Research Article
New Management Whole Process Evaluation of DSM Projects Based on Fuzzy-AHP Approach

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Abstract: In order to promote the development of DSM projects, it is necessary to establish a management evaluation indicator system considering whole process. This study analyzes key factors of every stage of DSM projects combining with the whole process theory and proposes a new evaluation indicator system of DSM projects management. Also we use fuzzy analytic hierarchy process which combines analytic hierarchy process and fuzzy comprehensive evaluation method to evaluate DSM projects management considering the whole process.

Keywords: DSM project, indicator system, management evaluation, whole process

INTRODUCTION

DSM (Demand Side Management) is a power-related activity carried out to improve the utilization efficiency and utilization ways of power resources, which aims at achieving scientific, conservative and orderly utilization of electricity (Eric *et al*., 1996). In recent years, China has made active exploration and practice in policies and regulations, economic leverage, technical measures and advocacy training, all of which are actively used to promote the implementation of demand side management projects in various fields, resulting in significant social and economic benefits. However, because of short time for DSM research and lack of experience, China's Demand Side project implementation is still at the exploratory stage compared to the countries whose DSM carried out earlier (Chang-Ming *et al*., 2012). The whole process management of DSM project is an activity that project managers take overall consideration in organizational structure, decision-making and planning phase, implementation phase and test and acceptance phase, in which project managers will also control key points and management elements of the whole management. When DSM project is accepted, it is required to reflect the management level and assess project management comprehensively through the establishment of evaluation mechanism of DSM project. With the evaluation mechanism, the defect in whole process project management can be analyzed and this process is known as DSM project management assessment. The assessment content and process is different from stage assessment or post evaluation, but less domestic and foreign research has been made on management assessment of the DSM project at present (Cunbin and Peng, 2012).

In order to carry out the DSM project management assessment effectively, this study studies management elements of assessment and build a DSM project evaluation indicator system from organizational structure, decision-making and planning, implementation and test and acceptance in various stages. Also fuzzy analytic hierarchy process which combining analytic hierarchy process with multi-level fuzzy comprehensive evaluation method is selected to evaluate the whole management process of DSM project, which will provide theoretical support for DSM project management assessment.

DSM PROJECT EVALUATION INDICATOR SYSTEM

DSM project evaluation indicator system is constructed to reflect management status in various stages of whole process and problems in the implement of DSM project (Monjezi *et al*., 2012). The set of evaluation indicators are not only needed to explain the main body of evaluation object, but also with the versatility so as to compare different types of projects. In order to guide the implementation of DSM project management better, analyze whole management process of DSM project more comprehensively and direct problems clearer, it is necessary to make DSM project management processes and elements clearly, as shown in Fig. 1.

It can be seen from Fig. 1 that, in accordance with organizational structure, decision-making and planning, implementation and test and acceptance process,
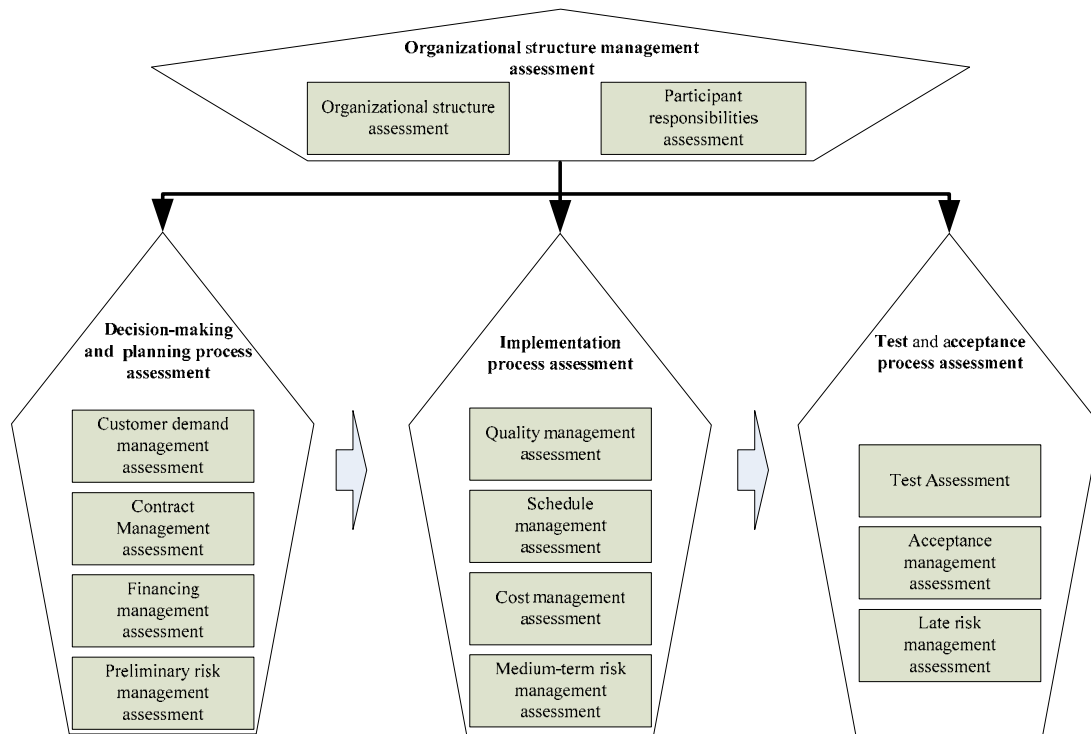
Fig. 1: The management content of DSM projects in the whole process

indicators should be established with the content of DSM process management assessment so as to assess elements related, thus we can get the comprehensive DSM project management assessment system from the perspective of process management.

Organizational structure management assessment: The organizational structure of DSM project generally includes three structures: government-led Grid, corporation-led Grid and energy services company-led Grid and specific form of organization is in accordance with specific circumstances of DSM project (Yongchang *et al.*, 2011). Assessing the organizational structure management of DSM project should make a comprehensive evaluation in the implementation of project organization and whole management process, including assessing the reasonability of organization structure, as well as the clarity of project responsibilities of all parties involved.

Decision-making and planning management assessment:

- **The assessment content of customer demands management:** Customer demands management of DSM project includes many aspects, such as customer energy demands of various types of DSM project, potential analysis and pre-assessment, project planning, project feasibility analysis, target market selection and customer communication and

relationship management, etc. Customer demands management assessment of DSM project is mainly studied from the analysis degree of market potential, the reasonability of target market selection and the level of customer relationship management (Jiang, 2012).

- **The assessment content of contract management:** The evaluation of decision-making and contract management of whole management process in DSM project should be started from the following two aspects: firstly, the whole management process of DSM project in various stages should be supported by contracts to implement the responsibilities of all parties involved; secondly, the whole management process of DSM project should be implemented according to the contract in various stages. As for the assessment of DSM project contract management, it should be implemented in terms of contract management institutions, the reasonability of contract form and the complete extent of contract management system.

- **The assessment content of finance management:** The finance management of DSM project is endowed with various options for different projects. Generally speaking, DSM funds are constituted from direct financing of government agencies, commercial financing and the enterprises funds. Besides, the funds of DSM project can be raised from other ways, such as International Fund, equipment leasing and super energy service

companies, etc. Finance management assessment elements need to take capital structure (i.e., the proportion of project capital and debt) and the reasonability of indicators such as Capital Cost Rate (CCR) into consideration. Among them, the CCR is shown as below:

$$CCR = \frac{\text{Capital occupation fee}}{\text{Total raised funds}} \times (1 - \text{Financing rate cost}) \times 100\%$$

(1)

- **The content of preliminary risk management assessment:** In decision-making and planning stage of the project, the implementation of project risk management can identify project participants and their expectations, which can also used to analyze the possibility of establishing an appropriate overall goal of the project. The risk management assessment can be carried out in terms of project risk effect identification and project risk analysis in this stage.

Implementation management assessment:

- **The assessment content of quality management:** Quality management of DSM project is to test the deviation between actual project quality and project objectives and to analyze its causes and possible influencing factors according to the basic characteristics of project implementation. It is also of great significance to feedback information, make decisions timely and take necessary measures to achieve project goals. Quality management assessment considers many factors, including the coordination degree of project objectives and the occurrence frequency of quality problems.
- **The assessment content of schedule management:** The schedule of DSM project donates the timing of construction activities in the project contract duration, which involves major interests of main contract participators and is the key of the successful contract implementation. The project implementation schedule should be comprehensively determined by technology relationship, organizational relationship, beginning and ending time, labor plan, materials plan, mechanical plans and other assurance plans. Schedule management assessment mainly includes following content: progress and plan deviations, the timeliness and scientific of schedule adjustments, the percentage of extension time in total duration time, etc.
- **The assessment content of cost management:** Cost management of DSM project is to carry out effective management activities according to overall objective and specific requirements of projects, such as organization, implementation, control, tracking, analysis and assessment in the implementation process of project. By this way, enterprises can strengthen their management, improve cost management system and cost

accounting standards, also reduce project costs so as to achieve target profits and create good economic benefits. The cost management of DSM project can be implemented from the perfection degree of cost management plan and the deviation degree of budget and final accounts (DDG). The latter can be accounted as follows:

$$DDG = \frac{\text{Project accounts} - \text{Project budgets}}{\text{Project budgets}} \times 100\%$$

(2)

- **The assessment content of medium-term risk management:** In the implementation phase, the incidents risk can be avoided, slowed down and transferred due to the implementation of risk management plan and risk response plans. Even risk occurs, its losses can be reduced to minimum, which will ensure normal operation of system. Risk management in this stage is the key part of overall project risk management. Risk control and treatment level of the project are intended to be used as risk management assessment indicators in this stage.

Test and acceptance management assessment:

- **The assessment content of test:** The test of DSM project is to detect and certificate energy saving of projects and assess their energy efficiency so as to determine whether the project has achieved its target. Test assessment mainly includes the completeness of assessment indicators for project financial benefits, also for electric power and energy conservation.
- **The assessment content of acceptance:** The acceptance of DSM project is an official activity between DSM project team, the representatives of users and project managers. In the process of project acceptance, project management representatives will verify whether the project products delivered and supporting documentation meet the needs and goals of project. Therefore, it needed to consider the rationality of project acceptance process and the completeness of acceptance documentation (Farahani *et al.*, 2012).
- **The assessment content of late risk management:** In the test and acceptance phase of a project, it is required to confirm the project scope, acceptance quality and calculation costs. Moreover, project information should be collated, transferred, accepted and settled in the implementation process of project evaluation. However, risk management report is the improvement of project information and the effectiveness evaluation of risk management strategy. Therefore, "the integrity of the project risk report" can be used as risk management assessment indicator in this stage.
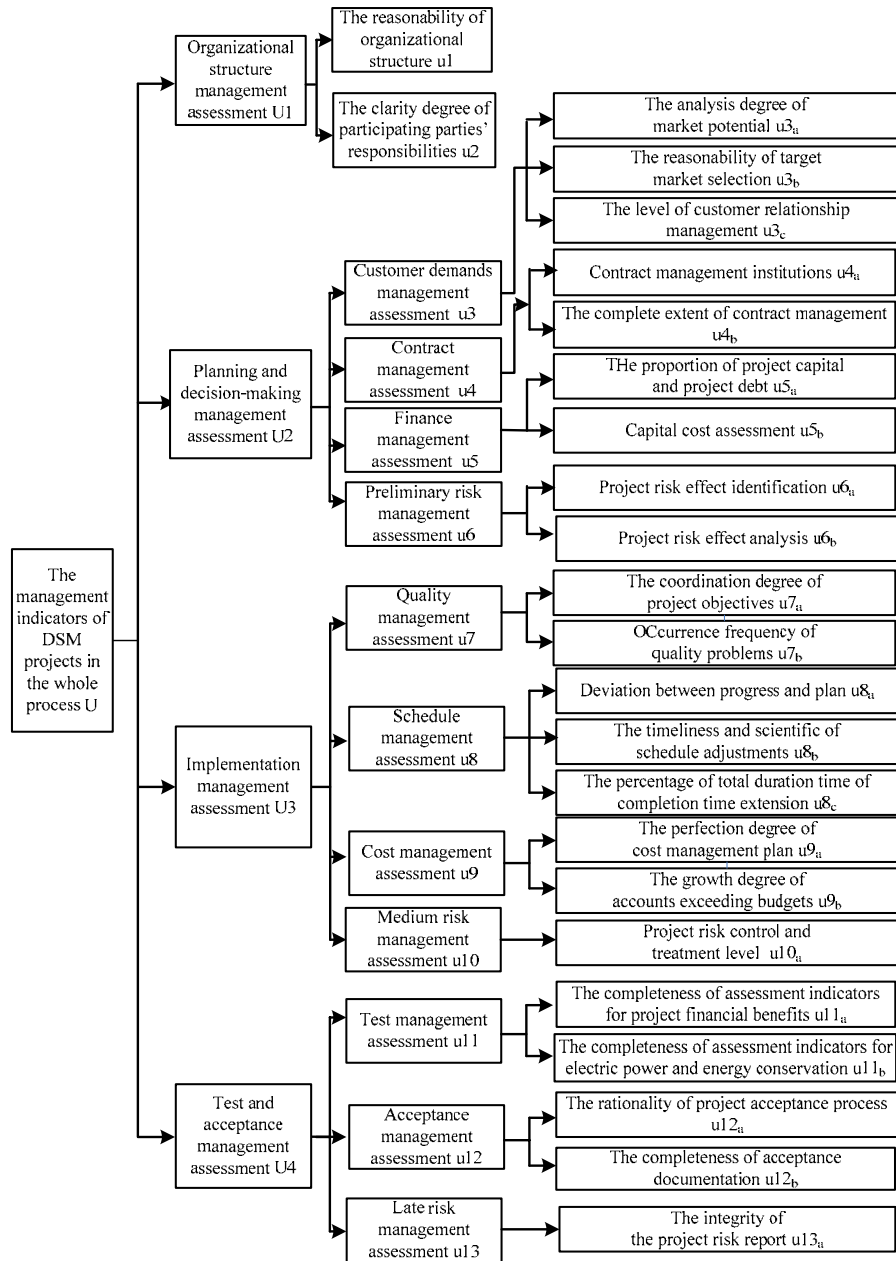
Fig. 2: The management indicators of DSM projects in the whole process

According to the analysis of key elements of DSM project management in various stages, the evaluation indicator system of DSM project management can be constructed as Fig. 2:
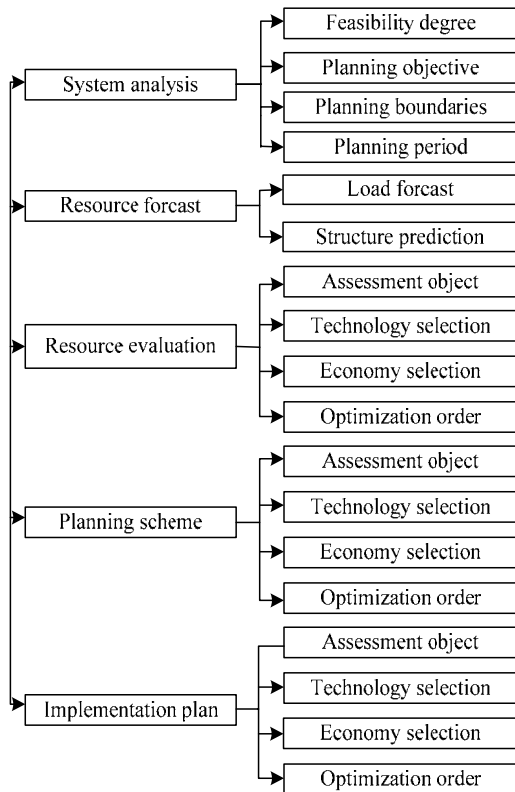
CASE STUDY

A company's power system, which is equipped with 172 substations with the level of 35~220 kV voltage and total capacity scales to 3,794,730 kVA, is one super grid combination of generation, transmission, distribution and consumption of electricity. Except this, this power system also possesses a captive power plant,

with its installed capacity totaling to 1.04 million kW. This company aims at carrying out pilot study of DSM and IRP technology. The development procedures and work steps can be seen in Fig. 3.

The specific process of DSM case management assessment is as follows:

The determination of indicator weight by Hierarchy analysis method:

- **The establishment of judgment matrix by Nine-scale method:** Judgment scale (William and Robert, 1977) is the quantity scale reflecting the

Fig. 3: The project procedures of project IRP/DSM

Table 1: The evaluation matrix for key indicators on the first level

U	U1	U2	U3	U4
U1	1	0.25	0.4	1
U2	4	1	0.625	1.5625
U3	2.5	1.6	1	2
U4	1	0.64	0.5	1

relative importance between two elements. First make U1 the evaluation criteria and the evaluation matrix for key indicators on the first level can be obtained by pairwise comparison of next sibling element, as is seen in Table 1.

From Table 1, the judgment matrix of first level indicators can be expressed as follows:

$$W = \begin{bmatrix} 1 & 0.25 & 0.4 & 1 \\ 4 & 1 & 0.625 & 1.5625 \\ 2.5 & 1.6 & 1 & 2 \\ 1 & 0.64 & 0.5 & 1 \end{bmatrix}$$

- **Judgment matrix solution:** It is required to obtain feature vectors of the judgment matrix and determine the relative weights a_i (Fujun, 2011) of factors at all levels in the assessment. Calculation results: the largest characteristic value is 4.1186 and the feature vector A = (0.3402, 0.8602, 0.9973, 0.4459).

- **Normalization:** According to equation (3):

$$A_R = \sum_{i=1}^{n} a_i \qquad a_i^0 = \frac{a_i}{A_R} \tag{3}$$

A = (0.3050, 0.5192, 0.7379, 0.3050) is normalized and the result becomes, A° = (0.1287, 0.3254, 0.3772, 0.1687), as the indicator weight for U = (U1, U2, U3, U4).

- **Inspecting and ensuring the consistency of judgment matrix:** Due to that evaluators can only evaluate the value of $w_{ij} = w_i/w_j$ and will not determine its accurate value, therefore, it is needed to inspect and ensure the consistency of judgment matrix through Eq. (4)~(5).

$$CI = (\lambda_{max} - n)/(n-1) \tag{4}$$

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(WA)_i}{a_i} = \frac{1}{n}\sum_{i=1}^{n} \frac{\sum_{j=1}^{n} w_{ij} \cdot a_j}{a_i} \tag{5}$$

The consistency test (Cunbin *et al.*, 2012) in this case is CI = 0.0202, after inquiring the average consistency indicator (RI) of n matrix, the results become: n = 4, RI = 0.9, CR = CI/RI<0.1, which is of strong consistency. The weight values of all indicators can be determined in accordance with the above methods and procedures and the result is as shown in Table 2.

Table 2: The weight for the key indicators in DSM project

First-level indicator	U1	U2	U3	U4				
Wight values	0.13	0.32	0.38	0.17				
Second-level indicator	u1	u2	u3	u4	u5	u6	u7	
Wight values	0.67	0.33	0.40	0.23	0.23	0.14	0.40	
Third-level indicator	u8	u9	u10	u11	u 12	u 13		
Wight values	0.23	0.23	0.14	0.55	0.24	0.21		
Forth-level indicator	u3$_a$	u3$_b$	u3$_c$	u4$_a$	u4$_b$	u5$_a$	u5$_b$	
Wight values	0.4	0.4	0.2	0.67	0.33	0.5	0.5	
Fifth- level indicator	u6$_a$	u6$_b$	u7$_a$	u7$_b$	u8$_a$	u8$_b$	u 8$_c$	
Wight values	0.5	0.5	0.67	0.33	0.55	0.24	0.21	
Sixth-level indicator	u9$_a$	u9$_b$	u10$_a$	u11$_a$	u11$_b$	u12$_a$	u12$_b$	u13$_a$
Wight values	0.5	0.5	1	0.5	0.5	0.5	0.5	1

Whole process management assessment by fuzzy comprehensive evaluation method:

- **The establishment of factor set:** From the evaluation indicator system of whole process management in DSM project, as is shown in Fig. 2, it can be seen that the fuzzy comprehensive evaluation in this case belongs to multi-level fuzzy comprehensive evaluation (Mary, 2006) and all factors in the indicator system are needed to be considered.
- **The establishment of judgment set:** $V = (v_1, v_2, \ldots, v_m)$, v_i donates the various possible evaluation results. Fuzzy comprehensive evaluation, based on all factors, aims at obtaining excellent evaluation results from judgment set, which is set as $V = \{$Excellent, good, Fair, Poor$\}$ in this case.
- **Single factor fuzzy evaluation:** Ten experts are selected to evaluate the single factor U_i ($i = 1, 2, \ldots, n$) and each expert would fill out evaluation forms according to their own evaluations. On this basis, the evaluation matrix R_1 of U_1 is as follows:

$$R_i = \begin{bmatrix} 0.13 & 0.23 & 0.48 & 0.16 \\ 0.09 & 0.35 & 0.5 & 0.06 \end{bmatrix}$$

- **The establishment of weight set:** According to weight calculation by AHP in Appendix, the weight set of U_1 is: $A_1 = (0.6667, 0.3333$
- **Fuzzy comprehensive evaluation:** When weight set and single factor evaluation matrix known, fuzzy transformation can be made to carry out comprehensive evaluation. The fuzzy comprehensive evaluation model can be expressed as follows:

$$B_i = A_i \circ R_i = (0.6667, 0.3333) \circ \begin{bmatrix} 0.13 & 0.23 & 0.48 & 0.16 \\ 0.09 & 0.35 & 0.5 & 0.06 \end{bmatrix}$$

$$= (0.12, 0.27, 0.49, 0.12)$$

Likewise,

$$B_2 = A_2 \circ R_2 = (0.29, 0.42, 0.23, 0.06)$$
$$B_3 = A_3 \circ R_3 = (0.26, 0.38, 0.23, 0.13)$$
$$B_4 = A_4 \circ R_4 = (0.38, 0.13, 0.41, 0.08)$$

In accordance with multi-level fuzzy evaluation method (Zhihong *et al.*, 2006) and comprehensive evaluation value of B_1, B_2, B_3, B_4 in four stages, the single factor evaluation matrix of $U = (u_1, u_2, u_3, u_4)$ can be obtained:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = \begin{bmatrix} 0.12 & 0.27 & 0.49 & 0.12 \\ 0.29 & 0.42 & 0.23 & 0.06 \\ 0.26 & 0.38 & 0.23 & 0.13 \\ 0.38 & 0.13 & 0.41 & 0.08 \end{bmatrix}$$

Combining A° = (0.1287, 0.3254, 0.3772, 0.1687), the indicator weight obtained through AHP method, the comprehensive evaluation of U is:

$$B = A^0 \circ R = (0.1287, 0.3254, 0.3772, 0.1687)$$
$$\circ \begin{bmatrix} 0.12 & 0.27 & 0.49 & 0.12 \\ 0.29 & 0.42 & 0.23 & 0.06 \\ 0.26 & 0.38 & 0.23 & 0.13 \\ 0.38 & 0.13 & 0.41 & 0.08 \end{bmatrix}$$
$$= (0.27, 0.34, 0.30, 0.09)$$

As the evaluation set $V = \{$Excellent, Good, Fair, Poor$\}$ in this case, it can be seen from the calculation results, the possibility of "excellent", "good", "medium" and "poor" for comprehensive evaluation is 27%, 33%, 30% and 10% respectively. In conclusion, the evaluation result of whole process management assessment in this DSM project is "good".

CONCLUSION

The establishment of DSM project examination and evaluation mechanism aims to achieve the two following purposes. Firstly, evaluation methods will be provided for DSM project management. The "bottleneck" of DSM Project Management can be found and the management level and development direction of DSM project will be cleared by comprehensive assessment of DSM project management, project implementation status and effectiveness in various phases. Secondly, it will provide important guidance for DSM project planning and investment decisions. The assessment process is the cognitive process, which is the premise and foundation for scientific decision-making. The whole process management assessment of DSM project built in this study can reflect the comprehensive grasp of DSM project and will guide DSM project planning in all aspects, thus, it makes program comparison easier and provide reference of investment decision-making for related sections. All of this above will improve the management level of DSM project.

ACKNOWLEDGMENT

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