Visualization of UTP's Energy Consumption And Its Carbon Footprint (ENVISION)

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INFORMATION & COMMUNICATIONS TECHNOLOGY

UNIVERSITI TEKNOLOGI PETRONAS

JANUARY 2013

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A project dissertation submitted to the
Information Communication Technology Programme
Universiti Teknologi PETRONAS
In partial fulfillment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(INFORMATION & COMMUNICATION TECHNOLOGY)

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CERTIFICATION OF APPROVAL

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Approved by,

_____
(Prof. Alan Oxley)

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

_____

(WONG SING YUNG)

ACKNOWLEDGEMENT

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The author's gratitude also goes towards Universiti Teknologi PETRONAS (UTP) and the lecturers of Final Year Project of the Computer Information Sciences (CIS) department for the excellent organization and management of this course.

Last but not least, the author wishes to thank his family members and friends who have provided valuable moral support towards the author for the accomplishment of this project.

ABSTRACT

The author has done the research on the field of Green IT and the required primary analysis on implementing Green IT in Universiti Teknologi PETRONAS (UTP). This lead the author to believe that the first step to implementing Green IT policies in UTP is to make the UTP's senior management aware of the current situation in UTP in terms of UTP's energy consumption and carbon footprint levels. In order to raise awareness, the author has developed a visualization based system for visualizing UTP's energy consumption and its carbon footprint levels. This system can help UTP's management to review the general energy consumption of UTP in order to take immediate action or suggest future energy saving policies. As such, the objective of this project is to study the potential of the project regarding energy consumption and then based on the study, model, and design and develops a user interface that allows the UTP management to make analysis and review on UTP's energy consumption and its carbon footprint levels. This system is developed using web programming such as PHP and XHTML by using Dreamweaver CS5 in order to develop an interactive webpage. This project focused on how to effectively and efficiently visualize the data regarding energy consumption and carbon footprint. Critical review of related works on data visualization has been conducted to develop an optimized user interface that is effective. The review will focuses on how to show the data in graphical form so that the senior management in UTP can survey the rough estimate of the current energy consumption and carbon footprint in UTP over a specific period of time and make an analysis from the visual graphics provided by the system.

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Chapter 1 INTRODUCTION

1.1 Background of Study

The system for the Visualization of Carbon Footprint and Energy Consumption Generated in UTP is an enhancement on the current system for reviewing energy consumption developed to be used by the UTP senior management. The developed system has not been implemented and this project aims to enhance the existing system by making it more effective, efficient and practical for use by the UTP management. The reason for this proposed system if that as Petronas is an energy company, thus it would be absolutely necessary to manage responsibly the energy consumption and carbon footprint that is generated in the university area. This would give the public perception that Petronas is aware of its operations' surrounding and is practicing good energy management. By practicing good energy management, Petronas will also contribute to the global movement to conserve energy. Petronas will be known as an environmentally responsible company and it is a well-known fact that people buy from responsible company. The many importance of conserving energy is that as our resources are limited and our resources depends on the natural environment, wasting energy will be contributing to the degrade of our natural environment.

Therefore, the proposed system will help the management in making energy conserving decisions and strategies by providing them the current energy consumption and carbon footprint generated in UTP. With the existence of the integrity of the system, the management can take actions to implement energy management policies around the campus area.

1.2 Problem Statement

The problem statement of this project is that the management in Universiti Teknologi Petronas (UTP) is unable to track energy consumption of UTP and the carbon footprint generated in the campus area. Energy wastage in the world has caused global problems like global warming due to greenhouse gases. Prior to this, the management in UTP does not have a reliable system, if not, an existing system or process to review the energy consumption and carbon footprint that is generated in the campus area. Thus, it is impossible for the management to justify any energy conserving methods or strategies to be implemented. Each building in UTP has before and until now, uses any laboratory equipment, computers and electricity without any limitations. Machines might be turned on for a whole day without anyone using them. Hence, these energy wasting actions are the ones that will contribute to the emission of greenhouse gases and high electricity bills.

Petronas and UTP, as an organization that is in the energy business, should be conserving energy instead of neglecting the energy wastage that is occurring on the campus grounds. As a research university, UTP plays an important role to reduce energy wastage by utilizing IT solutions. However, before coming up with a strategic plan to conserve energy, we need the data and the data already exists. However, the process of retrieving data of the energy consumption and carbon footprint, analyzing it and finally visualizing the data is difficult and complex. Consequently, added with the administrative division of UTP, there is no initiative taken so far to visualizing the energy consumption efficiently to the management in UTP.

From this point of view, it is absolutely necessary to create a system for visualizing the data for the management in order to take actions on conserving energy in UTP. With this system implemented, the management in UTP can use it as a reliable reference to take immediate actions or set up policies regarding energy consumption by the facilities in UTP. This way, UTP will be playing its role to the global need to save energy.

1.3 Objective

The objectives of this project are

- ✓ To study the potential of the project regarding energy consumption
- ✓ To model, design and develop a user interface to visualize UTP's energy consumption and its carbon footprint.
- ✓ To create a system that possesses integrity and high availability

1.4 Scope of Study

This project focuses on how to effectively and efficiently visualize the data regarding energy consumption and carbon footprint. Critical review of related works on data visualization will be conducted to develop an optimized user interface that is effective. The review will focuses on how to show the data in graphical form so that the senior management in UTP can survey the rough estimate of the current energy consumption and carbon footprint in UTP over a specific period of time and make an analysis from the visual graphics provided by the system. If possible, the management could take action to reduce the waste of electricity consumption and carbon footprint.

1.5 Feasibility of the Project within the Scope and Time frame

As with the problem statement stated above and the preliminary analysis done, the author would like to express that the project is fully feasible within the scope of the study.

With the preliminary studies done during the course of FYP I, the author would only need to focus on system development during the course of this semester. The time set to fully develop and test the system is 8 weeks from the period 20th January 2013 to 18th March 2013. By focusing on rapid system development rather than much documentation. The author would like to express that it is fully feasible within the time frame too to continue developing the system.

Chapter 2 LITERATURE REVIEW

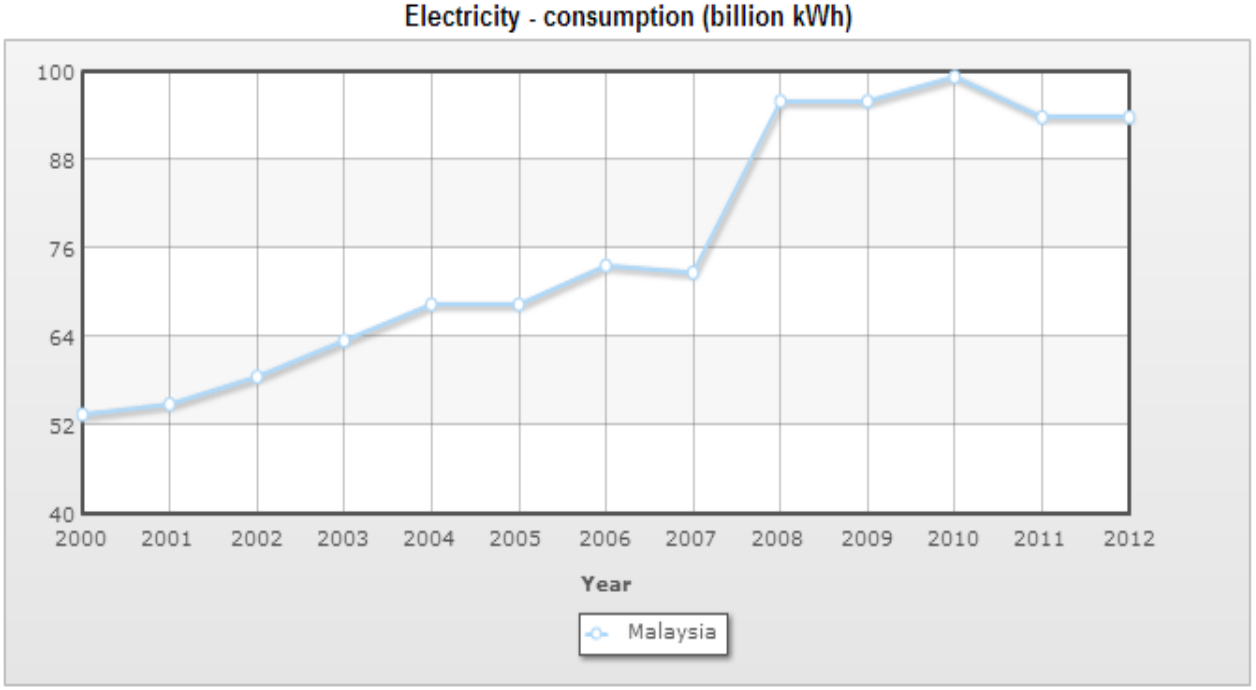
2.1 Problem Formulation

The development of Visualization based Energy Management System for reviewing energy consumption and the carbon footprint generated in UTP is a forward-looking objective by both the developer and the project sponsor. This system is required to improve energy management in the campus area. Studies and preliminary analysis has been carried out to research and examine the potential of energy management policies for energy saving. Results from the study and analysis suggest that the proposed system would be a huge help in aiding the management to review the energy consumption and carbon footprint in UTP.

The problems faced by the management currently are mainly the absence of a system that will allow them to visualize the energy consumption by UTP and its subsequently generated carbon footprint. Without a proper review of both high level and detailed information regarding the energy consumption by UTP, it is impossible to justify that UTP needs to overcome energy wastage as they can't see the immense amount of energy UTP consumed. Therefore, by implementing the proposed Visualization based energy management system, the senior management in UTP will find it easier to review the estimate of the current energy consumption and carbon footprint in UTP over a specific period of time.

2.2 Energy Consumption and Carbon Emission in Malaysia

Historical data recorded by IndexMundi has shown that Malaysia's demand for more energy has been increasing over the years. According to the studies done by IndexMundi, Malaysia's electricity consumption as of last year, 2012, is 93.8billion kWh compared to 6 years ago which was only 72.7billion kWh. The cause of this increased demand for energy can be traced to the nation development growth, especially in the industrial sectors and economic sectors. In Malaysia, its offices and organization buildings have been identified to be the biggest sources of electricity energy demand. The figure below, Figure 1 shows the statistics of electricity consumption for Malaysia for the year 2000 to 2012.



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Malaysia	53.42	54.87	58.59	63.48	68.4	68.4	73.63	72.71	95.98	95.98	99.25	93.8	93.8

Figure 1: Electricity Consumption in Malaysia from 2000 to 2012

A study has been done by Md.Azizul (2008) regarding the energy consumption and CO2 emissions in residential sector from 2008-2020 in Malaysia. His studies predicted that in 2008, the CO2 emission from residential sector in Malaysia in 2008 will be 2,347,538 tons and it can be increased up to 11,689,308 tonne by 2020. His assessment was that the large amount of increased CO2 emission has been and will be caused by the immense consumption of the electricity and liquid petroleum gas (LPG). The increased demand for electricity energy as said above is largely attributed to the rapid nation growth and the Malaysian economic growth due to the fact that everyone wants to increase their standard of living and thus there are more air conditioning, more visually attractive lighting and all these will contribute to the total electricity consumption. As a result of increased energy demand, there will be an increase in the rate of CO2 emission too.

2.3 Energy Consumption in Universiti Teknologi Petronas (UTP)

Honeywell Pte Ltd has done an energy audit assessment by monitoring the cooling load between the period 25th October and 3rd November 2008. The assessment has shown that the estimated existing energy consumption of Air Handling Units (AHU) and Mechanical Ventilations (MV) fans per year in UTP is 5,576,090 kWh/Year which is equivalent to RM1, 672,827/Year at the charge of RM0.30/kWh during the period of the calculation.

Shaarani (2009) studies have shown that the Building Energy Indes (BEI) for UTP 5 years ago in 2008 is 287/kWh/meter squared. Shaarani (2009) has shown that the BEI of UTP is well above the baseline of 250. In other words, UTP has consumed too much energy and is not practicing good energy management. This huge consumption of electricity energy will directly lead to an increase in CO2 emission.

2.4 Green IT through energy saving in campus

Green IT refers to initiatives and policies that directly or indirectly address environmental sustainability in an organization. Although Green IT has been widely talked about and started to be incorporated into daily practices in organizations, there is still insufficient research done in the field of Green IT.

The norm in organizations today is to practice energy management in their offices. Office energy management policies regarding electrical equipment and computers have a huge potential for energy saving (Kaoru Kawamotoa, b, Yoshiyuki Shimodab, Minoru Mizunobg, 2004). Another way that can implement efficient energy management in a campus area is the power management regarding server systems.

2.5 Data Visualization

In today's world, data visualization is a thriving field and business. There are many organizations out there that employ services of data visualization in order to help them visually analyze their data, build their desired visualizations and visually display data sets of all kinds. The reason for the thrive of data visualization is that the human's visual system is well built for visual analysis (Noah Liinsky, 2012).

There are multiple researches on how to create effective data visualization. The first core of data visualizations is colors. Data grouped in different categories of colors provide good differentiation for the viewer to search for their desired data sets (Healey, C.G, 1996). The other benefit provided by data visualization is pattern matching. In data visualization, patterns can be derived from the visually presented data. Such meaningful patterns can come in kinds of trends, gaps and outliers.

Data visualization is a very prominent tool in conveying knowledge to the viewer. By using data visualizations, data can be casts into a format that can be grasped by the general audience and much more understandable compared to raw data that consists of numbers. Graphical representations of data are found to be better at conveying knowledge than textual methods[1].

[1] http://www.dartmouth.edu/~nyhan/opening-political-mind.pdf

Data visualizations also provide the viewer an actionable insight into the data presented. Through data visualizations, the viewer will be able to understand better the knowledge within the data and then act on it. When applied in the proposed system, this data visualization technique will provide the management with actionable insight. Without this insight, the management can be effectively lost, the integrity of the decision making process will be degraded.

Figure 2: Cores of Data Visualization

2.6 Energy Consumption, Energy Savings, and Emission Analysis

R.Saidur (2009) has studied the energy consumption of commercials buildings in Malaysia. His studies show that a rapid growth of energy usage within the office and commercial buildings in directly linked to the rapid growth in population and standards in Malaysia. Meanwhile in UTP, we have all sorts of modern facilities such as air conditioning, lifts, fridge and many more which consumes large amount of energy and will also contribute to the generation of carbon footprint in UTP.

This research by R.Saidur has also voiced out the importance of everyone's participation in managing and reducing energy consumption as it will contribute not only towards energy wastage, but also huge amount of CO2 gasses. As a responsible university, it is of upmost importance that UTP start to look into the matter of energy savings. R.Saidur has stated in his journal that the most cost-effective ways towards achieving energy savings goals is by having a smart way to manage the electricity usage in commercial and office buildings rather than focusing on buying more environmental friendly instruments and facilities' tools.

2.7 Preliminary Analysis and Proposed System

The preliminary analysis concluded that currently, the senior management in UTP does not have an energy management system. Without proper energy management system and policies, this can lead to huge energy wastage such as a machine being left on for days without anyone employing the use of it. Although effort was done by both staff and students to turn off the electricity when not in use, this was not acceptable as a permanent solution.

Therefore, the author proposed the Energy Management System in which contains a user interface that the management can use to review the energy consumption and carbon footprint that is generated in UTP. It is a web based system that can only be accessed by approved authority that aimed to help the senior management of UTP by providing them with actionable and quality information.

The development of this system will be done in a rapid application development (RAD) method and the end product will be a web-based system. A web based system is both interactive and heterogeneous; the system can be installed on any platform that has a web browser. In order to increase the security of this system, the proposed system will be a closed system or "offline applications". The proposed system will generally carry on UTP's local network and is available only for the senior management or any selected employees (Janko Jovanovic, 2010).

The proposed system will focus on its user interface as there are vast quantities of data to input into the system and this system is still at its early age. Thus, the current system will be simulated using static data. Said system will require further research and further development in the future for it to be able to retrieve data by itself. The point of focus, the user interface, will possesses the ability to generate graphical representation of data from raw dataset on the energy consumption in UTP. These graphical representations of data will allow the senior management and selected employees to have an effective view on energy consumption amounts and areas in UTP.

Chapter 3 METHODOLOGY

3.0 Research Methodology

In completing this project, the methodology used is Rapid Application Development (RAD) method. RAD is a software development methodology that requires minimal planning in exchange for rapid prototyping.

3.1 Rapid Application Development (RAD)

This methodology, Rapid Application Development (RAD) is chosen out of other software development methodologies due to time constraints of this project which is around 8 months from September 2012 to May 2013, divided into 2 semester parts. The RAD methodology is chosen also due to the possibility that there will be user requirement changes and also technological changes that might affect the feasibility of the project. The planning of the product developed is interleaved with writing of the software itself. Without extensive pre-planning, it allows for the product to be written faster, and it is easier to edit should there be any change in requirements.

RAD involves methods which include iterative development, which is to develop the product through repeated cycles, allowing developers to learn and improve on past versions of the product, and software prototyping, where a prototype of the product is created and tested, such as incomplete versions of the software program or demos. Structured techniques and prototyping are often used in RAD to define users' requirements and for the design of the final system. There are four phases of RAD, as shown below:

- Analysis and Quick Design Phase
- Prototyping Cycles (Building, Refining, and Demonstrating process)
- Testing Phase
- Implementation Phase

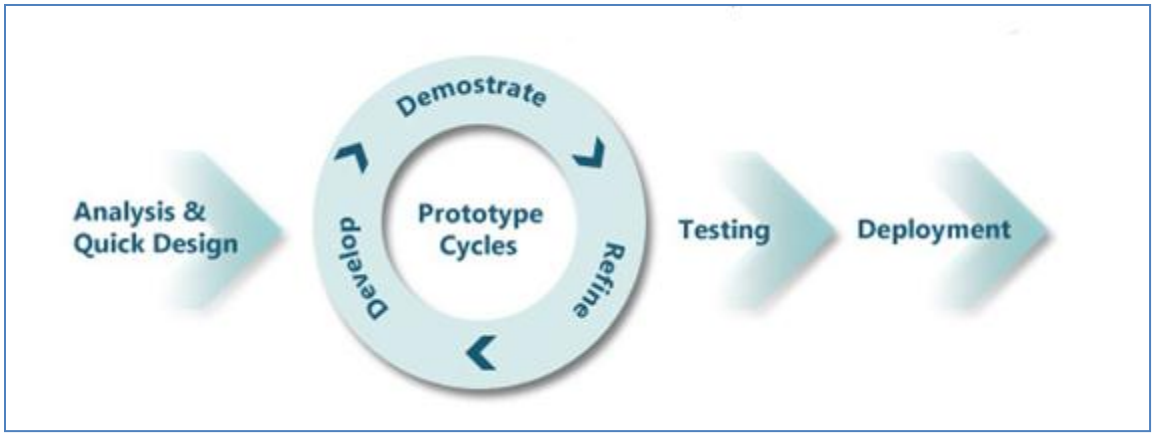


Figure 3: Rapid Application Development cycle.

3.1.1 Analysis & Quick Design Phase

This main objective of this analysis is to gather the user's requirements. This is of upmost importance in order to produce a system that meets the user's expectations and requirements. In this phase, the current available system is analyzed to identify opportunities for improvement and to develop a new concept for the proposed system. The main activity of this analysis phase is to conduct analysis on the current systems available and to gather user requirements from the project stakeholders.

In the quick design part of this phase, more will be focused on the technical part of the system in terms of how the system should operate and what are the requirements for the project such as databases and files. This phase is the initial architectural designs of the proposed system in terms of interface design, system modules and program design. Thus, the deliverables of this phase are the system proposal as well as the initial proposed system model design.

This stage has been mostly completed during the 1st phase of the project which is FYP I. With all of the necessary data gathered which are user requirements and system functions, the basic design architecture of the system has been drawn up. This design architecture of the system is necessary in order to act as a reference when developing the physical system by serving as the blueprint of the system. This design architecture covers all the elements of the project which includes user input, data archive and data representation as output to the user.

3.1.2 Prototype Cycles Phase

The prototype cycles phase is consisted of three stages, developing the prototype, demonstrating the prototype and then refining the prototype and sent back to the development stage and the whole cycle will repeat itself. Generally in the prototype cycle phase, the prototype will be developed part by part and demonstrated to the users and project sponsor. The prototype will then be refined and sent back to the prototype development stage of the cycle.

During the development stage, the system is built according to gathered user requirements and the deliverable should be a functional prototype. In the demonstration stage, the prototype is then presented to the users and the feedback is recorded. The users will have to provide comments and feedback about the presented prototype and these feedbacks will be used to re-analyze, re-design and re-implement a second prototype that provides more of the features required by the users. The prototype cycle should continue until the users agreed that the prototype had provided enough of agreed functionality. The deliverables of this phase are the prototypes for the user to test it out.

3.1.2.1 *Develop*

Now that the system requirements and other necessary data have been gathered, the author can begin developing the system. The system will be developed in 7 parts. These parts are referred to as “Login Page”, “Main Page”, “Tutorial”, “Data Master”, “Dataset History”, “Graph Representations” and “Contact”.

The first part of the system, the “Login Page” is the page where the user is required to login to the system. This is required to prevent any unauthorized access to the system.

The second part of the system, the “Main Page” is the main terminal of the system that will allow user to select any of the 5 pages that are “Tutorial”, “Data Master”, “Dataset History”, “Graph Representations” and “Contact”.

The third part “Tutorial” will be a straightforward and simple step by step lesson that will teach the user on how to use the system and introduce the system functionalities.

The fourth part, “Data Master” is the page where user can add, edit or delete any existing data in the system, be it consumption data or data sources.

The fifth part “Dataset History” is the part where users can view the raw data of the system. The fifth part will be a strict view only function of the system.

The sixth part, “Graph Representations” is the part of the system where users can view visualized graphical reports of the raw data in the system.

The seventh part “Contact” is the page which holds the contact information of the system developer/author or any parties responsible should there be any issues with the system.

Figure 4 will show the high level system architecture that the author follows to design this program.

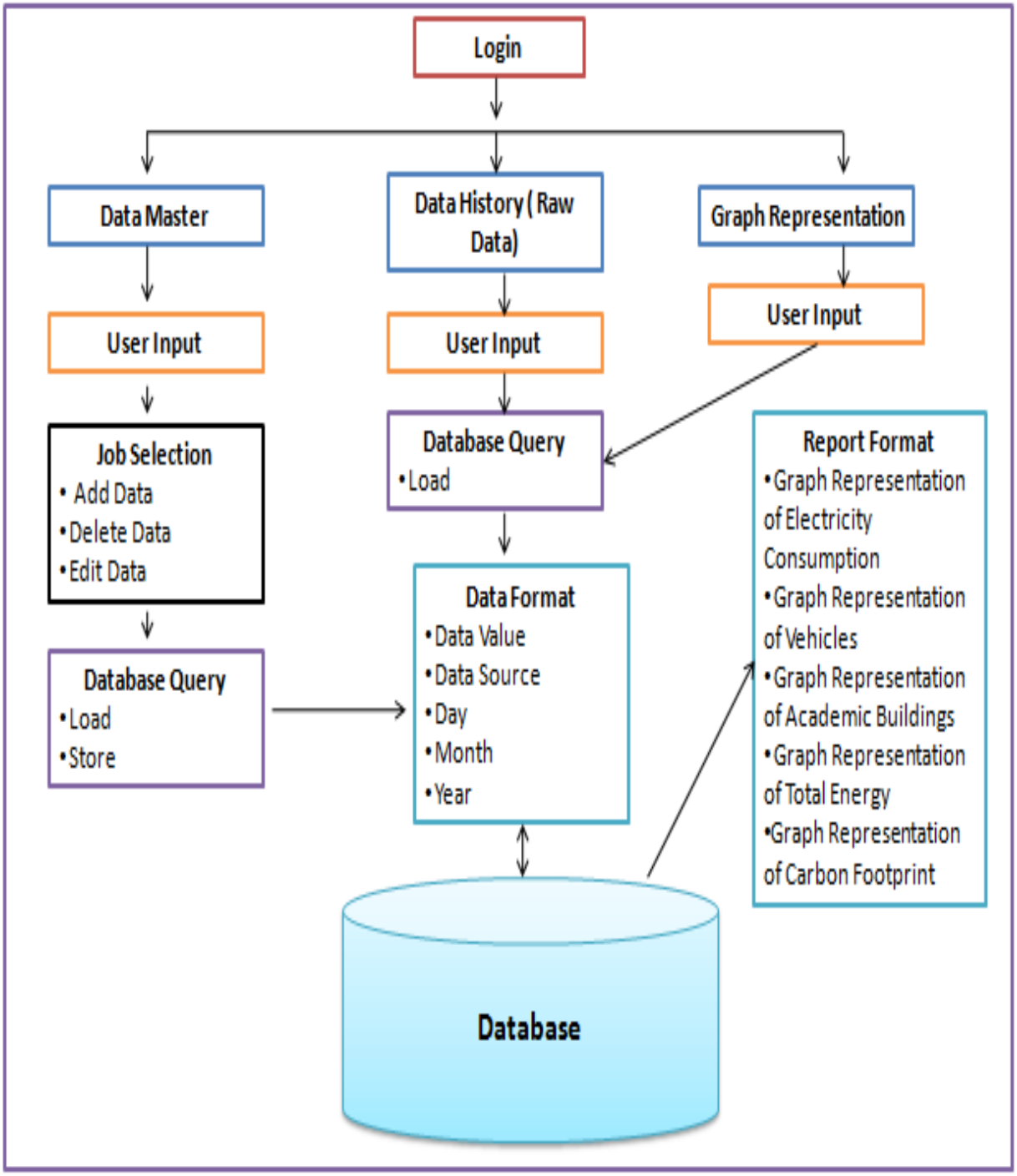


Figure 4 : System Design Architecture

3.1.2.2 *Demonstrate*

The Demonstrate stage will be started when all of the components have been built and integrated as a complete system. The author will carry out a full tutorial on the system for the audience, the users and project sponsor, in order to gain feedback on the system as a whole.

During the demonstration, each of the seven parts of the system will be explored thoroughly in front of the audience.

3.1.2.3 *Refine*

With the feedback from the users during Demonstrate stage, the changes and modifications to the system will occur during this stage. This is the stage where the system components and the seven interface pages will undergo modification with respect to the feedback.

After the final prototype has been chosen. The application development will then move onto the next phase, the testing phase. This is the phase where the prototype is treated as the actual system and fully tested from the point of User Acceptance Test (UAT) and functionality testing by the developer himself. The UAT test is undergone to ensure that the user can fully accept and utilize the system. The functionality test is done by the developer to ensure that the system performs as per designed. Testing is one of the most critical phases in any application development. In the testing phase, the system will be tested in the users' environment or platform in order to make sure it work successfully on the targeted user's platform. The deliverables from this testing phase is Internal Test, Application Test, Stress Test and User Acceptance Test. Testing in short, is done to ensure that the system produced is error and possesses quality.

The completed subpages of the system are currently undergoing testing and more refining now before they are to be integrated to form the complete system. Full system testing will be done once all of the subpages are completed and integrated. The testing done is recorded in the table below.

Testing	Date
Subpage Testing	28/1/2013
User Testing	20/3/2013

Table 1: Testing Log

3.1.3 Deployment

The final phase is the deployment phase. This is the phase where the actual system is being implemented. The goal of this phase is for the successful and correct implementation of the system. After the system is rolled out, the system will be tested again to ensure that it performs as expected in the users' environments without any major issues. The deliverable of this stage is the implementation of the actual system.

3.2 Project Activities

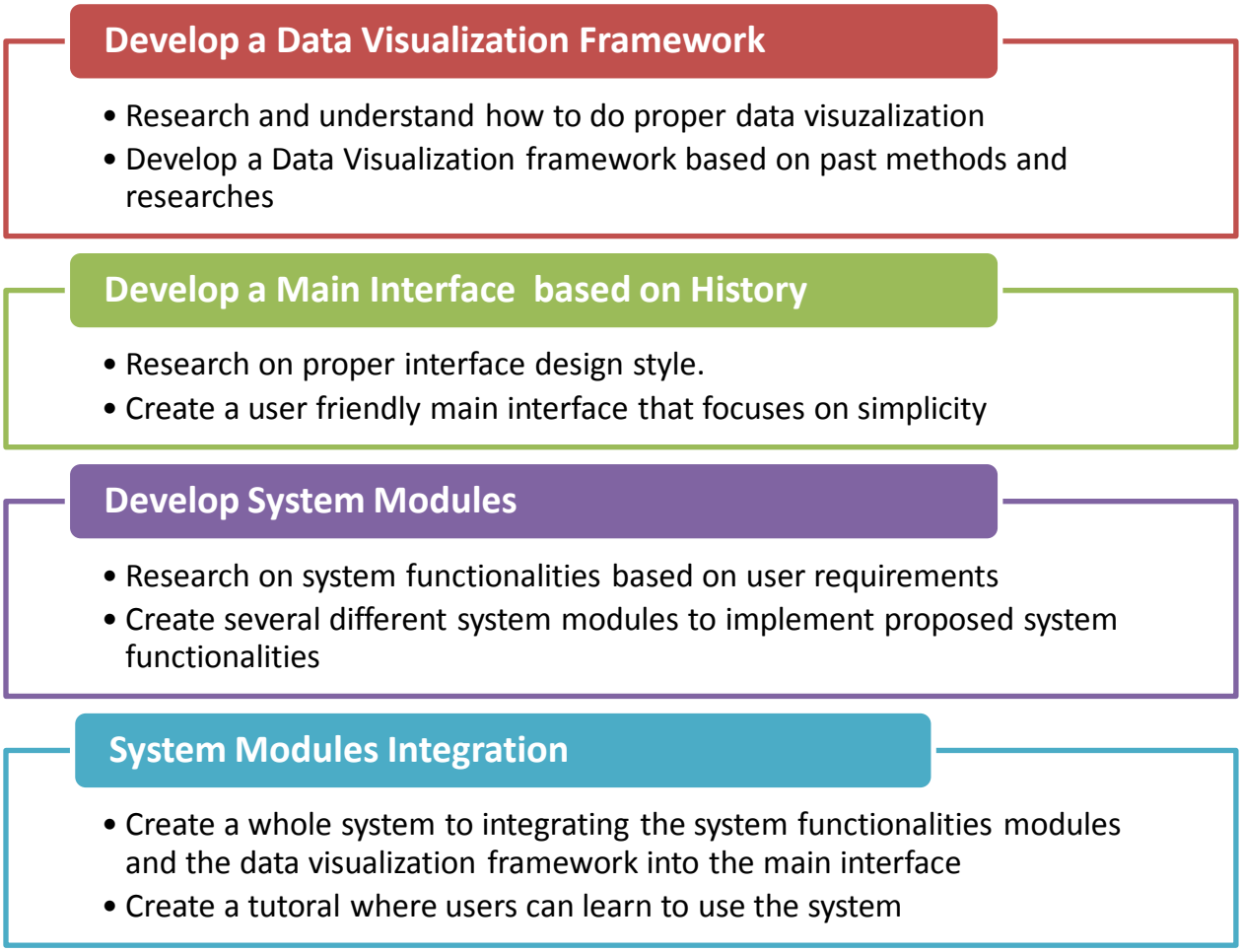


Figure 5: Project Activities

3.2.1 Critical Study on Data Visualization & Development of Graphical User Interface

The project is initiated with a detailed background study on how effective data visualization can be implemented and achieved. Related works on green information technology (Green IT) is also studied to determine the layout of graphical user interface (GUI) of the proposed system.

The development of the GUI of the proposed system will implements the result from the critical study above in order to create an effective GUI for data visualization. The GUI will be done in iterative prototype models and undergo a user acceptance testing (UAT) before being implemented into the system.

3.2.2 Physical Design

The project will be developed using a personal computer of the author with the aid of design software and multiple compilers.

3.2.3 Testing

After the system is complete, the system will undergo a full user acceptance test (UAT) in order to get final feedback.

3.2.4 Project Tools

Listed below are the tools, both hardware and software, that will be used in the development of the proposed system

1) Software : Macromedia Dreamweaver CS5, Apache Server, Photoshop, Java Compiler, Notepad ++
2) Programming Language : HTML, XHTML, XML, PHP, SQL(if required)
3) Hardware : Laptop

3.3 Key Milestones

- Week 2: Learn on how to use development tools
- Week 4: Complete Main Interface
- Week 6: Complete all System Components
- Week 7: Complete System Integration
- Week 8: Complete Testing and Refining
- Week 10: Roll off for Pre-Sedex

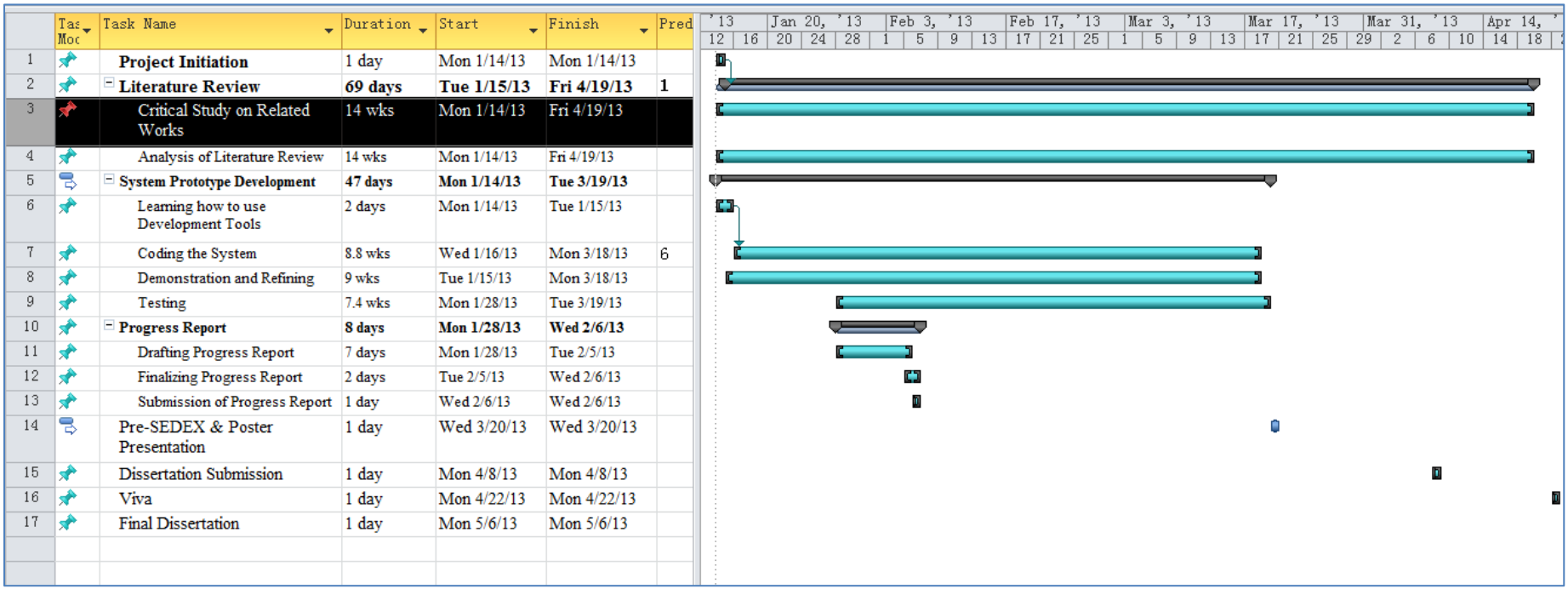
Planned

Completed

No	Task Name	Week 1	2	3	4	5	6	7	8	9	10
1	Learn on how to use development tools							MID-SEMBREAK			
2	Complete Main Interface										
3	Complete all System Components										
4	Complete System Integration										
5	Complete Testing and Refining										
6	Roll off for Pre-Sedex										

Figure 6: Key Milestones

3.4 Gantt Chart



	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**Project Initiation**	1 day	Mon 1/14/13	Mon 1/14/13	
2		**Literature Review**	**69 days**	**Tue 1/15/13**	**Fri 4/19/13**	**1**
3		Critical Study on Related Works	14 wks	Mon 1/14/13	Fri 4/19/13	
4		Analysis of Literature Review	14 wks	Mon 1/14/13	Fri 4/19/13	
5		**System Prototype Development**	**47 days**	**Mon 1/14/13**	**Tue 3/19/13**	
6		Learning how to use Development Tools	2 days	Mon 1/14/13	Tue 1/15/13	
7		Coding the System	8.8 wks	Wed 1/16/13	Mon 3/18/13	6
8		Demonstration and Refining	9 wks	Tue 1/15/13	Mon 3/18/13	
9		Testing	7.4 wks	Mon 1/28/13	Tue 3/19/13	
10		**Progress Report**	**8 days**	**Mon 1/28/13**	**Wed 2/6/13**	
11		Drafting Progress Report	7 days	Mon 1/28/13	Tue 2/5/13	
12		Finalizing Progress Report	2 days	Tue 2/5/13	Wed 2/6/13	
13		Submission of Progress Report	1 day	Wed 2/6/13	Wed 2/6/13	
14		Pre-SEDEX & Poster Presentation	1 day	Wed 3/20/13	Wed 3/20/13	
15		Dissertation Submission	1 day	Mon 4/8/13	Mon 4/8/13	
16		Viva	1 day	Mon 4/22/13	Mon 4/22/13	
17		Final Dissertation	1 day	Mon 5/6/13	Mon 5/6/13	

Figure 7: Gantt chart

Chapter 4 RESULTS AND DISCUSSION

4.1 Preliminary Research Work

In addition to the preliminary analysis of the current situation in Universiti Teknologi Petronas (UTP), research work has been done to study the potential of the project regarding energy management. With the results from the research work, the developed will be able to model, design and develop an effective and highly practical Graphical User Interface (GUI) for the senior management in UTP. With the proposed system, the UTP management will be able to analyze and survey the rough estimate of the current energy consumption and carbon footprint that is generated in UTP and if the situation demands it, make actions to streamline current energy management policies in UTP. It is also of upmost importance that the proposed system possesses integrity and high availability and meets the users and project sponsor's requirements.

4.2 System Prototype I: Visualization of UTP's Energy Consumption and It's Carbon Footprint

After the preliminary analysis was done, all factors of a successful data visualization based framework are studied and a system prototype is created. Development of the system prototype is split into 4 stages:

i. Research and planning
ii. Development of system prototype
iii. User acceptance testing
iv. Refining the system and repeat (i).

4.2.1 Research and planning

It is vital for us to familiarize ourselves with the kinds of data to be visualized before any development of the system prototype commences. Therefore, during this research and planning stage, it is vital for us to have a firm grasp of UTP's electricity and carbon footprint sources.

First of all, the author have obtained a previous project by Siti Maisarah (2012) and Terryson (2012) to act as a reference to what kind of data sources are there in UTP and their significance in terms of contribution to the energy consumption and carbon footprint that is generated in UTP.

After a clear view on which data sources is obtained, start planning the system modules by drawing up the design architecture of the system, focusing on simplistic design for the modules to be more user friendly.

After the design architecture has been completed, the subpages of the 7 parts of the system are developed based on the main design architecture. The subpages will be developed with regards to be centralized around the system GUI, which will be the main interfacing tool between the system and the user instead of other means of access such as using Notepad++ or Dreamweaver.

The developer is also taking into account the impact of importing excel files in a specified format into the system and the system should extract the data.

4.2.2 Development of System Prototype

Once the initial planning and research is completed, the development of the system prototype will commence. The development of system prototype will further be divided into three stages, namely development of web based resources, development of a system search engine, and lastly, development of output to the user.

In the first stage, development of web based resources, the basic layout to store hardcoded data is created. Hardcoded dummy data is used in this prototype.

4.2.2.1 Data Master

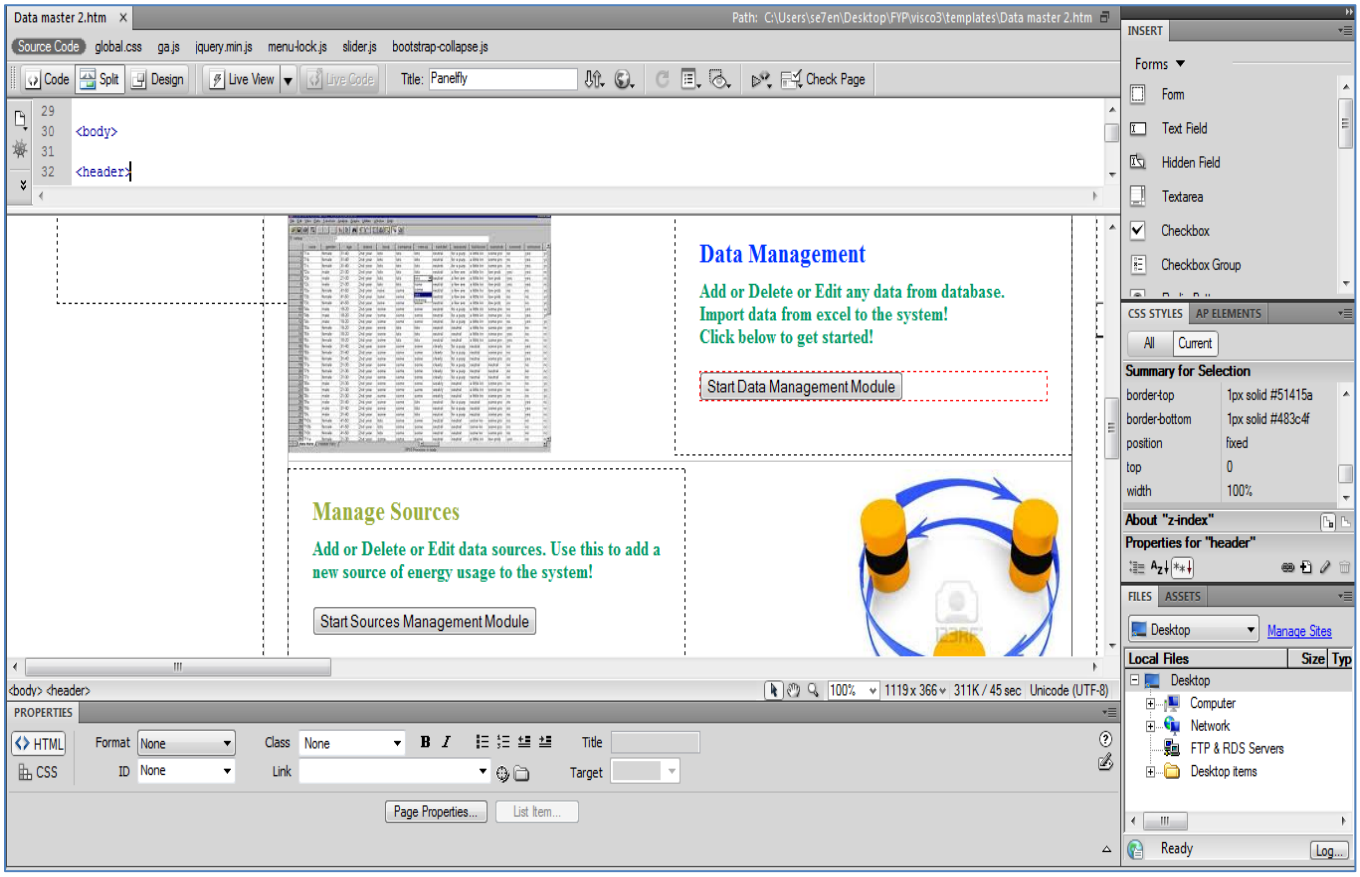


Figure 8: System Prototype I- Coding Data Master Interface

Data Master will allow the user to view everything regarding the data in the system be it raw data value, data dates and data sources. Data Master is coded with a Data Management module where the user can add, delete or edit any previous raw data stored in the system. The Data Master will also contain another module call Source Management module where the user can add, delete or edit any data sources in the system. The data sources are used to identify where the raw data does comes from, e.g. Raw Data: 72.5kWh, Source: Academic Buildings.

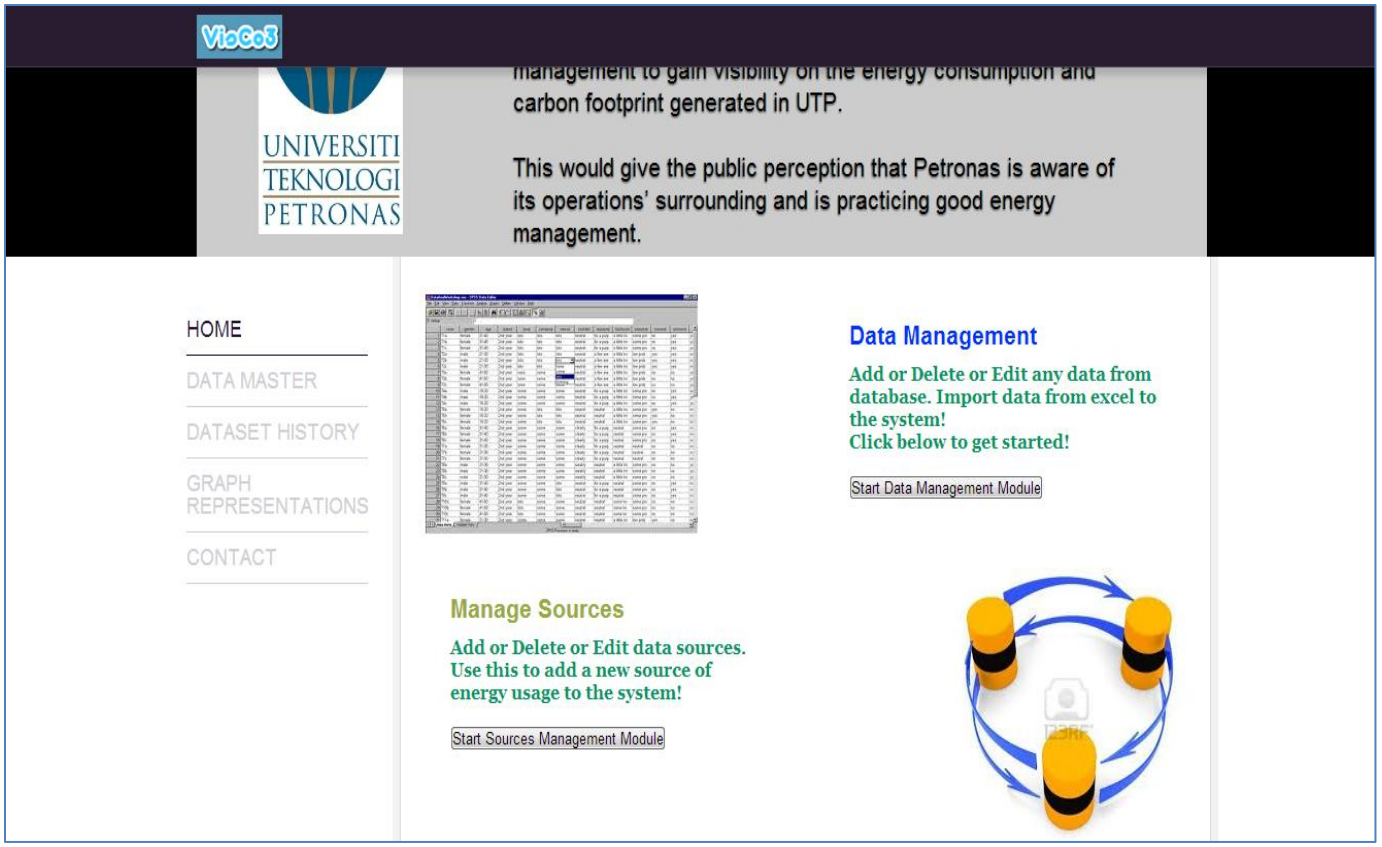


Figure 9: System Prototype I - Data Master Interface

The figure above shows the implemented Data Master interface when run using the program. The Data Master is coded using HTML and JavaScript to invoke animation in the interface in order to make it more attractive to the user.

4.2.2.2 Dataset History

For the Dataset History part, the author is required to code a search engine into the system for the user to select specific data to show. The Dataset History is a main part of the complete system that will retrieve the raw datasets that the user desires. As the database is deemed unfeasible to be used in System Prototype I, he search engine is coded to be linked to a scraper that will retrieve hardcoded data from the source HTML and put it in a table to be displayed to the user. The Dataset History search engine is coded for the user to search for a wide variety of datasets, from specific day energy consumption data from a specific source to a whole month of energy consumption data from all sources.

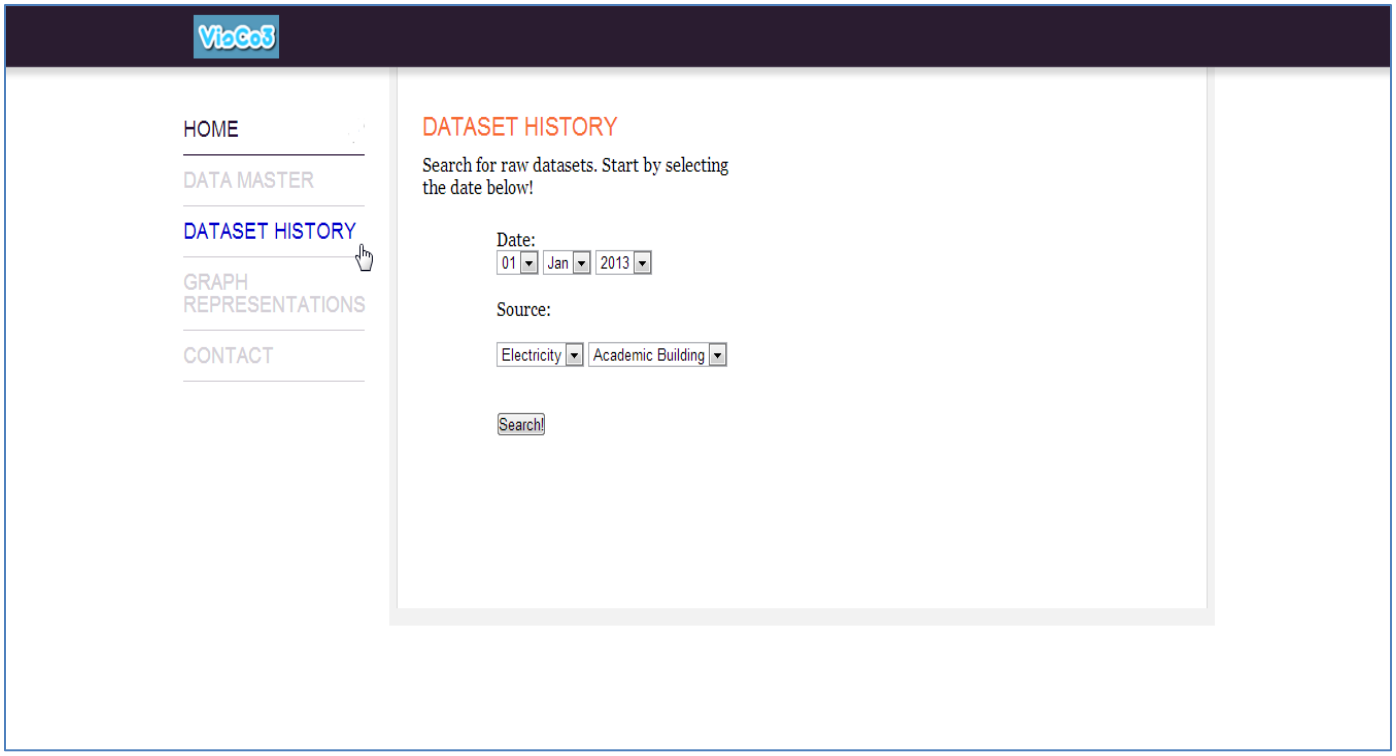


Figure 10: System Prototype I -Dataset History Interface

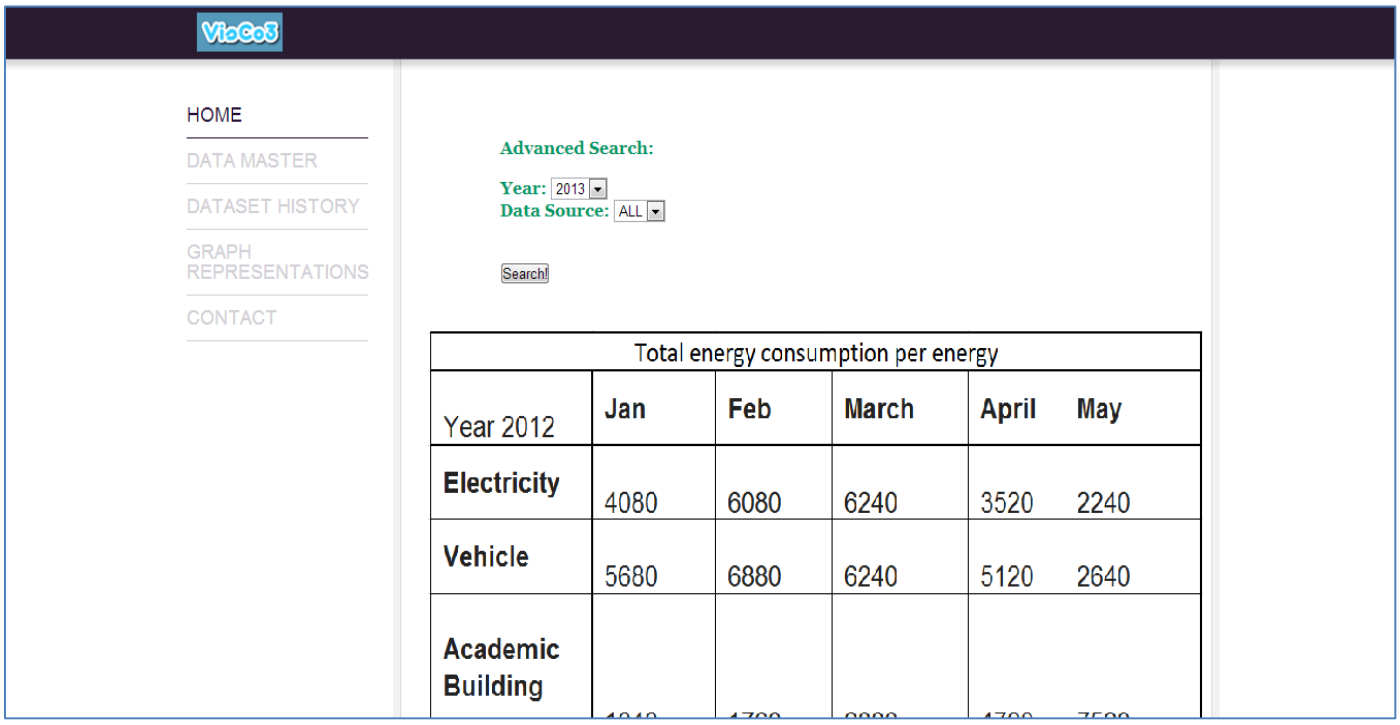


Figure 11: System Prototype I - Dataset History Advanced Search

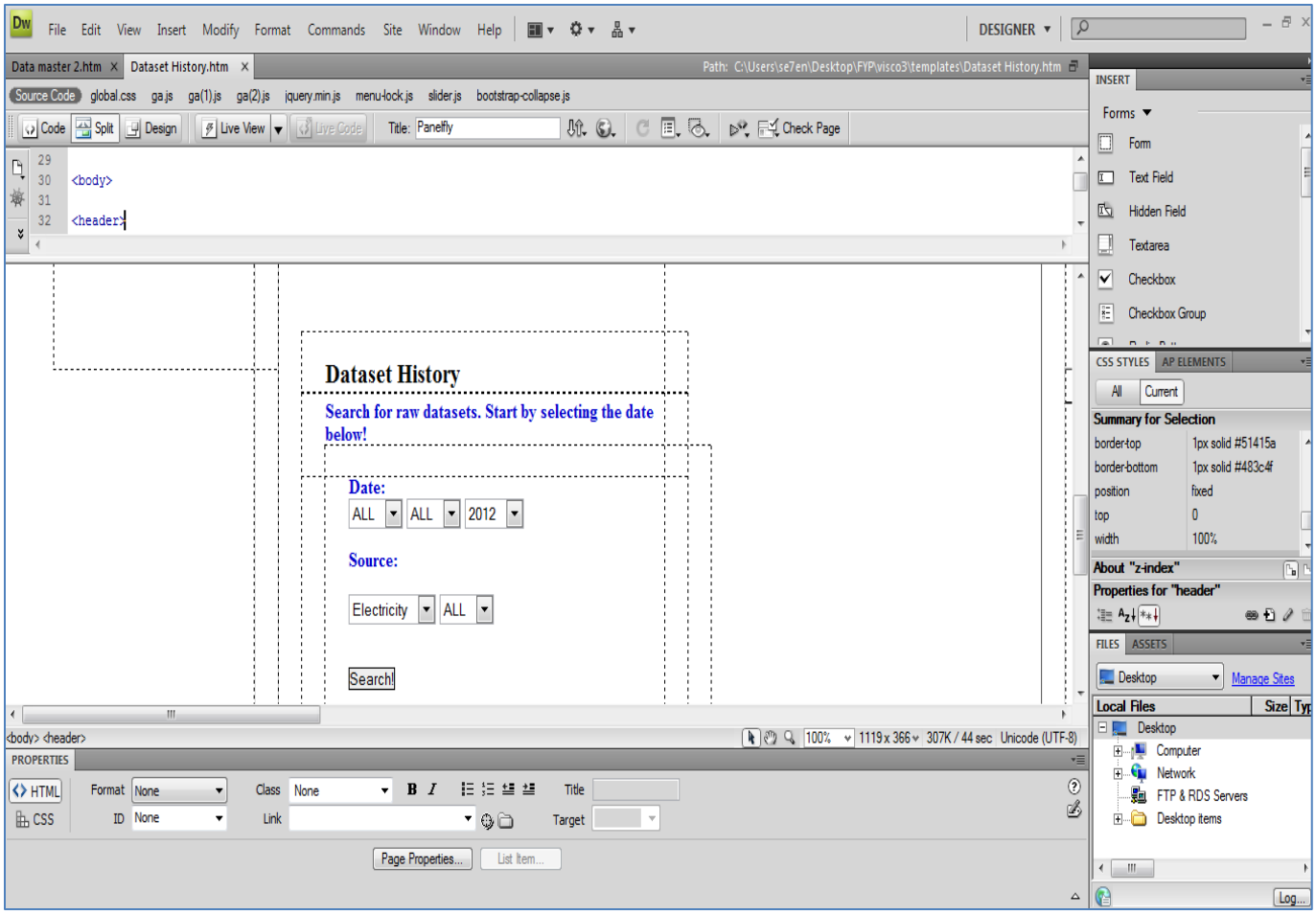


Figure 12: System Prototype I -Coding the Dataset History Interface

4.2.2.3 Login Page

The next part of the system included in this prototype is the Login Page. The login page is designed to not only be able to log users in, but also retrieve passwords using the staff office ID and be able to register new users. As a security measure, new user's registration would require an existing user's Login ID and password.

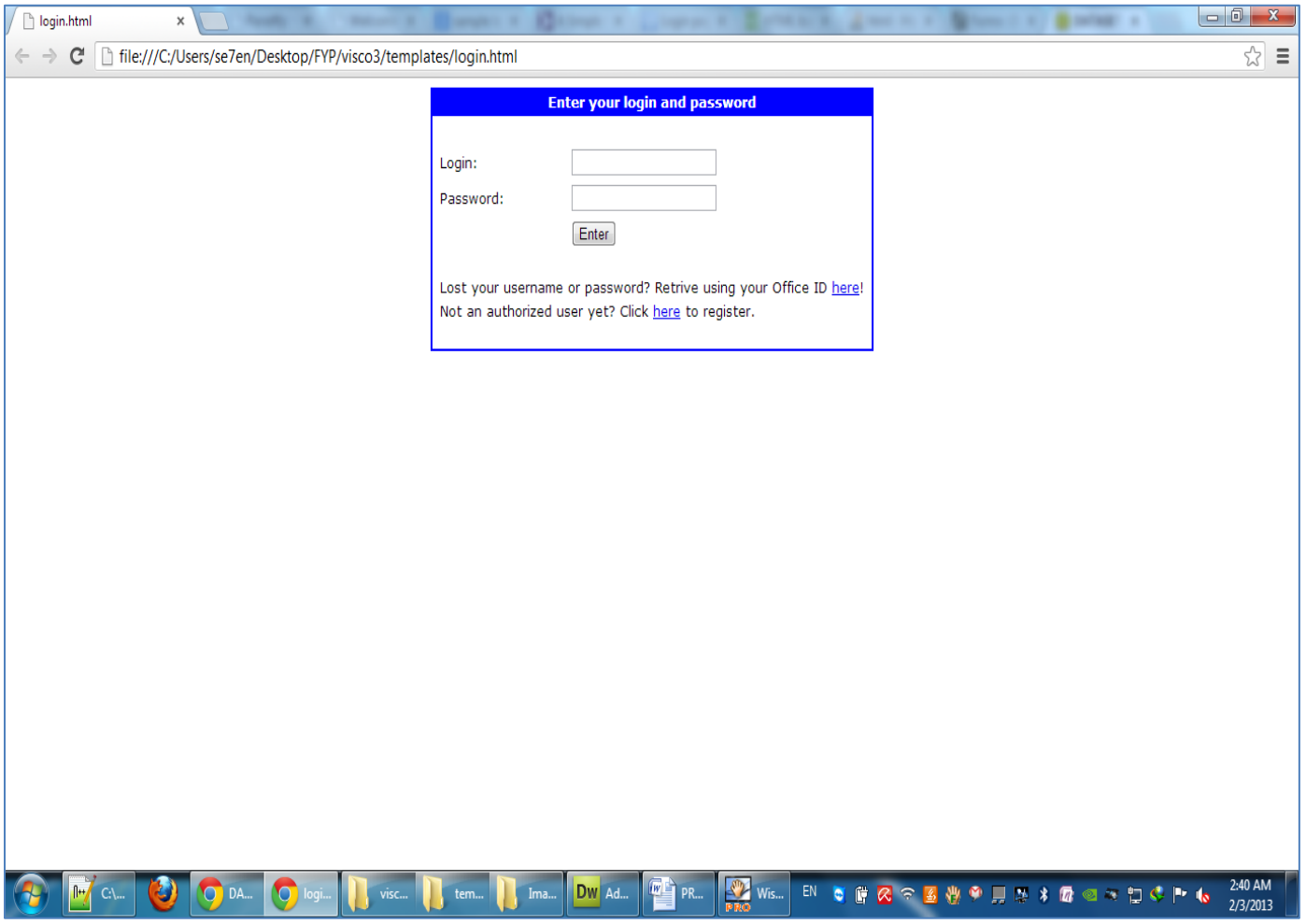


Figure 13: System Prototype I -Login Page Interface

4.2.2.4 Main Page

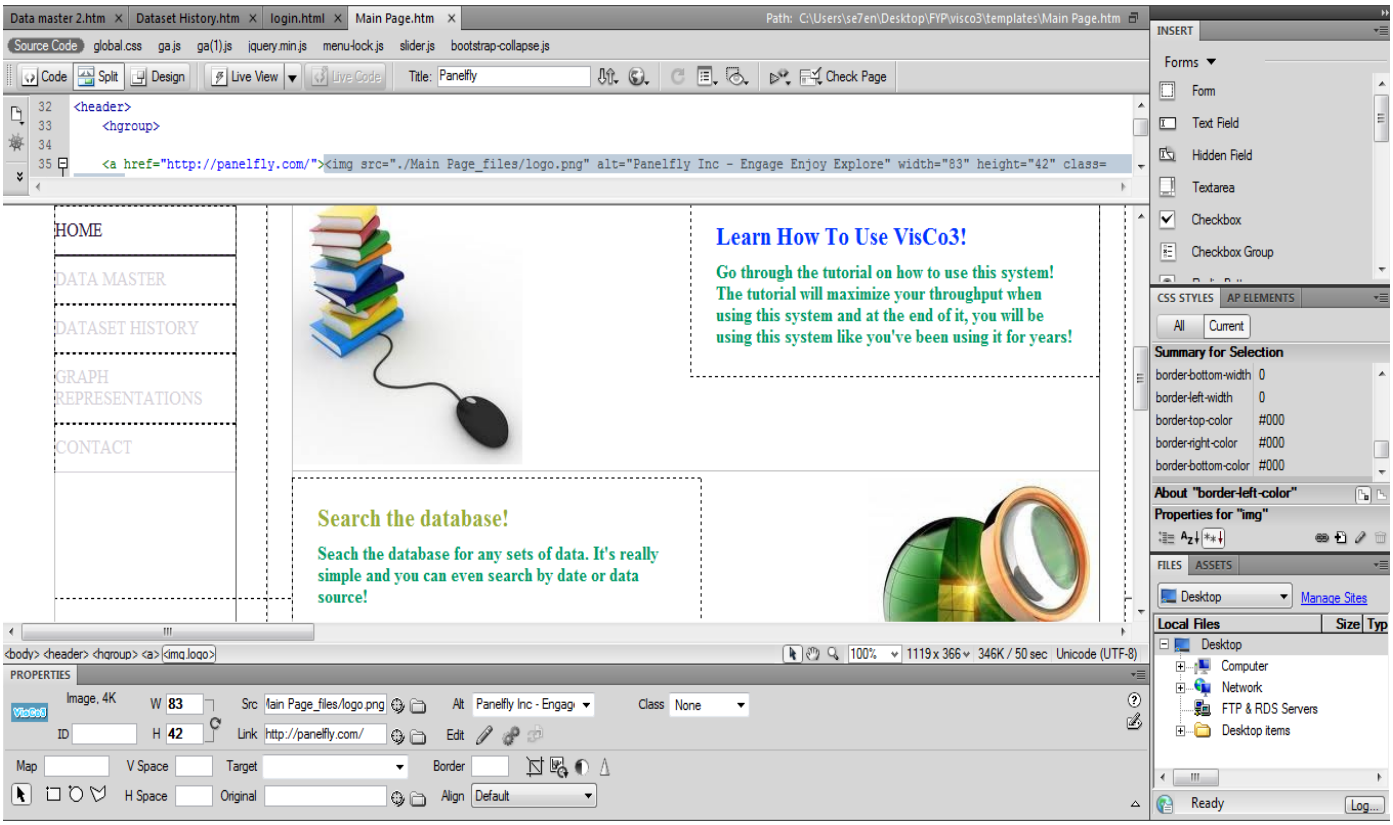


Figure 14: System Prototype I -Coding Main Page Interface

The Main Page is coded to invoke some animation, graphical representations of data in the corner of the page in order to attract the attention of the users. The Main Page is designed to be very simple and user friendly with lower color variety to give a sense of calmness and curiosity towards the system's functionalities. As the preliminary analysis has shown that the first thing users notice will be at the center of one's webpage, the author has coded the Tutorial link to be at the center of the Main Page so that the user will have no need to ponder upon how to use the system.

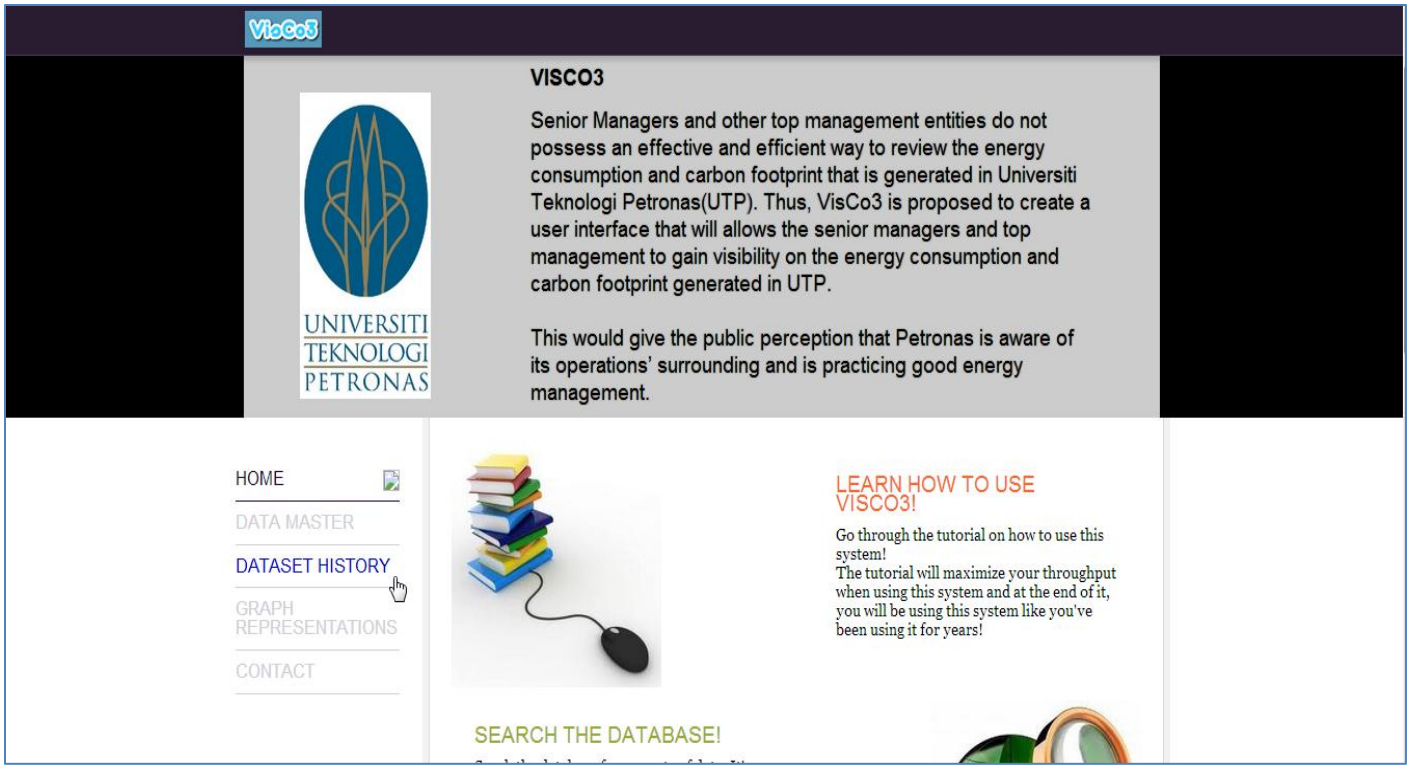


Figure 15: System Prototype I -Main Page Interface

4.2.3 User Acceptance Testing

System Prototype I has been tested on 28th January 2013. The beta testers have commented and provided feedback regarding the system. Every beta testers' comment was noted down and analyzed. Based on the feedbacks and comments, the non-useful and non-constructive feedbacks were filtered out and the system has been redeveloped and improved. The table below will show the modifications that have been implemented in the refined system and the author call the refined system as System Prototype II.

System Page	Modification	Remarks
Project Details	- Renamed Visco3 to ENVISION - Added database to the project - Inserted project heading which is Towards the Greenization of UTP - Changed project color theme to green	The author feels that the current system is entirely different from the original system that is Visco2. Database will be used in the refined system to store/retrieve data. Project heading is inserted into various parts of the project to attract user attention Project color theme changed from various colors to green in order to show focus on a specific theme, green-greenization
Login	- Added DB functionality - Changed page color scheme to project theme - Scrapped retrieve lost password - Added project heading to page	Login details can be created and be stored in the system database, not hardcoded. The author feels the retrieve lost password is not useful as user can create a new user anytime.
Main Page	- Changed page color scheme to project theme - Reduce side tabs - Edited Links - Added tabs to top form	Some colors when matched will induce dizziness. Do not use fluorescent colors in webpage design. Edited side links to provide only useful links

Tutorial	- Scrapped Tutorial Page until future version.	Do not assume user knows IT jargons.
Data Management	- Scrapped Data Master and renamed Data Management - Added Js to auto update form with existing data from the sql database - Added editing by source and year.	Data master is renamed as according to a user feedback, it sounded "corny". Allows users to specifically edit the data in the database by year and by source.
Data History	- Scrapped and implemented into Data Management and Report Generator modules.	Data history is combined into the Data Management Module where user can also view data history from the Data Management and Report Generator modules.
Graph Representations	- Renamed Report Generator	Graph Representations page are scrapped and reworked heavily.
Contact Page	- Added in Supervisor's picture and details, as well as the author's	Contact Page heavily redesigned to provide useful information

Table 2: UAT I

4.3 System Prototype II: ENVISION

After the testing was done in System Prototype I, the feedbacks are recorded and analyzed. Based on the analysis, the development for System Prototype II is started. Development of the system prototype is split into 4 stages:

i. Research and planning
ii. Development of system prototype
iii. User acceptance testing
iv. Refining the system and repeat (i).

4.3.1 Research and Planning

Based on the feedback from UAT I, the author have decided to implement the modifications in Table 2: UAT I in just a month. Thus, meticulous planning is required.

4.3.2 Development of the System Prototype

Once the initial planning and research is completed, the development of the system prototype will commence.

4.3.2.1 *Login Page*

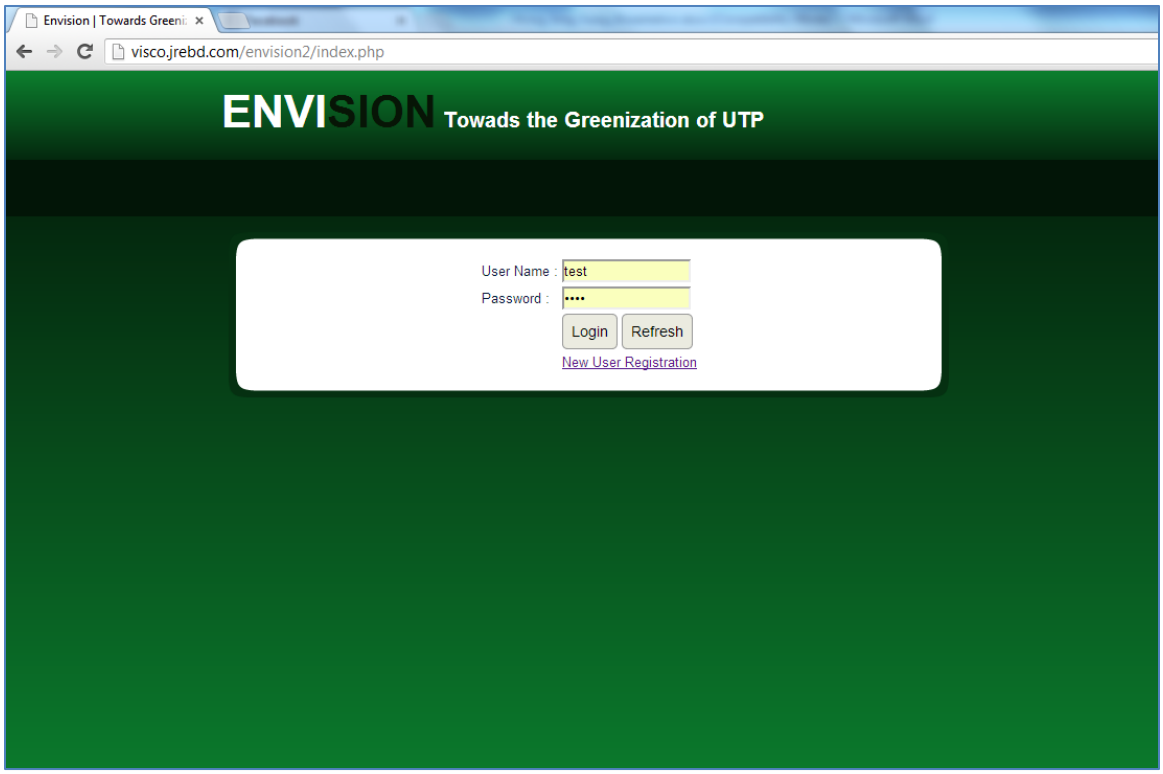


Figure 16: System Prototype II- Login Page Interface

The Login page is the first page to show the new project theme, green. The login page user login box has been reworked and is aligned perfectly to the middle of the screen. The login page will fully utilize the new database functionality in order to create and store new users.

4.3.2.2 *Main Page*

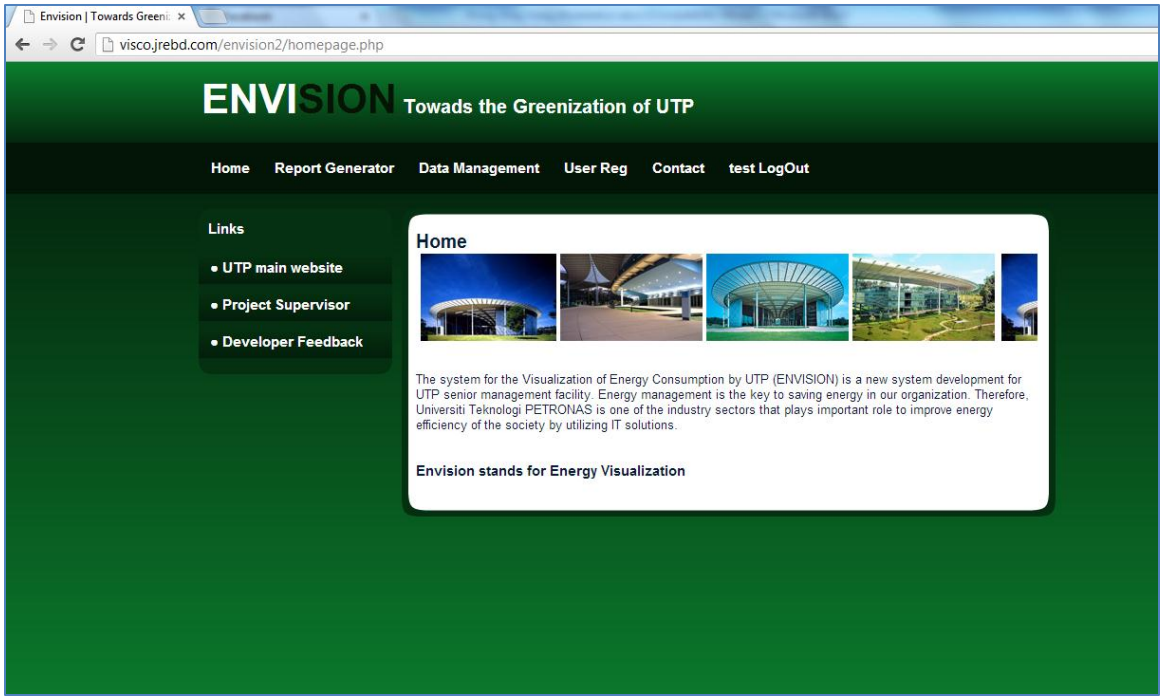


Figure 17:System Prototype II - Main Page Interface

The refined system main page has been reworked to include the project modules at the top bar. The side links are also reworked to show only useful links. UTP logos have been removed due to unrightfully use. The Main Page now only have side and top links to the other modules and now, shows the objectives of the project. The Main Page also have a logout link that call the logout JavaScript when an action occurs on the link.

4.3.2.3 *Report Generator*

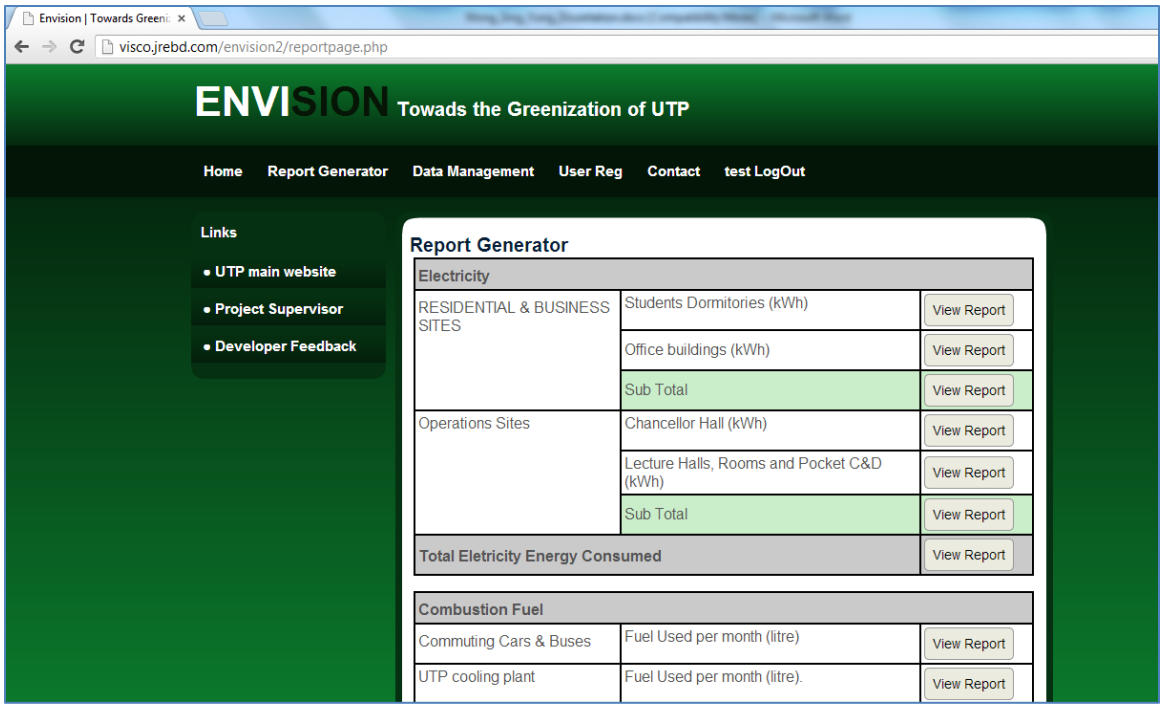


Figure 18 : System Prototype II - Report Generator Interface I

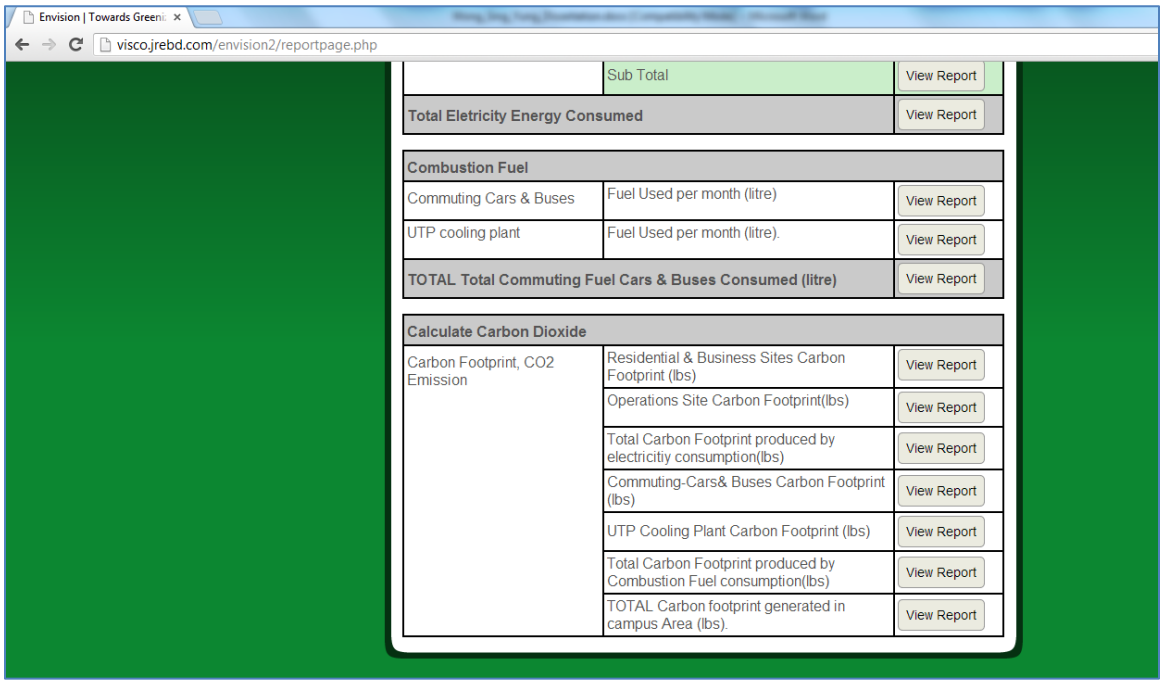


Figure 19: System Prototype II - Report Generator Interface II

The Report Generator module is created based on the feedback and discussion between the author and the supervisor. The Report Generator module is designed to allow the management to view both the high level energy consumption and carbon footprint of UTP and the detailed reports of, for example, the energy consumption by the student's dormitories. The table below shows steps and the development on the Report Generator module.

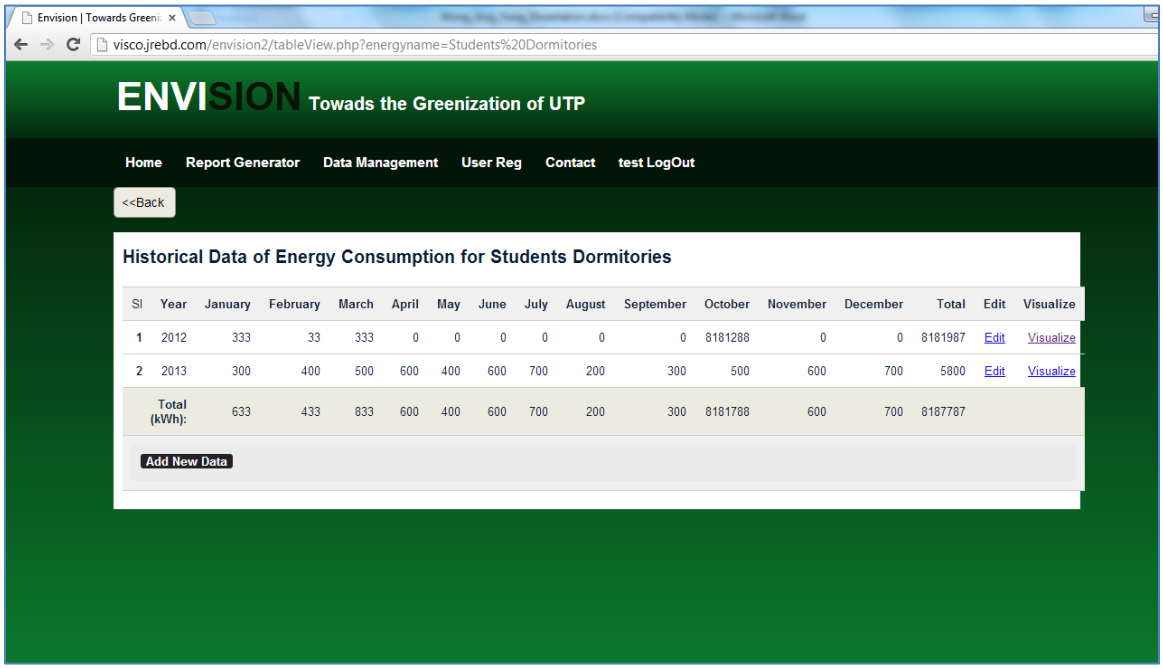
Main Category	**Sub- Categories**	**Sources (To be Report Generated/ able to input)**
Electiricity (electiricty, kwh)	Residential & Business Sites (All Sources able to be both report generated and input by user)	1. Students Dormitories 2. Office buildings 3. Total Electricity Energy Consumed by Residential & Business Sites
	Operations Site(All Sources able to be both report generated and input by user)	1. Chancellor Hall 2. Lecture Halls and Pocket C&D 3. Lecture Blocks 4. Total Electricity Energy Consumed) by Operatiosn Sites
	TOTAL (Report Generated Only, No Input)	1. Total Eletricity Energy Consumed
Combustion Fuel (litre)	Commuting- Cars (All Sources able to be both report generated and input by user)	1. Total Fuel Used per month
	Commuting – UTP Buses (All Sources able to be both report generated and input by user)	1. Total Fuel Used per month
	Fuel – Natural Gas by UTP cooling plant (All Sources able to be both report generated and input by user)	1. Total Fuel Used per month
	TOTAL (Report Generated Only, No Input)	1. Total Commuting Fuel Consumed 2. Total Natural GAS Consumed

Carbon Footprint, CO2 Emission (lbs)	(Report Generated Only, No Input)	1. Residential & Business Sites Carbon Footprint 2. Operations Site Carbon Footprint 3. Total Carbon Footprint produced by electricitiy consumption 4. Commuting-Cars Carbon Footprint 5. Commuting – UTP Buses Carbon Footprint 6. UTP Cooling Plant Carbon Footprint 7. Total Carbon Footprint produced by Combustion Fuel consumption 8. TOTAL Carbon footprint generated in campus Area.

Table 3: Report Generator Module Development Plan

4.3.2.3.1 Report Generator – Graph Generator

When clicked on a specific source, the user will then be taken to the Graph generator module.



Sl	Year	January	February	March	April	May	June	July	August	September	October	November	December	Total	Edit	Visualize
1	2012	333	33	333	0	0	0	0	0	0	8181288	0	0	8181987	Edit	Visualize
2	2013	300	400	500	600	400	600	700	200	300	500	600	700	5800	Edit	Visualize
	Total (kWh):	633	433	833	600	400	600	700	200	300	8181788	600	700	8187787		

Figure 20: System Prototype II- Graph Generator Interface

In this module, the system will show the user the current energy consumption that is stored in the system's database, listed by year. Should the user clicked on the Edit button, the user will then be lead to the Data Management module.

If the user clicked on the Visualize button, the user will then be taken to the Visualize Graph page where the energy consumption of the source and year chosen is visualized in a graphical form.

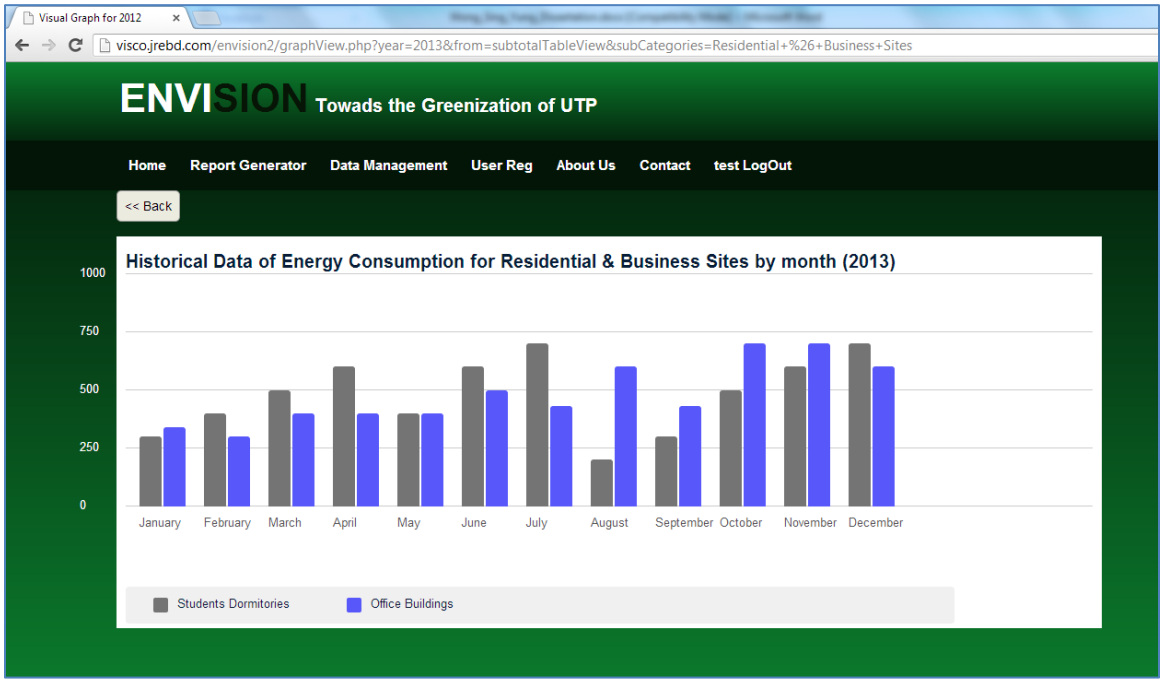


Figure 21: System Prototype II - Graph Generator

In the case of visualizing a carbon footprint level graph, the system will automatically retrieve the energy consumption of the source chosen and calculate its carbon footprint level based on the formulae below.

Calculation
1 kwh = 1.222lbs CO2, 1litre - 1.32277lbs CO2

Table 4: Calculation of UTP Carbon Footprint Level

4.3.2.3.2 Report Generator – Threshold Monitoring

Calculation

Utp = 990 acres
Threshold = 1000 pounds per acre
CO2 should be lower than 990000 lbs

Table 5 : Calculation of UTP Carbon Footprint Level threshold

The refined system as also included a threshold monitoring system so that should the carbon footprint levels exceeded the threshold as shown in the calculation above, there will be a warning to the management when one tries to visualize a graph as shown below.

Figure 22: System Prototype II -- Threshold Monitoring Interface

4.3.2.4 Data Management

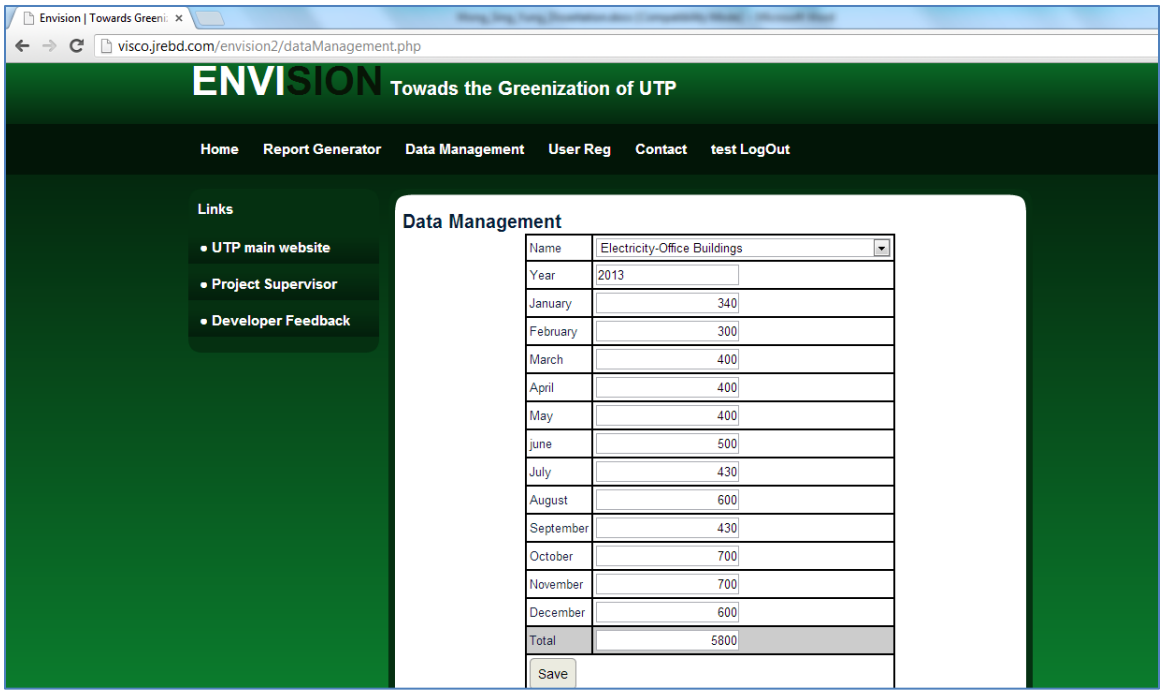


Figure 23: System Prototype II- Data Management Interface

In the Data Management module, Dataset History from System Prototype I is thought of when designing it. Thus, a JavaScript is invoked in this page to Auto-Reload the page with the results queried from the database. Thus, when the user selects a data source and keys in its year. The system will show the user the current existing data in the database and the user will only require to change the data however desired and click save to commit the data into the database.

4.3.2.4.1 User Reg

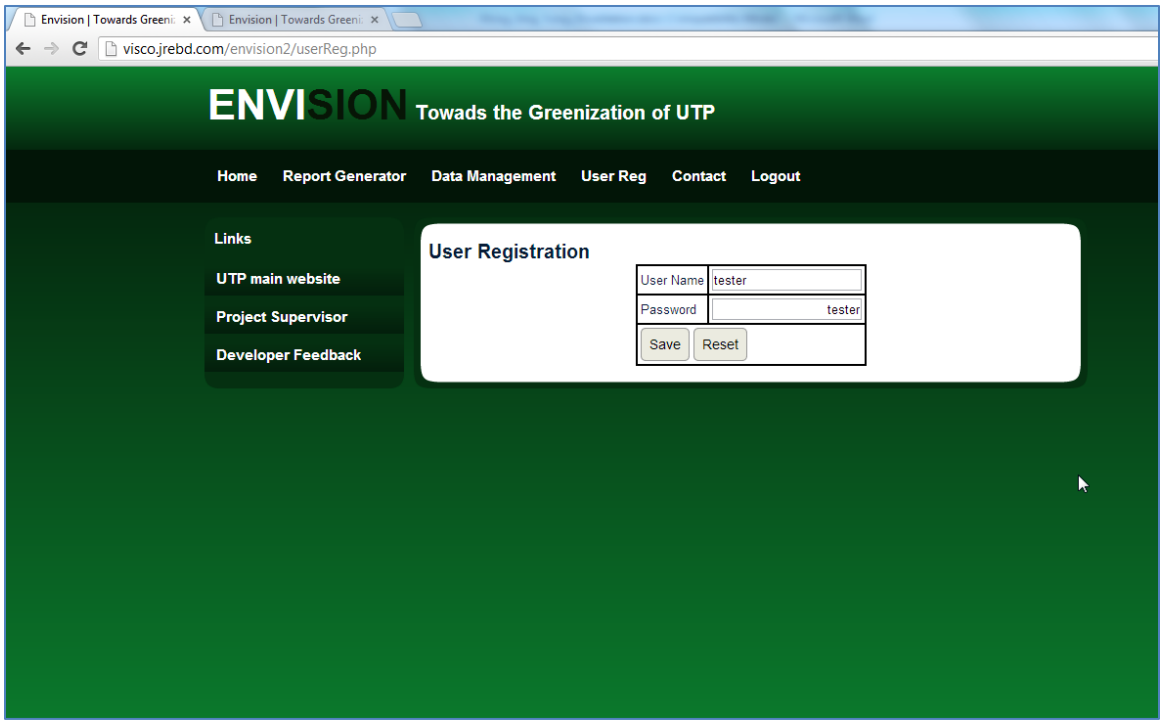


Figure 24: System Prototype II - User Reg Interface

The User Reg Module allows the management to create multiple accesses to the system. When logged in, a user will only require clicking the User Reg in the top bar, key in the username and password desired and click commit.

4.3.2.4.2 Contact

Figure 25: System Prototype II- Contact Interface

The Contact page gives the management useful information on the author and the project supervisor. This information is crucial in the case that the management is required to contact the project supervisor or the author regarding the system.

4.3.3 User Acceptance Testing

System Prototype II has been tested on 20th March 2013. The beta testers and the project supervisor were satisfied regarding the system and thus, System Prototype II will be used as the final prototype for this project.

Chapter 5 CONCLUSION & RECOMMENDATION

5.1 Conclusion

Visualization of UTP's Energy Consumption and its Carbon Footprint System is an online visualization based energy management system which allows the UTP's senior management to review the energy consumption in UTP more effectively and be able to track the amount of carbon footprint that is generated in UTP. This system can be used from anywhere with an internet connection and on any web browsers. This system is very significant due to its potential regarding energy management that will lead to the better management of energy around the campus and allows UTP to play its role in saving energy and promote a Green IT concept within the campus. This system however will not directly solve the excessive energy consumption issue in UTP and also the Carbon Footprint that is generated in UTP.

However, this system is expected to fulfill its objectivity which is a developed high quality energy management system that will allow users to view the records and data on the energy consumption in UTP. In the discussion between the developer and the project sponsor, it is shown that the proposed system deliverables are favorable to be implemented in formal practical use in UTP as the management will be able to effectively review the current situation in UTP with upmost integrity

5.2 Recommendation

This prototype of EVISION is developed as a result from the research of this FYP2 project. As it is still a prototype, more future work and effort can be put into this prototype in order to improve the system's current features and implement more features in the future. This system is recommended to be made to automatically retrieve energy consumption data from the electricity meters and thus, everything about this system will finally be automated.

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