POWER-SAVING BENEFITS OF DEMAND SIDE MANAGEMENT

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ABSTRACT

In order to measuring the benefits of implementing demand side management (DSM) and promote the strategy of an energy-saving society in China, the author builds up a power-saving evaluation system. Focusing on lighting program and electromotor program, this evaluation system can figure out customers', suppliers' and the society's power-saving benefits by using formulas. The result of benefit analysis proves that if we implement DSM successfully, the energy efficiency can be raised so that the goal of energy saving can be reached. Therefore customers, suppliers and the whole society will all get benefits.

INTRODUCTION

Nowadays the biggest challenge facing our world is energy shortage. In China, we also meet the same problem. Our countryĝs GDP is only 4% of the worldĝs, while the energy consumption is 40% higher than the global average consumption. Furthermore, the energy efficiency is far behind the developed countries. It is necessary to take energy efficiency as the key point so as to advocate an energy-saving society and obtained economic, environmental and society benefits. The implementation of demand side management can raise energy efficiency and has a realistic meaning to promote an economic and environment-friendly society. This method is not only cost-efficient but also energy saving and emission-decreasing of waste gas. To prove the significance of the implementation, the author assumes that if we carry out lighting and drive power energy saving programs in Shanghai eastern grid, benefits will be obtained among consumers, suppliers and the society.

ASSUMPTIONS OF DSM

What we can get from a successful implementation of demand side management? At present, some consumers join the DSM programs, while the participants are not enough for measuring the benefits. To illuminate the effect of demand side management, assumptions are made as follows on the basis of year 2012:

Assumption 1:

In 2012 30% consumers join lighting energy saving program and 20% consumers take part in drive power energy saving program in Shanghai eastern grid.

Assumption 2:

Single measure is taken for the sake of calculation. Lighting program is to use compact fluorescent lamp instead of ordinary incandescent lamp. Drive power program is to use frequency conversion and speed governing device.

BENEFIT ANALYSIS OF POWER-SAVING

Evaluation system and parameters

Evaluation system of power-saving

Electricity demand side management has a variety of objectives.

Load management focuses on modifying customer load profiles and reducing peak load in Shanghai eastern transmission and distribution grid. With this approach, the goal of power-saving and cost-efficient production can be reached for the suppliers.

For the consumers, they can save electricity costs by using power properly and scientifically.

Environment protection can be achieved.

On account of the above, implementing electricity demand side management will realize the ñtriple-winò effect among consumers, suppliers and the society.

The evaluation system is built on demand side, supply side and society side to validate whether the ñtriple-winò goal can achieve or not. (Figure 1)

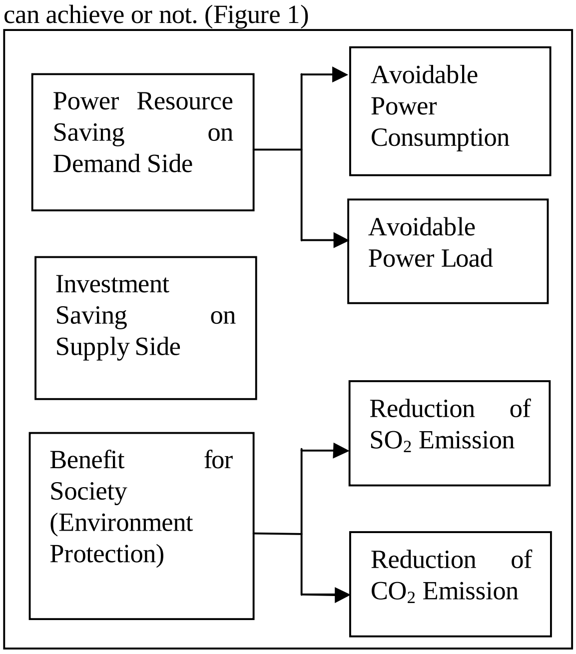

Figure 1 Evaluation System Sketch Map

Evaluation Parameters

According to assumption 1, 30% customers join in lighting program so the participant rate of lighting program is 0.3. With the same reason, the participant rate of drive power program is 0.2. In 2012, the transmission loss is 0.057 within Shanghai eastern grid. Here we take 0.06 for calculation.

The power consumption rate β of the power plant depends on many factors, such as the structure and the scale of the plant. Generally β for coal-fired power plant is ranging from 0.07 to 0.09. β =0.07 is taken. The lighting power-saving rate λ_z is 75%, which indicates changing ordinary incandescent lamp to compact fluorescent lamp. The drive power-saving rate λ_d is an important parameter. It depends on many factors, such as operating characteristic and running status of our consumers. The drive power-saving rate has no fixed numerical value and cannot get by calculation. It can only be defined by experiences. On generally, the driver power-saving rate is ranging from 15% to 50%. To be persuasive, we take 15% for calculation. The parameters needed for power-saving analysis are all listed in form 1.

Form 1 the Parameters for Evaluation

Name	Code	Numerical Value
Participant Rate of Lighting Power Saving	$\omega_{n.z}$	0.3
Participant Rate of Drive Power Saving	$\omega_{n.d}$	0.2
Regional Transmission Loss Coefficient	α_w	0.06
Regional Plant Consumption Rate	β	0.07
Lighting Power Saving Rate of Using Compact Fluorescent Lamp	λ_z	0.75
Drive Power Saving Rate	λ_d	0.15
Construction Cost per KW (¥10000/KW)	k_d	2
Coefficient for the Reduction of SO_2 Emission	λ_{so_2}	0.0187
Coefficient for the Reduction of CO_2 Emission	λ_{co_2}	0.57
Reduced Parameter for Standard Coal-fired	k	1.4
Generating Coal Consumption (kgce/kWh)	b	0.35

Evaluation of Power Resource Saving on Demand Side

Evaluation of Avoidable Power Consumption

Formula 1 to 5 can figure out the avoidable power consumption.

$$\Delta W_{n.s} = \omega_{n.z} \cdot \Delta W_{n.s.z} + \omega_{n.d} \cdot \Delta W_{n.s.d} \quad (1)$$

$$\Delta W_{n.s.z} = \frac{\Delta W_{z.b}}{(1-\alpha_w)(1-\beta)} \quad (2)$$

$$\Delta W_{n.s.d} = \frac{\Delta W_{d.b}}{(1-\alpha_w)(1-\beta)} \quad (3)$$

$$\Delta W_{z.b} = \lambda_z \cdot W_z \quad (4)$$

$$\Delta W_{d.b} = \lambda_d \cdot W_d \quad (5)$$

$\Delta W_{n.s}$ ð ð the avoidable power consumption on demand side, GWH;

$\Delta W_{n.s.z}$ ð ð the avoidable lighting power consumption on demand side, GWH;

$\Delta W_{n.s.d}$ ð ð the avoidable drive power consumption on demand side, GWH;

$\Delta W_{z.b}$ ð ð the avoidable lighting power resource on demand side, GWH;

$\Delta W_{d.b}$ ð ð the avoidable drive power resource on demand side, GWH;

W_z ð ð the power consumption of incandescent lamps in Shanghai eastern grid in 2012, GWH;

W_d ð ð the power consumption of drive power in Shanghai eastern grid in 2012, GWH.

In 2012 the power consumption of incandescent lamps Shanghai eastern grid is 5523 GWH; the drive power consumption is 7364 GWH. Based on assumption 1, putting all the parameters needed into formula 4, the avoidable lighting power resources in 2012 can be got. $\Delta W_{z.b}$ is 4142.25 GWH.

With the same reason, $\Delta W_{d.b}$ is 1104.6 GWH by formula 5. $\Delta W_{n.s.z}$ is 1263.56 GWH by formula 2 and formula 3. Putting all the data into formula 1, we can get:

$$\Delta W_{n.s} = \omega_{n.z} \cdot \Delta W_{n.s.z} + \omega_{n.d} \cdot \Delta W_{n.s.d}$$
$$= 0.3\times4738.33+0.2\times1263.56 =1674.2 \text{ GWH}$$

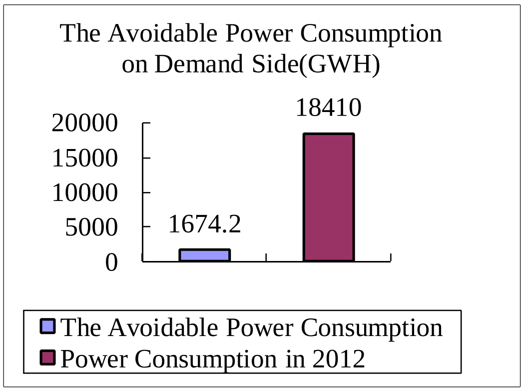

Figure 2 the Avoidable Power Consumption

Therefore, in 2012 if the assumed demand side management carried out in Shanghai eastern grid, 1674 GWH will be avoided. In Shanghai eastern grid the annual power consumption of 2012 is 18410 GWH, thus the energy saving is 9.09% of it. The demand side management shows us a good effect.

Evaluation of Avoidable Power Load

The formula, which can figure out avoidable power load, is listed as follows:

$$\Delta N_{n.s} = \omega_{n.z} \cdot \Delta N_{n.s.z} + \omega_{n.d} \cdot \Delta N_{n.s.d} \qquad (6)$$

$\Delta N_{n.s}$ ð ð the avoidable power load on demand side, MW;

$\Delta N_{n.s.z}$ ð ð the avoidable lighting load on demand side, MW;

$\Delta N_{n.s.d}$ ð ð the avoidable drive power load on demand side, MW.

In 2012 the annual load factor of lighting power saving is 0.3. The annual load factor of drive power saving is 0.4. The simultaneity factor of lighting peak load in Shanghai eastern grid is about 0.7. The simultaneity factor of drive power peak load is near 0.9.

The avoidable lighting load can be calculated by the avoidable lighting power consumption, the annual load factor of lighting power saving and the simultaneity factor of lighting peak load. The avoidable lighting power consumption $\Delta W_{n.s.z}$, which equals 4738.33 GWH, is known. Therefore in 2012 the avoidable power load $\Delta N_{n.s.z}$ is 1577.64 MW.

With the same reason, in Shanghai eastern grid the avoidable drive power load $\Delta N_{n.s.d}$ in 2012 is 420.7 MW. Putting all the data into formula 6, we will get the avoidable power load that is 557.43 MW.

From the above, we can see that if in 2012 30% customers take measures to save lighting power and 20% customers take actions to save drive power, 557.43 MW power load will be reduced in Shanghai eastern grid. In 2012 the highest average monthly power load in Shanghai eastern grid came up in July, which is 2846.95 MW. The reduced power load is 19.58% of the highest monthly power load. A generation set of 600 MW will be saved. If we make the same assumptions in 2011, 484.26 MW power load would be cut off.

Evaluation of Avoidable Investment on Supply Side

Energy Saving Investment on Demand Side

The average annual energy saving investment on demand side can be figured out by formula 7.

$$\Delta K_n = \omega_{n.z} \cdot \Delta K_z + \omega_{n.d} \cdot \Delta K_d \qquad (7)$$

ΔK_n ð ð the average annual energy saving investment on demand side, million RMB

ΔK_z ð ð the average annual investment on light saving, million RMB

ΔK_d ð ð the average annual investment on drive power saving, million RMB

The cost on taking compact fluorescent lamp instead of ordinary incandescent lamp is 0.243 RMB/KWH. The cost on using frequency conversion and speed governing device is about 0.2RMB/KWH. The avoidable lighting power resource $\Delta W_{z.b}$ is 4142.25 GWH, so the annual average investment on light saving ΔK_z is 220.92 million RMB. Using formula 7, we know that the power saving investment on demand side ΔK_n is 346.15 million RMB.

Investment Saving on Supply Side

$$\Delta K_{n.s} = \Delta K_{n.d} - \Delta K_n \qquad (8)$$

$$\Delta K_{n.d} = k_d (\Delta N_{n.s} - \Delta N_{n-1.s}) \cdot 10^3 - \Delta K_n \qquad (9)$$

$\Delta K_{n.s}$ ð ð the reduced investment of the whole society in year n, billion RMB

$\Delta K_{n.d}$ ð ð the avoidable investment on supply side in year n, billion RMB

$\Delta N_{n-1.s}$ ð ð the avoidable power load in the year n-1, MW

In the former charter, we have known that $\Delta N_{n-1.s}$ is 484.26 MW in 2011 if we carried out the same demand side management. According to formula 9, the avoidable investment in 2012 on supply side is 1.46 billion RMB. As the power saving investment on demand side is 0.34 billion RMB, the reduced investment of the whole society is 1.12 billion RMB. (Figure 3)

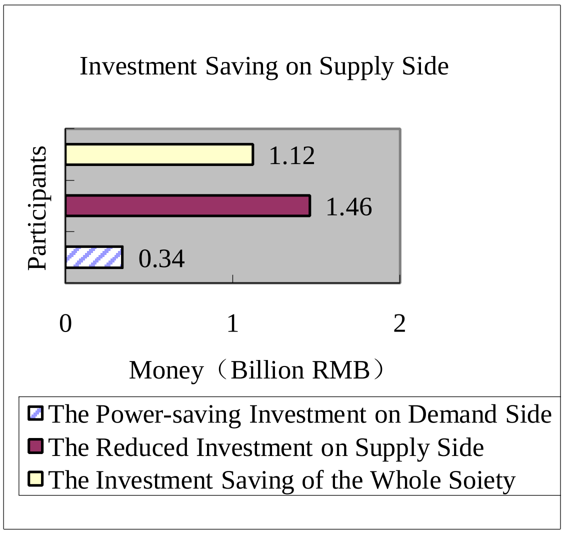

Figure 3 Benefit Analysis on Supply Side

From Figure 3, we can see that if customers pay 0.34 billion RMB for power saving, the power suppliers will save 1.46 billion RMB. Therefore the whole society will save 1.12 billion RMB. The investment on power saving is few, but the effect of energy saving is huge. The more customers take part in demand side management, the more avoidable investment on electricity will be got.

Evaluation of Environment Protection

If we implement the demand side management, the benefit that the whole society will get is environment protection. Because the power saving will cause the reduction of power generation. Consequently, the fuel for power generation will be reduced so that less waste will be discharged from power plant and more environmental benefit will be brought to the society.
In Shanghai eastern grid the electricity is generated by coal-fired power plant. The discharged waste is mainly made of sulfur dioxide and carbon dioxide. If the assumed demand side management is put into use, the reduced waste can be calculated by formula 10 and 11.

$$A_{so_2} = \lambda_{so_2} \cdot k \cdot b \cdot \Delta W_{n.s} \cdot 10^{-3} \quad (10)$$

$$A_{co_2} = \lambda_{co_2} \cdot k \cdot b \cdot \Delta W_{n.s} \cdot 10^{-3} \quad (11)$$

$$\lambda_{so_2} = \alpha_s \cdot \beta_{so_2} \cdot \gamma_s \quad (12)$$

$$\lambda_{co_2} = \alpha_c \cdot \gamma_c \quad (13)$$

A_{so_2} ð ð the reduction of SO_2 emission, ton

A_{co_2} ð ð the reduction of CO_2 emission, ton

α_s ð ð the rate of sulfur contained, %

α_c ð ð the rate of carbon contained, %

β_{so_2} ð ð the coefficient of changing sulfur to sulfur dioxide, $\beta_{so_2} = 2$

γ_s ð ð the emission rate of S, %

γ_c ð ð the emission rate of C, %

In china for all the coal-fired power plant that α_s is 1.1%, γ_s is 85%, α_c is 60% and γ_c is 95%.

The avoidable power consumption $\Delta W_{n.s}$ is 1674.2GWH.

Putting all the data into formula 10 and 11, we will get that A_{so_2} is 15341 t and A_{co_2} is 467604 t.

The air pollution will be eased. Consequently, our environment will be protected.

CONCLUSIONS

The benefit analysis of DSM is not only a method of quantitative analysis but also the basis of DSM policy decision. The energy saving evaluation has proved that the implementation of DSM can raise energy efficiency and has realistic meaning to promote an economic society, especially in the situation of power shortage.

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