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Development perspectives of Microgrid in Uzbekistan

*[1]Ziyodulla Yusupov, [2]Muhammet T. Guneser and [3]Jurabek Izzatillaev
*[1]Faculty of Engineering, Department of Electrical and Electronic Karabuk University, Turkey
[2]Faculty of Engineering, Department of Electrical -Electronic Karabuk University, Turkey
[3]Power Engineering and Automation Institute, Academy Sciences of Uzbekistan, Uzbekistan

Abstract

Last decades with rapidly penetration of distributed energy resources to the power system, the interest on microgrid is growing. Microgrid appears with the development of distributed generations and distributed energy resources, such as PV, wind, microturbines, fuel cell, combined heat and power, etc. A microgrid combines distributed energy resources, storage devices (flywheels, energy capacitors and batteries) and flexible loads, and connected to the power grid via switches. Microgrids as a key component of the smart grid are intended to improve energy efficiency, a reliability of power system and decrease carbon dioxide emissions. In this paper are introduced the concept and operation of microgrid, as well as considered the problems and development perspectives of microgrid in Uzbekistan.

Key words: microgrid, smart grid, distributed energy resources, distribution generation

1. Introduction

Problems of environmental protection, energy security and economic development, referred to as the “three E” (Environment, Energy, Economics), are interlinked global challenges of the modern era. Nowadays it is becoming clear that the challenges facing the energy sector are becoming acuter. Power systems operation becomes more labor-consuming, which ultimately will require the widespread introduction of intelligence in the interest of safety, economy and efficiency, thereby creating the preconditions for the emergence of "Smart Grid" concept. These problems have led to a new concept of Smart Grid. According to the European Technology Platform of Smart Grids [1], a smart grid (SG) is an electricity network that meets future requirements for energy-efficient and economical operation of the power system through the coordinated management and using modern two-way communications between the elements of electrical networks, power plants, accumulating devices and consumers. The evolution of the traditional power grid towards smart grid involves the grid decentralization into microgrids (MG). Microgrid is a basic element of smart grid and as a key component of the smart grid are intended to improve energy efficiency, the reliability of power system and decrease Carbon dioxide emissions. The term microgrid refers to the concept of single electrical power subsystems associated with a small number of distributed energy resources (DERs), both renewable and/or conventional sources, including photovoltaic, wind power, hydro, internal combustion engine, gas turbine, and microturbine together with a cluster of loads [2]. Last decades with the rapidly penetration of distributed energy resources to the power system, the interest on microgrid is growing.

*Corresponding author: Address: Faculty of Engineering, Department of Electrical-Electronics Engineering, Karabuk University, Demir-Celik Campus, Baliklarkayasi Mevkii 78050, Karabuk TURKEY. E-mail address: ziyadullayusupov@karabuk.edu.tr, Phone: +903704332021/3838

2. Microgrid Definition and Concept

The pioneers of MG the Consortium for Electric Reliability Technology Solutions (CERTS) and the European Commission Project Micro-Grid gave the following definitions to MG:

According to the CERTS [3] "*Microgrid is the cluster of loads and microsources operating as a single controlled entity and providing both power and heat energy. The microgrids are power electronically interfaced as they enhance the power reliability and quality of the power supply*". A vision of MG by CERTS is illustrated in fig.1.

According to the EU research projects [4, 5]: "*Microgrids comprise LV distribution systems with distributed energy resources (DER) (microturbines, fuel cells, PV, etc.) together with storage devices (flywheels, energy capacitors and batteries) and flexible loads"*. A vision of MG by EU research projects is illustrated in fig.2.

The main components of MG are:

- distributed generation sources such as photovoltaic panels, small wind turbines, fuel cells, diesel and gas microturbines etc.;
- distributed energy storage devices such as batteries, supercapacitors, flywheels etc.;
- critical and non-critical loads.

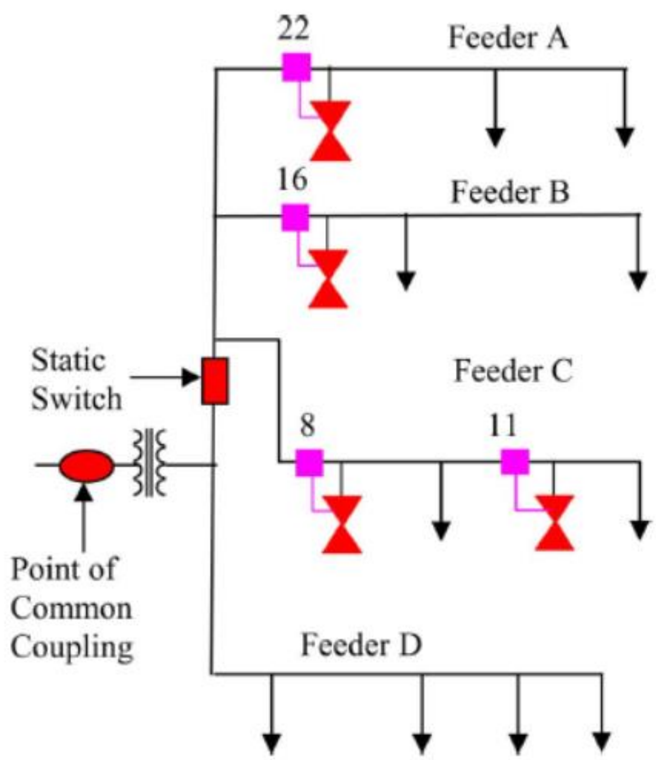


Figure 1. A vision of MG by CERTS [6]

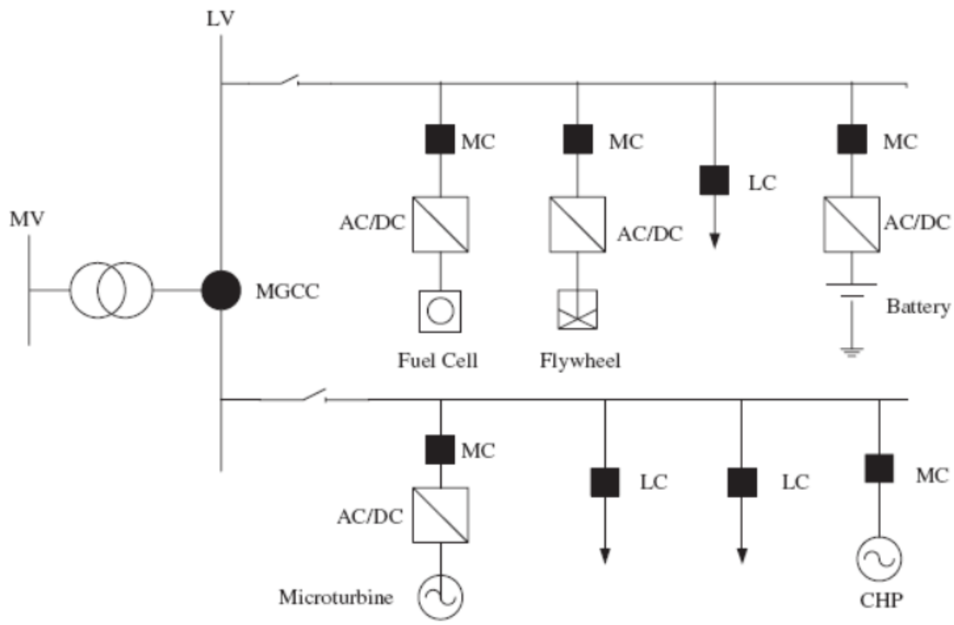


Figure 2. A vision of MG by EU projects [7]

2.1. Operation and control of Microgrid

MG can be operated:

1) in stand-alone or islanded mode, if MG operates autonomously;
2) in grid-connected mode, if MG connected to the main grid.

In stand-alone mode, microsources provide loads with necessary power energy and MG never connects to the main grid.

In grid-connected mode, MG remains connected to the main grid either totally or partially and extra power generated in MG can be exchanged with the main grid providing auxiliary services.

MG consists of a group of radial feeders (A, B and C), which could be part of a distribution system architecture and a collection of loads (figure 3). The radial system is connected to the distribution system by a point of common coupling (PCC) via a static switch. The Point of Common Coupling (PCC) is on the primary side of the transformer and separates main grid from MG. Each feeder has a circuit breaker and microsource controller [6]. Local critical loads connected to the local generation resources while non-critical loads do not have any local generation. The static switch is capable of islanding the MG when disturbances occur or for maintenance purposes.

MG control can be mainly classified into the following control levels:

- Local;
- Secondary;
- Tertiary;

The *local control*, also known as primary control or internal control, is the first level in the control hierarchy. This control is based on local measurements and requires no communication. The purpose of this control level is to manage the current and voltage of microsources.

The *secondary control* ensures that the frequency and average voltage deviation of the MG is regulated toward zero after every change in load or supply. It is also responsible for inside ancillary services.
The *tertiary control* is the highest level of control and provides optimal operation in both operating modes of MG and power flow control in grid-tied mode. This tertiary control is responsible for coordinating the operation of multiple MGs interacting with one another in the system, and communicating needs or requirements from the host grid (voltage support, frequency regulation, etc.). [8, 9].

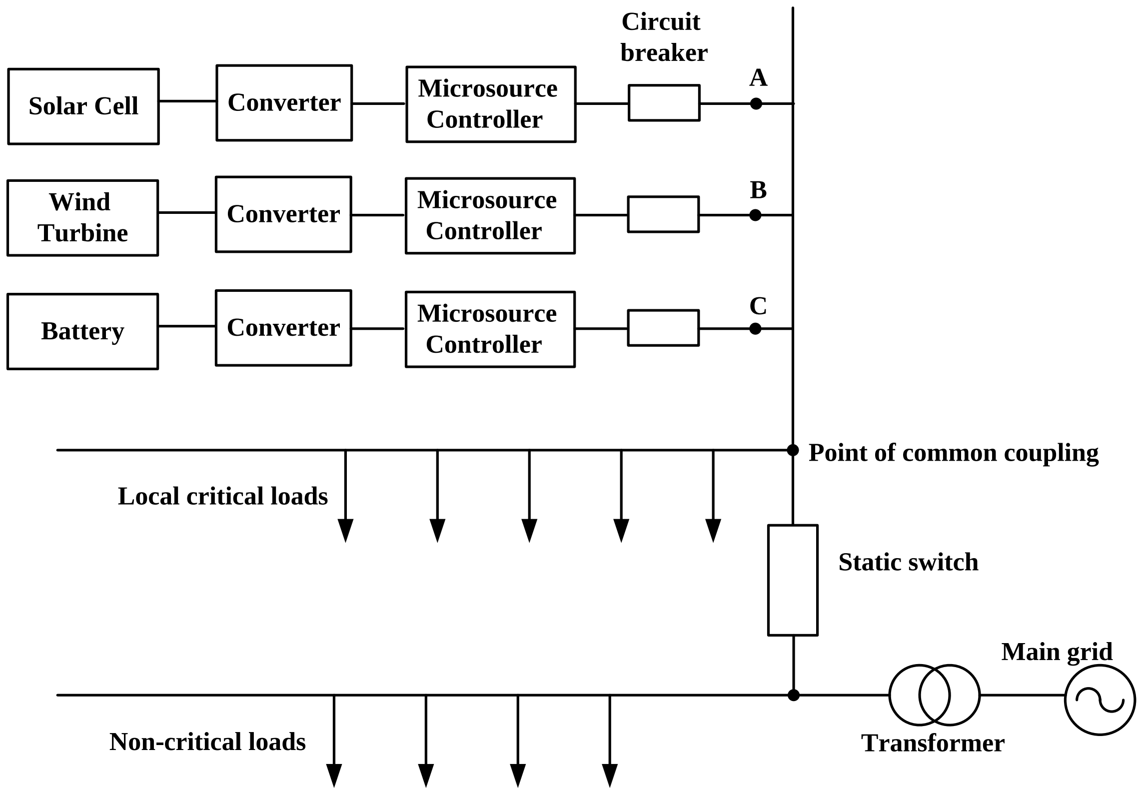


Figure 3. Schematic diagram of the microgrid

2.2. Benefits and advantages of Microgrids

The works [10, 11, 12] conducted by researchers present technical, economic and environmental benefits associated with MGs.
There are several technical benefits of MG:

- the lack of vulnerability of large networks
- power blackouts reduction
- energy loss reduction
- improved voltage quality via coordinated reactive power control and constrained active power dispatch

- relief of congested networks and devices, for example during peak loading through selective scheduling of microsource outputs.

The economic benefits of MG consist:

- higher energy efficiency
- reduced transmission and distribution costs
- minimization of fuel cost
- the small scale of individual investments reduces capital exposure and risk, by closely matching capacity increases to growth in demand.
- the low capital cost potentially enables low-cost entry into a competitive market.

The environmental benefits of MG include:

- reduced emissions of greenhouse gases
- reduced emissions of criteria pollutants.

Researchers note that MG offers a number of important advantages [6, 13, 14]:

- The ability of MG, during a utility grid disturbance, to separate and isolate itself from the utility seamlessly with little or no disruption to the loads within the MG;
- In peak load periods it prevents utility grid failure by reducing the load on the grid;
- Significant environmental benefits made possible by the use of low or zero emission generators;
- The use of both electricity and heat permitted by the close proximity of the generator to the user, thereby increasing the overall energy efficiency;
- MG can act to mitigate the electricity costs to its users by generating some or all of its electricity needs;
- Enhancing the quality of power which is delivered to sensitive loads.

3. Power Energy of Uzbekistan

One of the major factors that could contribute to sustainable development and competitiveness in the economy is a more efficient use of energy resources.

The majority of Uzbekistan's power generation, transmission and distribution assets are owned and operated by subsidiaries of a single holding company – Uzbekenergo. Currently, the majority of energy consumed in Uzbekistan is produced by thermal power plants. At the same time, the main share in the structure of energy consumption belongs to the oil and gas resources. Uzbekistan has substantial proven reserves of organic fuel and a robust hydroelectric potential. It accounts for more than 40% of the entire Central Asia's natural gas and some 20% of Central Asia's oil. The proven reserves of condensate oil exceed 350 million tons, of a natural gas reach around 2,000 billion cubic meters, and coal almost 2,0 billion tons. Uzbekistan is among the top ten largest producers of natural gas in the world. Hydrocarbons are the main sources of electricity in Uzbekistan.

The installed capacity of Uzbekistan power plants exceeds 12.5 million kW, which represents more than half of all the generating capacity of the Interconnected Power System of Central Asia that includes the power systems of Turkmenistan, Tajikistan, Kyrgyzstan and southern Kazakhstan. Power plants include 10 thermal power plants with a capacity of 11.1 million KW and 29 hydraulic electric stations with capacity of 1.4 million KWh (figure 4) [15].

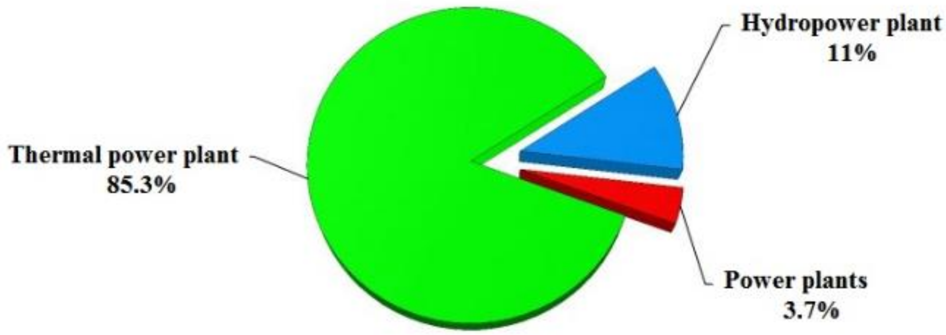
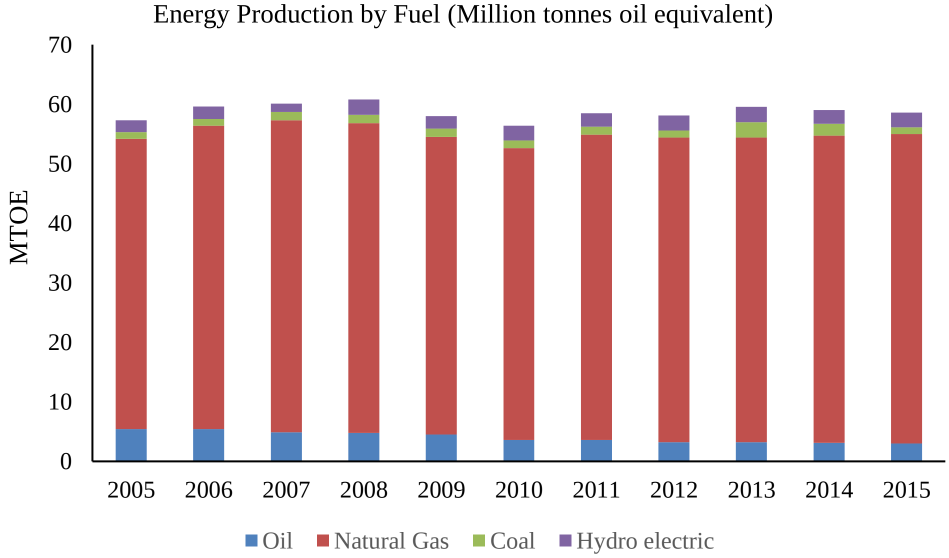


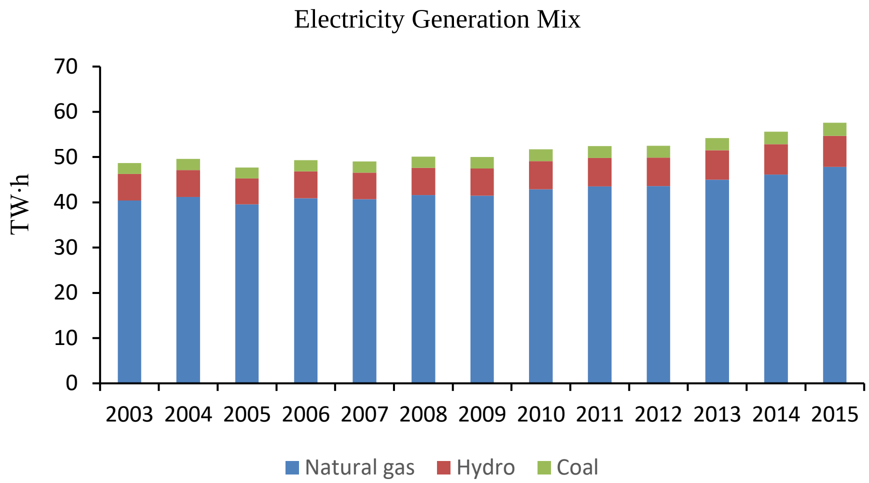
Figure 4. The structure of the installed capacity of power plants in Uzbekistan

Experts of the center for economic research believe that country's proven reserves of hydrocarbons are enough to keep its economy running steadily for the next 20-30 years [16]. In the figures 5 and 6 are illustrated an energy production by fuel and electricity generation mix in Uzbekistan during last ten years. As shown in Figure 6, total electricity generation in Uzbekistan grew from 47.7 Terawatt hours/year in 2005 to 57.6 Terawatt hours/year in 2015.
Calculations show that the country's electricity demand in 2030 will rise against the current year is approximately 2 times and amount to more than 105 billion kW·h.



Source: BP Statistical Review of World Energy, 2006 - 2016

Figure 5. Energy production by fuel



Source: BP Statistical Review of World Energy, June 2016

Figure 6. Electricity generation mix

3.1. Development issues of microgrid in Uzbekistan

Uzbekistan has a huge potential of renewable energy sources, especially in a solar energy. So the number of sunny days there are more than 300 days. The climatic and geographical conditions of Uzbekistan allow active use of solar energy to produce electricity and thermal energy on an industrial scale. Data from multi-year observations from solar activity measurement and monitoring stations in Uzbekistan show that the duration of sunshine varies between 2410 and 3090 hours/year, with seasonal fluctuations of 11-13 hours/day in summer and 3-5 hours/day in winter. There is also a difference of solar radiation amount is 27 MJ/m^2 per day in the summer and about 7 MJ/m^2 in winter.

The potential of renewable energy sources is estimated at almost 51 billion t.o.e. and their technical potential is estimated at 180 million t.o.e., of which are currently utilized 0.72 million t.o.e. or 0.33% (table 1) [16, 17].

Table 1. The Potential of Renewable Energy Sources in Uzbekistan

Renewable energy resources	**Energy potential, million toe**		
	Gross	**Technical**	**Put to use**
Hydropower: including: • large rivers • small rivers, water-storage reservoir and channels	9.2 8.0 1.2	2.32 1.81 0.51	0.72 0.56 0.16
Solar	50973	176.8	-
Wind	2,2	0.4	-
Biomass	-	0.5	-
Geothermal	0,2	-	-
Total	**50984.6**	**180.02**	**0.72**

According to the information of Uzbekistan's Ministry of Economy, implementation of measures to promote renewable energy resources in the basic sectors of the economy will lead to savings of 250.1 million KWh electric energy, of natural gas – 3 million of cubic meter and heat energy – 20.1 Gcal [18].

The most important factor driving the development of distributed energy in the world as well as in Uzbekistan is the diversification of energy balance by increasing the share of local and alternative sources of energy (biomass, renewable energy, etc.), which entails more rational use of strategic resources - hydrocarbons. Therefore, one of the most important areas of energy policy at the present stage is the transition from traditional, centralized model of unified energy system of Uzbekistan with a predominance of large generation sources to a variety of types and forms of harmonious combination of distributed generation in Uzbekistan regions.

Undoubtedly, the development of MG in Uzbekistan requires state support measures aimed at stimulating the expansion of its use. There is required to develop a regulatory framework providing the development of MG; to create an appropriate methodological basis; to amend the legislation providing customs and tax incentives for the development of MG such as reduction of import duties on equipment, preferential taxation of production.

According to today's experience and publications, MGs can find its application in Uzbekistan in the major MG market segments such as (i) institutional and campus MGs, (ii) commercial and industrial MGs, (iii) military MGs, (iv) community and utility MGs, (v) island and remote "off-grid" MGs. MG helps the transition from a centralized system using large sources of electricity generation, the use of different types of DER, the most appropriate to natural conditions and features of specific customers.

In the last years some work on the development of renewable energy is carried out in the republic. As part of the regulations and Decrees of the President of the Republic of Uzbekistan from March 1, 2013 # BP-4512 "On measures for further development of alternative energy sources" and # RP-1929 "On creation of the International Solar Energy Institute" Solar Energy Institute established.

The solar PV station with capacity of 130 kW was start of operation on December 7 2015 in Pap district of Namangan region.

A mobile stand-alone solar power plant with capacity of 1.2 MW has been put into operation in Bukhara region at the beginning of 2016. The station is designed for the continuous provision of energy production facilities and the construction of infrastructure projects Kandym deposits of the Russian company "Lukoil", staying away from the central power supply networks.

In addition, the works on involving in the fuel and energy balance of renewable energy sources are carried out by Joint Stock Company "Uzbekenergo". In the medium term, planned construction of solar photovoltaic power plants with a capacity of 100 MW in Samarkand, Namangan and Surkhandarya regions.

Conclusions

The MG as a basic element of smart grids has an important role to increase the grid efficiency, reliability, and to satisfy the environmental issues. This paper presents the architecture, operation and control of MG.

Uzbekistan has a huge potential for using renewable energy sources and the issues of developing the concept of a microgrid in Uzbekistan have been examined.

The evaluations of gross and technical potentials of renewable energy sources in Uzbekistan give the following conclusions:

- the availability of some types of renewable energy is almost all over the country is required for radical revision of using strategy of national energy resources, both in the near and in the long-term perspective;
- the implementation of MG will be bringing above mentioned technical, economic and social benefits to the economy of Uzbekistan;
- large-scale use of renewable energy sources by switching to a decentralized energy supply would solve a number of problems to improve the energy supply facilities in rural areas, especially in remote inaccessible areas.

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