POWER SUPPLY SYSTEMS FOR STAND-ALONE CONSUMERS WITH HIGH RENEWABLE ENERGY PENETRATION

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Abstract

In the given article, discussing perspective of power efficiency increasing on the basis of unique developments in the decentralised electrical supply systems with participation of renewed energy sources, systems of accumulation and the active consumer by application of adaptive algorithms of management, use of rational schemes for teamwork of the equipment, use of unique hybrid stores of the electric power of system on the basis of supercapacitors and accumulator batteries (AB), executed on AGM and GEL technologies.

Overview

About 70 % of territory of Russia concerns zones of the decentralised electrical supply where lives by different estimations from 10 to 20 million persons. The majority of these territories are located in areas with severe environmental conditions - Siberia, the Far East, the Far North.

Standalone electrical supply systems usually based on autonomous diesel power stations (DPS):

- Total exceeds 50 thousand
- Rated capacity reaches 15 million in kW

As sources for a stand-alone electrical supply system they possess both doubtless advantages and the significant lacks:

- The big expense of organic raw materials;
- High cost of the produced electric power;
- Low reliability of an electrical supply;
- Harmful influence on environment.

Application of renewable energy sources as a part of autonomous power systems allows lowering a fuel component in the cost price of the developed electric power that essentially raises their technical and economic efficiency.

Power strategy of Russia provides 20 million ton of equivalent fuel replacement. Traditional energy carriers at the expense of renewable energy sources (RES). Now the share of power stations on renewable energy sources in Russia makes nearby 1 %, and the Government of the Russian Federation a task in view of its increase to 4,5 % by 2020 [1, 2]. Achievement of this point is impossible without complex consideration multicriterion problem of increase of technical and economic efficiency of operating conditions of the decentralised power stations with use of the

dispersed energy sources, a part from which renewable. Works in this direction are conducted practically in all large research laboratories on the given subjects [3-9].

Foreign experience in construction of similar systems shows possibility of considerable economy of organic fuel and in certain cases, under the favorable external conditions, full replacement of organic fuel. In particular, Mr. A. Carta in the operational reports published in editions IEEE (Institute of Electrical and Electronics Engineers), shows economy of diesel fuel to 50 % in the severe conditions of Alaska as much as possible approached to conditions of Siberia. And Mr. A Stavros in the publications shows efficiency of application of hybrid schemes in island micro grids [10].

Works in this direction are actively conduct in all large research centres which are taking up the problems of development and increase of efficiency of functioning of a power economy. Application of hybrid power stations allow to solve problems of power deficiency with use of renewable energy sources, to optimise loading of the generating equipment, to improve quality and stability of an electrical supply.

In Europe researches investigate basically in an island systems way (in connection with presence of a significant amount of the islands needing electrification or increase of generating capacities). In the USA and the countries of Asia and Africa the isolated micro systems more intensively investigated, that is connected with extensive territories with a weak infrastructure and low power density of load. In Russia it is possible to observe requirement for systems of both types, but nevertheless with displacement towards the isolated systems. Such systems are on almost all northern areas of our country, and also on the areas located in the Asian part of Russia.

Nevertheless, existing technologies do not insure the most effective expense of organic fuel and motor potential of diesel power stations. The coordination of wind generators work and diesel power stations work use the low effective algorithms which are not considering application of buffer storages and active consumers. Even on nowadays placed in operation or modernised (Kuriles, Bering's island) hybrid electropower complexes are not applied the advanced decisions of automation and power efficient control teamwork of the basic power generating equipment.

The investigations in this field are conducted throughout last three decades in Tomsk polytechnic university. In 80th and the beginning 90th great attention was given to the micro hydroelectric power stations, which else till 1990th was more than 150 units across the Tomsk region. Directions of researches actively developed in wind energy field.

By this time, the laboratory complex including a wide spectrum wind- and photovoltaic equipment, energy storages, and also their physical models is created.

Research of operating modes, physical modelling, management system engineering wind- and diesel-generators, development of operating algorithms conducted on the real equipment, with the specialised electrotechnical equipment, making a basis of hybrid wind-diesel system [11-13].

Description of technology

Increase of power efficiency and overall performance of stand-alone electrical supply systems is possible by adoption of new technology – the hybrid power stations including interchangeable unitized power blocks: diesel-generators (DPS), wind generators (WPS) and PV-installations (PV-PS), Biomass Energy (Pyrolysis or Direct Combustion), Heat Pumps and also electric power buffer stores. Important feature of hybrid systems with energy stores is possibility of loading optimization of the generating equipment and the matching of consumption and electric power generation.

During project performance the technical problem of creation of diesel-generators on variable frequency of rotation of a shaft as part of hybrid power station at change of capacity and character of power loading. Microprocessor automatics allow DPS to operate in most power effective mode.

Application of unique buffer accumulator-condenser systems for accumulation of the electric power allow to smooth the production schedule of the consumer and decrease the rated capacity of the generating equipment.

The economy of motor life is reached by application of buffer storage and the competent coordination of teamwork of the equipment wind-diesel power station with application of adaptive algorithms in a control system of a micro grid.

Replacement of a part of organic fuel of diesel-generators is provided by introduction in power station structure wind- and photo-electric installations;

The increase in reliability of an electrical supply by means of power supplies backup, intellectual and adaptive management of power flows, increase in controllability of a distributive network by use of microprocessor automatics;

Conclusion

Key factors of acceptance by them of decisions are:

- Cost of a final product/service and a time-frame of recoupment of capital investment
- Modernization of existing objects of the decentralised electrical supply
- Putting in operation of new power effective objects of the decentralised electrical supply
- Decrease in the cost price of the generated electric power
- Implementation of the developed technical solutions at installation of local energy sources
- Implementation of the developed technical solutions in the distributed generation, including hybrid buffer stores for indemnification of peaks of electric loadings
- Scientific and technical level of engineering
- Practical realizability of the project

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