Research on energy management and its control strategies of microgrid

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Abstract: In this paper, the microgrid which is composed of photovoltaic cells, microturbine, storage device and load is researched. On the basis of analysis of the typical structure of microgrid and the operation modes of every microsource, the program of energy management is presented and designed, and its control strategies are researched under the condition of both grid-connected mode and islanding mode. Several algorithmic examples have been studied through simulation, and the simulation results verify the correctness of the energy management's control strategies. The research results indicate that it can ensure the high efficiency and stability operation of microgrid through the coordinated control of energy management.

Key words: microsource, energy management sytem, control strategies, operation modes

I. INTRODUCTION

In recent years, with the increasing emergence of worldwide energy pressure and various disadvantages of extra-large scale power system, Technology of Distributed generation which is represented by solar energy power generation system and wind energy generation system has got more and more recognition. However, some bottleneck problems exist such as high cost of single machine being connected into power grid, difficulties in controlling; a great impact on the network exists in the development. An effective solution to these problems is to develop microgrid technology. Microgrid is a system which is composed with load and microsource and expressed as a single controlled unit to network and a customizable source to user. Microsource is the core unit of microgrid, the electric energy switching, grid-connection and necessary energy control of which is accomplished by power electronic equipment. In insuring the normal running of microgrid under the condition of both grid-connected mode and islanding mode, it is a key problem in research of microgrid technology that how to manage these individual sources reasonably in order that microgrid can meet the demands of users in power quality and achieve ideal economic efficiency effects.

It is an effective way in researching and developing energy management of microgrid in order to ensure flexible running mode and high-quality power supply service, solving all problems such as voltage control, load flow control, load distribution when system is disconnected, stability and operation. In this paper, according to the analysis of the typical structure of microgrid and the operation modes of every microsource, the program of energy management is presented and designed, and its control strategies are researched under the condition of both grid-connected mode and islanding mode. Several algorithmic examples have been studied through simulation, and the simulation results verify the correctness of the energy management's control strategies.

II. MICROGRID STRUCTURE AND WORKING WAYS OF MICRO SOURCES

A. Typical Microgrid Model

As shown in figure 1, microgrid structure for office district of small capacity is designed combining with the typical microgrid structure proposed by CERTS. In this figure, there are three feeder lines in the microgrid, line A and B are in connection with the sensitive load and general load, line C is only in connection with general load. The microsources connected with feeder lines A and B are photovoltaic cells, microturbine, and storage device. When light is plentiful, photovoltaic cells can provide free clean energy, because the output of photovoltaic cells is changing intermittently with the meteorological conditions, in order to ensure continuous supply of load, storage devices are installed in microgrid, and microturbine can provide energy for load when there is no output of photovoltaic cells and storage device. Microsources are installed in different position of the feed lines instead of in the public place; this access mode can reduce the line loss and provide terminal voltage support to feed lines. Circuit breaker, power and voltage controller are installed in each microsource outlet, adjusting their power output for the regulation of the feeder trend under the control of the energy management system.

In order to ensure uninterrupted power supply of important sensitive load of microgrid. When such power quality problems as voltage disturbance or the power failure are monitored, static switch S1 acts and microgrid switches to the island operating mode. At the same time, under control of the energy management system, each microsource adjusts its output power to ensure normal operation of microgrid. For the normal load on feeders A and B, C, the system will remove them correspondingly based on the power balance needs of microgrid.

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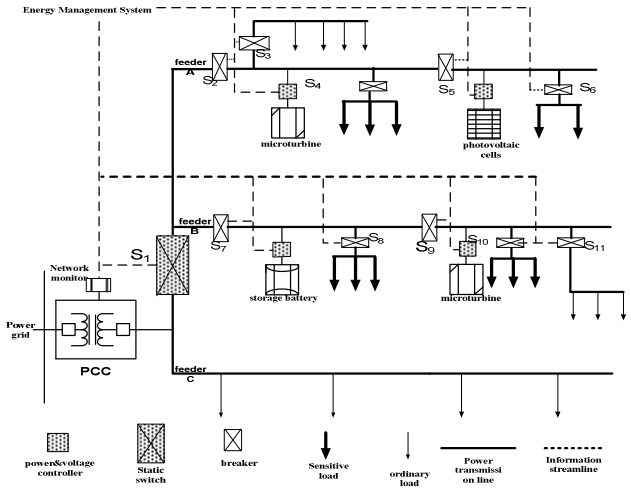

Fig.1 Frame of the Microgrid

B. Working Mode of Microsource

Distributed generation, according to the use of energy and power mode in different ways, can be divided into two types: One is DC source, such as photovoltaic cells, fuel cells, storage device, etc, which need to transform DC into standard AC through the *inverter*, to supply load or be incorporated into grid. The other is AC source, such as microturbine, which supplies load directly or is incorporated into grid. The microsource in this paper adopts photovoltaic cells and microturbine and lead-acid battery representatively as the research object.

1) Working mode of photovoltaic cells

Working mode of Photovoltaic cells can be divided into MPPT mode and fixed power mode.

a) MPPT mode:

Output power integrated into grid of Photovoltaic cells is real-time controlled by Controller, and Photovoltaic cells may generate electricity with the greatest power probably under the role of MPPT control algorithms

b) Fixed power mode:

Photovoltaic cells are operated in the set power. If the set power is higher than the biggest power output of photovoltaic cells, photovoltaic cells will be operated in fixed power mode.

2) Working mode of microturbine

Microturbine with PQ and VF control functions can regulate the power output quickly according to the load changing. There are two kinds of operation mode: high output operation and low output operation. The operation mode is decided by the energy demand of load in island state.

3) Working mode of lead-acid battery

Storage battery has two kinds of working mode.

a) Recharging mode: storage battery is charged normally until it is full when the remaining capacity of battery is 0. When the storage battery works as an adjusting power, remaining capacity should be checked at all time before the operation, and it cannot be charged temporarily, especially when the battery works in the island mode and the residual capacity is 0.

b) Discharging mode: In the island mode, when sensitive load demands higher energy, and the energy output of photovoltaic is not enough, storage battery is demanded to provide energy through discharging. Discharging controller has PQ and Vf control function in response to the change of load, can provide good power supply quality.

III. MICROGRID ENERGY MANAGEMENT SYSTEM AND ITS CONTROL STRATEGY

A. Microgrid Energy Management System Functions

Microgrid energy management system integrates data processing, programming, command distribution and combining microgrid function, including the management of the microsource, energy storage management, loading management, breaking and combining network control functions.

1) Microsource control function

Microgrid has self-adaptive function regulating power by adjusting the power-electronic conversion and controller fast tracking the active and reactive power changes. And it can adjust its energy output and maintain system power balance.

2) Management of energy storage devices

management has such functions as Battery's charging and discharging, voltage, power management, detecting electrical storage charge and discharge status, it can manage the charging and discharging system depending on requirements of system, and can control the output voltage, the active and reactive power, and participate with the active and reactive power control.

3) Load management

It can be to distribute microsource output according to the detected load , maintain the balance of microsource and load, remove normal loads to ensure the normal power supply for sensitive loads in the operation of island mode of the microgrid,

4) Mode switching and on-off control

When testing large electric network calls, micro-grid will automatically run the transition from the island mode to the Grid mode. When failure happens after combining grid and in the exterior of micro-grid, it can be determined the fault severity through the main network to communicate with the microgrids. If exceeding self-regulation extent, the corresponding microgrid can break with the main network and run into the island mode. It can achieve a seamless transition between two modes of operation. Based on the working state of micro-grid, it can send the switching logic signals of microsource, load, and the circuit breaker.

5) Monitoring function

The controller uploads respective status information through the communication line, including the network parameters of the PCC point, the output characteristics parameters of the microsources, circuit breakers' on-off state, the all power parameters of loads, according to the comprehensive data processing through energy management system. It can establish microsource switching, working mode switching, power output and other regulations, the circuit