A Study on Analysis Support System of Energy and Environmental System for Sustainable Development Based on MFM and GIS

Qi Zhang, Hidekazu Yoshikawa, Hirotake Ishii and Hiroshi Shimoda

Socio-Environment Department, Graduate School of Energy Science, Kyoto University

An analysis support system has been developed of various energy and environmental system for the sustainable development. The proposed support system can model, simulate and account the flows of matter, energy and information with tens or hundreds of elementary processes in the target energy and environmental system. It is based on the combination of Multilevel Flow Model (MFM) and Geographic Information System (GIS) and can account various indices for sustainability. The values of the evaluation indices can be utilized to not only test the feasibility of one scenario but also carry out the inter-comparison of various optional scenarios.

1. Background

The sustainable development of the energy and environment is a vital issue for the survival of entire humankind. Achieving sustainable development of energy and environment on large scales from the world, a country, even to a local town requires the judicious use of various energy technologies. In order to plan the suitable usage of energy technologies and to monitor the environmental consequences caused by energy technologies, an analysis support system has been developed. In fact, various energy and environmental systems have the character as that of the process plants because they have the flow networks of matter, energy and information in the process system. In this respect, one feature of energy and environmental system is the usage of geographical information. It should be also introduced in the study of energy and environmental systems. The combination of MFM and GIS can provide a comprehensive and easy-understanding interface to carry out the analysis and evaluation of energy and environmental system from many aspects of sustainable development.

2. MFM

The MFM is a kind of semantic graphic modeling method not only to describe the hierarchical structure of objects from goal to function and to component, but also to represent the "internal process" of physical behavior by flow structure of mass, energy and information by using a series of standard symbols. Traditionally, the MFM has been mainly applied in the process control areas ranging from signal validation, fault monitoring, fault diagnosis to procedure generation and human modeling, etc. While in our study, the applications of MFM are extended to analyze and evaluate various energy and environmental systems from the aspects of sustainable development.

3. GIS

The GIS is a computerized system designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information which affect the energy and environment problems (especially various renewable energies) in the form of digital maps and attributed geo-relational databases. Modern GIS platforms are equipped with various efficient tools and have frequently been applied to resources and environment impact assessment, site identification as well as optimum path choice and so on.

4. Case Study

As a case study, the analysis system is used to push the JHFC (Japan Hydrogen and Fuel Cell Demonstration Project) and to help the policymaker or analyzer to design the hydrogen development scheme in domestic of Japan. The cost and the environmental impact of various hydrogen production systems in the local cities of Japan are investigated.