LOADING MODE CONTROL SYSTEM IN A DISTRIBUTED GENERATION

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ABSTRACT

In article the loading mode control system in a distributed generation is considered. The main feature is that system described contains the model of operating power balance dynamics according to supervision based on Kalman's filtration algorithm.

INTRODUCTION

The subject addressed is the question of loading mode control of a distributed (local) generation at parallel work with a network taking into account non-uniformity of the consumer load. Satisfying and responding to consumer requirements is one of the key features of the liberalised electricity markets. The problem of mode control is important from the point of view of reliability and efficiency maintenance of system with the distributed generation.
The question of power balance regulation of local power system is considered at parallel work with a regional power system taking into account a planned power overflow between systems.
The problem is that the non-uniformity of the consumer load leads to the inefficient work of distributed generation with high fuel consumption and work in undesirable modes.

DISTRIBUTED GENERATION CONTROL

At designing of the small complex power systems (CHP, PV, Wind farms, etc), working in parallel with regional (centralized) power systems through a distributive network, there is a problem of control of such small station (generator) current capacity depending on the demand of consumers which are focused on power supply from the given station.
The expediency of such regulation is caused by necessity of economically effective small generator capacity realization in the electricity market.
Thus, there is a technical problem of address management of small station capacity depending on load in nodes of a distributive network.
For the decision of this problem it is offered to carry out the management of capacity balances on the basis of a specialized complex of program-technical means.

THE SYSTEM CONTRUCTED

For the decision of these problems the system of operating power balance dynamics according to supervision on the basis of Kalman's filtration and prediction algorithm has been constructed [1]. The power-efficient management block realizes algorithms of Kalman's filtration and optimum planning with the purpose of achievement maximum power compatibility and technological reliability of system internal power resources.
The physical sense of the power criteria contains in the fact that for the maintenance of power compatibility it is necessary to minimize the internal power resources system dispersion. The technological criteria define such system parameters, which in a present situation of time provide as much as possible authentic conformity of system energy conditions to technology requirements. From these positions the primary goal of energy management system is the maintenance of such power resources condition at which the maximal-authentic conformity to requirements of technological process is provided at the minimal dispersion of energy.

ELECTRICITY MARKET MODEL

The basic participants of the retail electricity market in Russia are: the small (distributed) generator, the Distribution System Operator and the consumer.
Occurrence of 3 kinds of overflows is generally possible:
- From the generator to the consumer;
- From the generator to the Distribution System Operator;
- From the Distribution System Operator to the consumer.

Therefore for management process of power balance at the expense of the generator capacity it is necessary to supervise overflows and to carry out regulation of balance on the basis of the accepted business model.
Such controllable overflow of capacity (physical or virtual) can be on considerable distance from the adjustable generator and it leads to necessity of the corresponding telecommunication channels organization and delay occurrence between measurement and regulation [2].
By results of bidirectional data exchange at territorially-organizational level between the distributed generation and the consumer delivery of necessary control impacts on the generator by results of the information processing is provided.
Also, attention must be paid to how to align the emerging new business and service models in the market

environment with new Internet/web and electrical architectures.
Electricity producers and traders have to forecast their production and consumption, and the forecast of demand and supply must be in balance with the market as a whole.

THE MODEL OFFERED

For the purpose of technical and economic system indicators increase, it is necessary to minimize irregularity of generation capacity, in particular, to reduce a dispersion of this capacity. It is possible, if into system to enter the accumulator and to carry out planning of generation load according to supervision (forecasting).
In the figure below the block diagram of such model is presented, where G – is the distributed generator, A - is the accumulator, N - is the consumer load, $\bar{X}$ - is the generator capacity, V - is the accumulator capacity, X - is the Distributed Generation capacity and U, w - is the load stochastic characteristics.

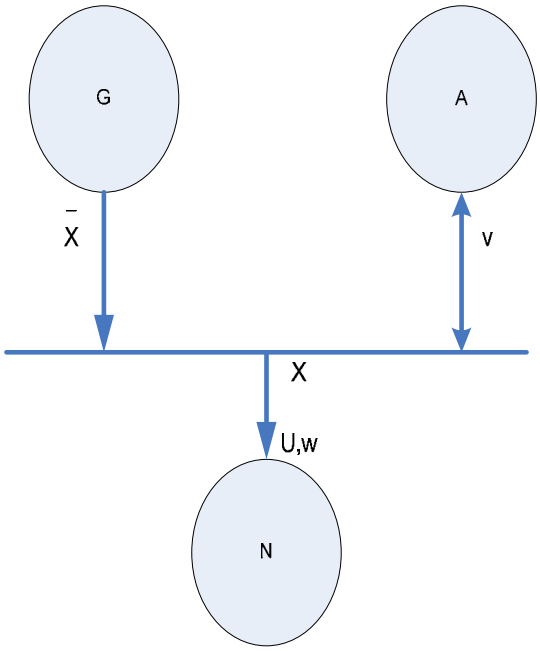

Fig. 1. Stochastic system with energy accumulation

The system is described by continuous-discrete set of the equations in space of conditions

$$\frac{d\hat{x}(t \mid t_k)}{dt} = \mathbf{A} \cdot \hat{x}(t \mid t_k) + \mathbf{B} \cdot \bar{u}(t) + \mathbf{G} \cdot w(t),$$
$$x(t_0) = x_0, \qquad (1)$$
$$y(t_{k+1}) = \mathbf{H} \cdot \hat{x}(t_{k+1} \mid t_k) + v(t_{k+1}),$$
$$t_K \in [t_0, \infty), k = 0,1,2,\ldots, \qquad (2)$$

where $\bar{x}(t \mid t_k)$ - planned generation load capacity;
$\bar{u}(t)$ - mathematical expectation of consumer demand $\{w(t), t \in [t_0, \infty)\}$ - white noise with zero mathematical expectation and covariance $\{\mathbf{Q}(t), t \in [t_0, \infty)\}$;
$\{v(t_{k+1}), t_k \in [t_0, \infty), k = 0,1,2,\ldots\}$ - white sequence with zero mathematical expectation and covariance $\{\mathbf{R}(t_{k+1}), t_k \in [t_0, \infty), k = 0,1,2,\ldots\}$,
$\mathbf{H}$ - supervision matrix and $\hat{x}(t_{k+1} \mid t_k)$ - forecasted generation load capacity.
For the purpose of decrease in irregularity of the generator load schedule under condition of consumer maintenance with necessary value of energy, planning of the generator load capacity at the moment of time t_{k+1} according to supervision at the moment of time t_k is expedient for carrying out on the basis of the least squares method that is reduced to the decision of a problem of parametrical identification.
On figure 2 the process of forecasting algorithm is demonstrated.

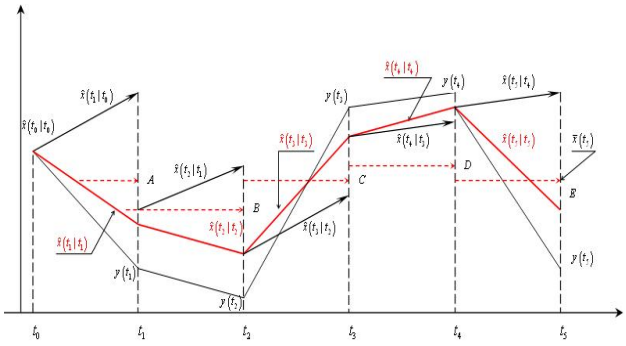

Fig.2 Filtration trajectory averaging procedure of a generator capacity

The stochastic nature of power consumption causes occurrence of a commercial risk.
Thus degree of this risk directly influences size of the tariff put for the consumer. Accordingly, if it is possible to manage this risk we have an opportunity to reduce the tariff that in turn attracts on itself restraint of tariffs growth and creation of competitive power supply organization technology.

IMPLEMENTATION

The technology given has been realized at the decision of the overflow (power balance) control problem at parallel work with a network of the distributed generation object (CHP) for needs of "Russia's railways".

In the distributed power grids of the consumer (Russia's railways), where own distributed energy resources are used (CHPs, power stations, etc) have appeared the following problems:
- The prohibition of electric power export to the centralized network since it is a real loss at the expense of a tariffs difference in the consumed and given out energy;
- The direct interdiction of the Distribution System Operator for delivery in its networks distributed generation energy;
- The non-uniform schedule of energy consumption on object (day - night, by turns , summer – winter, etc).

Overcoming of the specified restrictions without loss of power resources could be only achieved by implementation of loading mode control system in the distributed generation in real time with maintenance of following functions:

● Control and regulation of the active capacity overflow on feeding feeders within an admissible adjusting range of power station in normal and repair schemes at parallel work with a network;
● Start/Stop of the distributed generator at achievement of capacity below/above the established limit in an order defined by the management algorithm;
● Uniform loading of the distributed generator. Uniform use of the distributed generator resource at the expense of start-up sequence management;
● Unloading of the distributed generator at decrease in an overflow of active capacity from a network on controllable feeders;
● Selective protection of electric systems and grid;
● Possibility of the operative authorized parameters and protection adjustment on controllable parameters;
● Electricity parameters history, events and messages storage;
● Remote monitoring of the data and telecommunication control through Internet.

Besides functions above, the control system offered allows to make operative forecasting of necessary generation volume taking into account satisfaction of the consumer needs, and also to introduce in a distributed generation effective accumulation (based on the Kalman's filtration algorithm). The accumulator in offered system carries out a role of the buffer, allowing to accumulate energy at minimum and to use this energy at maximum of loading consumption. At the figure below one can see the block diagram of the described system.

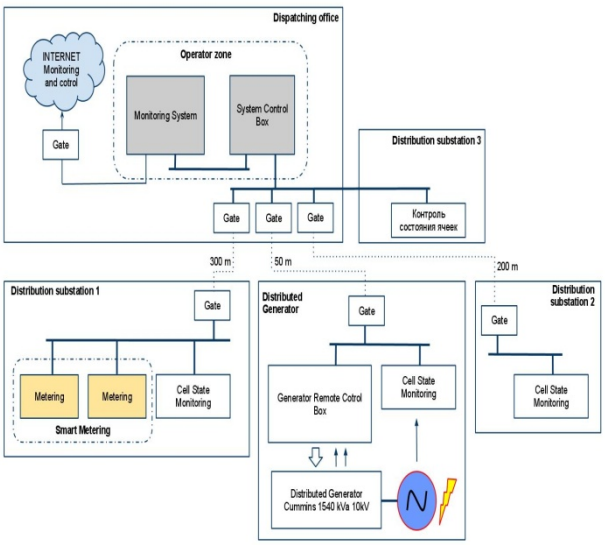

Fig.3 System block diagram

Thereby, the general result of the control system implementation is the increase of reliability, quality and profitability of the consumers power supply.

BENEFITS

- Received on algorithm considered, the generator capacity is necessary and sufficient for the consumer maintenance with energy in full volume. Accordingly, the stochastic deviation of the consumer load from the generator capacity is compensated by the accumulator.
- Offered generation mode management on the basis of planning model on algorithm of Kalman's filter will reduce electric load maximums and will lower requirements for capacity reserves;
- Possibility to regulate the capacity balance and also to choose the most economical generation modes and electric power expenditure allows distributed generation to solve more effectively as a whole the problems put before it and conducts to decrease in specific cost of electric power watt.

Thus, the possibility of widespread integration of distributed generation (CHP, PV, Wind farms) is provided at modern level of the consumer demand satisfaction.

REFERENCES

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[2] O.Z. Brandt, 2003, *The Analysis of the data. Statistical and computing methods for science officers and engineers*, AST Publishing house, Moscow, Russia, 323-327.