# Study of the Power Grid Enterprise Performance Based on Data Envelopment Analysis

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***ABSTRACT*—In this paper, data envelopment technology is applied to estimate the comprehensive technical efficiency of power grid enterprises and study its pure technical efficiency and scale efficiency. The calculation result is analyzed. Through the analysis of the actual operation results of the input redundancy and output deficiency, this result is associated with the local GNP data. The reasonable value of the input and output of the power grid enterprises to achieve the best performance is obtained by the prediction of the future local GNP values.**

***KEYWORD- DEA, power grid enterprises, investment a nd outcome***

## 1. INTRODUCTION

With the promulgation of the new electric power reform policy, the highlight is that the grid has a clear positioning. Grid is a high-speed channel of the electricity transmission. Grid is no longer to get the difference of internet and the sale price as the main source of income, but to charge the crossing fee in accordance with the approved by the government of the transmission and distribution price[1].Net service fee is unified by the state, so if the power grid companies want to further profit it needs to find new revenue points such as improving the quality of brand services, reducing operating costs and the damaging of network equipment.

Policy has increased the new five category of electricity sales and broken the situation that the grid is the only company which can direct purchasing electricity from power generation enterprises [2].Power grid enterprises were striped out from the traditional link, forming a commercial operation of the enterprise. So it is necessary to improve the performance level of the power grid enterprise and enhance its core competitiveness in the whole system [3].In this paper, the efficiency of twelve power supply companies in a certain region is analyzed by using data envelopment analysis, and the improvement measures are put forward. Innovation point lies in the final analysis result in contact with the local GNP. By analyzing the relationship of least input and largest output and the local gross national product it is put forward that according to the predicted local GNP decides the minimizing input and the maximum output to obtain the best performance of power grid enterprise.

## 2.Data Envelopment Analysis Model

Data envelopment analysis (DEA) is a linear programming methodology for evaluating the relati ve technical efficiency for each member of a set o f peer decision making units (DMUs) with multipl e inputs and multiple outputs[4].Technical efficiency refers to the extent to which the production proce ss of a production unit reaches the technical level of the industry and is measured by input and outp ut[5].Technical efficiency is measured by the extent of the maximum output when the input has been

determined. When output has been established, tec hnical efficiency is measured by the extent of the minimize input.

**2.1 The CCR Model of Constant Return to Scale**

The CCR model assumes that the scale efficiency is constant, and the technical efficiency is included in the scale efficiency [6], so it is called the comprehensive technical efficiency.CRS=VRS*Scale Efficiency.

The paper supposes that the number of technical efficiency of DMU is n denoted by $DMU_j(j=1,2,\cdots,\ n)$.Each DMU has m different kinds of inputs denoted by $x_i=(i=1,\ i=2,\cdots,\ m)$.The weights of inputs are expressed as $v_i(i=1,2,\cdots,\ m)$ [7].The number of outputs is q denoted by $y_r(r=1,2,\cdots,\ q)$.The weight of output is expressed as $u_r(r=1,2,\cdots,q)$. $DMU_k$ is being measured.

Linear programming model is as follows:

$$\max \sum_{r=1}^{q} u_r y_{rk}$$

$$s.t. \sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0$$

$$\sum_{i=1}^{m} v_i x_{ik} = 1$$

$$v \ge 0; u \ge 0; i=1,2,\cdots,\ m; r=1,2,\cdots,\ q;\ j=1,2,\cdots,\ n$$

**2.2 BCC Model of Variable Return to Scale**

The BBC model is based on variable return to scale and technical efficiency excludes the influence of scale [8]. So it is called pure technical efficiency PTE.

$$\min \theta$$

$$s.t. \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{ik}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rk}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda \ge 0; i=1,2,\cdots,\ m;\ r=1,2,\cdots,\ q;\ j=1,2,\cdots,\ n$$

**2.3 The Adjustment of Input And Output**

Through the analysis of the relative efficiency situation of each decision-making unit, it finds ou t the ineffective DMU [9].The improving value of i nvestment is represented by negative numbers and the improving value of the output is represented w ith positive numbers. Therefore, the calculation met hod of the input and output projection value of D MU can be expressed as Target = original value + improvement, Strong effective target = original va lue + proportional improvement value + relaxation improvement, Weak effective improved value = ori ginal value + ratio improvement [10].In this paper, selection of modifier is the second strong target ef fectively.

According to the modifier can obtain input an d output values which make the power grid enterp rises to the best performance [11]. In this paper, th ese values are linked to the gross national product. The next year power grid enterprises can choose the best of input or output values according to the predicted local national gross national product (G NP).

**3.The Application of Data Envelope in Power Grid Enterprises**

**3.1 Basic Data**

According to the previous references and the characteristics of the power grid enterprises, three input indicators and two output indicators are selected

including the substation capacity below of 110kV,cost of power supply, the length of transmission line, electricity sales, the number of customers. The local national product is considered as a reference indicator.

Table 1:Data of twelve electric power companies in a certain area

| DMU | Substation Capacity Below of 110kV(100MVA) | Cost of Power Supply(Million ) | The Length of Transmission Line(Kilometer) | Electricity Sales(100MWh) | The Number of Customers(Ten Thousand) | GNP(Billion ) |
|---|---|---|---|---|---|---|
| 1 | 103.02 | 129.41 | 448.7 | 102.8 | 69.78 | 242 |
| 2 | 177.76 | 179.48 | 1542.3 | 249.8 | 86.25 | 161 |
| 3 | 153.85 | 186.64 | 2142.72 | 211.9 | 140.28 | 215 |
| 4 | 177.56 | 165.23 | 1265.48 | 344.8 | 120.88 | 340 |
| 5 | 102.84 | 152.6 | 2124.95 | 183.1 | 67.38 | 82 |
| 6 | 97.38 | 168.42 | 3285.78 | 127.8 | 109.54 | 101 |
| 7 | 113.3 | 215.21 | 3094.22 | 220.5 | 79.18 | 89 |
| 8 | 100.23 | 182.35 | 2943.93 | 128.7 | 162.03 | 181 |
| 9 | 214.26 | 226 | 2690.37 | 172.9 | 150.23 | 280 |
| 10 | 80.24 | 172.46 | 2733.71 | 105.7 | 223.99 | 112 |
| 11 | 48.759 | 76.97 | 1316.1 | 78.7 | 51.36 | 69 |
| 12 | 47.11 | 103.27 | 1433.78 | 115.1 | 126.55 | 134 |

### 3.2 The Calculation Results

In this paper, according to the characteristics of the power grid enterprise itself wants to use fewer inputs to get the corresponding output. Therefore, the paper uses input-oriented DEA model to calculate the input-output efficiency of each power company and use the CCR model to calculate the comprehensive efficiency of decision making units. The BCC model is used to evaluate the pure technical efficiency and scale efficiency of decision making units. These theories are used to get the comprehensive technical efficiency, pure technical efficiency and scale efficiency value shown in the following table.

Table 2:Scale efficiency

| DMU | Technical Efficiency Score(CRS) | Pure Technical Efficiency Score(VRS) | Scale Efficiency Score | RTS |
|---|---|---|---|---|
| 01 | 1 | 1 | 1 | Constant |
| 02 | 0.712128 | 0.771791 | 0.922696 | Increasing |
| 03 | 0.741412 | 0.756933 | 0.979494 | Decreasing |
| 04 | 1 | 1 | 1 | Constant |
| 05 | 0.823563 | 0.833565 | 0.988 | Decreasing |
| 06 | 0.580946 | 0.612017 | 0.949231 | Increasing |
| 07 | 0.836242 | 0.943963 | 0.885885 | Decreasing |
| 08 | 0.714309 | 0.731361 | 0.976686 | Decreasing |
| 09 | 0.614736 | 0.634082 | 0.96949 | Decreasing |
| 10 | 1 | 1 | 1 | Constant |
| 11 | 0.733828 | 1 | 0.733828 | Increasing |
| 12 | 1 | 1 | 1 | Constant |

It can be seen from the above that four power company as the DEA is relatively effective. Company is better in general. For other two power supply company scale efficiency is higher (>0.8).The lower comprehensive efficiency of 11th companies was caused by the lower scale efficiency. The other five companies mainly because of lower pure technical efficiency, in turn, affects the overall efficiency. In the later business, these companies pay attention to the improvement of technical efficiency. There are five companies in the decreasing returns to scale. They Should narrow the scale of production and reduce inputs. And there are three companies in increasing returns to scale. Therefore, these companies Should expand the scale of production and increase inputs.

For inefficient companies we need to analyze the degree of redundancy and adjust its input and output values, so that it reaches the relative efficiency. The analysis of redundancy is shown in the following table.

Table 3:Data after adjusting

| DMU | Score | Substation Capacity Below of 110kV(100MVA) | Cost of Power Supply(Million ) | The Length of Transmission Line(Kilometer) | Electricity Sales(100MWh) | The Number of Customers(Ten Thousand) |
|---|---|---|---|---|---|---|
| 1 | 1 | 103.021 | 129.410 | 448.700 | 102.8 | 69.780 |
| 2 | 0.712128 | 126.586 | 127.814 | 1087.255 | 249.8 | 102.102 |
| 3 | 0.741412 | 99.805 | 138.379 | 1551.980 | 211.9 | 140.280 |
| 4 | 1 | 177.557 | 165.230 | 1265.480 | 344.8 | 120.880 |
| 5 | 0.823563 | 84.695 | 125.681 | 1469.483 | 183.1 | 132.161 |
| 6 | 0.580946 | 56.555 | 97.846 | 1238.463 | 127.8 | 110.382 |
| 7 | 0.836242 | 94.755 | 179.982 | 2371.413 | 220.5 | 210.446 |
| 8 | 0.714309 | 59.715 | 130.257 | 1873.082 | 128.7 | 162.030 |
| 9 | 0.614736 | 81.808 | 138.936 | 1653.930 | 172.9 | 150.230 |
| 10 | 1 | 80.242 | 172.460 | 2733.710 | 105.7 | 223.990 |
| 11 | 0.733828 | 35.781 | 56.484 | 683.394 | 78.7 | 61.219 |
| 12 | 1 | 47.105 | 103.270 | 1433.780 | 115.1 | 126.550 |

According to the above adjusted data and the local gross national product (GNP) as the reference data predicts that electric power company in the same output has minimum inputs and in the same input amounts may obtain the maximum output in the future. The curve can be made including the local gross national product and the best investment and output. And when the gross national product (GNP) is forecast between 69 ~ 340 billion through this point makes the straight line paralleling to the vertical axis. The intersection point of the straight line with other line is the optimal value of the input and output. The line chart is shown in the below.

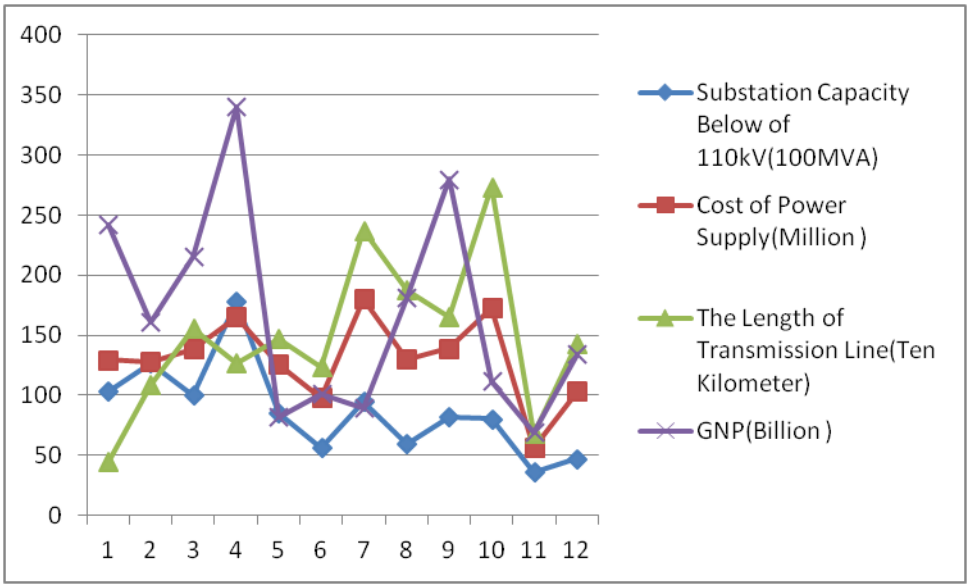


Figure1 GNP and inputs diagram

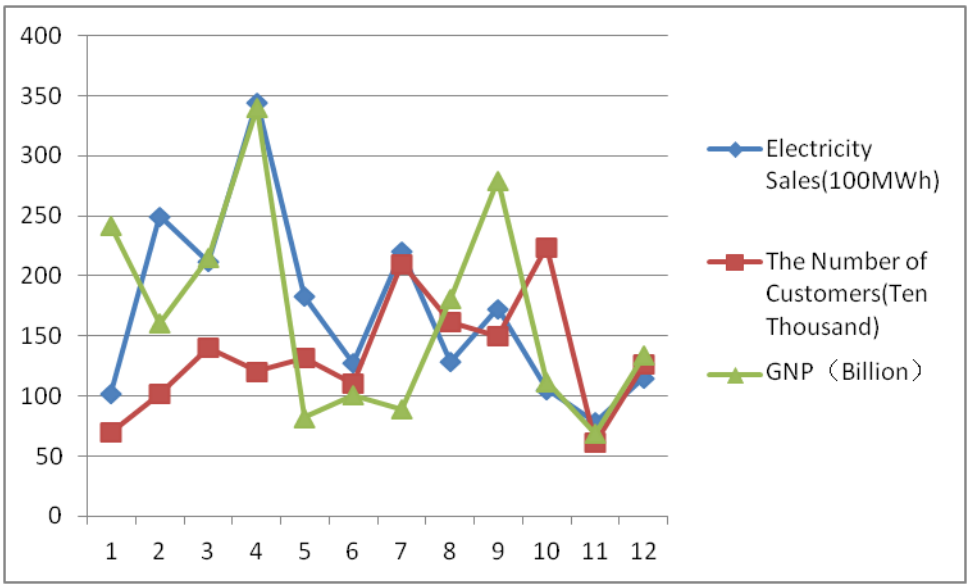


Figure2 GNP and output factor diagram

**4. Conclusion**

In this paper, the CCR and BCC model of the input oriented data envelopment analysis is carried out to analyze the comprehensive technical efficiency, pure technical efficiency and scale efficiency of 12 power enterprises. Improvement opinions are put forward. The redundancy analysis for12 power companies show the best production and output which is associated with the local GDP. And then, when the gross national product is predicted to be in a given range, the best input and output can be obtained according to the line chart.

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