Journal of
Applied Sciences

Evaluation and Application of the DSM Energy-efficiency Labeling

[1]Zhong Ming, [1]Li De-Zhi, [2]Zeng Ming, [2]Duan Jin-Hui, [2]Liu Xiao-Li, [2]Xue Song and [2]Shi Hui
[1] Institute of Electricity and Energy Efficiency, China Electric Power Research Institute,
Beijing, 100192, China
[2]Research Center of Energy and Electricity Economics, North China Electric Power University,
Beijing, 102206, China

Abstract: Energy-efficiency labeling is a kind of management mechanisms and techniques. It is emerging in recent years. However, the specialized research on energy efficiency labeling of DSM program has not been started in China. So the research about energy efficiency labeling evaluation of DSM projects is necessary. This study puts forward the contents of energy efficiency label assessment system of the DSM project. And it analyzes energy efficiency label subject and energy efficiency label assessment process, constructs the evaluation indexes. Then it puts forward the grades of energy efficiency labeling of DSM program. Finally, energy conservation of the building project is chosen for DSM analysis of the typical case. The problems in the application of energy efficiency labeling in China can be effectively pointed out by analyzing the evaluation systems. And it is vital to the implement of DSM energy efficiency labeling system in China.

Key words: DSM projects, energy efficiency evaluation, energy efficiency labeling, evaluation index

INTRODUCTION

Energy-efficiency labeling, as a kind of management mechanisms and techniques, is emerging in recent years. Energy efficiency labeling system with the advantages of small investment, fast effect, large impact on consumers and etc., has been recognized by many countries and widely popular around the world (Hao *et al.*, 2009). Compared with developed countries, the development of China's energy efficiency labeling program is behind. The specialized research on energy efficiency labeling of DSM program has not been started, so the research about energy efficiency labeling evaluation of DSM projects is necessary (Shi, 2006).

This study puts forward the contents of energy efficiency label assessment system of the DSM projects and analyzes energy efficiency label assessment mode, energy efficiency label assessment process and energy efficiency label subject of China's DSM projects. It constructs the evaluation indexes of energy efficiency labeling of the building energy efficiency, air-conditioning energy saving, green lighting, generators, heat pump projects and appliances. Then it puts forward the grades of energy efficiency labeling of DSM program. This study analyses the application of energy efficiency labeling in China by typical case.

MATERIALS AND METHODS

Under the condition that all the related provision items meet current national standard of energy conservation, energy efficiency evaluation of DSM projects can evaluate the basic theory value or measured value of energy efficiency for various types of DSM projects. First, evaluate the energy efficiency provision items of participating DSM projects; then, evaluate basic items in the case that all provision items meet current national standard; finally, evaluate selection items and conclude energy consumption level and grade of the participating DSM projects.

Energy efficiency label assessment process of DSM projects: The specific process of energy efficiency labeling evaluation for DSM projects is as follows (Yin *et al.*, 2007):

* The commissioning party gets evaluation materials and re-energy-saving products ready and applies the energy efficiency theoretical value identifies of DSM projects
* Evaluation agencies tests theoretical energy-saving value of the DSM projects
* Submit the DSM projects evaluation report on the energy efficiency theoretical value (including basic items, provision items and selection items)

Corresponding Author: Shi Hui, Research Center of Energy and Electricity Economics, North China Electric Power University, Beijing, 102206, China Tel: 010-51963851 Fax: 010-51953851
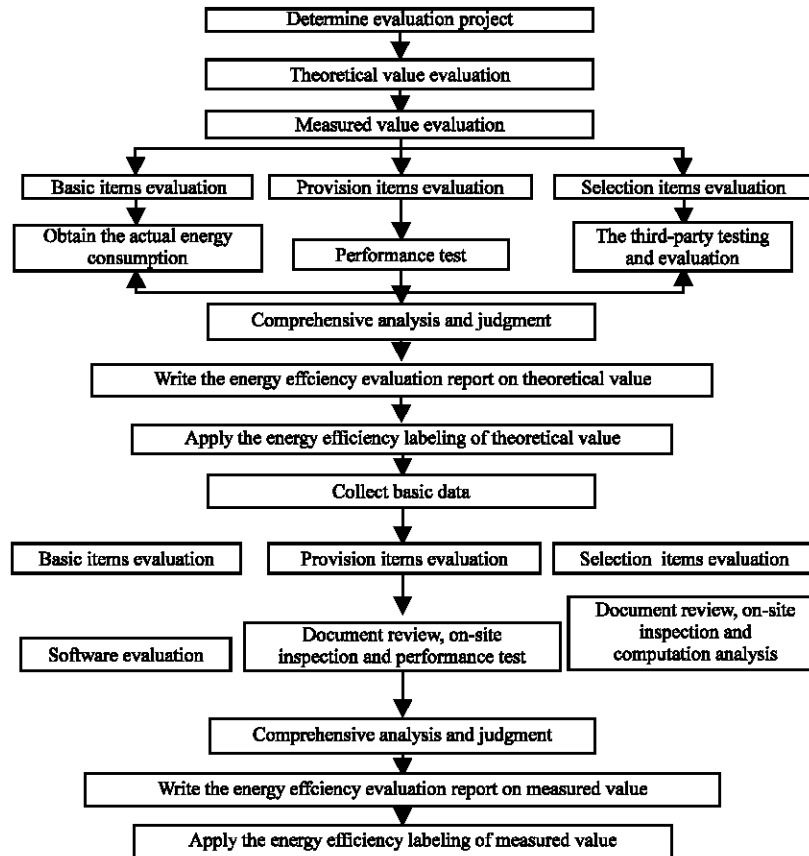
Fig. 1: Flowchart of efficiency labeling evaluation for DSM projects

- Based on the application materials of DSM projects energy efficiency theoretical value identifies, DSM projects authorities issue energy efficiency theoretical value identifies of DSM projects
- Evaluation agencies continuously on-side measures the actual energy efficiency level of DSM projects for more than one year
- Submit inspection report on energy efficiency measured value of the DSM projects
- Based on the application materials of DSM projects energy efficiency measured value identifies, DSM projects authorities issue energy efficiency measured value identifies of DSM projects

The specific process of energy efficiency labeling evaluation for DSM projects is shown in Fig. 1.

Energy efficiency label assessment subject of DSM projects: Based on the diffident assessment subjects, energy efficiency labeling of DSM projects can be divided into two kinds. One is the first-party evaluation labeling. Its main feature is that the investor or implementers of DSM projects own test and assess DSM projects energy consumption and public evaluation

results in the label way. The other one is the third-party evaluation labeling. Its main feature is that the third-party evaluation agencies which are authorized by the government, test and assess energy efficiency level of DSM projects, issue supporting materials about its energy efficiency level based on the evaluation results and public the materials in the label way.

Shang et al. (2000) has pointed out that there are three kinds of energy efficiency assessment label subject of DSM projects: The investor or Implementers of DSM projects, the evaluation agencies and the administrative departments.

APPLICATION

The construction of evaluation index on DSM projects energy-efficiency labeling: The content of DSM projects energy-efficiency evaluation labeling includes basis items, provisions items and selection items. According to the classification of DSM projects, the following will analyze evaluation index on energy-efficiency labeling of diffident kinds of projects, including building energy efficiency, refrigeration air-conditioning energy saving, green lighting, generators,

heat pump projects and appliances. Evaluation index contains basis items, provision items and selection items of each DSM projects.

Energy-efficiency labeling index on building energy efficiency projects: Basic item index includes total annual heating energy consumption (kW h m^{-2}), total annual refrigerating energy consumption (k Wh m^{-2}), heating load (W m^{-2}), air conditioning cooling load (W m^{-2}), total annual energy consumption (k Wh m^{-2}) and energy-saving rate.

Provision item index contains building envelope, air conditioning heating equipment, water pumps and fans, room temperature regulation, hydraulic equilibrium as well as lighting control.

Selection item index includes renewable energy, cool and heat storage technology, thermal energy recovery technology, natural ventilation and lighting, energy-saving technology of variable air volume or variable water volume, all-fresh air or variable fresh air technology.

Energy-efficiency labeling index on refrigeration air-conditioning projects: Basic item index contains air-conditioning energy consumption per unit area, air-conditioning cooling consumption per unit area, heating consumption per unit area, heating rate and cooling rate.

Provision item index is divided into the water system performance index and air system performance index. Water system performance index includes actual performance coefficient of the unit, consistency of the backwater temperature, temperature difference between the supplied water with back water and pump efficiency; air system performance index includes unit energy consumption power of fan units as well as the system balance degree of fresh air volume and constant air volume.

Selection item index includes cool and heat storage technology, waste heat recovery and cycle utilization technique, all-fresh air or variable fresh air technology, seasonal heating performance coefficient.

Energy-efficiency labeling index on green lighting projects: Basic item index contains energy consumption of energy-saving lamps per unit area, electricity savings per unit area, heat output per unit area, lighting installation power and lighting power density.

Provision item index includes actual performance coefficient of energy-saving lamps, service life, average indoor temperature, power transmission efficiency, power loss coefficient, thermal loss rate of grid management and illumination values.

Selection item index includes energy efficiency ratio, design and automatic control.

Energy-efficiency labeling index on generator projects: Basic item index contains the coal consumption for power supply, water consumption for generating and fuel consumption for generating of the unit generator, generator power consumption rate.

Provision item index contains generator operating efficiency, turbine heat rate, generation loss factor and the circulating cooling water consumption of main auxiliary engine.

Selection item index contains waste heat capturing technology, ash handling technology.

Energy-efficiency labeling index on heat pump projects: Basic item index contains heating energy consumption per unit area, heat consumption per unit area, heating coefficient of heat pump, energy utilization factor and total primary energy input.

Provision item index contains heating network efficiency, power consumption of the unit, unit operation efficiency, generation efficiency, transmission efficiency.

Selection item index contains energy efficiency ratio, seasonal energy efficiency ratio, seasonal heating performance coefficient, heating rate and cooling rate.

Appliance energy-efficiency labeling index: Basic item index includes thermal efficiency, electrically insulating performance coefficient, temperature control performance coefficient, comprehensive power loss and ground resistance.

Provision item index includes utilization ratio of new energy-saving materials, utilization ratio of new energy, utilization ratio of power integrated circuits, the use amount of power-saving controller and micro components and actual operating efficiency.

Selection item index includes fuzzy control technology, frequency conversion velocity modulation technology, flexible manufacturing technology, CAD technology, exterior design and automatic control.

Energy efficiency labeling grade standard of DSM projects: According to the analysis of existing buildings energy-efficiency labeling and energy-efficiency labeling grade standard of air conditioning, green lighting and other products and equipment and combined with the characteristics of DSM projects, energy efficiency labeling of DSM projects can be divided into the following five grades: One to five star (Shen and Guo, 2010). It is divided by the proportion that basic items accounting the energy saving.

CASE STUDY

Building energy efficiency, as a typical DSM project and China's research has accumulated rich experience in

this field. Therefore, this study selected one international apartment II project in Shanghai as the case and carried out energy efficiency labeling evaluation analysis from the evaluation process, provision items evaluation, basic items evaluation, selection items evaluation and other aspects.

Project profile: This international apartment II project is located in the Pudong New Area of Shanghai, with a total construction area of 154,000 sq. m, underground 32,000 sq. m, ground 122,000 sq. m. It consists of 11 buildings, including 6 8-story buildings and 5 18- story buildings. Select NO. 3 residential building as identified building. For this building, gross floor area is 12,106.8 sq. m building height is 57.6 m; with 18 floors and 1 basement; and the structure style belong to frame shear wall structure.

Evaluation process: According to the energy efficiency labeling system of DSM projects studied above, reference to the application methods demonstrated in the second section, evaluate the measured values of building energy consumption. First, evaluate the energy efficiency provision items of participating building; then, evaluate basic items in the condition that all provision items meet current national standard; finally, evaluate selection items and conclude energy consumption level and grade of the participating DSM projects.

Provision items evaluation: In the process of provision items evaluation, building envelope, air conditioning heating equipment, water pumps and fans, hydraulic

equilibrium and unit efficiency are evaluated by the method of combining performance test and document review and hot and cold source of air conditioning heating, the is evaluation of the building envelope, hot and cold source of air conditioning heating, room temperature regulation and lighting control are evaluated by the document review (Yin, 2006). The evaluation results are shown in Table 1.

Basis items evaluation: This study uses three software to joint evaluate basis items of the project. The software are PKPM software developed and designed by China Building Research Institute, DEST software developed by Tsinghua University and TRNSYS software jointly developed by the University of Wisconsin Solar Energy Laboratory and France's CSTB. The evaluation results are shown in Table 2.

Selection items evaluation: In the process of selection items evaluation, renewable energy, natural ventilation and lighting, cool and heat storage technology, energy recovery technology, all-fresh air/variable fresh air, variable water volume/variable air volume, building automatic control, management methods are evaluated by the method of combining performance test and document review. Selection items include 8 items, with 62 points. The evaluation results are shown in Table 3.

For this project, all 8 provision items, 5 basis items and 8 selection items met the requirements, so the project can add 62 points. According to the energy-efficiency labeling grade set in Section 2.3, the project's final energy efficiency labeling grade is four stars.

Table 1: The evaluation content, evaluation methods and evaluation results of provision items

Evaluation content	Evaluation method	Evaluation result
Building envelope; the tightness of exterior windows and transparent curtain wall; grade 3	Performance test	Qualified
Hot and cold source of air conditioning heating; air conditioning cooling source; effective	Document review	Qualified
Air conditioning heating equipment; type; performance coefficient	Performance test	Qualified
Air conditioning heating equipment; screw water-cooled chillers; 4.06 (Found)	Performance test	Qualified
Water pumps and fans; transport energy efficiency ratio of cold water pump in the air conditioning system; 0.018	Performance test	Qualified
Water pumps and fans; unit air volume consumption power of fans;0.34	Performance test	Qualified
Room temperature regulation; average indoor temperature control; comfortable	Document review	Qualified
Hydraulic equilibrium; with some hydraulic equilibrium device; Balance error is less than 0.01	Performance test	Qualified
Lighting control; the use of LED and other energy-saving lamps; control system adopts sound and light control and infrared control; effective	Document review	Qualified
Unit efficiency; Heat pump units; 5.24 (found)	Performance test	Qualified

Table 2: The evaluation Index, reference building, identified building and evaluation results of basis items

Basic items evaluation index	Reference building	Identified building	Evaluation result
Total annual heating energy consumption (kW h m^{-2})	41.53	37.99	Qualified
Total annual refrigerating energy consumption (kW h m^{-2})	19.70	17.00	Qualified
Heating load (W m^{-2})	19.20	17.60	Qualified
Air conditioning cooling load (W m^{-2})	10.53	9.09	Qualified
Total annual energy consumption (kW h m^{-2})	29.75	16.77	Qualified

Table 3: The evaluation content, evaluation methods and evaluation results of selection items

Evaluation content	Evaluation method	Evaluation result
Renewable energy; take solar thermal and photovoltaic systems	Document review	20
Natural ventilation and lighting; take into account the natural ventilation in architectural planning and monomer design; introduce wind environment outdoor and apartment layout simulation to the design	Document review	6
Cool and heat storage technology; take ice storage technology as a cold source of air-conditioning systems	Document review	6
Energy recovery technology; take all- heat recovery fresh air ventilator, reduce air load effectively	Document review	6
All-fresh air/ variable fresh air;fresh air fans with variable frequency control; air volume is controlled according to the concentration of carbon dioxide	Document review	6
Variable water volume/variable air volume; take primary pump variable flow system; variable frequency chilled water pump is controlled by differential pressure controller at the end of the user's system	Document review	6
Building automatic control; take building automation system	Document review	6
Management methods;improve the management system; the cold source equipment, lighting and other facilities using automatic control mode	Document review	6

CONCLUSION AND RECOMMENDATIONS

Based on China's actual implementation situation of DSM project, this study researches energy efficiency label assessment system of the DSM projects, including assessment mode, assessment process and assessment subject of the energy efficiency label. And in terms of contents, grade and index system of the energy-efficiency labeling, this study elaborates the applications of DSM energy-efficiency labeling. The DSM project identification and evaluation of energy efficiency labeling and evaluation of DSM projects have an important practical significance in China. It can effectively improve the implementation efficiency of DSM project, worthy of promoting.

Due to the set of expiration date, management costs and technology cost of energy-efficiency labeling are increased, so there are some obstacles in the implementation and promotion of it. At the initial stage, the government can take encouraging or voluntary manners and give certain preferential policies. When the system gets a certain degree of recognition, mandatory energy efficiency labeling evaluation of DSM projects in a wide range should be carried out.

REFERENCES

Hao, B., Y.N. Liu and J. Cheng, 2009. Labeling system program options analysis for building energy efficiency evaluation. HVAC, 10: 39-39.

Shang, C.H., H. Zhang and P. Liu, 2000. Talking about green lighting. Commun. Sci. Technol. Heilongjiang, 3: 29-31.

Shen, N.J. and Y. Guo, 2010. The establishment and development of civil building energy efficiency evaluation labeling system. Anhui Inst. Archit., 17: 20-26.

Shi, G., 2006. Measures and application of building energy efficiency. Anyang Inst. Technol., 4: 21-22.

Yin, B., 2006. Research on building energy efficiency labeling management. Master's Thesis, Tianjin University,China.

Yin, B., Y. Wu and Y.Z. Liu, 2007. International experience and inspiration of building energy efficiency labeling system. Constr. Technol., 36: 54-56.