Management of operating mode at a heat electro power station in a wholesale energy market of RUSSIAN FEDERATION

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The main aspects considered in this article are: planning of operations at power stations under wholesale energy market conditions;acting model of the energy market in RF;main principles of operating mode management of a grid system.

Particular consideration is given to concept of short-term mode formation at heat electro power stations and mode optimization.[1]

Key words: mode optimization, wholesale energy market, modelling of power stations load.

I. INTRODUCTION

Many authors investigated problems of operating mode management at heat *electro* power stations and got significant scientific and practical results. However, radical changes occurred in electric-power industry during the last years. The structure of power industry was changed: natural monopolistic (electric-power transmission, day-to-day dispatcher's management) and potential competitive functions (generation and sale of energy, repairs and maintenance) were divided; Instead of former vertically integrated companies which performed all these functions new structures specialized on a particular kind of activity were created.

Reformations resulted in significant changes in power system features and revision of scientific and practical methods of mode management accordingly.

Competitive market where prices set as a result of supply and demand cooperation was created. Prices are not regulated by government, they established by interaction of competitors. This led to changes in principles of operating mode management. Modern management is built on price signals formed by market and addressed to generators and consumers.

Cardinal changes were made in supervisory (dispatching) control system with amendments to existed business processes, traditional technologies of mode management and appropriate methodological guidance and instruments.

Optimization criterion in target function for defining modes is maximizing whole prosperity, but traditionally it was minimization of fuels' costs. Market model has some features and limitations which could have an adverse effect both on generate companies and energy consumers.

Particular attention in this report is paid to the problems of power stations load regimes because there are a lot of technological features which constrain operations on the wholesale market just at the heat electro power stations.

II. MODE FORMATION AT THE POWER STATIONS AT THE WHOLSALE ENERGY MARKET

According to the wholesale energy market model the load-line of power station is defined by correlation of market price and price at the application of generator company than enables to load own power facilities if market price is higher than fuel costs and do not produce energy if the market price do not cover fuel costs.

Existing model makes it more possible for generating companies to plan and control load of own power stations and to optimize fuel consumption structure.

In order to calculate equilibrium price and energy volume for planed production (by the hour) and consumption (by the hour) by the wholesale market members the optimization

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problem should be resolved. The optimizableort variables are planned volume of produced/consumed energy by every hour of operating day at the wholesale market, on the measure (criterion) of maximizing linear target function of wealth.

System Operator in accordance with planned system conditions; calculation of optimum is made with glance of system limits – price auction resulted in participants' obligations (schedule of supply/purchase and prices); on the basis of this decision regime parameters of Power grid and its elements are defined that enables to implement the results of auction.

For the heat power plant indispensable condition is delivery of energy in a volume in accordance of working in cogeneration, for the hydroelectric power plant in a volume of technological reasons and environmental safety. [1, article 82]

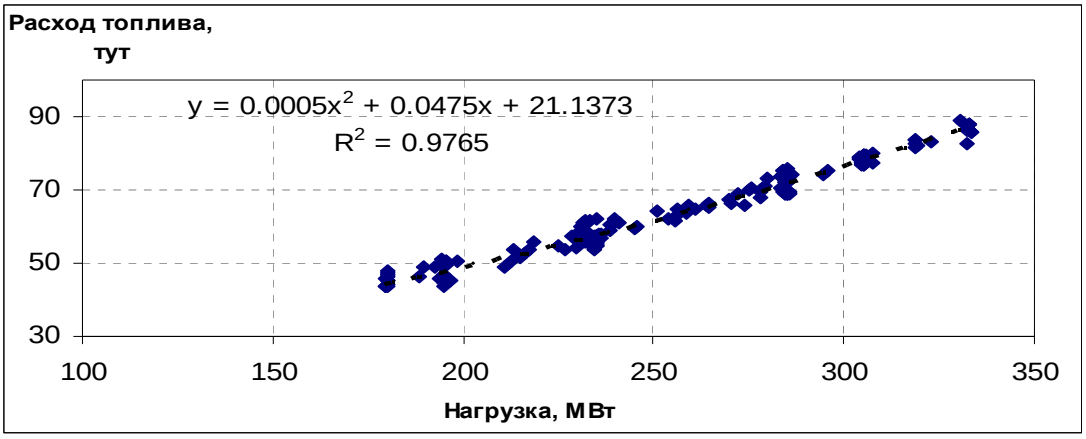
Model of the whole sale market suppose making of procedure competitive selection or trading with using total computed model of UES RF.

Today model included more then 7000 nodes, more then 10000 branches and 800 generators.

This is short exposition of load principles at the power stations working at the wholesale energy market shows that sufficient consideration is given to optimization decisions. However during the discussions and analysis of optimization mode principles it is possible to notice that these principles do not consider optimization mode features in full.

III. SPECIFICS OF RELATIVE INCREASE OF FUEL CONSUMPTION CHARACTERISTICS UTILISATION.

It is possible to point that the optimal price application for the power stations at the competitive market is price application appropriate to characteristics of relative increase of equivalent fuel cost. Let's reveal this by the real heat electropower station example. Regression model is based on statistical data and shows correlation between loading and equivalent fuel consumption. (Picture 1).



Picture 1. Correlation between equivalent fuel consumption and power generation

Picture 1 shows that correlation coefficient is equal t 0,977 that indicates close relations between the factors. The following should be mention: heat supplied was fixed for modeling that simplified model making and statistical model search and enable to find sufficient qualitative characteristic eventually.

Statistical correlation between equivalent fuel consumption and power generation at the heat electropower station with fixed heat supply was made with Excel program instruments (Formula 1).

$$B = 0{,}0005 \times P^2 + 0{,}0475 \times P + 21{,}14 \qquad (1)$$

Where P – station load.

By differentiating function 1 it is possible to calculate relative increase of equivalent fuel consumption.

$$\frac{\delta B}{\delta P} = b_{хоп} = 0{,}001 \times P + 0{,}0475 \qquad (2)$$

It is possible to present function of marginal profit from energy sale at the wholesale market in the following way:

$$MC = Выручка - затраты\ на\ топливо \qquad (3)$$

$$= \mathrm{P} \times \text{Црсв-}(0{,}0005 \times P^2 + 0{,}0475 \times P + 21{,}14) \times Цтоп$$

By differentiating function (3), inserting formula 2 at the function (3) and equaling to zero we obtain that function extremum is achieved when the relative increase of fuel cost equals to price at the spot market.

$$Црсв = b_{хоп} \qquad (4)$$

With a view to power station load at the wholesale market given equation could be interpreted the following way: power station load is reasonable before the relevant increase of energy production cost at the power station is lower than market price for supplementary load sale; only in this case the maximum economic effect of working at the wholesale market could be achieved.

Such effect could be achieved only in case if price application corresponds at SPOT market corresponds to relevant increase of equivalent fuel cost.

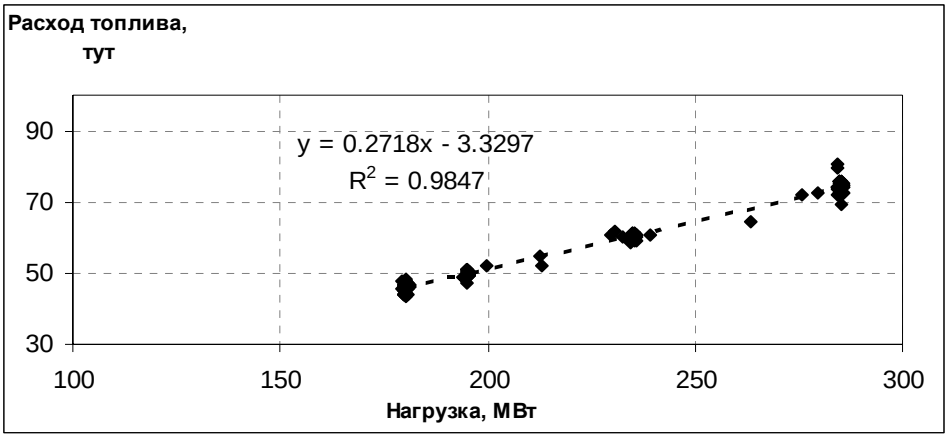
At the same time prediction of given characteristics is difficult task enough under the uncertainty conditions that could accordingly lead to the losses/ opportunity costs from the operations at the wholesale energy market.

Characteristics of heat power stations in particular are influenced by heat supply mode. Structure of operating equipment, its condition, usage and maintenance is also influence the power stations characteristics.

At present time all these factors relate to the internal activity of generating companies by the affect the wholesale market price and final user price.

The Picture 2 illustrates statistical correlation between equivalent fuel usage and energy production of the same power station while heat energy generation changes concerning heat generation that was used in calculation showed at picture 1. (heat energy generation distinguishes by 13% on average that is caused by temperature outdoor air changes.)

Characteristics of relative increase are got by decrease of heat energy output from 230 giga-calories per hour to 200 giga-calories per hour (picture 2).



Picture 2. Fuel usage and load of heat power station at the condition of heat output decrease.

Picture 2 illustrates that determination coefficient R^2 is equal to 0,98 that indicates close relationship between the factors.

At the load of 200 MWt the relative increase in the first case is equal to 0,248 TOE/MWt and in the second – to 0,272 TOE/MWt. Moving to the characteristics of energy production cost (considering fuel cost equal to 3000 RUR/TOE) we get price application equal to 742 RUR/MWt per hour at the first case and 816 RUR/MWt per hour at the second case.

If market price is higher than 742 RUR/MWt and lower than 816 RUR/MWt and application is formed in accordance with initial forecast of heat energy load (picture 1) the station will be loaded at a price lower than relevant increase of energy production cost and will get an adverse effect from that load; the load mode will not be optimal.

Thereby, mistake at the heat energy output forecast could lead to either unreasonably high load of the power station and sale at the price lower then relevant increase of equivalent fuel cost or either to underloading and effect decrease of energy sale.

This could be possible resolved by using expected values in calculations with regard to prices formed at the SPOT market and balancing market.

For example, if warming is expected and probability of energy production cost increase is estimated as high, then the risk adjustment is reasonable while forming the price application at the SPOT market and in the sequel during operations at the balancing market characteristics recalculation is possible and keeping changes while forming applications at the balancing market.

Statistical data does not permit to get expected characteristics of model and influencing factors at the majority cases that is why multifactor regression construction seems to be more real. That experience exists and it has obtained at the industrial control (ASU TP).

Opportunity of using contemporary computer technologies and systems for the characteristics forecast of relevant increase and selection of optimum price application should be used.

Particularly, utilization of method for prediction/correction of price application based on neural networks – special mathematical models is possible. The main advantages of such models are: ability to find and model complex nonlinear relations, ability to operate with a huge input data volume and ability to reveal significant factors.

Unfortunately, the article format does not allow to set out principles of working with neural networks and opportunities of usage that networks for load optimization task decisions at the power stations. While the researches made author revealed an opportunity of broad usage of mathematical models based on neural networks for region's task decisions of load forecast of energy consumption. Without this decisions optimization of power stations operating is not possible. Important advantage of neural networks towards the regression models is an opportunity for independent education and model reconstruction when the type of correlation is changed.

IV. CONCLUSION

By analyzing rules of energy market and the heat electropower station working it is possible to make a conclusion that the base of market structure was done and it is working now, and in particular events it is effective for producer and consumers of energy.

But at the same time by the heat electropower station working at the wholesale market different problems are usually emerging. These problems require special approach. May be it needs the rules of wholesale market to be changed.

For example, it is known that the competitive selection corresponds to mathematic models that represent imprescriptible part of market rules, but some processes, for example, selection of plant configuration, definition of reserves not enough formalized, and it allows for System Operator to influence operations of generators and consumers when it realized such processes. And markets' members can't control these actions of SO.

The problem of coercive work on technological minimum of thermal power plant is not decided. In some periods it can make the power plant ineffective, and separate production would be better.

The market construction is developing now and market members have to make decisions for improving market roles.

One more complex problem in power station work is a problem of short term optimization of regime and variation of facts and predictions parameters that influence fuel consumption.

Researches indicate that opening wholesale market of electric energy raised requirements to planning costs and accounting costs by making characteristics in prices applications by generating companies in a large degree. Errors in planning can reduce effect of working in the wholesale market.

The decision of this problem, accordingly to research, is adoption in companies modern computing technologies, modeling of power station operation and adoption modern system of AISCAE and industry control. That allows receive information about plants working in real-time.

V. PUBLICATION

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VI. BACKGROUND INFORMATION

Taran Andrey Sergeevich is an advanced student of Novosibirsk State Technical University, Novosibirsk, Russia. Essential scientific interests are optimizations of power plants regimes, prediction watt-hour energy usage, modeling and analysis electric power station work in energy wholesale market.