Scientific Research

A New Life Cycle Assessment Database System Design

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Abstract: Under the current situation of the life cycle assessment work and combined with network technology, it is important to improve the old life cycle assessment databases and solve the problem that most databases are independent and information are not shared between apartments, regions and fields. This paper describes the design and implementation of a new life cycle assessment database system, as well as the framework for the research database. This paper also describes the details about the database system such as the components design, the goal and scope, basic rules, subsystem division, network design, interface design, data dictionary and database design, function design and system implementation. Above all, this paper emphasized on the system design, database design and goal and scope. This life cycle assessment database system provides network service and shared information to different apartments, different regions and different fields.

Keywords: LCADS; system design; database; network

1. Introduction

With the rapid development of the nation's economic simply from the perspective of pollution control solutions to environmental problems can not meet the requirements of environmental management, as a means of preventing environmental pollution, environment management is paid attention by more and more people. Life cycle assessment (LCA) is one of the most effective ways of the environment management, and it is an evaluation that assesses the product, include the service, or the activities from the beginning of extraction and refining of the raw material, to the impact of the manufacturing, transporting, using, retirement and final disposal of the product. LCA generally includes four inter-related technical aspects which are scope and goal, inventory, impact assessment and interpretation. Environmental management standards ISO Technical Committee (TC - 207) obligate 10 standard codes in the ISO14000 serials of environment management system standard, known as ISO14040 to ISO14049[1]. The codes which have already been published among them are as follows:

- ISO14040, principles and framework, 1997
- ISO14041, goal and scope definition and inventory analysis, 1998
- ISO14042, impact assessment, 2000
- ISO14043, interpretation, 2000

The phases of LCA defined in ISO14040 are showed in Figure 1.

The life cycle assessment database system (LCADS) is tool to analyze and estimate the economical efficiency and environment impact of all activities in the life cycle of the product, which is aims at the application of the LCA of the product theory. It can support the complicated and dynamic state LCA, leading the modern management to multi-area, multi-department and multi-fields. Perfect functions and runs reliably is important to grasp the life cycle of all information-centric environment, information resources.

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2. Current Research Status

2.1. Current Abroad Research

LCA studies largely evolved from the specific case of LCA to the environmental impact of such a process database. From the emergence of LCA, around the world LCA studies, there are over 1000 databases about the environmental impact, several well-known databases reach 10, such as Boustead (Britain), R. F. Weston (United State of American), ChemSystems (United State of American), EMPA (Switzerland), PIRA International (Britain), Charlimers Industriteknik (Sweden), SimaPro (Holland), NIRE (Japan). Boustead database is not designed to give any value judgments to those a variety of output and input data changed into the system, such as sulfur dioxide emissions to the waste water, as not make life cycle assessment about the system.

Databases in different countries show a strong regional level. At present, developed countries in the LCA studies occupy an important position, leading almost all of their LCA database created, and has been well maintained. Take the Japanese NIRE (National Institute for Resources and Environment) for example, it basically concentrated on the LCA of household appliances between the years 1993 to 1996, and started to establish a public LCA database system from 1997.

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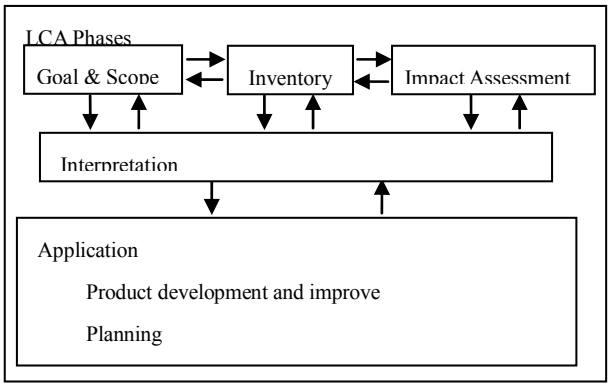

Figure 1. LCA Phases. (ISO14040,1997)

In Switzerland, several public Life Cycle Assessment database systems existed have partly cover the same economic sectors. At the same time, LCA is more and more an important tool used by e.g., Integrated Product Policy (IPP) and Technology Assessment or Design for Environment (DFE), so Rolf Frischknecht and Gerald Rebitzer did a research on a comprehensive web-based LCA database called The ecoinvent database system[2].

2.2. Current Research in China

Current research in China it is mostly emphasized on the theory of LCA which can be divided into two parts: macro LCA and micro LCA. The macro LCA is mainly about the construction energy consumption statistics and surveys which belong to the area of energy consumption. However, as a part of consumer, theses surveys have long been split in the different areas of the energy consumption, such as the energy consumption is classified as urban and rural living energy consumption, while other types of construction energy consumption are classified as non-material production sector energy consumption.

Began in 1989, the China Building Energy Economic Policy Research group led by Fengxiang Tu started to systematically studied the actual process about the energy consumption, thermal environment and energy saving. This survey covered the heating region in northern China and all kinds of building types in four cities along the Yangtze River in Chongqing, Yichang, Wuhan, Nanjing.

The micro LCA is typically focused on specific or individual building energy consumption. In recent years, the research on the environmental impact of the life cycle of construction energy consumption is also gradually carried on by professional researchers of environment using the theory of LCA, taken the consumption as a part of the entire LCA environmental impact of the construction to assess. They concerned about the impact but not the consumed energy itself. So the integrity and accuracy of the entire analysis were not precise enough to represent the real meaning of the research.

2.3. Research Comparison

Although the LCA database system has been in a great development, there still have many problems in the current systems in the aspect of data accuracy, data consistency and system integration:

- Current database system is based on the old and unreliable data. We can not be sure of the practical use of these data.
- When the goal and scope applied is changed, the change of the relevant information is too large to precisely grasp these changes.
- Due to the enterprise kept secret or partly disguised their collected information about resources, energy waste and technique, it is hard to quantitative the information.
- Due to different situation of different countries, the information of the databases built by different countries can not be shared.
- Most of the current system is static but not dynamic, we can hardly make assess to the dynamic process so we can not provide reliable suggest to make the decision-making.

In parallel with the rapid trend for the LCA applications, and meet the high demand of a tool for dealing with quantity data, a new and improved life cycle assessment database system should be designed and meet the need.

3. System Design and Database Design

3.1. Components of System Design

The modules [3] in the core of the LCADS (life cycle database system) are as follows, showed in Figure 2.

The controller controls three part of the work: users input and output, standard database modules and calculation module. Users input the existed data into the system, and then the calculation module calculate these data by the default LCA calculation method so as to characterize the data into the four default databases make up of the standard database modules: Evaluation method database, Basic material database, Material environmental load database and the standard database. When the characterization is done, result is output and showed in the windows so the users can get it.

Input and Output. The input and output interfaces are the basis of the entire system. Whether the interface is friendly decides that the system is applied in wide range and accepted by wide users. The input window asks the user to select the type of the next assessment step. Meanwhile, some necessary information such as resources, energy, emissions are showed in the windows. The output windows output the result of the input above.

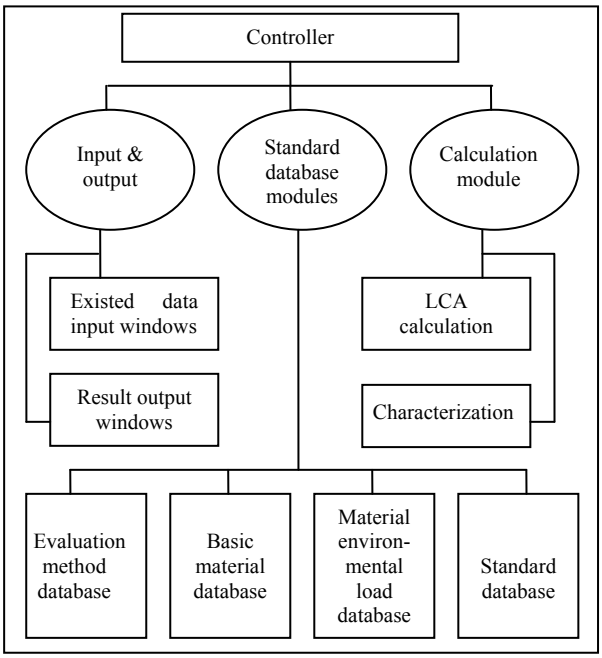

Figure 2. LCADS Modules

Standard Database Module. The standard database includes static database and dynamic database, which characterized by the exchange of the data. Static database includes standard and method base, such as environmental load units, pollution factor reference value. Dynamic database is the information belt of other modules, established during the assessment.

Calculation and Analyze Module. This module is the core of the entire system, including the value of pollution standards, impact characterization, analysis and the evaluation results of analysis and program evaluation. It is mainly about the standardization of environmental impact analysis to determine the value of its impact on the environment.

3.2. Integrated System Design

1) Goal

Using the network technology and LCA model, based on the building of the information base, LCADS makes the whole LCA process computerization, networking, and easy environmental decision-making. The goal includes (a) Life cycle assessment process, computer automation and web-based technology, evaluation of information resource sharing and exchange. (b) System should be comprehensive and accurate managed. Life cycle assessment based on all information and data updates should be easy.

2) Basic Rules

According to the theory of software engineering, LCADS is flexible, open, integrity, fault-tolerance, and extensible.

- Flexibility. The system should be a good user interface and users learn to understand, simple, flexible.
- Open. The system should have great compatibility in the input and output interface and can be a variety of different data format conversion.
- Integrity. Various data in the database should be comprehensive, complete and can meet the needs of the various functions.
- Fault-tolerance. In case of failure the database system can still work properly.
- Extensibility. The system should have a good interface and secondary development will be accomplished so as to extend and perfect the system.

3) Subsystem Division

Subsystem design is independent. During the design process it continuously draws users to provide survey information, and will present them with actual production need and future development in mind, constantly modified. Divide the system into several subsystems that meet the need. Take the whole system as a module, according to the functions divide it into a number of first level modules in tandem with one another to complete the LCADS function, then functional decomposition of the first level of blocks, and so on, until that each module is simple. Each subsystem is independent which make the system extensible. A subsystem functions as well as the entire system and if fails can be replaced by other subsystem as soon as possible. The subsystem allocated to the system logic design and physical design of the foundation, and guarantee for the entire operation of the system.

4) Network Design

LCADS is based on Browse / Web Server, Client / Server network architecture model, made up by browsers and web servers distributed in the clients. The web architecture of the system is showed in Figure 3. When users get online through modems and WAN (Wide Area Network), they are ready to input data, then through the Web Server, NT Server and in case the Backup Server to get the result. The order execution and data calculation are completed in the NT Server. Users can query the LCA information through the web.

5) Interface Design

The system interface is design to make user easy using, taking C# as the front language, which is a simple programming tool in Windows. We use the properties of the control generic programming data input in the evaluation of database management system[4].

3.3. Database Requirements Analysis

As the life cycle assessment is still in research, nowadays it only provides the information of pollution control, resources protection and waste reduce and lack of the general assessment. It also faces a problem that it is single-oriented and can not meet the need of application in multi-department. So, a database system that is multi-LCA modules oriented and can use on web is the best solution to these problems.

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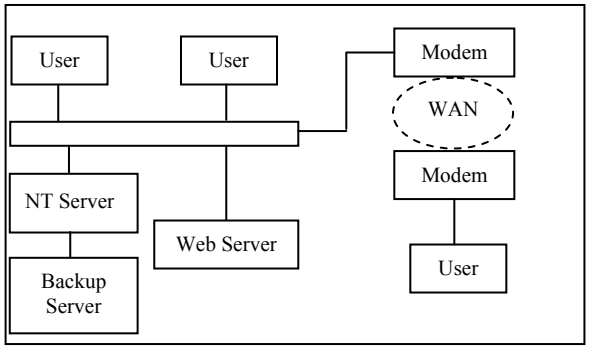

Figure 3. Web architecture of the system

Requirements analysis is the start and key procedure:

- Existed Data Model. This is a real model of the data, showing a variety of research materials (steel, cement, paints, ceramics, etc.) of the environmental load list.
- ISO14040 series of standards define the framework of the LCA, such as LCA goal and scope definition, functional unit, the information requirements of stakeholders.
- ISO14048 provides literature on the LCA data, reporting, interpretation and data collection, data calculation and data dissemination and data exchange framework and requirements.
- Environmental load of data exchange SPOLD format.
- LCA database based on the basic requirements, such as effective data organization and management, the database has well scalability to provide data exchange, online data query and data disseminations.

3.4. Data Dictionary and Database Design

Considering the information needed analyze and according to the specific database function, we defined the complete data dictionary, including all data item, data operation, data flow and data storage. Data dictionary usually shows the sub databases, data sheets and the relation of the sheets, data integrity, consistency constraints and operational rules[5].

LCADS can connect the SQL Server or MYSQL through web service and contains three basic databases: evaluation method database, basic material database and material environmental load database [6].

- Evaluation Method Database. This database reveals the characteristics of the current widespread use of the LCA evaluation method. It contains the entire index data of several typical LCA evaluation method, such as physical characteristics of the data load factor, damage assessment model, standardized factor and weighting factor.
- Basic Material Database. This database define the property of the material during LCA in a way sorting the material of resources consumption, energy emissions, air emissions, water emissions, solid emissions, soil emissions and non-material emissions.
- Material Environmental Load Database. It contains the entire environment load data during the whole production of the typical material (steel, cement, chemical materials, etc.), such as data of resources consumption, energy emissions, air emissions, water emissions, solid emissions and soil emissions. This procedure of building the database will become more perfect in accumulation.
- Standard Database. Standard database in accordance with the characteristics of the database, can be divided into static and dynamic databases. The static database consists of the standard base and method base, known as the environmental load units, pollution factor reference value etc. The dynamic database dynamically generated by the evaluation process and is the information link to connect the various functional modules. Standard database should be a good opening and updating.

4. Goal and Scope

4.1. Goal

The constructions support service to mankind using the energy and circulating. The system contains two parts: internal system and system environment. Expression systems, including systems and modules within the product flow process and the basic flow through the system boundary, and product flow[7].

Building systems should include the formation of structures within the boundary and its subsidiary entities and functions facilities, a series of intermediate products and process flow consisting of a collection of units, including construction materials and components and parts processing, transportation, construction and installation, use of the building running and maintenance, recycling, removal and disposal. The main target of the goal of LCA is showed in Figure 4.

The limit of the constructions sustainability is according to the definition in the construction files.

4.2. Scope

This paper use the Pareto Principle (80/20 Rule) [8] to determine the principles.

Decorative materials in terms of both quality or cost of construction can not constitute several major materials (concrete, steel, etc.) compared to its production and use of the process involving a large number of chemical reaction process, the environmental impact is huge. If the evaluation is not to include the environmental impact of decorative materials come in the objectivity of the evaluation results greatly. Evaluation of decorative materials can be listed separately, in the range of decorative materials and then determine the scope of the evaluation under the 80/20 rule.

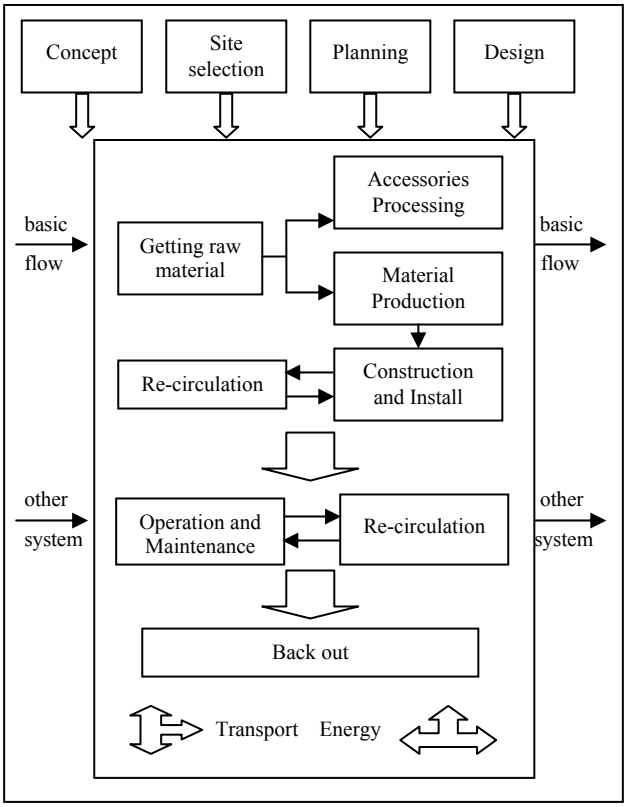

Figure 4. Construction system and boundary

Building materials, components and parts in the course of energy consumption are without the need, therefore under the guidelines of quality criteria and cost evaluation of the object can be determined. Construction materials relate only to the consumption of turnover, so you can determine the basis of quality criteria; construction and installation of mechanical energy consumption during use, such as gasoline, diesel, electricity, etc., can therefore determine the criteria according to energy. As construction materials and components and parts not involved in the construction and installation phase of chemical changes, and in building materials and components and parts manufacturing stage to calculate the environmental impact, therefore not repeat the calculation of the construction process.

Operation and maintenance phase of the environmental impact of construction equipped mainly by the energy, water consumption caused by energy consumption, therefore water consumption norms and make standards.

5. Function Design and System Implementation

LCADS includes database management subsystem and model base management subsystem. The function of database management subsystem includes date storage, analysis, statistics, evaluation, query, update and attribute mapping, so the subsystem functions in database structure operation, data content operation, data logic calculation, data query and data table output. User can search the data existed randomly of which the value inside can be enough shared. Also user can return the result to the database in case for the next user and other model, maximize the functions of the subsystem.

According to the characteristics of life cycle assessment, LCADS include a simple matrix model, variable weight comprehensive evaluation model, Delphi model, hierarchical model, fuzzy comprehensive evaluation model, gray correlation analysis model, matter element analysis model, gray clustering model, integrated index model, vector projection model and so on, to keep them ready.

LCADS is based on the network system which is based on Browse / Web Server and supplemented by Client / Server. The construction of the database use user interface and network queries, transmission and the design of user interface and network queries and transmission function use the programming language of HTML, C #, Java and others comprehensively.

6. Conclusion

The structure and function LCADS system, database structure, coding technology in this article is described summarily. LCADS system involves the entire product life cycle phases. So far, the development and improvement of the LCADS is ongoing. With the development of system functionality and the material environment which meet database, LCADS which is in line with Chinese national conditions will fully reflect their potential applications and potential economic value. Though we set up such a primarily database system, there is still a lot of work to do:

- More details about implementation of the LCA database system based on web.
- By increasing the basic data, standard data and the method model, we need to further improve the functions of the database.
- Design a more human interface so as to provide excellent user experience.

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