Analysis of impact distributed generation on features of electric power systems

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Abstract – In article classification of sources of the distributed(allocated) generation, the basic characteristics is resulted. The opportunity of the approached estimation of cost of installation of sources and its influence on reliability indexes and quality of supply is considered [1].

Key words: **Power system, distributed generation; distributed network, indicators of reliability and quality of an electrical supply.**

I. INTRODACTION

At present, commissioning the new generating capacities lags behind the energy consumption in Russia; besides, the problem rapidly compounds in complexity due to existing generating capacities aging. To solve the problem of improving the energy consumption reliability and safety, maintaining the power system stable operation as well as optimizing the electric energy cost, the following solutions can be proposed:

- limiting the energy consumption during the peak load periods and shifting it onto the off load periods;
- making long-term bilateral contracts on energy and power purchasing;
- locating the low capacity sources (distributed generation – DG) near the consumers;
- introducing energy saving technologies into goods and services production.

The some solutions can be implemented in a short-term perspective without additional investments, while the some of them are impossible to realize without significant financial and time resources.

According to the rate of centralization the power supply of consumers might be divided into the following categories:

- *centralized*, i.e. the supply sourced from major electric power plants via trunk transmission lines or through distribution networks;
- *decentralized*, i.e. fed by independent supply sources;
- *combined*, i.e. the supply of consumers supported by an independent supply source with reserving or additional supply from a main distribution network.

In uncertain market conditions of developing the sector of power electricity the most popular way to enhance the reliability of supply consumers with power is to place facilities of DG close to the load centres [1].

In this case the risks of power shortage and losses of electric supply from a main substation of a backbone network are reduced; the reliability of power supply equipment is improved as well as quality metrics of electrical energy; the losses of power and electrical energy are also reduced.

Generally on the occasion of new technologies and development of low-power stations the issues of changing the key properties of EPS have become a subject of main attention. The process features the changes in engineering data provoked by heterogeneity of electric system components.

Distributed generation allows creating efficient and reliable systems of producing high-quality electric and heating power in immediate proximity to local consumers with taking into account their specific needs [2, 3].

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High rate of investment attractiveness as well as cost efficiency of distributed power plants is caused by the following aspects:

- the relatively low level of initial investments;
- the possibility of prompt and also step-by-step launching (implementation);
- the total control on the hand of consumer, including the salability of extra power, i.e. the ability to be sold by a consumer.

The combined system of electric power supply provides consumers with additional and reserved centralized EPS. Meanwhile a consumer, e.g. industrial enterprise which possesses its own source of energy, has also the following advantages:

- the opportunity to receive electric and heating power cost less than fixed rates;
- the real evidence of enhancing reliability of power supply;
- the possibility to derive additional benefit from selling the power to sub-consumers;
- the real evidence of reducing peak loads in a power system in general; and
- the clear opportunity of the most efficient exploitation of local fuel. This is quite significant point in case of substitution of combined-cycle plant, gas-turbine power station.

II. THE TYPES AND TECHNICAL CHARACTERISTICS OF DG

The opportunity and expediency of construction of sources of small generation existed always, as a rule, it there were small factory thermal power stations. For example, for territory of Sverdlovsk area by small stations becomes covered from 4 to 10 % of capacity of loading. In figure 1 the diagram of manufacture of the electric power on researched territory is submitted by the stations having access on the wholesale market of the electric power and capacity. From the diagram it is visible, that more than 90% of consumption are provided with stations such as a state district power station, heat-electric generating plant, total energy power station and the atomic power station.

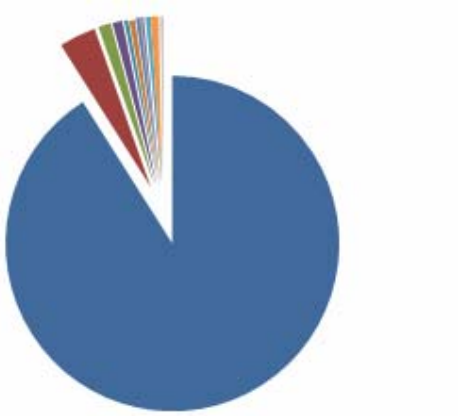

Fig.1. Manufacture of the electric power on territory various objects of generation

Stations of low power, including block - station and separate stations of low power cover basically a base part of loading. On fig. 2 the production schedule of one of stations for which the factor of non-uniformity makes is resulted $k = \frac{P_{\min}}{P_{\max}} = 0,78.$

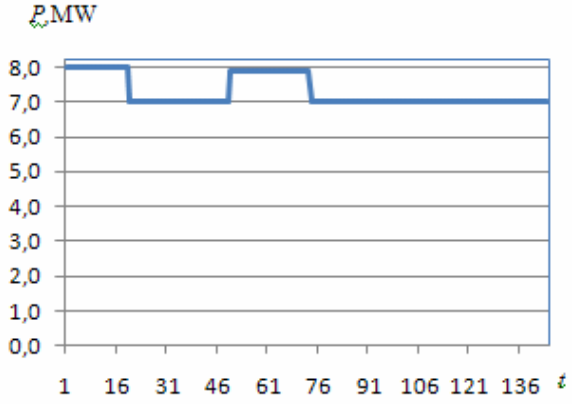

Fig.2. Production schedule of station

In table 1 the basic characteristics of the most widespread sources DG are resulted [1, 2, 3].

TABLE 1. THE BASIC CHARACTERISTICS OF SOURCES DG

Type DG	Diesel reciprocating generation	Gas-turbine power station	Combined-cycle plant	Solar	Wind power
Fuel	Products of oil refining	Natural and biogas	Natural and biogas	Energy of a sunlight	Wind power
Schedulable	Schedulable	Schedulable	Schedulable	Not schedulable	Not schedulable
Opportunity of regulation	Probably	Probably	Probably	Is limited	Is limited
Capacity	1 kW – 6+ MW	0.1 – 30+ MW	30 kW – 10 MW	1 kW- 1 MW	0.1 – 2.5MW
Power efficiency	30 – 45%	30 – 45%	20 – 40%	6 – 20%	1 -35%

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In conditions of a constant rise in prices on the electric power and the greatest distribution is warm in Russia have received combined-cycle plant, gas-turbine power station to individual capacity from 0,5 MW up to 15 MW.

Sources DG can be in addition classified by the form connections to the basic network:

- directly connected to a network (electromechanical connection);
- inverter connection through the converter of frequency.

The majority of sources of the distributed generation for large industrial consumers have last appearance of connection to the basic branch circuit as reduction of the occupied area by the gas-turbine power station in this case is possible. The generator gives out parameters of an alternating current with frequency of 100 Hz.

The typical connection diagram of the block the turbine - generator to a branch circuit 6 (10) kV has the features. Conclusions stator windings of the generator are separated from the basic branch circuit by the following elements: the cross-connect equipment; converters of frequency; chokes for restriction of currents of switching of the converter; mains transformers.

Basic connection diagram of blocks the turbine unit – the generator of low power which most are frequently applied in territory of Sverdlovsk area, are shown on fig. 3.

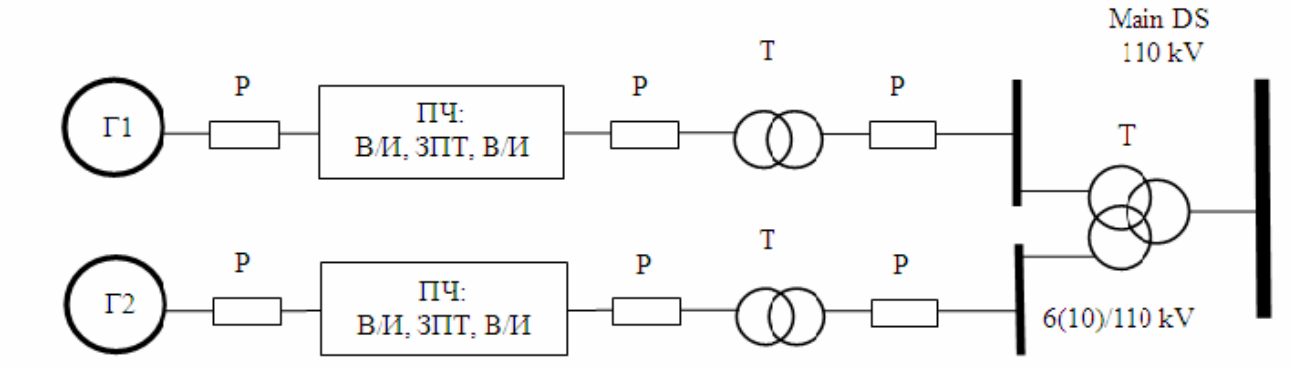

Fig.3. The Block diagram of a source of the distributed generation:
Г - *the generator;* ПЧ - *the converter of frequency;* В/И - *the rectifier / inverter;*
ЗПТ - *a part of a dc;* Р - *the choke;* Т - *mains transformers*

III. MULTI-PURPOSE MODEL OF ISTOCH-NICKNAMES DISTRIBUTED GENERA-TSII

It is considered multi-purpose mathematical model for which it is defined optimum a parity between investitsi-onnymi components, influence DG on regime in parametres EPS, and also rice-kami of loss normal funktsionirovanija a source of the distributed generation.

For the integrated estimation of building of a source of the distributed generation the mathematical model for which primary factors are increase of reliability of an electrical supply and quality of the electric power is formed. The model is presented by following components.

1. Cost of expenses in the first year of operation of own generation by the following expression

$$F_1 = \min\left(kP + C_{\text{экс}} + C(\Delta W) + C_{\text{топл,ЭЭ}} - D(P)\right), \quad (1)$$

where k – cost of specific capital investments in $\frac{\text{thousand rbl}}{\text{кW}}$ on 1 kW of an installed capacity, $C_{\text{экс}}$ – annual costs on operation of the equipment, $C(\Delta W)$ – costs on compensation of losses of the electric power, $C_{\text{топл,ЭЭ}}$ – cost of purchased fuel and the electric power, $D(P)$ – decrease of the costs connected to reduction of volume of the purchased electric power.

2. Improvement of quality of electrical supply – stabilization of deviations on a voltage

$$F_2 = \min\left(V_{\text{ном}} - V_t\right) = \min \Delta V, \quad (2)$$

Where ΔV it is approximately determined under the formula

$$\Delta V = \left[V_{\text{ном}} - \frac{P_0 r + Q_0 x}{V_{\text{ном}}} + \left(\frac{P_0 - Q_0 r}{V_{\text{ном}}} \right)^2 \cdot \frac{1}{2V_{\text{ном}}} \right]. \quad (3)$$

3. Optimization of losses of electric energy for the considered period:

$$F_3 = \min\left(\int_0^T \Delta P(t)dt \right). \quad (4)$$

3. A reliability augmentation of electrical supply – minimization of a population mean from breaks in electrical supply [4]

$$F_4 = \min\left(P \cdot \gamma \sum (T\omega \cdot \varepsilon)\right), \quad (5)$$

where ω – parameter of a stream of refusals, γ – cost of specific damage from restriction of loading, ε – a share of disconnected loading.

Criterion function includes above the named components in view of weight coefficients which while are offered to be established in the expert way.

$$F(P) = \min(\beta_1 F_1(P) + \beta_2 F_2(P) + \beta_3 F_3(P) + \beta_4 F_4(P)), \quad (6)$$

Where $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 1$.

Meaning of factors depends on insistence of the consumer to quality of power and necessity of maintenance of reliability and uninterrupted operation of electrical supply. Last parameter is the most significant as specific damages of emergency restriction of loading for different consumers can differ more, than in 100 times. For example, for open-pit mining coal from emergency restriction duration till 3 o'clock makes specific damage near 0,5 $\frac{\$}{\text{kWh}}$, and for the enterprise on oil refining 40 $\frac{\$}{\text{kWh}}$ (the data are resulted from [5]).

For the approached estimation of cost of installation of sources of the distributed generation meaning 20 $\frac{\text{thousand rbl}}{\text{kW}}$ that corresponds 850 $\frac{\$}{\text{kW}}$ for 1 kW of an installed capacity is ac-

cepted, meanings of specific damages can be accepted in conformity c by a kind of industrial production [5], meanings of parameters of a stream of refusals while are offered to be accepted on the data received on the basis of field experience as a whole for installation.

IV. THE CONCLUSION

The offered model takes into account only a part of features and the situations arising at an estimation of influence of distributed generation on properties EPS. A separate problem for rational development and management electrical power systems with the distributed generation is development of principles of optimization of modes which should take into account new regulating properties of consumers and their independence of dispatching decisions.

The further researches will allow to receive quantitative assessments of efficiency and investment appeal of installations of the distributed generation in view of risks of its use.

V. REFERENCE

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