

Hui, S. C. M., 1999. Web-based information system for energy efficient technologies in HVAC and the built environment, In *Proc. of the 1999 Asia-Pacific Conference on Built Environment*, 29 November - 2 December 1999, Taipei, Taiwan.

WEB-BASED INFORMATION SYSTEM FOR ENERGY EFFICIENT TECHNOLOGIES IN HVAC AND THE BUILT ENVIRONMENT

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ABSTRACT

Dissemination and application of energy efficient technologies in buildings are often hindered by the lack of available and accessible information. The Internet and World Wide Web can provide an efficient and rich environment for communication and information management to help promoting energy efficiency in the built environment and collaboration among the building professionals. A web-based information system is being developed at the University of Hong Kong to help people understand and achieve energy efficiency in buildings. The potential and implication of using web technology to promote energy efficient buildings is being investigated. This paper describes the approach of the research, presents its initial findings, and discusses the future development of the system. It is believed that web applications will proliferate and form an important tool for studying and improving energy efficiency in the built environment.

1. INTRODUCTION

Energy efficiency in the built environment is important for supporting socio-economic development and environmental sustainability of the community. However, the dissemination and application of energy efficient technologies in buildings are often hindered by the lack of available and accessible information. Although most people agreed that energy efficiency is a good thing, a number of technical, socio-economic, and behavioral barriers are limiting market diffusion and application of the energy efficient technologies. To disseminate sound technologies for energy efficient buildings and promote research and good practices, an effective method is needed to distribute the information, promote technological development and innovation, increase understanding about the technologies, and encourage collaboration among the building professionals.

The rapid growth of the Internet and World Wide Web (WWW) provides highly customised, accessible, and interactive sources of information. It has a good potential to serve as an efficient means of communication and information transfer for the building professionals and researchers. A research initiative has been started at the University of Hong Kong to develop a web-based information system for energy efficient technologies in heating, ventilating and air-conditioning (HVAC) and the built environment. The objective of the research is to explore how web technology can be used to build a flexible and efficient information system for dissemination, analysis and evaluation of the energy efficient technologies.

This paper describes the approach of the research and the current efforts to build up the web-based information system. The initial findings of the research are presented and the

future development of the system is discussed. It is hoped that the study will form a basis for promoting energy efficient buildings in our region and encouraging building professionals to use web technologies.

2. INTERNET AND WORLD WIDE WEB

The Internet technology has evolved very rapidly over the past few years. Due to the ease of use and high accessibility, WWW is the most popular and visible component of the Internet. It is being increasingly used to support various activities in a wide variety of disciplines in the society, including the building industry.

2.1 Basic Concepts

The Internet, sometimes called simply "the Net", is a worldwide system of computer networks - a network of networks in which users at any one computer can, if they have permission, get information from any other computer (and sometimes talk directly to users at other computers). Today, the Internet is a public, cooperative, and self-sustaining facility accessible to hundreds of millions of people worldwide. Physically, the Internet uses a portion of the total resources of the currently existing public telecommunication networks. Technically, what distinguishes the Internet is its use of a set of protocols called TCP/IP (Transmission Control Protocol/Internet Protocol).

Nowadays, the most widely used part of the Internet is the World Wide Web, also known as "WWW", "Web" or "W3". The WWW is the universe of network-accessible information, the embodiment of human knowledge (W3C, 1997). Through the use of hypertext and multimedia techniques (including graphics, video clips and sound) for cross-referencing and presentation, the web is easy for anyone to roam, browse, and contribute. Using the web, people have access to millions of pages of information and web "surfing" is done with a web browser, such as Netscape Navigator and Microsoft Internet Explorer.

The WWW is based on two standards for exchanging files: Hyper Text Transfer Protocol (HTTP) and Hyper Text Mark-up Language (HTML). HTTP describes the way that hyper text documents are fetched over the Internet; HTML specifies the layout and linking commands present in the hypertext documents. Resources on the web are specified with a Uniform Resource Locator (URL). A URL indicates the protocol used to fetch a document as well as its location.

2.2 Benefits and Potential

The WWW is basically an access phenomenon: it provides easily accessible information to a widely distributed user base, with the benefit of platform independence and global accessibility. Compared to traditional paper-based communication, the web as a network infrastructure has the great advantage of flexibility, low cost and rich environment. It is a constantly updated mine of information and is being increasingly used as a place for learning, to buy equipment, to publish information and to locate people, companies and products. The Internet web technology is changing the way the world shares information; the applications it supports are revolutionising the means people work together.

Currently, the web's greatest use is for dissemination of information and software. The WWW offers both an interface and a delivery channel for the information as well as being a medium for linking distributed users. By sharing knowledge and promoting communication,

the WWW can also be used to support collaborative design development, for example, in various disciplines of the built environment sector (such as architects, engineers, and builders). The potential of the web to promote best practice in building profession is an important area that people are investigating at present (Doherty, 1997).

2.3 Application in HVAC and Building Industry

For over the years, the HVAC and building industry has been slow to adopt WWW technology. However, there are already signs that this situation is changing as the possibilities of the Web and other options for improving both internal and external communications are more widely appreciated (Hui, 1999). A good example of WWW application in the HVAC industry is the "ASHRAE Online" (ASHRAE, 1999). Even the HVAC industry in the mainland China, which is constrained by its Internet infrastructure at present, has created web presence and is making use of WWW applications (Qiu and Wang, 1998; Zhang, 1999).

For effective use of WWW technology within the building profession, strategic planning for information technology (IT) is important (Ivanovich, 1996). It is expected that the level of Internet penetration in this sector will increase in the coming years and a number of interesting issues should be considered (Ivanovich, 1997), like IT training and working styles. The Internet is booming in the world and the HVAC community in the Asia Pacific region has a vast potential to benefit from the surge in on-line information and interaction. One of the important areas for investigation is the development and promotion of energy efficient buildings.

3. ENERGY EFFICIENCY IN THE BUILT ENVIRONMENT

More than one third of world primary energy is consumed by commercial and residential buildings, and the building sector accounts for 25-30% of total energy-related carbon dioxide emissions (Wiel, et al., 1998). However, at present, proper knowledge of energy efficiency in buildings is lacking in many levels of the society, especially for developing countries. Existing and emerging technologies for energy efficiency are not widely understood and integrated into the buildings. There is an urgent need to develop efficient information management and access systems for promoting energy efficient technologies and applications in the built environment.

3.1 Energy Efficient HVAC and Buildings

The primary objective of a HVAC system is to provide and maintain the required indoor environmental conditions. An energy efficient HVAC system is one which meets the primary requirements while consuming the least amount of energy. Given that there are always a number of alternative system design options that can meet the operational requirements, selecting the most cost effective and energy efficient solution can prove to be no easy matter. The situation is made more complicated by the fact that energy performance of buildings is difficult to measure and compare in a consistent way.

In cities with warm climates, like Taipei and Hong Kong, energy consumption of air-conditioning systems is the most important part of the energy requirements in buildings. The design and efficient operation of HVAC systems depend not only on the engineering factors, but also on the architectural settings and other constraints. To achieve optimum solutions for energy efficient buildings, one must understand the various aspects of building design that may affect the energy performance, such as building envelope, building systems, climate and

site. At present, information about building energy design is scattered and varying in quality, and the technologies for improving energy efficiency are changing rapidly. The result is that, building designers and owners, who are looking for ways to investigate and improve building energy efficiency, are either frustrated by a lack of information, or puzzled by the complexity of the problem.

3.2 Integration and Coordination

The multi-disciplinary and integrated nature of building design and construction poses a great difficulty to individual disciplines when they are trying to study and optimise building energy efficiency, since an energy-saving design for one aspect may affect the building design and energy performance of another. An integrated approach that considers the balance between different requirements is needed and an optimised design process to minimise loads, energy consumption and costs for the whole building for its life cycle is important. It is believed that effective integration of architectural and building services designs can significantly reduce building energy use and HVAC equipment size.

Nevertheless, cost-effective energy efficiency measures are often not undertaken as a result of lack of information or knowledge on the part of the building designer or owner, or a lack of confidence in the information, or high transaction costs for obtaining reliable information. Even where the information is available, it can be incomplete or inconsistent. The building project design and/or operation teams require detailed information regarding technical options for energy and material efficiency improvement. Bodies or agencies providing energy efficient products or services also need an effective channel for promoting their markets and communicating with the building designers. To ensure proper uptaking and development of energy efficient technologies, the quality and availability of information provided through governments, energy agencies, vendors, trade and professional associations, or other appropriate bodies should be coordinated and improved.

3.3 Information Needs

Levine, et al. (1995) has discussed the factors limiting the acceptance of end-use energy efficient technologies. They have pointed out that lack of information can lead consumers to use short payback times for the investments in energy efficiency, adding unnecessary constraints and market distortions. Insufficient knowledge and experience about energy efficient technologies will also affect decision-making for building design and operation. To overcome the market failure, efficient information management is one of the key issues; the gaps in information for energy efficient technologies should be reduced.

Information access is essential for "capacity building activities" such as education, training, and technology transfer. Generation of awareness (for the public and the professionals) and development of human resources are crucial to the success of energy efficiency programmes. It is believed that education and training for customers, designers, and energy managers offers the greatest potential for achieving long term energy efficiency savings, especially for developing countries. Flexible and effective methods are needed to carry out these activities and to keep people informed of the energy conservation measures and potential.

It is clear that adequate information is important for the formulation and implementation of energy efficiency policies and programmes. The type and quality of information required depend on the nature of the policies and programmes. For instance, information on energy supply and demand at the sectoral level is needed in order to identify those sectors and

subsectors where energy conservation efforts should be addressed first and will have the greatest impact. Energy balances and energy-flow diagrams are needed at the plant and process levels and can contribute to sectoral energy information systems. All in all, the energy information systems should be adapted to address the information needs of energy-conservation programmes, including their environmental and economic implications.

4. WEB-BASED INFORMATION SYSTEM

A web-based information system for energy efficient technologies in HVAC and the built environment is being developed at the University of Hong Kong. The aim and objectives of the system, its basic structure and approach, and the initial research findings are described.

4.1 Aim and Objectives

The web-based system aims to build up an information resource to help researchers, designers, architects, engineers, builders, code officials, and others involved in the building life-cycle to study and improve energy efficiency in buildings. The system will provide information to assist people in understanding and employing technologies and practices that use energy more efficiently. By making known new and innovative technologies and ideas, it can help promoting understanding and accelerate commercialisation and take-up of the technologies.

Main objectives for setting up the system are:

- (a) to increase the accessibility of technical information in the application of energy efficient technologies;
- (b) to keep energy users and building designers informed and motivated to include energy efficiency good practices in their activities; and
- (c) to encourage policy makers and managers to become more aware of the potential and benefits of energy efficiency, and capable of establishing pragmatic conservation policies.

Another important function of the system is to support education and training activities through the development of a web-based learning environment (Hui and Cheung, 1999). Teaching materials and fact sheets are designed to increase awareness, acceptance, and use of particular technologies or services. It is believed that the web has the potential to support the learning process in many more ways than its traditional information delivery role.

4.2 Basic Structure and Approach

The web-based system is made up of a group of modules containing information, data, and hyperlinks for a set of topics of energy efficiency in buildings. Table 1 shows the basic structure of the system which consists of six major sections and various sub-topics. The "*Fundamentals*" section contains basic concepts and descriptions of the issues; the "*Technologies*" section provides information on different aspects of building energy design; the "*Resources*" section contains data and information sources for further study and exploitation; the "*Cases*" section provides examples of building projects and good practices; the "*Exchanges*" section allow users' interaction and feedback; the "*Others*" section contains miscellaneous Internet tools.

Table 1: Basic structure of the information system

<i>Fundamentals</i>	Basic concepts and principles; laws and standards; climate; energy data and statistics; analysis methods/ tools; software; economics; glossary
<i>Technologies</i>	Site design; architectural planning; building envelope; HVAC; lighting; electrical services; lift and escalators; plumbing and drainage; hot water services; town gas supply; landscape; appliance efficiency; energy audit and survey; energy performance contracting; energy services companies
<i>Resources</i>	Climate data/databases; design guides; references; journals and magazines; projects; associations; current and published research; products and services; web links
<i>Cases</i>	Case studies; good practices; demonstrations
<i>Exchanges</i>	Feedback; discussion forum; networking; newsgroups
<i>Others</i>	Frequently asked questions (FAQ); search tools; Internet basics

Knowledge needs to be captured, edited and disseminated to those parts of the community that need it most. The web-based system is intended to give people a manageable subset of the information available on the WWW and to allow them to start working with practical guidelines and data. Information is drawn from related web sites, both within and outside the University, so as to make the best use of the resources on the WWW to supplement the content. In-house information and external links are organised in a logical way to guide beginners to the best sources and to provide directions for guided explorations. Information about products and services, technology, applications, legislation and regulations will help people in the planning, designing, operating and maintaining of their building and energy systems.

4.3 Initial Findings

Most people valued the flexibility, timeliness, efficiency and breadth of access to relevant information offered by the WWW. Initial research study indicated that there are many web sites in the world which contain useful sources of information and materials for energy efficiency. Some examples of them are shown in Table 2. Usually, the web sites provide information not only for energy efficiency, but also for renewable energy. This is understandable since these two energy topics are closely related to each other and renewable energy (in particular, solar energy) is an important strategy for reducing consumption of conventional fossil-based energy.

Table 2: Web sites with useful sources of information

http://www.eren.doe.gov/	Energy Efficiency and Renewable Energy Network (EREN), by U.S. Department of Energy (USDOE)
http://solstice.crest.org/	Solstice, by Center for Renewable Energy Systems Technology (CREST)
http://wire.ises.org/	World-wide Information System for Renewable Energy (WIRE), by International Solar Energy Society (ISES)

Although there is an enormous amount of information on the Internet, it is often quite difficult for one to search for required information, for example, using the Internet search engines (such as Altavista and Excite). The tools and systems that exist to filter the specific information that one requires are not currently able to match the amount and complexity of the information. There is much dross as well as good information on the Internet and this is

largely due in part to the nature of a largely unregulated Internet. Locating web sites of quality information is sometimes more a case of good fortune than good planning in the selection of search key words and phrases; keeping track of all the relevant "links" is not easy since documents on the WWW are ephemeral and dynamic in nature.

At present, the web-based system is being developed and tested internally. It will be made available online by the end of 1999 through the home page of Building Energy Efficiency Research (BEER) at <http://arch.hku.hk/research/BEER/>. Feedback and comments are welcomed.

4.4 Discussion of Related Issues

An important issue specific to the developing countries in our region is the lack of information about local conditions and practices. As energy efficiency in buildings is location- and climate-dependent, it is very important to understand the local environment and constraints. Materials from the North American and European markets focuses on western architecture and societies; not all of them are applicable to Asian countries. Adopting the technologies from other countries without careful assessment of the implications might lead to unsatisfactory results. Therefore, technology transfer in association with the development of local research and information is an important strategy for energy efficiency improvement. To support these activities, an efficient information system will play a significant role in the communication and information dissemination between researchers and practitioners. As many developing countries in our region have similar social and economic structure, cooperation among them for energy efficiency activities can promote better understanding and operation. The costs of information can also be reduced by centralised information and dissemination.

Another interesting issue relating to the Chinese societies in our region is the language we are using for preparing the information. Although English is now dominant on the Internet, people in Mainland China, Hong Kong and Taiwan would prefer Chinese (or bilingual) information for the sake of easy understanding. There are recently some Chinese web sites about building energy efficiency coming up to serve these needs. Table 3 gives some examples of them. For effective communication and understanding, it is necessary to investigate the language issues when developing the information system. The language issue does not confine to Chinese, but also applies to other languages as well. To establish a multilingual information exchange through the WWW, the interface should be designed to be multilingual or language-independent.

Table 3: Related web sites in China, Hong Kong and Taiwan

http://www.ccbn.com/	CCBIN [Mainland China]
http://www.jinnuo.com/	Jin Nuo [Mainland China]
http://arch.hku.hk/research/BEER/	Building Energy Efficiency Research (BEER) [HK]
http://energy.archi.com.tw/	Building Energy Efficiency Web [Taiwan]

5. FUTURE DEVELOPMENT

How to design information for the web and build a durable and useable web site is a challenging task, since the trends in Internet technology are changing rapidly and there is a wide range of proficiency and expectations among the users. The web-based system and its functioning on the WWW will be strengthened to increase the added value; the opportunities

of the web to assist design and business for the energy efficiency market will be studied.

5.1 Strengthening of the System

Web-based software and databases are being developed to provide essential information for design and analysis of energy efficiency in buildings, to point out sources of information for inquiry and seeking advice, and to encourage exchange of information and experience.

(a) Build up databases

A number of databases are being established for the essential information of energy efficiency in buildings. They include weather database, energy statistics database, references database, case studies database, and energy standards database. The databases will be fully searchable using a keyword query search.

(b) Promote exchanges

As energy efficiency is a subject which requires multidisciplinary inputs, functions will be designed within the system to encourage interactions and coordinations among the users. Online discussion forums, chat-rooms, bulletin boards, and group mailing lists may be used to facilitate communication, collaboration and sharing of materials. The web-based communication can be used to create a virtual network where people can interact and work with each others efficiently.

(c) Explore web capabilities

New and emerging web features are coming up every month. As web pages become much more interactive, new tools and techniques are needed to exploit this capability. Studies will be made about deploying scripting languages, CGI, XML, Java, ActiveX and other web technologies to enhance the web interface and develop tools for energy analysis. For example, Java and VRML can be used to develop visually-based tools; JavaScript can be used for writing small analysis tools in the future; HTML interface can be used for energy modelling and simulation (Forowicz, 1999).

5.2 Design Assistance and Web-based Business

Improvements in both computer hardware and software are allowing faster Internet access, which encourages wider use of the Web. With the increasing proliferation of the web technology and application for building development, it is envisaged that the system may include in the future other interactive capabilities such as energy design assistance, energy code compliance, and building project communication. If HVAC and building professionals can use WWW as a useful resource of information for building energy design, there is a better chance of widespread and application of energy efficient technologies. It is hoped that feedback and comments will be received from the interested persons and bodies for enhancing the system and strengthening the information.

Web marketplace and Internet business are becoming more and more realistic and easy. It is possible for the practitioners of the energy efficiency market to make use of the web for business management and electronic commerce (E-commerce). This way of promoting and purchasing goods and services can reduce the overheads and is suitable for the small and medium enterprises which are commonly found in the energy efficiency industry. Tools for "E-business" will be examined to see how they can be utilised to help promote energy efficient products, services and projects.

6. CONCLUSION

The web technology is changing the way people shares information and work together. It can provide an efficient and rich environment for studying and promoting energy efficiency in the built environment. The information available on the WWW about this subject is growing steadily and will form an important source for investigating and improving the energy efficient technologies. It is hoped that the web-based system of this research will provide groundwork for further discussion of the energy efficiency issues and encourage development and application of the energy efficient technologies.

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