Investigation of Wind Power Parks Islanding Conditions in Small Parts of Smart Power System

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Introduction

Wind power stations which are working with power converters have control chain to measure the frequency and voltage in connection point and according these measurements the converters output values are operated. During emergencies of power system when frequency and voltage in network are dropped down, the converters of wind station do not can to work and wind stations are disconnected from system (Fig. 1).

![Fig. 1. Measurements of frequency and voltage in coupling point](image)

If wind power stations parks are tangible parts of system generation’s capacity, unexpected lost of uncorrupted generators are heavily governed situation [1]. One of possible solution of this problem can be creating of small power systems, sometimes named as microgrids in conjunction with concepts of smart power system’s information system [2]. The microgrids were developed to involve the renewable energy sources and considerable number of experiments was performed in many universities of European countries and US [3, 4].

The necessity part of small power system is local synchronous generator which can be for example renewal thermal or hydraulic generator and which can be guide for strike and regulate local frequency and voltage. The key role of this generator is balancing of active power in small power system, because wind station parks production has very changeable character [5].

![Fig. 2. Scheme of small power system’s elements](image)

Small power system architecture

Idea and research of small power system are targeted to wide-ranging renewable energy sources utilization [6]. In place of low voltage microgrid the small part of electricity power system, which consist from several high voltage (110 kV) lines and its generators’ and consumers’ substations (Fig. 3).

![Fig. 3. Small energy system as an islanding part of system](image)
The small power system can be named as midisystem. The control system of small power system must to work independently and to operate power balancing, frequency, voltage and its quality by information network and consist from controlling units.

Researches show that small power system can not work without continuous leading synchronous generator, which is worked as frequency etalon. Wind power parks and solar photovoltaic power stations can to work together in small power system when power storages units or accumulators batteries are worked together. These storages are smoothed out the peaks of generated energy and consumers demands maximums. Smooth operation of future electrical energy system is possible by having developed network of various models of storage system.

Small power systems can start to work only during emergencies time of big power system or it can be continuously working part of big system. In this case new smart control and management tasks can be realized (Fig. 4).

![Fig. 4. Small power system’s control and management systems](image)

Overload, fault and disconnection possibility is increasing due to limited power line capacity. Possibility The creation of small power systems and its working in island regime is one of methods to increasing power supply reliability overall. Proper preparation for island regime, preparation of local power generation for autonomous control and further operation in island regime are essential objectives of new control and management system.

Other purpose of small power systems is involvement of energy consumers in active power balancing. Smart control device, for example, smart meter should track momentary electricity price and control consumer’s electric equipments which may standby for cheaper energy.

In further future the extension of electrical car park will became new part of small power system, because it will be powerful energy storage factor.

**Model of small power system**

Small system model consists from one 110 kV line sector with its consumers and thermal power station with two generators and two wind parks on the strength (Fig. 5).

The basic regimes of small power system were simulated. At firstly the moment of disconnection from big system and creation of islanded conditions was investigated.

![Fig. 5. Example of small power system](image)
system in the event of an accident. Short circuit occurred in
the substation of Varduva of 110 kV line near Mažeikių
station.

The changes of voltage and frequency are described
in Fig. 6, Fig. 7.

![Image](image1.png)

Fig. 6. Voltage change during disconnection while system
generates 17 MW and wind power generation is according to area
average wind.

![Image](image2.png)

Fig. 7. Small system frequency change after disconnection.

The transient process of generator power is as
maximum continued for 10 s – 15 s and finished when
stable regimes were achieved. The transient regime of
voltage continued 4 s only. The results of short circuit
simulating are described in Fig. 8.

Small power system power fluctuates during
disconnection moment and in short circuit regime was
investigated. Active power and reactive power change in
14 MW wind power park point during disconnection are
given in Fig. 9.

The wind parks power changes were measured every
2 minutes in real time. From the point of view of
simulation the most complicated operation moment was in
2200 minute cycle, when wind power fluctuation up to
10 MW per 2 min is presented in Fig. 10.

The capability of thermal generators to change its
output power is only 6.4 MW/min or 12.8 MW per 2 min.
The regulation of frequency in small power system is
complicated task and only common efforts by thermal and
wind generation units it can by solving.

These limits put forward requirements to control
equipment and programmes of small power system.

![Image](image3.png)

Fig. 8. Generator power change at different regimes in small
system where short circuit location is on 110 kV line (Mažeikių
station – Varduva substation).

![Image](image4.png)

Fig. 9. Active and reactive power change in 14 MW wind park
point during disconnection from network system while thermal
generators generates 2x40 MW.

![Image](image5.png)

Fig. 10. Wind power park’s generated power during the period

Load forecast model must be applied for this region
after disconnection. Mažeikių station generators are loaded
based on load forecast model.

Disconnected small power system must to balance
and to regulate voltage rapidly, in order to ensure the
quality of system operation real-time control system must
be installed. The investigation shoes that to this control 5 s
periods are suffice.

It is essential to forecast wind power parks generated
power that small power system’s generators and consumers
might prepare for disconnection and control and
management system could calculate the future price of
electricity.

Detection when small power system can to disconnect
and start to work separately is described in [7].

Electric engineers are very interested in electric car
development and widespread usage. Firstly, electric cars
are environmental friendly using electricity instead of
gasoline. Secondly, electric car park is a powerful
electricity consumer capable of variable power consumption of excessive electrical energy system generated power.

Decentralized electrical energy system development would provide competitive energy supply to the market besides the expected direct economic benefits. Electrical energy system development is faster and more efficient because of open market conditions which priority is the most efficient market solutions.

However, there is no experience how operates small power systems and if there is impact to energy cost and expenditure [8]. It is essential to accumulate as much as possible reliable and practically tested solutions while small power system’s operational standards are being created. In the future the power storage units must to play important role too.

Conclusions

Small electrical system can be created with the installation of complex control and management system, in advance to forecast power balance between generators and consumer, control and regulation devices which are necessary to supply power in the grid. If the source is generating too much power excessive power is allocated to energy storage or wind power parks have to be disconnected.

Small power system would shut down if the main generator was disconnected during the short circuit, but a small system could to start work if wind parks have emergency diesel generator that can start as small system again.

Small power system’s dynamic and static stability tests identify that disconnected systems can operate independently, generators reaction speed is sufficient to compensate the changeability of wind power generation and the balancing of small power system is capable to implement.

References


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The work of wind stations is analyzed in condition of small power system, which is established in complicated moments of large energy system, when breakdown or other bottleneck regimes are occurred. The switching of wind power parks to islanding regime as small power system can by one of means to keep wind station in work state, because now in emergencies of system wind stations are disconnected and stopped. An analyzing transients of islanding moment and transients of short circuit where can be took place in small power system can by one of means to keep wind station in work state, because now in emergencies of system wind stations are disconnected and stopped. An analyzing transients of islanding moment and transients of short circuit where can be took place in small power system can be created. In the future the power storage units must to play important role too.

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Analizuojamas vėjo elektrinių darbas yra mažosios elektros sistemos sudėtyje. Ši sistema sukuriama sudėtingais didžiosios elektros sistemos darbo momentais, kai įvyksta avarinis atjungis arba kai pasukėja darbo sąlygos. Vėjo parkų perjungimas dirbtai mažosių elektros sistemos sudėtyje gali būti vienas iš būdų išlaikyti vėjo elektrinių darbinę būklę, nes dabar per sistemos avarijas vėjo elektrines atjungiamos ir stabdomos. Štaiame straipsnyje pateikiama perėmimo viršunės, atsiskirianti nuo sistemos į salos režimą ir trumpojo jungimo akimirksniu, analizė. Pateikiami mažosios sistemos išmaniajai valdymo sistemai keliami reikalavimai. Aptariamos tolesnio tyrimo kryptys. Il. 10, bibl. 8 (anglų kalba; santraukos anglų ir lietuvių k.).