# USING A COMPREHENSIVE KPI FRAMEWORK TO EVALUATE AND MONITOR THE OVERALL ASSET MANAGEMENT PERFORMANCE

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## ABSTRACT

*LCAM (life cycle asset management) is an important strategy for power grid companies, which aims to balance the operational performance and investments (both Capex and Opex). In order to measure how well a power company meets the requirements, this paper introduces a new Key Performance Indicators (KPI) framework. The Framework consists of result-oriented (R-KPI) and process-oriented (P-KPI) indicators. The Result-oriented KPI is used to evaluate the overall performance of a company's Asset Management initiatives while the Process-oriented KPI can be used to evaluate the effectiveness and efficiency of key business processes. A dimensional, comprehensive R-KPI is designed and calculated by a number of sub-indicators. By calculating this single top R-KPI, we can evaluate the asset management performance from all aspects including safety, reliability, utilization and life-cycle cost. The paper also presented some KPI results calculated using real data from several power grid companies.*

## 1 LCAM KPI

In response to increasing industry pressures, utilities must become more targeted and re-focus their asset management. Thus, implementation of LCAM (life cycle asset management) is an urgent need of the company to achieve a comprehensive, coordinated and sustainable development under the new situation and also a strategic initiative to build a world-class power grid, a world-class enterprise and lead power grid company's development into a new level. By using the "right Key Performance Indicators" to evaluate the performance of their asset, utilities can significantly improve business management. Therefore, this paper introduces a new KPI framework which consists of result-oriented (R-KPI) and process-oriented (P-KPI) indicators.

### 1.1 Principal of Designing KPI

KPIs should directly link to the critical success factors of company's strategy, and balance the key factors, such as safety, efficacy and cost (both Capex and Opex), in order to improve assets management.

### 1.2 Framework of KPI

In order to evaluate how well a power grid company manages its asset and how efficient its process are, , result-oriented (R-KPI) and process-oriented (P-KPI)

indicators are designed to meet different objectives and application requirements. Eventually, they are combined into one KPI framework, which can evaluate all organizational levels in companies from the top executives of headquarter to front-line field workers. **Figure 1** illustrates the whole framework of LCAM KPI.
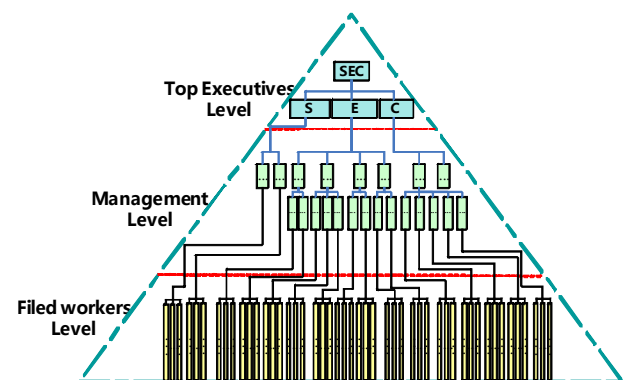


Figure 1 LCAM KPI framework

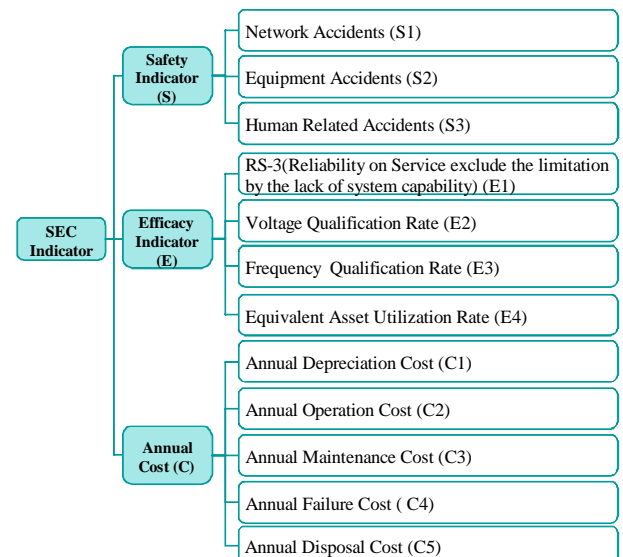## 2 INTRODUCTION OF R-KPI

### 2.1 Overview



Figure 2  R-KPI Framework

The R-KPI focused on result of Assets Management helps to evaluate how well a company meet the requirements of Life Cycle Asset Management. The R-KPI framework, designed as a tree structure, takes a top-down approach. On the top of the structure are three strategic objectives of power grid companies—safety (and security), efficacy (efficiency and reliability) and life cycle cost. In order to

analyze performance of total asset as well as individual asset categories, a single comprehensive indicator and several sub-indicators for each asset category are designed as the evaluation model.**Figure 2** illustrate the R-KPI framework.

## 2.2 Definition of R-KPI

Annual *SEC* indicator: annual cost of all assets/a certain category of assets. (¥/ (Year ¥ MVA))
Safety indicator *S*: the number of accidents in a year including network, equipment and employee accidents
Efficacy indicator *E*: Efficacy (efficiency and reliability) performance in whole year, including $E_1$, $E_2$, $E_3$, and $E_4$;
Annual total cost indicator: cost of whole assets or a certain part of assets.
$C_1$-annual depreciation cost
$C_2$-annual operation cost
$C_3$-annual maintenance cost
$C_4$-annual failure cost
$C_5$-annual disposal cost
The top indicator-*SEC* is used to evaluate the overall performance of a company's Asset Management initiatives. Accordingly, the sub-indicator ($SEC_j$) is use to evaluate performance of a certain asset category.

### 2.2.1 Formula of Overall indicator
$$SEC = \sum_j \left(k_j \times SEC_j\right) \times f_S \times f_E$$

"*j*" represents different kinds of transmission assets
Define "*j*" such as:
T-Transformer;
B-Breaker;
GIS- Gas Insulated Switchgear;
O-Other substation assets;
OVH-Overhead line;
CA-Cable;
"$k_j$" represents to the proportion of a certain asset category in the whole assets. The formula is
$$k_j = \frac{S_j}{S_{NET}}$$

"$S_j$" is the capacity of Asset Category J, $S_{NET}$ is the equivalent overall network capacity. $f_S$ is the coefficient of safety indicator; $f_E$ is the coefficient of the efficacy indicator.
（1）*SEC*
Explanation: Evaluate the overall performance in terms of safety, efficacy and whole-life cost through a comprehensive calculation of all assets /one kind of assets in one year
Objective: Improve the level of overall operation by decreasing the indicator value of *SEC*
（2）Safety Indicator (*S*)
Explanation: According to the regulations in "Electricity Industrial Accidents Investigate Procedures" published by the State Grid Corporation of China (SGCC), we can get

all records, such as the number of power grid-accidents, the number of equipment-accidents and the number of employee-accidents. The accidents contain three levels which are, general, major, and serious.
Objective: Improve safety operation ability during operation
Formula: Safety indicator $f_S$
$$f_S = f_{S1} \times f_{S2} \times f_{S3}$$
S1- Serious Accidents
S2-Major Accidents
S3-General Accidents
$$f_{Sj} = 1 + \frac{2^{n_{Sj}}}{k_{Sj}} \quad (j=1、2、3)^{[1]}$$

$N_{sj}$, $K_{sj}$ represents the number of accidents and coefficient for adjusting.
(3)Efficacy indicator
Explanation: Efficacy indicator consists of RS-3(Reliability on Service exclude the limitation by the lack of system capability), Voltage Qualification Rate, and Frequency Qualification Rate.
Objective: Improving the efficacy and quality of net operation
Formula: efficacy indicator
$$f_E = f_{E1} \times f_{E2} \times f_{E3}$$
E1: RS-3
E2: voltage qualification Rate
E3: frequency qualification Rate
$$f_{Ej} = \frac{k_{Ej} - \ln(100 - 100 \times E_{jS})}{k_{Ej} - \ln(100 - 100 \times E_j)} \quad (j=1、2、3)$$
$K_{Ej}$、$E_{js}$ represent the standard value[2] and coefficient for adjust [3]

### 2.2.2Formula of Sub-indicator
$$SEC_j = \sum_{i=1}^{n_j} \frac{C_{ji}}{E_{4ji} \times S_{ji}}$$

$SEC_j$: sub-indicator of a certain assets category;
$C_{ji}$: annual total cost of certain kind of equipment;
$S_{ji}$: the scale of a certain kind of equipment. For Substation asset, The capacity of transformers is used. For Transmission asset, the equivalent capacity of overhead line and cable is used.
$E_{4ji}$: Equivalent Assets utilization Rate
$n_j$: The quantity of a certain Assets category
The sub-indicator is calculated by multiplying the sum of ratios of annual total cost, $C_{ji}$, (for individual asset of

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1Adjust Coefficients of Serious, Major , General accidents are 10,50,100 respectively
2 The Value is set by the SGCC headquarter according to real data of each power company
3Adjusted coefficient includes RS-3 coefficient, Voltage qualification Rate coefficient, Frequency qualification Rate coefficient

certain category) asset equivalent utilization rate, $E_{ji}$, scale (capacity), $S_{ji}$ by the average load rate of the grid. The $SEC_j$ indicator represents the total cost (life cycle cost) per unit equivalent operation time and per unit capacity for certain asset category. The annual total cost indictor is composed of capital investments, operation cost, maintenance cost, failure cost and disposal cost, which covers the whole asset life cycle.

Annual total cost （$C$）：$C = C_1 + C_2 + C_3 + C_4 + C_5$

$C_1$：capital investment $C_1 = V_0/L$ ，$V_0$ is the Initial Asset Value ，$L$ is the life expectancy；

$C_2$：operation cost $C_2 = C_{21} + C_{22}$，$C_{21}$ is labor cost and materials costs, $C_{22}$ is power loss costs;

$C_3$：maintenance cost;

$C_4$：failure costs $C_4 = C_{41} + C_{42}$，$C_{41}$ is the internal labor cost and materials cost during failure, $C_{42}$ is loss the possible power transmitted during failure and the compensation to the customer for the outage;

$C_5$：disposal cost $C_5 = C_{51} + C_{52} - C_{53}$，$C_{51}$ is retirement cost, $C_{52}$ is disposal cost, $C_{53}$ is Gain (Loss) on Sale of Assets

## 3 INTRODUCTION OF P-KPI

P-KPI evaluates efficiency and effectiveness of LCAM processes, and it realizes performance assessment from headquarters top executives to field workers by implementation.

### 3.1 Definition of P-KPI

P-KPI is involved in the assets management process and activities and covers all the stage of assets life cycle, such as planning, procurement & bidding, construction, operation & maintenance, disposal. **Figure 3** illustrated a framework of all LCAM process.
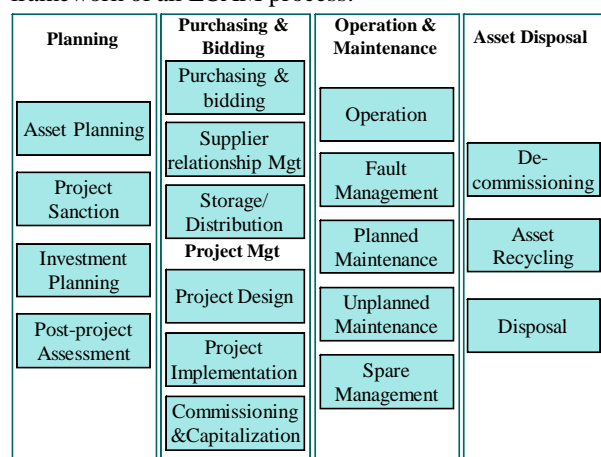


Figure 3 main LCAM business process

P-KPI is designed on the basis of R-KPI. Success factors of R-KPI should be understood before setting the P-KPI. Furthermore, corresponding indicators were set according to relevant principles.

Firstly, we separate the R-KPI to sub–indicator according

to the different drive factor. Secondly, we analyze all separated sub–indicators. Thirdly, analyze the key success factor and link it to relevant business process. When setting the indicators, business processes should be taken into consideration. Finally, judge whether designed indicators meet the requirements which are the processes are conducted in time, meet compliance and used advanced methods. **Table 1** illustrated method and the example.

| P-KPI Categories | No. | Requirement | Definition & Example |
|---|---|---|---|
| Advanced | 1 | We should consider the optimization of life cycle cost other than cost for one stage. | Using "LCC method "in planning scheme : Numbers of schemes using LCC/total scheme number *100% |
| | 2 | In each stage, all the processes should be implemented efficiently and less costly | Centralized Equipment procuring rate :the centralized purchasing value /overall purchasing value |
| Timely | 3 | In order to ensure realize planned target, all the process should meet the plan and budget effectively | Project Capitalization Rate: The number of capitalized projects / total number of projects which shall be capitalized |
| Compliance | 4 | Processes shall be implemented and relevant data shall be recorded in time and exactly to meet compliance requirement | The number of unplanned projects |

**Table 1  Key requirements for P –KPI definition**

### 3.2 Cascade down approach of P-KPI

After main P-KPIs have been defined, sub indicators should be setting according to demands of relevant department and all organizational levels. Specific methods are as follows:

1. It covers vertically from headquarter top executives to front-line field workers.

2. It covers horizontally major departments responsible for different stages of asset life cycle.

"Vertically" means what parent companies use to evaluate is also the indicators for subsidiary companies. Generally speaking, the parent company concern about the key indicators, subsidiary companies should concern about what parent company assigned and they can add some important indicators for themselves.

"Horizontally" means an indicator relating to more than one department should be split in order that one indicator corresponds to one department. Therefore, different

departments are not responsible for same indicator.

## 4 APPLICATIONS AND NEXT STEP

We have calculated the KPI based on real data (year 2006-2008) of almost 29 Chinese Power Companies. After calculation, relevant factors have been optimized and the KPI framework has been improved. Based on the result, State Grid Corporation of China issued this KPI to the sub-companies. Basically, it can help to evaluate performance of asset management.

We designed P-KPI for a power company of municipal city, and split the indicators in one of its subsidiaries. Therefore, we can establish a Asset Management KPI framework from headquarter top executives to field workers by define the KPI and split the indicators, which motivate the various business departments work effectively and enhance the performance of asset management. Eventually, P-KPI supports the assessment requirements of R-KPI and will be optimized continuously. In order to collect KPI data conveniently, the power company will establish monthly or quarterly reports of P-KPI. It helps employees understand "what to do" and how they performed. Moreover, P-KPI should combine with relevant department regular meeting. Therefore, business problems can be analyzed and monitored timely.

To sum up, this KPI framework can combine the method of LCAM and help Chinese power companies evaluate the performance of assets management. In the future, this KPI framework will continuously be researched and improved based on feedbacks from practical application.

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