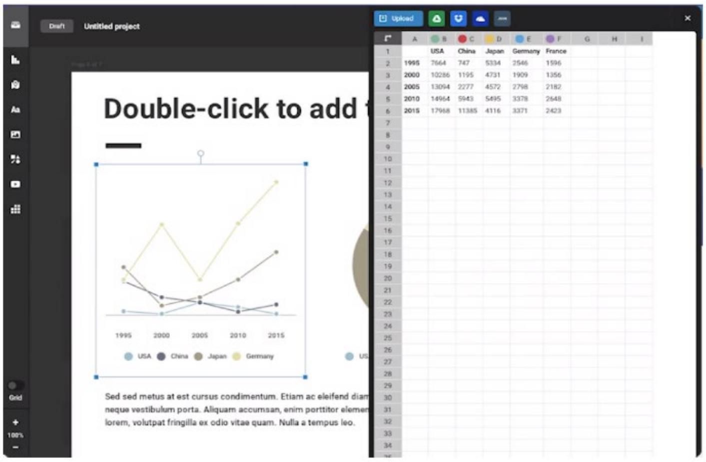

Fig. 3. Example of Infogram

Source: https://infogram.com

Google Charts, a Java library, utilizes HTML5 and SVG technologies to ensure full cross-browser compatibility, even with older versions of Internet Explorer using VML. The library enables users to create interactive charts that support zooming in for a user-friendly experience. Furthermore, the Google Charts website features an attractive and comprehensive gallery showcasing various visualizations and interactions that users may need (Caldarola & Rinaldi, 2017). An example of data visualization using Google Charts is depicted in Fig. 4.

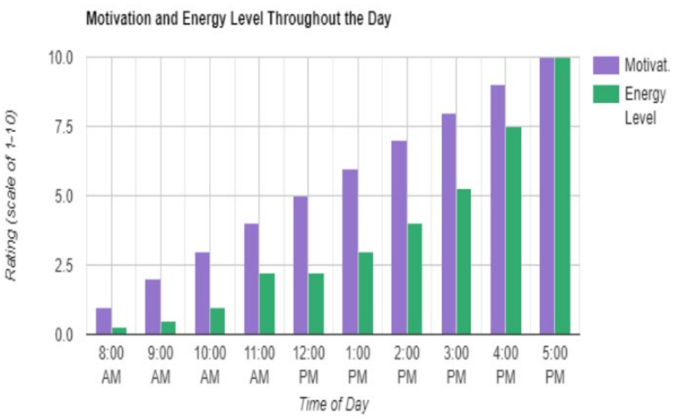

Fig. 4. Example of Google Charts

Source: https://developers.google.com/chart

FusionCharts is the most comprehensive JavaScript charting package, boasting over 90 charts and 900 maps. Compatible with libraries like jQuery, frameworks such as AngularJS and React, and programming languages like ASP.NET and PHP, it allows users to export charts in various formats, including JSON and

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XML data, as well as image formats like PNG, JPEG, SVG, and PDF (Caldarola & Rinaldi, 2017). An example of data visualization using FusionCharts is depicted in Fig. 5.

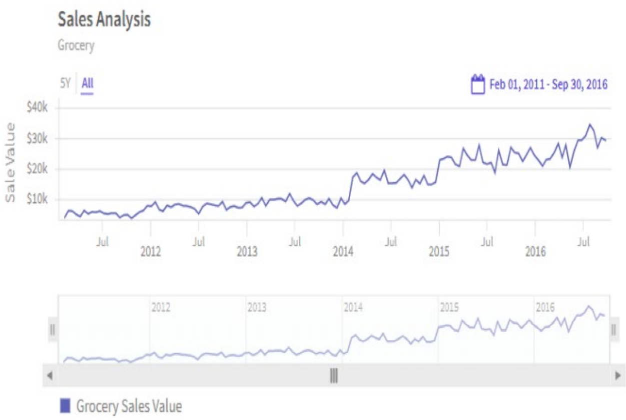

Fig. 5. Example of FusionCharts

Source: www.fusioncharts.com

2.4 Similar Web Applications

Several web applications share functionalities with the solar energy data visualization project. Solar-Estimate.org (https://www.solar-estimate.org) provides users with comprehensive solar panel cost estimates and savings calculations. This platform features interactive visualizations that allow users to see potential savings and the performance of their solar systems, making it easier for them to understand the financial benefits of solar energy.

The PVWatts Calculator (https://pvwatts.nrel.gov), developed by the National Renewable Energy Laboratory (NREL), is an online tool that estimates the energy production and cost savings from solar photovoltaic systems. This calculator provides users with detailed visual representations of energy output and savings, helping them assess the feasibility and economic benefits of installing solar panels.

EnergySage Solar Calculator (https://www.energysage.com/solar/calculator) offers a platform where users can receive quotes for solar installations and analyze the financial benefits of solar panel systems. The platform includes visualizations that highlight potential savings and system performance, aiding users in making informed decisions about solar energy investments.

The SolarCity Solar Calculator (https://www.tesla.com/solarpanels), now part of Tesla, allows users to estimate the costs, savings, and performance of solar systems through interactive charts and graphs. This tool helps users understand the economic impact and efficiency of their potential solar investments.

SolarGraph (https://www.solaranalytics.com/solargrap) by Solar Analytics is another notable application. It is a data visualization tool designed for solar energy systems, offering detailed charts and graphs on system performance and energy savings. This application helps users monitor and analyze the efficiency and output of their solar installations.

These web applications share a common focus on solar energy data visualization, user interaction, and performance analysis. They aim to provide users with valuable insights into the financial and energy-saving benefits of solar energy, similar to the objectives of the solar energy data visualization project. By

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leveraging interactive visualizations and detailed performance metrics, these applications enable users to make informed decisions about solar energy adoption, thus promoting the use of renewable energy sources.

3. METHODOLOGY

The proposed methodology commences with Phase 1, Project Initiation, concentrating on project requirement analysis and development technique identification. Phase 2, Design and Development, encompasses tasks including data collection, system design, and coding. Finally, Phase 3, Testing, emphasizes system and data testing, especially pertinent due to the system's focus on data visualization. An overview of the proposed development method is illustrated in Fig. 6.

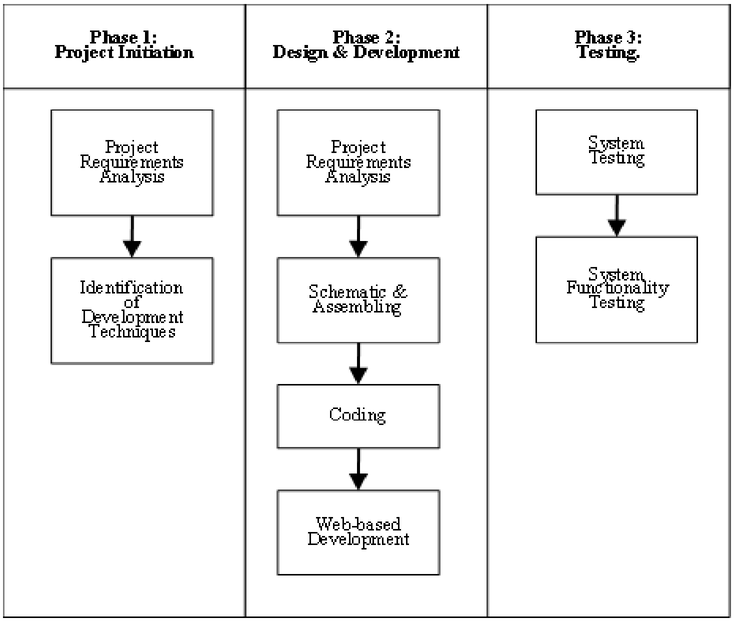

Fig. 6. Development method

3.1 Initiation Phase

The initial phase of the project involves identifying its requirements, encompassing aspects like design, function, purpose, and other pertinent factors. This phase holds significance as it ensures the seamless progression of all subsequent stages. Successful completion of this phase allows for easy implementation of any required changes in later stages. The processes involved in project initialization are outlined in Fig. 7.

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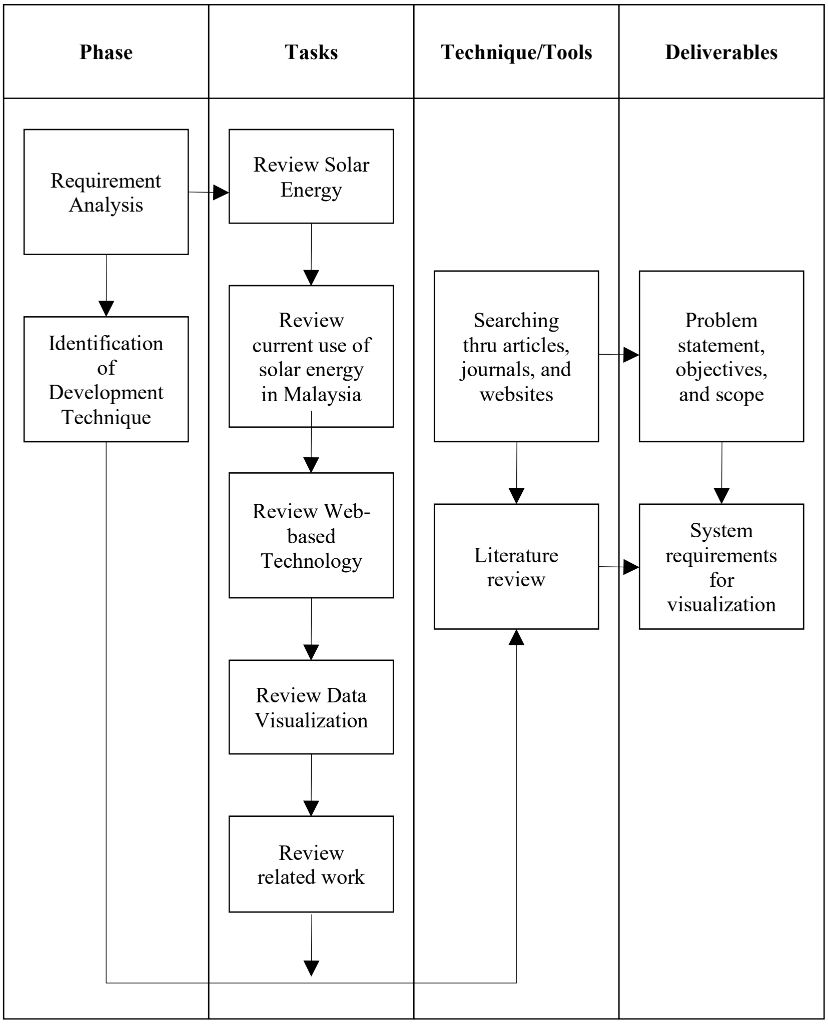

Fig. 7. Initiation Phase

3.2 Design and Development Phase

The Design and Development phase emphasizes the system's design and the consolidation of gathered data to facilitate user-friendly data comprehension via visualization. Software like Tableau or Power BI will be essential to merge multiple datasets into a unified format. The processes involved in design and development are delineated in Fig. 8.

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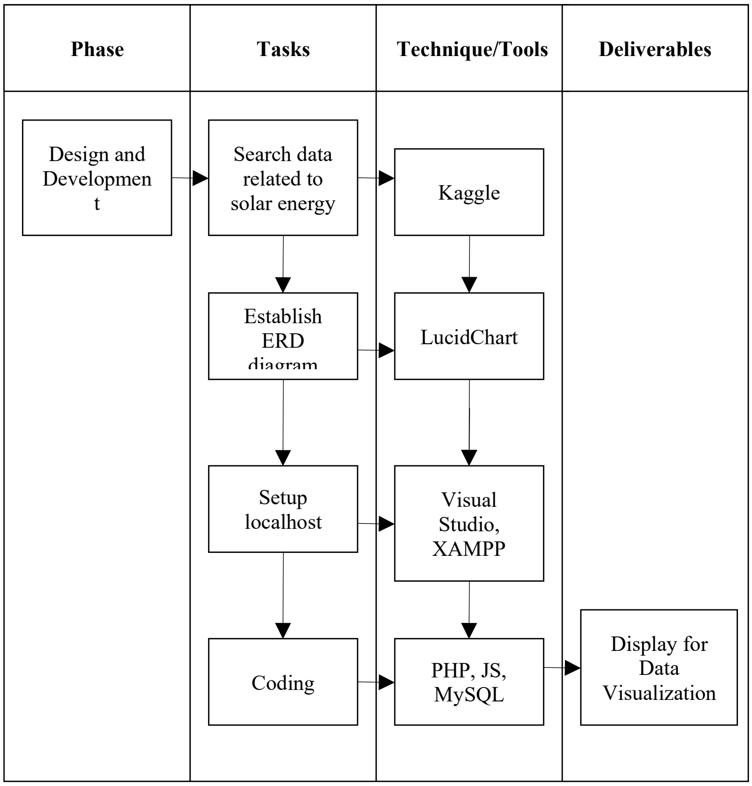

Fig. 8. Development Phase

3.3 Testing Phase

After each unit has undergone testing, all units generated throughout the design and development phase are integrated into a system. Consistent testing of the system is imperative to verify the absence of errors or mistakes. Additionally, tests should be conducted to ascertain that users can operate the system seamlessly and interpret the data effectively. The processes involved in testing are elaborated in Fig. 9.

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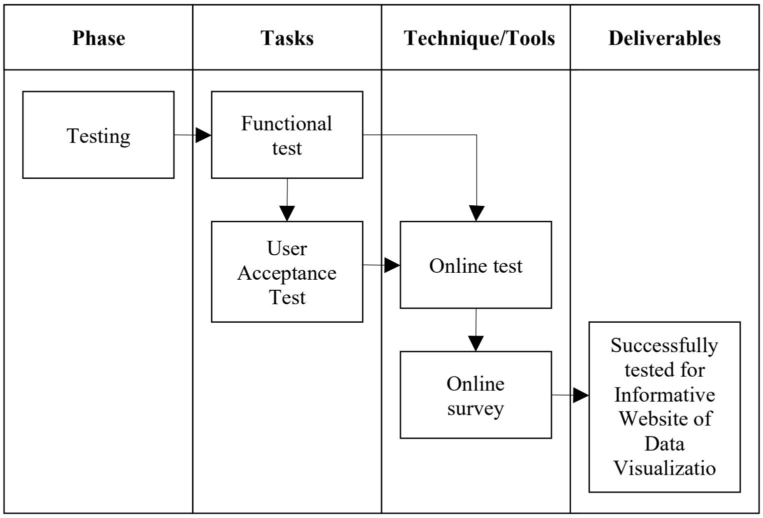

Fig. 9, Testing Phase

4. DEVELOPMENT

4.1 Development Requirements

A laptop served as the primary tool for all tasks related to designing the web system, coding, data cleansing, and data visualizations during the development of the informative web-based system.

The software utilized in the development process included Visual Studio Code, XAMPP, Weka, Tableau, and 000webhosting. Visual Studio Code was employed for designing and coding the web-based system. XAMPP, an open-source web server solution stack package, provided a local-host development environment.

Weka, a robust data mining and machine learning tool, facilitated the development of an automated system for analysing user engagement with the solar energy website. Tableau, a data visualization tool, was instrumental in generating visualizations based on user interaction data. Finally, 000webhosting, a web hosting service provider, facilitated the deployment of the system online.

XAMPP was utilized for monitoring the web-based system, as the XAMPP server software offers a suitable platform for testing PHP projects on local computers (refer to Fig. 10).

Fig. 10. XAMPP Control Panel

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Weka played a role in data cleansing, effectively eliminating redundant data types, null values, and other unwanted data elements from datasets (refer to Fig. 11).

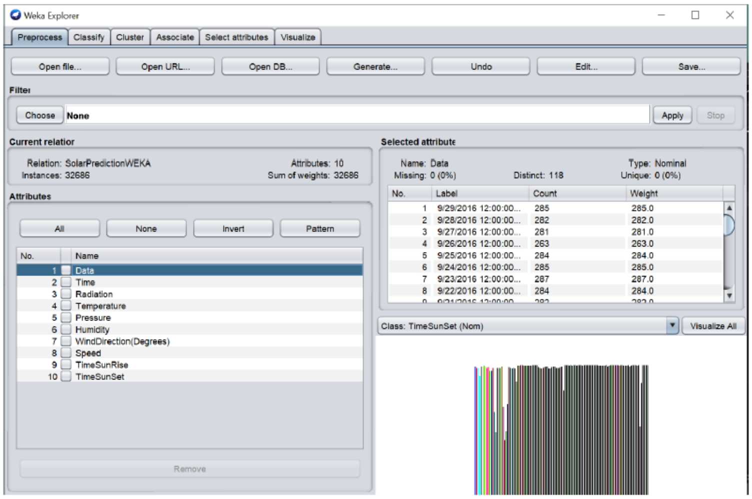

Fig. 11. Weka Interface

Tableau served as a visual analytics platform, transforming datasets from Microsoft Excel into more presentable and comprehensible data presentations (refer to Fig. 12).

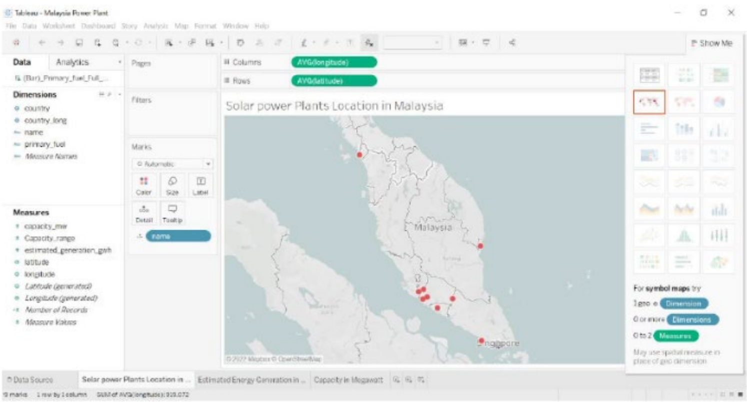

Fig. 12. Tableau Interface

4.2 Design Interface

The visual layout and appearance of a system's user interface play a pivotal role in shaping users' perceptions of an application. Essentially, the design interface acts as the users' first encounter, significantly influencing their assessment of the application's quality, ease of use, and functionality. Consequently, developers must meticulously craft the design interface, aiming to forge an intuitive and visually captivating user experience that leaves a positive initial impression.

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4.2.1 Design Sitemap

The description of the informative web-based application is presented in the sitemap design, delineating the entire process occurring on the website. Fig. 13 illustrates the sitemap, comprising four pages. The initial page is the home page, enabling users to access information and insights regarding solar energy. The second, pivotal page is the dashboard, housing four data visualizations aimed at enhancing users' comprehension of solar energy in Malaysia. The third page, the about section, contains details about the developers. Finally, the feedback page offers users the opportunity to leave feedback.

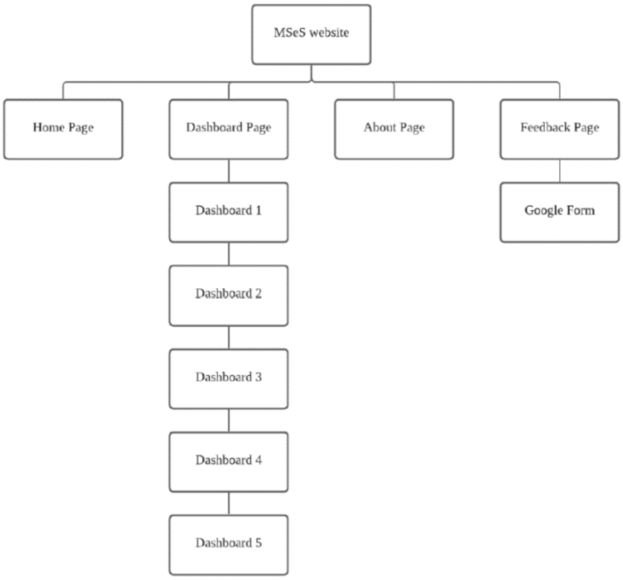

Fig. 13. Sitemap design

4.2.2 Drafting Storyboard

The storyboard was crafted using Balsamiq to generate ideas and design concepts in the initial stages of the design process. Fig. 14 illustrates the storyboard design, acting as a blueprint for subsequent development phases. It delineates the system's flow and design, offering a visual representation of the user interface and its various functionalities.

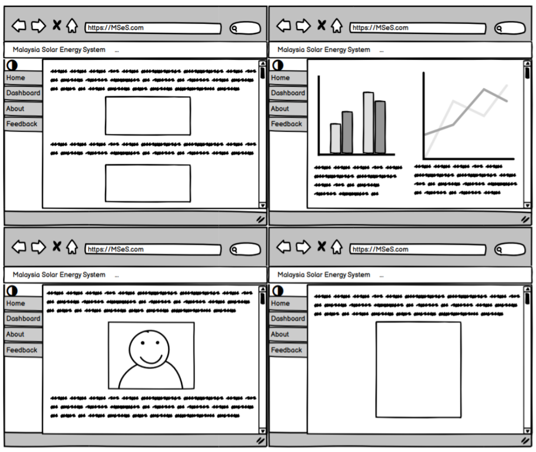

Fig. 14. Sketch storyboard design

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4.3 Website Development

The development phase is where the system is constructed based on the design created in the preceding phase, and where raw data is collected and transformed into visualizations.

4.3.1 Data Collection

This phase involves searching for and gathering data from the internet. The majority of the data used for the website was obtained from Kaggle.com and the Portal Data Terbuka Malaysia. Fig. 15 displays the data collected from Kaggle, while Fig. 16 showcases the data collected from the Portal Data Terbuka Malaysia.

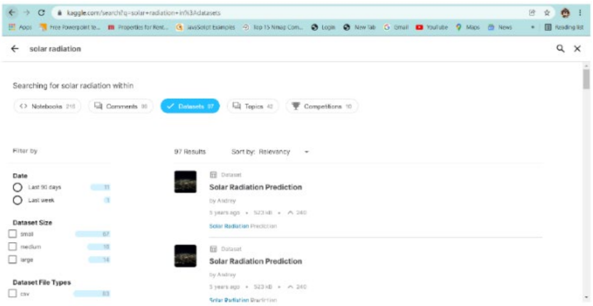

Figure 4.10 Kaggle

Fig. 15. Kaggle

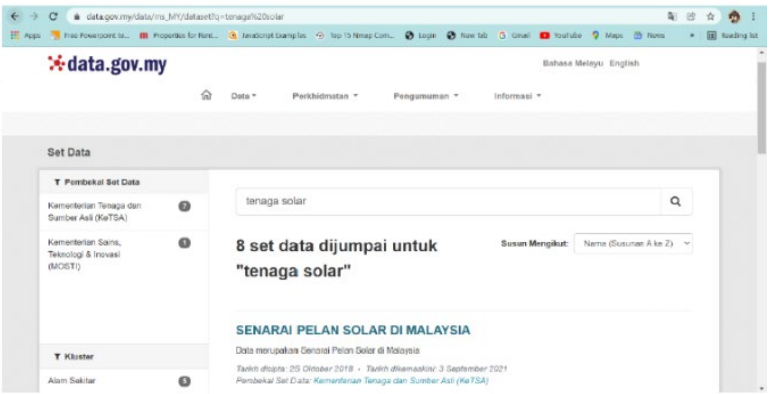

Fig. 16. Portal Data Terbuka Malaysia

4.3.2 Transform Data

Once all the data had been collected, it was essential to transform and cleanse the raw data. This step was necessary due to the presence of repetitive and null values, redundancies, and some irrelevant data within the collected dataset. The transformation and cleansing process were conducted using an application or software known as Weka, as depicted in Fig. 17.

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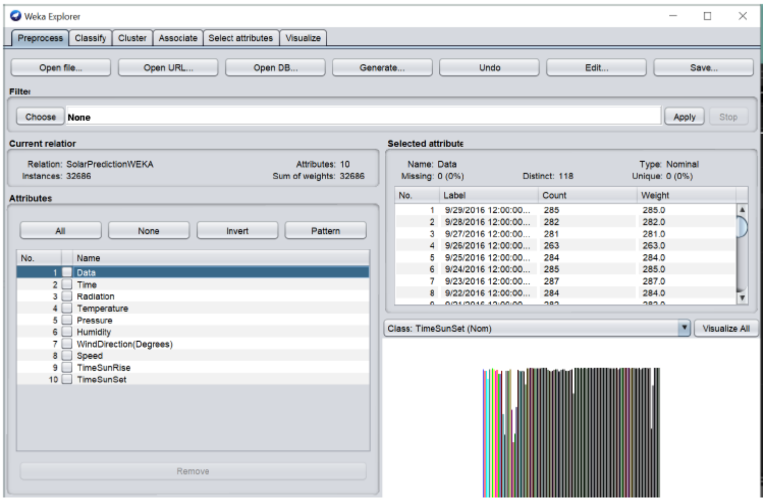

Fig. 17. Using Weka to cleanse data

4.3.3 *Visualization of Data*

Visualizing data is the subsequent phase following the cleansing of the dataset. Now that all the crucial data in the dataset are available, they can be visualized utilizing Power BI or Tableau. In this project, Tableau was the chosen tool. Fig. 18 depicts the flowchart illustrating how to visualize a dataset using Tableau.

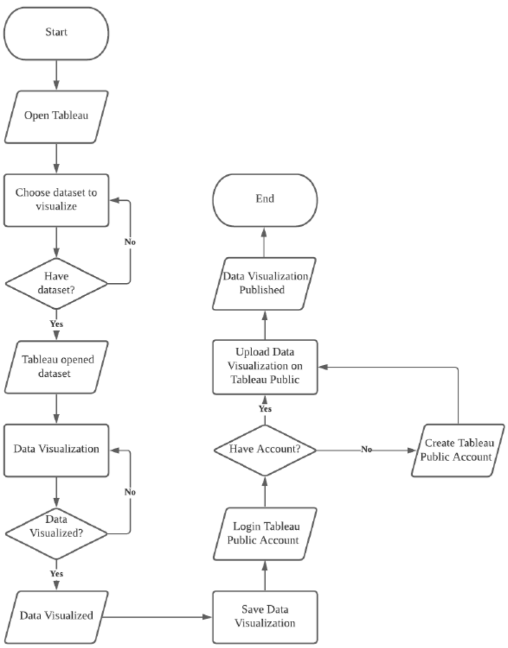

Fig. 18. Flowchart of visualizing data

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4.3.4 Integration of Tableau and Website

This represents the ultimate stage of data visualization. The system integrates Tableau Public with its website, enabling effortless embedding of data visualizations. Each data visualization uploaded to Tableau Public will acquire embedded code, facilitating its addition to the system's website (Fig 19).

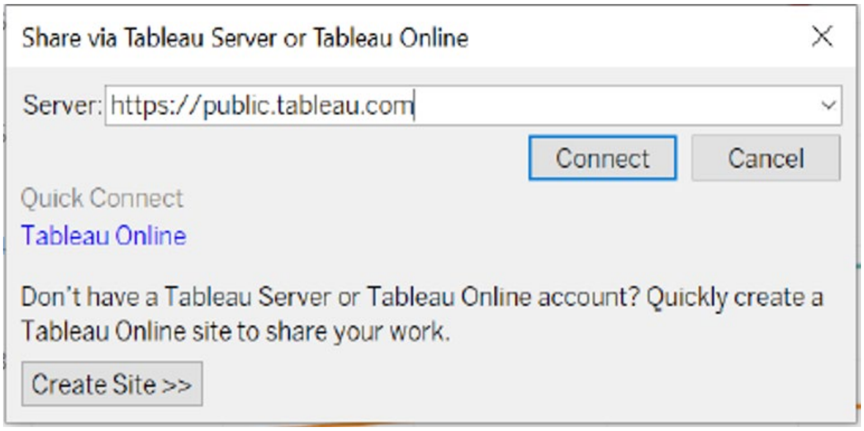

Fig. 19. Uploading data visualization on Tableau Public

Upon uploading the data visualization to the Tableau Public profile, it will be showcased on the Tableau Public website, as depicted in Fig. 20.

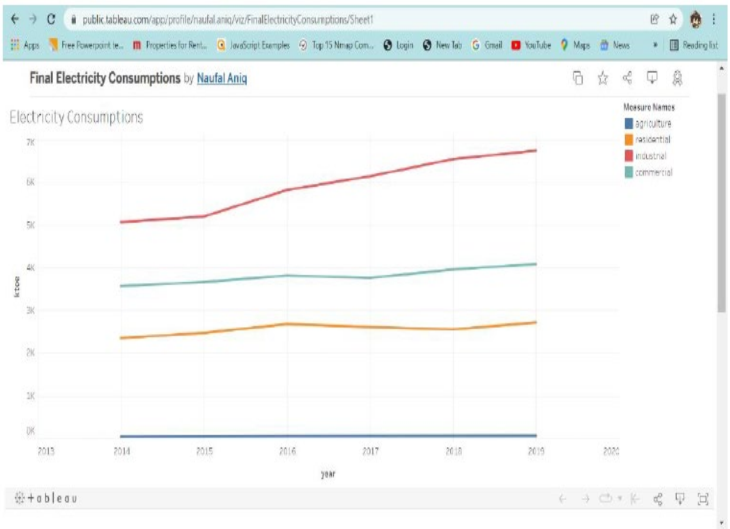

Fig. 20. Data visualization uploaded on Tableau Public

4.4 Acceptance Test

The Testing phase follows the design and development phase, involving testers or users to examine and navigate through the development by executing test cases, either manually or through automation (Zulqadar A., 2019).

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The User Acceptance Test (UAT) involved selected students from different universities, such as UiTM, UPM, and UKM. Two respondents, lecturers from UPNM specializing in the Electrical Engineering course, were chosen to evaluate the system. Involving university students in the UAT ensures the website on solar energy is critically evaluated by a tech-savvy, future-oriented audience, while the initial exclusion of industry professionals and the general public allows for a more focused and efficient testing phase to refine the website before broader testing.

The primary aim of the UAT was to create an informative website that allows users to explore data visualizations related to Solar Energy in Malaysia. Thirty UAT respondents received a Google Form questionnaire and a link to the informative website. After navigating through the website, respondents were required to answer several questionnaires regarding its functionality.

Results were calculated based on the percentage of responses in the Google Form, consisting of five options: Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5). The UAT was divided into two primary sections: Perceived Usability and Perceived User Satisfaction.

4.4.1 Result of Perceived Usability

Perceived usability refers to the degree to which a user perceives a product or system as easy to use and understand. It measures how well a product or system fulfils the needs of its users and how effortlessly users can accomplish their objectives while using it. Perceived usability is shaped by a user's individual evaluation of the product or system and can be influenced by its design, features, and user interface. A product or system with high perceived usability is more likely to be user-friendly, efficient, and successful, leading to heightened user satisfaction and engagement.

Table 2. Result of Perceived Usability

Perceived Usability	**Percentage (%)**				
	1	**2**	**3**	**4**	**5**
1. I found the website complicated.	16.7	83.3			
2. I think that I would use this website to receive awareness on usage of Solar Energy for the industrials in Malaysia.				90	10
3. I think that I would need the support of a technical person to be able to use this website.	20	73.3	6.7		
4. I thought the website was easy to use.				76.7	23.3
5. I found the various functions on the website were well integrated.				93.3	6.7
6. I thought there was too much inconsistency in this website	3.3	86.7	10		
7. I would imagine that most people would learn to use this website very quickly.			6.7	93.3	
8. I found the website very cumbersome to use.	13.3	86.7			
9. I felt very confident using the website.				76.7	23.3
10. I needed to learn a lot of things before I could get going with this website.	23.3	70	6.7		

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Summarizing Table 2, it reveals unanimous disagreement among respondents regarding the complexity of the website, coupled with unanimous agreement on the informative website's effectiveness in raising awareness about solar energy usage in Malaysia. A mere 6.7% of respondents expressed uncertainty about requiring assistance in navigating the website.

Additionally, all respondents unanimously agreed on the website's user-friendly nature and well-integrated functions. Moreover, a substantial 90% of respondents disagreed with the perception of website inconsistency. Furthermore, over 90% of participants concurred that they could swiftly grasp and confidently utilize the website.

4.4.2 Result of Perceived User Satisfaction

Perceived user satisfaction refers to users' evaluations of their satisfaction level with a product or system. This subjective assessment is rooted in how effectively the product or system meets the user's requirements and expectations regarding usability, functionality, and overall user experience. Factors such as design, reliability, ease of use, and perceived value can significantly impact perceived user satisfaction. Products or systems with high perceived user satisfaction tend to yield satisfied users, who are more inclined to continue using and recommending the product and maintain positive perceptions of the associated brand or company.

In summary, Table 3 illustrates that over 90% of respondents agreed that the website is user-friendly, comfortable, and facilitates easy visualization. Most respondents expressed satisfaction with the website's functionalities and capabilities, while a few respondents remained uncertain. All respondents conveyed contentment with the website's information organization and felt highly confident using it. Furthermore, 100% of respondents concurred on the following points:

- the information effectively aided in task completion and scenarios.
- they would recommend the website to others.
- the website's usability is straightforward.
- the website's information effectively explained how to interpret the visualizations.

Table 3. Result of Perceived Usability

Perceived User Satisfaction	Percentage (%)				
	1	2	3	4	5
1. It was easy to learn to use this website.				86.7	13.3
2. I felt comfortable using this website.				73.3	26.7
3. It was easy to view visualization using this website.				36.7	63.3
4. This website has all the functions and capabilities I expect it to have.			16.7	83.3	
5. The interface of this website was pleasant.			13.3	86.7	
6. I liked the interface of this website.			30	70	
7. I believe I could become productive quickly using this website.			16.7	83.3	
8. The organization of information on the website screen was clear.				80	20
9. I felt very confident using the website.				76.7	23.3
10. I needed to learn a lot of things before I could get going with this website.	23.3	70	6.7		
9. Whenever I made a mistake using the website, I could recover easily and quickly.				100	
10. The information provided was clear.				50	50
11. Overall, I am satisfied with how easy it is to use this website.				90	10
12. The information was effective in helping me complete the tasks and scenarios.				100	
13. I would recommend this website to others.				86.7	13.3

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14. The website information clearly told me how to read the visualization.	76.7	23.3
15. It was simple to use this website.	22	26.7
16. Overall, I am satisfied with this website	66.7	33.3

5. CONCLUSION

The objective of this project was to develop an informative website to address the lack of accessible and comprehensive information about solar energy usage in Malaysia. This project successfully achieved three key objectives: gathering system requirements to exhibit and present data on solar energy usage in Malaysia, crafting a data visualization to assess Malaysia's potential for leveraging solar energy, and developing an informative website enabling users to delve into solar energy data visualization specific to Malaysia.

The development of the informative website adhered to the Waterfall Model, progressing through phases such as requirements analysis, system design, implementation, and rigorous system testing. User Acceptance Testing (UAT) was carried out to gauge the perceived usability and satisfaction with the informative website. The UAT results affirm the website's acceptance as a tool that enables users to explore data visualization centered on solar energy in Malaysia.

Recommendations for enhancing the informative website encompass the incorporation of additional datasets pertaining to solar energy in Malaysia, considering the limited availability of current datasets. Furthermore, optimizing data visualization tailored to the specifics of each dataset is essential. Lastly, users anticipate the inclusion of real-time data visualization features, such as real-time solar radiation data in Malaysia.

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7. CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest regarding the publication of this paper. They have received no financial or personal relationships that could influence the research's findings or interpretation.

8. AUTHORS' CONTRIBUTIONS

The research paper was driven by **Naufal Aniq Khairol Amali**, who initiated the project and developed an informative website on solar energy in Malaysia. **Norziana Yahya** provided supervision and academic guidance, while **Mohd Azahani Md Taib** offered industry insights, bridging academia and practical application. **Gloria Jennis Tan** contributed technical advice, particularly in data visualization, and **Ernie Mazuin Mohd Yusof** ensured methodological rigor and proofreading. Together, they ensured the project's success and impact in promoting solar energy awareness and adoption in Malaysia.

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