An Integrated Web-GIS Knowledge Management System to Enhance and Promote Knowledge on Sustainable Energy Technologies

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Abstract: The objective of this paper is to report an integrated Web-GIS Knowledge Management System (KMS) to enhance and promote knowledge on sustainable energy resources among the rural communities in Thailand. It is expected that better knowledge and understanding on sustainable energy resources will increase the utilization of sustainable energy services. This will lead to benefits such as an improvement of quality of life and economic advantages for the communities. The developed system has been employed in a rural community at Thailand under a project termed Sustainable Energy Knowledge Management System (SEKMS). The SEKMS project aims at developing a network and service platform to supply an integrated solution based on data and knowledge management, publication and dissemination of information, and services to support the sharing of information and knowledge on sustainable energy technologies among the stakeholders and interested communities. The main purpose of this paper is to report on the progress of this project and to introduce the Sustainable Energy Knowledge Management System to the Thai communities.

Key-Words: - Knowledge Management System (KMS), Sustainable Energy Technologies

1 Introduction

Sustainable energy technologies relate to the provision of energy services using sustainable energy resources. The importance of these technologies is becoming more prominent due to changes in the global climate. While such technologies have been implemented successfully in many countries, they are not popular due to the high initial cost of the system. In addition, the distribution of such knowledge has been limited to only certain academic and research communities [1] [2] [3] [4]. Taking into consideration of other factors such as fuel and environmental issues, long-term utilization of these technologies is more efficient in terms of cost, energy consumption and with less environmental impacts. Research has shown that sustainable energy technologies have already reached a stage that they are bringing realistic benefits to the communities. The potential and availability of sustainable energy is adequate to supply energy services throughout the world [4]. However, among some of the communities, the energy usage has been inefficient and does not utilise the available sustainable energy resources. If the knowledge and utilisation of energy could be improved, the development and use of sustainable energy services could be increased. In addition, the availability of sustainable energy services can be used to enable and support additional businesses and industries. This will have a positive effect of building up employment opportunities among the local communities. This will reduce poverty and subsequently will improve the quality of life. Therefore, knowledge and utilisation of sustainable energy technologies is a significant factor for community development. This leads to the challenge on how to enhance and utilize the stakeholders' knowledge in order to gain benefits from sustainable energy resources.

A Knowledge Management System (KMS) is an approach that can be used to provide a platform to extract and exchange meaningful knowledge for the stakeholders relating to the design and use of sustainable energy services. KM platform has the potential to be an invaluable tool to assist communities in developing countries to handle the challenges relating to their energy needs. This paper presents the progress of the development of a proposed KMS on sustainable energy technologies for the Thai communities. This report includes a background on the sustainable energy technologies

KMS, an overview of the Information Technology (IT) and KM tools used in this project, and, a description of the developed KM platform – Sustainable Energy Knowledge Management System (SEKMS). Finally, the challenges encountered and proposed future works are discussed.

2 Knowledge Management on Sustainable Energy Technologies

Knowledge Management (KM) is an approach that concerns with the capturing, defining, storing, categorizing and linking of knowledge. It also includes searching for and subscribing relevant content from appropriate sources, and, presenting the contents with sufficient flexibility [5] [6] [7]. Such knowledge is thereby made available in ways that can help or assist the users to discover meaningful knowledge for an organization or a community. KM has been recognized as an important factor to increase the overall organizational value in terms of performance and assets [6] [8]. KM is not a single technology but a collection of indexing, classifying, and information-retrieval technologies coupled with methodologies designed to assist the users for the purpose of extracting and managing meaningful knowledge [7]. Processes of KM are often facilitated by knowledge management systems (KMS). The challenge of research in this area is to enhance the utilization of KMS in community by using the potential of information and communication technologies such as Internet, intranets, browsers, data warehouses, filters and software agents, to systematize, facilitate, and expedite firm-wide knowledge management. However, in order to implement the successful KMS, significant functions of KMS such as acquisition and capture, storage, retrieval, distribution and presentation should be included as the basic features in the KMS [6] [9]. Previous use of KMS but with limited functions on sustainable energy technologies are listed as follows:

Mini grid system for un-electrified villages in the north of Thailand [2] [3]: The system consists of a renewable energy hybrid power plant, a low voltage grid line, loads and energy management system. This system also generated 170 kWh/ per month. The total plant efficiency calculated is about 60.5%. The energy management system offers the ability to determine the most effective energy sources to be supplied to the required load.

Integrated Renewable Energy System (IRES) [10]: The Integrated Renewable Energy System (IRES) is a knowledge-based system that could be used to design and plan the utilization of available local renewable resources. IRES is a stand-alone system that uses a relational database and search algorithm. The objective is to find the rating and the size of storage a combined Photo-voltaic (PV) and/or Wind-Electric Conversion System (WECS) that minimizes capital cost and without compromising the loss of power supply probability.

Computer-based system on education of renewable energy (RE) technology [11]: The Internet-based teaching course in Renewable Energy Technology has been created in the University of Melbourne. This course covers knowledge of basic energy and advanced RE technologies including environment impacts such as availability of different non-renewable sources of energy, biomass energy system, and barriers to the developments of RE sources.

To a certain extent, all these examples offer inadequate services for the wider community. First, all of them are working on stand-alone systems. The information on these systems is inadequate to assist the development of the energy services due to the fact that the databases are not updated. Next, the user interfaces of the mini grid system and IRES are too complicated. They were also not designed for normal web browsers. Results also revealed that a low level of communication between technicians and local people leads to delays of system repairs and maintenance. However, the positive result is illustrated in the teaching course at the University of Melbourne. Students understand the renewable energy technology well due to the web-based and multimedia technologies. These technologies have facilitated the implementation processes of the RE systems by illustrating the processes clearly in graphical and animated fashion. Next section will recommend the information technologies and KM tools that can be used to tackle those problems encountered in previous research. Such tools will assist the development of KMS for the benefits of the communities.

3 Information Technologies and KM tools

Information technology is the fundamental enabler for development and implementation of KM processes for knowledge sharing across the

organization boundaries [5] [12] [13] [14]. Typical features and functionalities offered by IT include: electronic mail, Internet, collaboration technologies, bulletin boards and newsgroups. All these are essential to support the distribution of knowledge throughout an organization. They also provide a forum for employees to debate, discuss and interpret knowledge via multiple perspectives. Most importantly, information technologies enhance the sharing of knowledge by reducing the restrictions pertaining to time and distance [15]. Web-based approach is another technology that supports KM activities [5] and has the potential to offer to the communities the benefits from KMS. Also, web-based approach can provide high quality knowledge content and user-friendly interfaces [16] [17]. Fig 1 illustrates Client/Server (C/S) architecture for web based approach.

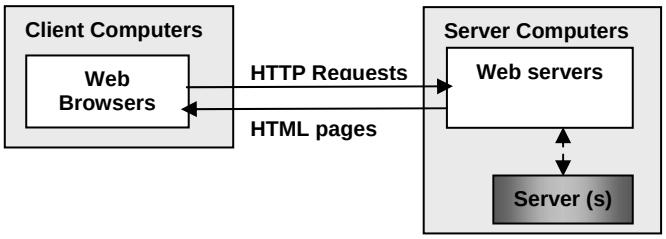

Fig.1: Client/Server (C/S) Architecture for web-based approach [5]

The Client/Server (C/S) architecture for web-based approach is illustrated in Fig. 1. The web browsers send the HTTP requests to the server. Servers process the requests and send the result back to the web browsers via HyperText Markup Language (HTML).

Data, information and knowledge on sustainable energy technologies are represented in various forms such as text, diagram and figure. In addition, 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, the most effective KM system has to support these various forms of data. Web GIS is an effective tool that can serve and support KMS functions. In particular, it is able to serve knowledge on sustainable energy technologies over the Internet including spatial information [18] [19].

Web GIS is the name describing the integration of web-based application and GIS (Geographic Information System). It is able to serve multiple users with both spatial and non-spatial information on a variety of platforms over the Internet [20]. Web GIS also has significant benefits for data managers and developers alike. It provides an environment for rapid system development and the potential to overcome longstanding issues such as security, updating and licensing [21] [22] [23]. The fundamental connection of web GIS is the same as C/S architecture. The additional GIS server is attached to the server computers. There are two basic approaches for the deployment of Web GIS, client-side and server-side applications. The s*erver-side applications*, 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 sends 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 map data is converted into standard HTML format that is transmitted to the web client. In contrast, the *client-side application*s need to be installed on client machines. Only vector data will be transmitted from the GIS server. The advantage of this approach being that the client-side application can use the full options of GIS tools without the need of a full GIS server being installed [21] [22] [24].

In the case of the sustainable energy sector, KM plays an important role for improving the monitoring, investment, and sustains the use of natural resources [2] [10] [17]. Web technologies, that is, the Internet, web applications, and web GIS, support and facilitate the provision of 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. A current research project, SEKMS for Thailand based on the integration of these web applications and GIS is described in the next section.

4 Sustainable Energy Knowledge Management System for Thailand

The SEKMS platform has been implemented using web GIS server-side application and installed at the School of Renewable Energy Technology, Naresuan University, Phitsanulok Thailand. In order to implement the KMS on sustainable energy technologies, data and information on sustainable energy technologies has been collected. It is classified into two categories, knowledge on sustainable energy technologies and regional data of sustainable resources at Phitsanulok, Thailand. The

first one was created and captured by the stakeholders and experts from the energy sectors and electrical power industry. The 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 form and stored on the server.

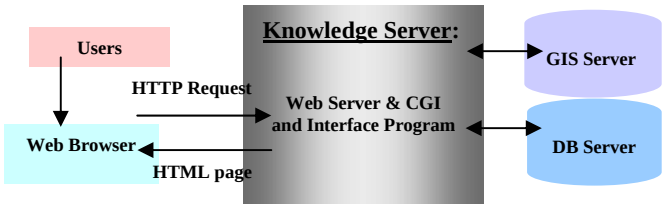

Fig. 2: Structure of the KM platform

Fig. 2 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 Window 2003 server and IIS (Internet information Server). The web 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 [25]. 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 KM platform will help local users to access knowledge on sustainable energy technologies in their local area. There are three groups of users: browsers, researchers and local government administrators. The browser will be browse and learn information on sustainable energy and the operation of how to use the sustainable energy with better efficiency. Researchers divided into two categories: user and admin. User, this group of researchers has priority to access as same as the browser. In the case of researcher with the admin status, the researchers are considered as the same as the previous group, however, the additional privileges can gain from accessing more knowledge that is related to their research work or to give the advices via 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 who will provide and access local information from the system. Main contributions are obtained from local administrators. They are related to the development or are responsible for improving the quality of life among the local communities. 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. The summary of access authority of each group of participants is shown in Table 1.

Table1: Features and access authority of participants.

Features\Participants	Browsers	Researchers		LGA*
		User	Admin	
1. Operation	X	X	X	X
2. Lesson Learned			X	X
3. Calendar	X	X	X	X
4. Forum	X	X	X	X
5. Local energy resources			X	X
6. Update data on the system			X	

* LGA = Local Government Administrator

The current research is divided in three phases: Initial phase, Build up phase and Evaluation phase. During the Initial phase, literature research on the background of the KMS on sustainable energy technologies has been carried out. The initial phase has gathered substantial information on the topic and the report has gained much interest from the communities. The Build up Phase involved the design and development of the KM platform. Research methodologies, tools and approval from the research ethic committee have also been finalised or obtained. The Evaluation Phase measures and assesses the usefulness of the developed KM platform. The research tool employed are pre-questionnaire and post-questionnaires. Interviews will also be used to obtain feedback and suggestions on the proposed system.

Up-to-date, the current research has launched the KM platform after collecting the pre-questionnaire.

The preliminary findings are discussed in the next section.

5 Discussion

The preliminary finding from this study shows that there are significant factors affecting the efficiency of the KM. Examples of these issues are given below:

Limitation over the speed of the Internet connection: Even though the network connection in Thailand is ready to support the basic KM platform, there are still hurdles to overcome and especially in the rural areas. Low-cost ADSL connection by the Telephone Organization of Thailand (TOT), Post Office Internet kiosks has already covered 31% of the rural areas [26]. SchoolNet and Internet Tambon are also available to the Tambons [27]. Internet Tambon project have also been 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) and TOT [28]. But the limitation of the speed restriction of the network can affect the usefulness of KM platform due to the streaming map over the Internet. However, some web technologies such as AJAX and Mashup can handle this problem.

Quality and quantity of knowledge: The amount of knowledge exists in KM platform should be adequate and meaningful for most users. An on-going research by the School of Renewable Energy, Naresuan University is to continual enhancement of such knowledge. The knowledge on the platform has to be validated before being released online. In addition, other stakeholders should be given the authority to manage and organize the knowledge content to enable them to be made suitable for the KM platform.

Language: The KM platform has been developed in Thailand and therefore it is designed to support local Thais. Both English and Thai are used on the KM platform as a lot of information on sustainable energy is originated in English. Translation between the two languages is a major challenge and demands a lot of efforts. Incorrect or inappropriate translation obviously will affect the quality of knowledge.

Community behaviour: Culture and behaviour of the community are significant factors that can affect the usefulness of the KM platform. It is recognized that the local administrator (Tambon council) plays a significant factor in contributing to the success of the project. The Tambon administrator is regarded as the leader of sub-district and is responsible for community development. Traditional Asian and Thai culture always looks up or follows the leader. Hence, the level of the involvement of the local administer will govern the use of KM and subsequent effective development or use of the sustainable energy services. One of the solutions is to ensure user-friendliness and ease of use of the system. This is an on going task to ensure the KM is utilized and bring forth the benefits to the communities. Further research and development on this will improve the usefulness of the system.

6. Conclusion

This paper reports the development and use of knowledge management system as an effective tool to improve knowledge on sustainable energy technologies for communities in Thailand. Information Technologies (web application, GIS over the Internet and web technologies) play an important role in the delivery of knowledge over the KM platform. The background of the research and design of the Sustainable Energy Knowledge Management System (SEKMS) is reported. The project has completed the Build up phase and the KM platform includes functionalities to facilitate browsers to access knowledge about the sustainable energy technologies. Contributors to the knowledge base of the system are both general browsers and Tambon administrators. Evaluation of this KMS is in progress and will be reported in the future.

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