Promoting Knowledge on Sustainable Energy in Digital Ecosystem

Payakpate J.¹, Member IEEE, Chun Che Fung², Senior Member IEEE, Nathakanakul S.³ and Marinova D.⁴

¹,² School of Information Technology, Murdoch University, W.A., Australia, e-mail: {j.payakpate, l.fung}@murdoch.edu.au
³ School of Renewable Energy Technology, Naresuan University, Phitsanulok, Thailand, e-mail: sukruedeen@nu.ac.th
⁴ School of Institute for Sustainability and Technology Policy (ISTP), Murdoch University, W.A. Australia, e-mail: d.marinova@murdoch.edu.au

Abstract— Electrical energy is the crucial element required to sustain the digital or ICT ecosystem. With the world’s attention on possible energy crisis, it is urgent to promote the knowledge and practices of sustainable energy services and technologies in order to achieve long term sustainability. Knowledge Management System (KMS) has proven to be an appropriate approach for the distribution and sharing of knowledge. A KMS could therefore be used to provide easy access to learn and share information and knowledge about sustainable energy services and technologies. This paper presents a web-based KMS on sustainable energy that is capable to bring benefits to Thai communities in the digital ecosystem. The main purpose of this paper is to report on the design and progress of the development. The evaluation of the development so far is based on qualitative and quantitative studies and utilisation of the system will be closely monitored.

Index Terms—Sustainable Energy, Knowledge Management System, Geographic Information System.

I. INTRODUCTION

Digital Ecosystem relies on a supporting infrastructure including communication networks, computer hardware and application software. The infrastructure offers and transports services and information thereby empowers proper functioning of the ecosystem. Obviously, electrical energy is the crucial element required to sustain the system. This implies the need for a reliable and high quality electricity supply. On the other hand, increasing population has caused surging demands for huge amounts of energy thereby driving the demands for energy resources. This leads to rising cost and reduction in the traditional energy reserve. With the promotion and increasing use of electrical appliances and machines, the community will face the reality that energy supply will be inadequate or less than the amount of energy demand. This will cause serious problems and disruption to the digital ecosystem. The lack of knowledge also leads to inefficient use of energy and other related problems such as health related and environmental issues. In terms of energy resources, the traditional carbon-based resources are reducing yearly while the price is steadily edging upwards [1]. On the other hand, renewable energy (RE) resources such as solar and wind are plentiful and they emit minimal amount of pollution. In the case of Thailand, there exists the availability of at least one type of renewable energy resource in most areas. Hence, in terms of economic and environmental reasons, the use of renewable energy resources should be better than the complete reliance on traditional energy resources. However, the lack of knowledge on renewable energy resources has been an obstacle on the utilization of renewable energy services and rendering such services to be unpopular. Steps must be taken to find a solution to prevent the shortage of energy for the community as soon as possible. A research project on the integration of Web-GIS (Geographic Information System) into a knowledge management system (KMS) is currently established. The project aims to promote sustainable energy technologies and to enhance the utilization of sustainable energy services. Sustainable energy technologies relate to the provision of energy services using sustainable energy resources (include traditional energy sources and renewable energy resources) [2]. The aim of this study is achievable through an efficient knowledge management platform. The following sections outline web-based KMS: technologies and tools, an ongoing research on web-based KMS on sustainable energy technologies, discussion on future trends of web-based application on sustainable energy technologies and conclusion.

II. WEB-BASED KMS: TECHNOLOGIES AND TOOLS

In digital ecosystem, knowledge management system plays an important role to improve the monitoring, investment, and sustains the use of natural resources [3] [4] [5]. Web technologies comprising the Internet, web applications, and web GIS, support and facilitate the provision of knowledge and information on sustainable energy services to the users. They also help to implement an effective KM system for promoting the utilization of sustainable energy services as an essential component in the digital ecosystem [6].

As with most KMS, information and knowledge on sustainable energy technologies are represented in various forms such as texts, diagrams and figures. The location or spatial data of sustainable resources are beginning to emerge as an important aspect of the knowledge. In order to enhance and promote sustainable energy technologies, an effective KM system has to support these various forms of data. A web-based application which is called Web-GIS is also incorporated. Web-GIS is the name describing the integration of web-based applications and GIS. It should be able to serve multiple users with both spatial and non-spatial information on a variety of platforms over the Internet [7]. In addition to providing the abilities to serve and support KMS functions, Web-GIS should be able to enable knowledge sharing and distribution on sustainable energy technologies over the Internet including spatial information [8] [9] [2].

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Web-GIS also offers significant benefits to data managers, developers and others within the digital ecosystem. It provides an environment for rapid system development. In addition, because the information is served from dedicated servers, Web-GIS has the potential to address issues such as security, updating and licensing [10] [11] [12] [13]. Web-GIS requires HTML in order to display the information to a user via a web browser. HTML is a data formatting language designed as a means of presenting static information for display purposes [9]. Therefore, HTML is inadequate for Web-GIS users as the information cannot be precisely defined with the limited tags set in HTML. The transmission of GIS data over the Internet relies on the capacity of the programming language for precise and effective data representation during transfer. It requires the integration of the other programming languages such as Extensible Markup Language (XML) [9] [13].

XML is a subset of the Standard Generalized Markup Language (SGML) which is similar to HTML. However, XML can avoid the common HTML drawbacks due to XML is a specification for designing platform-independent markup language in text format that is unambiguous. In addition, the creation of XML tags can be customised into specific types of information depending on the document storage structure and logical structure. XML allows the separation of the output of an application on both the screen and the output devices. The potential benefits for XML on Web-GIS applications are shown as follows [11] [13]:

- Meaningful data definition – The key motivation for developing XML on web based GIS is the user-defined tags. XML allows the creation of specific tag for their own data, and to handle and manage large and complex data.
- Model/view separation – Developer can describe their structured information much more precisely than with HTML. The errors arising from data exchange will be reduced by avoiding formatting tags. On the other hand, the meaning of the data itself is marked with user-defined tags.
- Database accessibility - With XML extensions such as XML query, XML-based web servers can access data from multiple databases and conventional file systems and return the results in HTML or XML formats.
- Graphical User Interface (GUI) flexibility – XML provides a better approach to transmit to web browsers across the Internet. The way map data is sent in XML and HTML is similar. However, XML will include attributes to generate various interfaces more complete than HTML.

In addition, Web-GIS requires a GIS server, also known as Internet Map Server (IMS). IMS is a spatial server which processes the GIS operations based on the request from web servers. IMS connects or collects information from the database server in order to process the GIS operation as required by the users. The IMS is required to be set up with additional programming languages for the implementation of the GIS features. There are both commercial and open-source IMS. An example of commercial Web-GIS package that includes IMS is called ArcInternet Map Servers (ArcIMS) produced by the Environment System Research Institute (ESRI) [13]. This software is classified as a Web-GIS server-side application. It offers ease-of-use, GIS web publishing capabilities, metadata services, data integration, multi-services architecture and scalable architecture [13]. In order to implement Web-GIS by ArcIMS, the developer needs to meet the licensing requirements. Depending on the functions of the features of the application program, other Arc softwares may be required. Examples of open-source IMS are MapServer [14] [15] and Google Map. There are two types of Web-GIS: client-side application and server-side application.

A. Web-GIS client-side application

Web-GIS client-side application (Fig. 1) is a client-dependent platform configuration which requires the client machine to process all the GIS operations such as spatial query, buffering, overlay analysis and network analysis [11] [15]. The server machine obtains the required data from the database and wraps it with the XML format. The data is then sent to the client. Once the data is on the client machine, the application is capable of manipulating the data locally. The web browser with the client-side programming language (e.g. script language, web-enable programming) can assist the client machine to perform the relevant GIS operations.

![Fig 1: Architecture of Web-GIS client-side application [11][15]](image)

Two clients may receive the same data from the server but may derive different outputs from the GIS operations. This will depend on the processing speed and graphical presentation. Data from the server could be both vector and raster data which is proprietary data supported by GIS operations. Developer can create complicated GIS operations on the client machine to manipulate the proprietary vector data that usually offer more efficient and flexible data processing than the generic web-recognized data format [11] [15]. Nevertheless, there are several disadvantages associated with the client-side application as stated by Neng-comma [15] that developers should be aware of. First, the security issues related to the license of GIS software and the copyright of the vector data should not be abused. Second, in order to ensure transmission of vector data across multiple platforms, the vector data must follow the standard format of the World Wide Web Consortium (W3C). Third, as the vector data is transmitted over the Internet, heavy communication load is unavoidable.

B. Web-GIS server-side application

Fig. 2 illustrates Web-GIS server-side application architecture. On the client machine, a web browser is used to generate server requests and to display the results. The host machine usually consists of a web server, GIS server and other servers. Users or clients send their requests to a web server. The web server passes the request to a GIS server, which runs a GIS application and a GIS database. Then, the
GIS server will wrap the result into HTML format and send it back to the web server, which will return the response to the user as a standard web page. All large GIS databases are on the GIS servers thereby allowing a simplified development and maintenance process. Only the result of the GIS operations is converted into standard HTML format that is transmitted to the web client. In Web-GIS server-side applications, all clients use the same GUI to perform the same set of GIS functions on the web browsers. All GIS operations are processed by the dedicated server as clients’ requests. Thus the problems related to data incompatibility, data inconsistency and data unreliability are eliminated.

In the case of the sustainable energy sector, KM plays an important role for improving these areas in terms of monitoring the investment, and sustaining the use of natural resources [3] [4] [5]. Web technologies such as the Internet, web applications, and Web-GIS support and facilitate the provision of information on sustainable energy services to the user. These technologies also form the basis of effective KMS for promoting the utilization of sustainable energy services [16] [17] [18]. A web based KMS on sustainable energy technologies in Thailand is described in the next section.

III. IMPLEMENTATION OF A WEB-BASED KMS ON SUSTAINABLE ENERGY TECHNOLOGIES

The KM platform has been implemented using Web-GIS server-side application and installed at the School of Renewable Energy Technology, Naresuan University, Phitsanulok Thailand.

A. System

In order to implement the KMS on sustainable energy technologies, data and information on sustainable energy technologies have been collected. They are classified into two categories: knowledge on sustainable energy technologies and regional data of sustainable resources at Phitsanulok, Thailand. The first category of knowledge was created and captured from the stakeholders and experts among the energy sectors and the electrical power industry. The second category, local data about the Phitsanulok region, was collected from related public organizations such as the District Agriculture Extension Office from each district (also known as “Ampher” in Thai) in Phitsanulok. This data is in the form of text, figure, table and spatial data. Both categories of data are then converted to the appropriate formats and stored on the server.

Fig. 3 illustrates the structure of the proposed platform. The system consists of the DB server, the GIS server and the knowledge server. A MySQL database runs on the database server which is a Windows 2003 server and IIS (Internet Information Server). The server interprets all the clients’ requests for services. Minnesota Map Server is installed on the GIS server which runs on a Linux and Apache environment. Minnesota Map Server is used to provide the basic GIS framework [11] [13] [15] [19]. The “user” in the Figure is a “browser” or a stakeholder who retrieves the information from the system over the Internet. The knowledge server consists of the web server and interface programs. The web server will receive request from users via the browsers over the Internet. The server translates the request into internal codes and invokes the appropriate functions by passing the request to the interface program. The interface program will then process the request and formats the information from the GIS and/or the database server for use by the client browser application.

The platform will represent knowledge as perceived from a GIS prospective. That can be in the forms of database view, map view and model or process view. Fig. 4 shows an example of a screen display of the system. Each link will connect to another page that will show particular features. For example, the link on operation shows a number of sustainable technologies that is used to generate the services for community.

Fig. 4: An example of screen shots on the KM platform on sustainable energy technologies - the main page of the platform

The KM platform will help local users to access knowledge on sustainable energy technologies in their local area. Fig. 5 describes the groups of participants and permission to access to the features on the platform. There are three
groups of users: users, researchers and local government administrators. The user will browse and learn information on sustainable energy and how to operate the sustainable energy system with better efficiency. Researchers divided into two categories: general user and admin. General users, this group of researchers has access priority similar to the users. In the case of researcher with admin status, the researchers are considered as the same as the previous group, however, additional privileges can be gained from accessing more knowledge that is related to their research work or to give advices in the forum.

In the context of Thailand, each district is divided into sub-districts which are known as “Tambons”. The Tambon council members are the local government administrators (LGAs) who will provide and access local information from the system [20] [21]. LGAs are related to the development or are responsible for improving the quality of life among the local communities [22]. By using KM platform, local administrator can be empowered with knowledge and know-how to assist them to develop appropriate system for their respective locations.

In addition, previous reports have shown that the infrastructure of Thailand is ready for the implementation and access to the KM platform. Reviews on the status of Information and Communication Technologies (ICT) in Thailand also shows that infrastructures for Internet connection via both land line or satellite are readily available in these communities [21] [23] [24]. Phitsanulok has the potential and infrastructure to build up the KM platform based on web technologies due to the Thai government’s policy [24] and experience from many pervious projects. For example, low cost ADSL connection by the Telephone Organization of Thailand (TOT), Post Office Internet kiosks have already covered almost over all the countries - 31% of the rural areas [23], SchoolNet and Internet Tambon projects [24] launched by the government. The 2001 report showed that 90 % of rural citizens have accessed the Internet via the services provided by Communication Authority of Thailand (CAT) [25] and TOT [21]. Therefore, using KM platform on sustainable energy technologies or services in Phitsanulok is appropriate. The finding from this study can be considered as a leading example for Thai communities and other developing countries.

B. Evaluation of the system

The KM platform has been launched to the public since February, 2007. Pre-questionnaire has been set up in order to survey the participants’ background, participants’ knowledge on sustainable energy and the Internet infrastructure of the community. Two hundred of pre-questionnaires were distributed to local communities at the same time that the platform was launched. A month later, post-questionnaire were distributed to the same cohort. There are dual purposes for the post-questionnaire: surveying the satisfaction of the participants to the platform and assessing the participants’ knowledge on sustainable energy.

Up to date, we received 100% return of the pre-questionnaire and 75% of the post-questionnaires. The findings reveal that 46% of researchers are experienced on KM, 19.55% of users and 14.29% of LGAs. The popular place that they access to KM is government sites. 60% of the places they visited were: work place, education institute and other places. Hence, the Internet infrastructure of community is appropriate.

Likert scale of 1 to 5 was used to measure the satisfaction of participants to the platform by setting up the following questions:

Q1. The graphical user interface of KM platform is user friendly.
Q2. The information on the KM platform is up to date.
Q3. The KM platform provides communication between you and others or experts i.e. e-mail, forum and etc.
Q4. The KM platform provides meaningful information.
Q5. The KM platform provides adequate information on Sustainable Energy Services for designing and building sustainable energy services.

All feedback received have an average score of more than three out of five scales. This shows that the participants are in general satisfy with the platform. In particular, Q4 has gained the highest score.

Paired-Sample T Test was used to measure the knowledge of people in community. Part of the survey named “test”, was set up in both pre and post questionnaires. This “test” portion consists of multiple-choice questions concerning knowledge on sustainable energy. The questions have been validated by the researchers of school of renewable energy technology, Naresuan University.

Fig. 6 shows the comparison of means value of the test. Paired-Sample T Test is used to analyse the score from the tests. The mean values illustrate that the score of post test is higher than the pre-test in every group. The mean values illustrate that the score of the post test is higher than the pre-test in every group. This reveals that the knowledge of the participants is increased after they have used the KM platform. The finding from this study can be considered as a leading example to enhance knowledge for Thai communities and other developing countries by using web-based KMS.
Knowledge management is not new. Implicitly, it is an integral component in the digital ecosystem. The challenge is how to use KM technologies effectively to enable capture and distribute knowledge to the community with the most efficiency [26] [27]. The web-based KMS on this study has been implemented since late 2005. The finding reveals that the study is satisfied by the stakeholders and participants. It also improves knowledge of local people depending by the time that they spend with the KM platform. The emerging of new technologies and internet techniques, such as Web 2.0, does not decrease the benefits of the web-based KMS. On the other hand, it increases the potential of web-based KMS in order to distribute knowledge [28] [29]. For example, following the format of wikipedia, any user other than the administrator can update the information on the platform. Anyone can share his/her experience on sustainable energy technologies and add the information or knowledge at anytime. The cooperation of stakeholders provides the meaningful information in the form of electronic format via the open ICT standards. This can reduce the time for validating or improving the information on the platform [30]. It can be expected that knowledge platforms with up-to-date information will attract better utilization of knowledge on sustainable energy services. In addition, the asynchronous features of the key components of web 2.0, JavaScript and XML (AJAX), support better and more efficient streaming of data over the Internet [28] [29]. This will benefit the rural communities in Thailand where they may have limitation on the Internet speed.

V. CONCLUSION

The promotion of knowledge on sustainable energy technologies or services is essential in the digital ecosystem. This will enable the Thai communities to improve their quality of life and to support local businesses. This study reports the development and the use of web-based KMS as an effective tool to improve knowledge sharing and distribution on sustainable energy technologies for Thai communities. The background of the research and design of the web-based KMS is reported. The project has completed the implementation phase. Contributors to the knowledge base of the system are both general browsers and Tambon administrators. Initial evaluation of this KMS has been carried and further work will be reported in the future. Ongoing work will include continue expansion and validation of the knowledge in the system. Monitoring, feedback collection, surveys and tests will also be carried out to ensure that the KMS is fulfilling its role in the digital ecosystem.

VI. REFERENCES


