MATCHING BUILDING LOADS WITH SOLAR AND WIND POWER IN OFFICE OF THE EAEPD AS A MICRO GRID

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ABSTRACT

With the development of distributed generation resources and the increase of energy generation technologies, the operation of power systems faced with new complexities. Using renewable energy resources with small installable capacities at the demand (consumption) side, emplacement is a way to reduce environmental pollution, the use of fossil energy resources and save transport costs. To achieve high penetration depth of renewable sources into the micro-grid, an exact system operation is needed. . This paper presents a real micro grid that composed at East Azerbaijan Electric Power Distribution Company (EAEPD). The network is made up a micro grid with distributed energy resources which is connected to the global network. GIS platform is solution for simulate and software for operation of this micro grid. The purpose of model is supplying power to the loads with minimum cost and pollution. The distribution network's required power is provided in two ways: Via the global grid and via small capacity wind turbines and solar panels. Specifically, we focus on network architecture, reliability requirements and challenges of both loads on the building and the resource power supplies.

INTRODUCTION

Along with the deregulation of the electric industry and the development of smart grid issues, distributed generation (DG) has increased significantly in the past decades as a promising approach to solve the emerged environmental and energy problems. The fast development of DGs and power electronic technologies has brought about the concept of micro-grid [1]–[5]. Using advanced techniques and technologies appropriate to the type of energy generation and utilization in power system control and operation is a part of the current requirements. Electric smart grids provide a future of managing energy distribution networks. Most commercial and administrative buildings obtain electric power from the grid, space heating from a furnace or boiler, and hot water from a gas-fired or electric-resistance water heater. A micro-grid could be defined as a low voltage network which incorporates local DGs, local loads, energy storage, etc., providing electrical power and heat. Generally, a micro-grid could be operated under two modes [1]:

1) Connected Mode: The micro-grid is connected to the utility grid as a downstream branch.

2) Islanding Mode: The micro-grid is islanded from the utility grid and works autonomously, affording the local loads independently.

As in the industrial sector (where processes that require sustained levels of both electricity and heat are common), combined heat and power (CHP) tends to be most attractive in commercial building applications having thermal loads that are relatively high and continuous. The CHP is great, but the price of this technology is high for sum of the buildings .

We will obtain an optimal model for a distribution network – building network. The purpose of model is supplying power to the loads with minimum cost and pollution. The distribution network's required power is provided in two ways:

- Via the global grid,
- Via small capacity wind turbines and solar panels.

Micro grids are separate regional parts in low voltage network level which are made up from the combination of small loads, distributed energy resources, storage resources, control and intelligent equipment and loads accountable to the system administrator. This paper presents a real micro grid that composed at East Azerbaijan Electric Power Distribution Company (EAEPD). The network is made up a micro grid with distributed energy resources which is connected to the global network.

Following the technology tendencies, the energy companies use the computational tools for geoprocessing, called Geographic Information Systems (GIS) and the ability to query and analyze the information directly from the georeferenced database for use in constructed models allow you to perform more refined studies and a higher level of detail. This integration between georeferenced databases with the models proposed in the methodology is considered, making the planning can be done from the real data coming from the database of georeferenced information system (GIS) of the company [6]. In this sense, an application with a friendly interface was developed allowing the use of such data. A real network is used as an example and computational results are presented.

SYSTEM LAYOUT AND OPERATION STRATEGY

Microgrids are separate regional parts in low voltage network level which are made up from the combination of small loads, distributed energy resources, storage resources, control and intelligent equipment and loads accountable to the system administrator [7-10].
Microgrid management reduces the cost of providing the required energy; Minimizes costs to customers, improves the power quality and increases social welfare. Several microgrids could connect the distribution network and have power exchange with each other. The utilized Microgrid control method in this paper is a hierarchical method. This control method is determined at different levels [11]:
Distribution Management System level (DMS), Microgrid System Central Controller level (MGCC), Microsource Controllers level (MC), and Load Controllers level (LC). These levels are shown in Fig. 1.

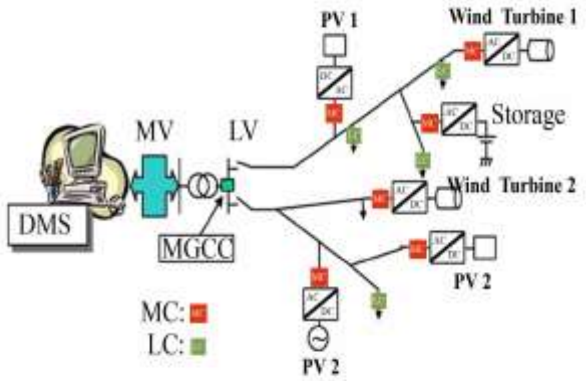
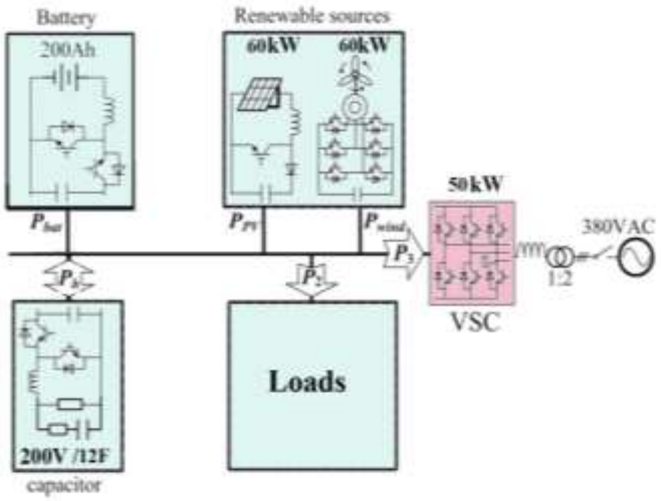


Fig. 1. Different control levels of a microgrid based on template of the reference [11]

As a typical renewable energy-based dc micro-grid, the configuration is schematically displayed in Fig. 2. It consists of the following elements:
1) 400 V dc bus of the micro-grid (for jointing all the units directly or through power electronic converters);
2) Renewable energy sources, including photovoltaic (PV) and wind turbines, are connected to the dc bus through power electronic converters;
3) Various loads including resistor load and power electronic converter interfaced load that are used on building.
4) Hybrid energy storage, consisting of battery which are used to smooth the power flow and shift the loads;



A GIS is fundamentally a database of objects, each of which can be indexed by a location in terms of an x-coordinate, a y-coordinate and elevation coupled with a graphical interface that displays these objects on a map. Generation units, power lines, transformers, substations, and buildings or other sites where loads occur can be represented in a GIS database and displayed on a computer screen so that operator can see clearly the components that make up the power system under operation. In addition, GIS provides a connection that permits linking the physical and economic databases of the electric grid to available sociopolitical databases, opening the possibility to study the effect public policy, public perception and other sociopolitical factors that influence decision makers in real systems [12]. Coupling the GIS system to the simulation program provides a seamless interface for the user between data entry and real condition. GIS Map Benefits for power system managements are:

- Reduce data-entry costs by using GIS-updated engineering data for system studies (every time)
- Avoid duplicate/incorrect data entry
- Full control of analysis results displayed on the GIS map
- Direct communication with Geo-database & map documents
- Flexible usage of engineering software (such as ETAP) modules for analysis

These cost-benefits are reason for renewable energy and loads simulation on GIS software.

FORMULATION

The combination of all large power plants and the global network made ups the primary network which connection to the microgrid is modeled (simulated) in this formulation. Regarding the microgrid´s conditions and its connection to the global network in the presence of distributed generation resources, the one day-ahead market will be selected for modeling. Increasing profits will be the market's main goal. The resulted profit includes the generation, consumption and network management profit. The main objective function of the problem will be shown as Equation (1):

$$\text{Max} \quad \text{Profit} = \text{Revenue} - \text{Expenses} \tag{1}$$

This relation will be studied at a 24 hour period. The income includes the amount paid to the large power generation units, the money paid to the distributed generation units and the promotion paid to distributed generation units with renewable energy resources. The microgrid management will try to increase its profits through applying intelligent systems. However, the constraints of the problem must also be considered.

The amount of energy generated by distributed generation resources in the microgrid in addition to the total delivered energy from the global network must provide the customer's demand.

$$P_{MG} + \sum_{j=1:N} P_{DG} \geq \sum_{i=1:L} P_{loadi} \tag{2}$$

In order to increase the reliability of the power network, the operator of the microgrid needs minimal power storage due to the network load, history of network events and available resources. This storage will be provided through the overall market or internal resources. A schematic diagram of a connected microgrid to the global network is shown In Fig. 3. The variable parameters are specified to display the constraints.

$$P_{DER} = P_{PVs} + P_{WTs} + P_{SEs} \tag{3}$$

$$P_{PVs}(t) = \sum_{r=1:R} f_r(T(t), Q(t)) \tag{4}$$

$$P_{WTs}(t) = \sum_{k=1:K} f_k(V(t)) \tag{5}$$

$$P_{SEs}(t) = \sum_{s=1:S} P_{SE}(t-1) + (P_{Gen} - P_{De})(\frac{\Delta t\alpha(t)}{V(t)}) \tag{6}$$

$$P_{SE}(t=0) = A \tag{7}$$

$$P_{SE}(t=Nt) = B \tag{8}$$

PDER is the amount of generated power by renewable distributed generation resources in this relation. This power includes the output power of small wind turbines and solar cells. $P_{SE}(t)$ and $P_{SE}(t-1)$ are the stored power in batteries. α (t) is the battery's efficiency at the time period t. It can be concluded from the relation relevant to the solar cell power which is shown with PPV that the amount of this power depends on the temperature and penetration level of the cells. The maximum and minimum stored powers in the batteries are shown with the words A and B.

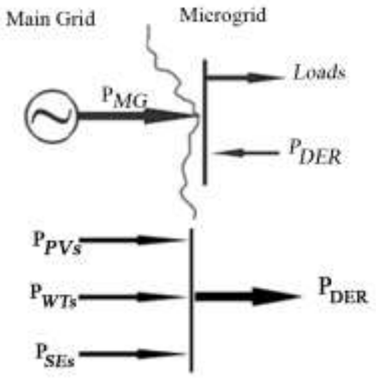


Fig. 3. Schematic diagram of a microgrid and energy resources

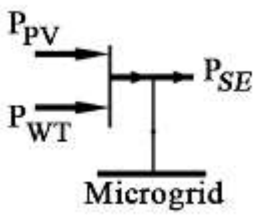


Fig. 4. Schematic diagram of the battery charging and discharging and power transmission to the network

SYSTEM OPERATION STRATEGY

As aforementioned, the conventional system operation strategy of micro-grids is characterized by bus voltage source alternation between the utility gird and their subsystems that support his loads. This operation design always takes with it a lot of great concerns that are difficult to address. To make the operation mode switching more flexible and reliable and also to simplify the power dispatching algorithm of the power system, this paper proposes a GIS-base system operation strategy:

- The amount of the received power by the distribution network is in any time period equal to the sum of the received power from the global grid, wind turbines, panels, and batteries:
- The generated power by the wind turbines and solar panels are flowing directly to the building network or being stored in the existing batteries.
- The global grid can provide all the required power for the network if it's necessary.
- The maximum gained power from the wind turbines and solar panels is equal to the sum of the maximum power stored in the batteries and the generated power by the wind turbines.

CASE STUDY AND SIMULATION

Case study is a real micro grid that composed at EAEPD. The network is made up a micro grid with distributed energy resources which is connected to the global network. The micro grid feeders that are fed radial are shown in Fig. 5.

Fig. 5. Case study simulation on GIS

Fig. 6 shows the graphs of the delivered powers by the global network in the simulation. The encourage cost paid to the distributed generation units for increasing their generation will be equal to $97 for a day. In addition to reducing the money transfer from the microgrid to the global network, the amount of the generated power by the renewable energy resources will increase and environmental pollutants will be reduced proportionally.

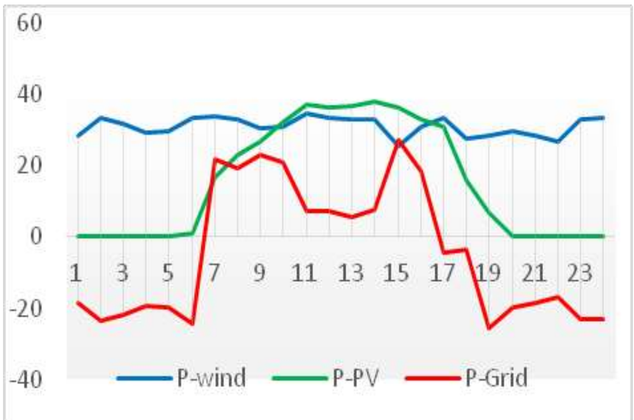


Fig. 6. The delivered power by the global network, PV and wind turbine generation on case study

CONCLUSION

This paper proposes a novel system operation strategy and the corresponding energy management method for a renewable energy-based small-scale building as a dc micro-grid using GIS, consisting of battery and capacitor. Using the capabilities of GIS software simplifies the operation of the network. There are also disappears many errors due to the wrong simulation.

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