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Some Aspects of Future Power System Scenario

V. Jayalakshmi[1], G. Devipriya[2], Mr. A. Alaudeen[3]

II Year EEE, Department of Electrical and Electronics Engineering, Dhirajlal Gandhi College of Technology, Salem, Tamil Nadu[1, 2]

Assistant professor, Department of Electrical and Electronics Engineering, Dhirajlal Gandhi College of Technology, Salem, Tamil Nadu[3]

Abstract: Generation, Transmission, Distribution and Utilization of Electrical energy is likely to undergo some very big changes in the years to come. This paper discusses some of these changes. The aspects covered are : Distributed Generation, Distributed Energy Storage System, Renewable Energy Resources, Proliferation of Power Electronic Devices, Electricity Deregulation, New Transmission Line Conductors.

Keywords: Energy, Renewable Energy, Distributed Generation

I. INTRODUCTION

Distributed generation means small size generating plants close to customer premises. DG systems are typically less than 5 MW. They feed the distribution system directly and may be installed by Utilities or by big consumers. They may be of any type but are most likely to be solar power plants or wind energy plants.

Advantages:

a) Utilities: Advantages to utilities include transmission capacity relief, distribution capacity relief, grid investment deferment, improved reliability, VAR support, energy and load management.

b) Consumers: Advantages to consumers include efficient use of energy from combined heat and electricity, lower costs, freedom from power cuts, improved power quality, incentives from utility for capacity reserve.

c) Commercial power Producers : The advantages to commercial power producers include new business opportunities, ancillary services market (reactive power, standby capacity)

1.1 Distributed Generation Sources **:**

Table 1 indicates some likely sources for distributed generation:

Table-1 Distributed Generation Sources

Energy Source	**Typical Rating**
Combustion Turbines	1 To 30 MW
Reciprocating Engine	10 kW To 10 MW
Micro turbines	1 To 300 kW
Fuel Cells	1 kW To 20 MW

2. Non Conventional:

Energy Source	**Typical Rating**
Biomass	1 To 5 MW
Wind Turbines	1 kW To 1 MW
Solar	1 kW To 20 MW
Photovoltaic	1 kW To 1 MW

1.2 ANTI-ISLANDING PROTECTION **:**

Interconnection of DG sources to grid raises many issues and technical difficulties. Islanding means the condition when the grid is intentionally or accidently disconnected from the distribution system. This condition may pose danger to maintenance personnel, public safety and equipment.

Therefore it is necessary to detect this condition. IEEE standard 929-2000 and IEEE standard 1547-2003 address this problem. Detection of this condition is done by a suitable anti-islanding algorithm.

1.3 APPLICATIONS :

These include local voltage regulation, Frequency Responsive Spinning Reserve, P.F Correction, Congestion Management, Intelligent power Scheduling, Peak shaving power quality services, Reserve Dispatch, Unit commitment, power Flow Control etc.

II. DISTRIBUTED ENERGY STORAGE SYSTEM (DESS)

1.4 NEED FOR DESS

Electrical Power system is very unique in one respect i.e demand and supply must match at every instant. The Electrical Engineers throughout the world have to predict the demand and be ready to meet the demand at every instant. Since the demand varies throughout the day and year, power plants have to be sometimes operated at low loads.

This causes loss of economy. The need for an efficient energy storage system has long been felt. Pumped hydro is one form of energy storage. Hydrogen has also been suggested as a storage option. The use of Solar and wind has also not been able to expand due to absence of storage.

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1.5 ADVANTAGES OF DESS

a) Utilization of solar and wind energy. Both these sources are very variable. Moreover their availability does not match with the requirement. An efficient storage system can help in more effective utilization of renewable energy systems.
b) Peak Shaving. It is very costly to operate power plant for a few hours every day to supply peak load. An efficient storage system can help mitigate this problem.
c) Deferring transmission/substation up gradation.
d) Reduction of losses.
e) Service to radially fed loads during fault.
f) Improved reliability of electric supply.
g) Reserve optimization.

1.6 ISLANDING

Islanding means isolation of certain load areas from the grid and supplying these areas by local resources. If DESS is available these areas can be supplied by battery through dc/ac convertor. This has been made possible because of advances in power electronics and battery technology. The ability to island during natural disturbances can improve reliability indices significantly. Multi MW multi MWh sodium sulphide batteries have been found to be very useful for such purposes. Areas which can benefit from islanding include i) Areas fed by long old lines ii) Areas with dense vegetation iii) areas prone to high velocity winds, storms, lightning etc.
Once a fault occurs on lines feeding such areas, repair and restoration can mean power supply disruption for several hours. In such situations DESS can be very effective in improving reliability.
Islanding can be either DDI or ADI

1.6.1 DDI

This means disconnecting discrete zones or sections of the grid and feeding them through DESS. Advanced communication tools are used for this purpose. These tools are distributed intelligence spread among the feeder sections and protective devices, which can communicate directly with each other to operate automatically.

1.6.2 ADI

ADI refers to turn ON and OFF individual customers through the use of advanced metering infrastructure. Thus each consumer load is treated as island and each consumer's meter can be controlled remotely. Thus critical loads (Hospitals, fire houses, Police stations etc.) can be given priority. Presently ADI devices are still in development stage but will become very popular in years to come.

III. RENEWABLE ENERGY RESOURCES

The world has been facing an energy crises for the past few years. The reserves of fossil fuels are fast depleting and renewable energy resources will play an increasingly important role in future energy generation programs. Many renewable energy options exist but solar and wind energy are likely to be the most prominent.

1.7 SOLAR ENERGY

The principle of solar energy utilization is very simple. When light radiation falls on a P-N junction, a voltage is generated. The photovoltaic cells convert Sun's energy into electrical energy. Many photovoltaic technologies exist. Some of these are : crystalline silicon, Multi crystalline silicon, Thin film amorphous silicon etc. It has been reported that production of solar cells is increasing exponentially every year.
Photovoltaic power generation systems can be stand alone systems, hybrid systems, grid connected systems and consumer application systems. All these technologies will be exploited in future.

The solar insulation varies during the day and also during summer and winter. Therefore it is necessary to control the terminal voltage of a solar array to get maximum output. The maximum power point is tracked by MPPT (Maximum power point tracker).
India has an ambitious solar energy utilization program. Jawahar Lal Nehru solar mission has been launched in January 2010. Under this programme 20000 MW of solar energy is likely to be added in the next 10 years. Moreover millions of solar water heaters, solar cookers, solar lanterns etc exist and many more are being added every year.

1.8 WIND ENERGY

Winds are caused by pressure differences. Many countries have very big wind energy utilization programs. The present installed capacity of WEG in some countries are : Germany 25000 MW, Spain 15000 MW, USA 16000 MW, India 9000 MW. Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat are some leading states in this respect.

Selection of sites for WEGs depends on wind availability, availability of land, access to land and grid stability.
The average capital cost of WEG in India is about 1 crore per MW and the generation cost is about Rs 2.25 per KWh. These costs are likely to come down in future due to large scale manufacture of wind turbines and generators.
Synchronous generators, Permanent magnet synchronous generators and induction generators are used in wind programs. Induction generators require reactive power to set up the magnetic field. This leads to Tand D losses and voltage instability.

IV. PROLIFERATION OF POWER ELECTRONIC DEVICES

The use of power electronic devices is increasing tremendously. Power electronic devices inject harmonics into the system and cause power quality problems. However these problems can be solved by the use of shunt active filters.

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1.9 POWER ELECTRONICS INTERFACE

All renewable energy utilization programs require a power electronics interface. The functions of this interface are:

a) Power conversion from a variable dc or ac voltage compatible with grid voltage and frequency.
b) Output power quality assurance with low total harmonic distortion, low voltage and frequency deviations and low flickering.
c) Protection of system from abnormal voltage, current, frequency and temperature conditions with additional functions as anti islanding protection, electrical isolation etc.
d) Control of system with objectives like maximum power point tracking of PV arrays, maximum power extraction from wind energy system etc.

1.10 HVDC SYSTEM

HVDC power transmission has been found to be economical for long distance bulk power transmission. Sometimes HVDC is also used due to its technical advantages. Each HVDC project uses an ac-dc convertor at sending end and dc-ac convertor at receiving end. With greater and greater number of HVDC systems being installed the use of power electronic devices is expanding tremendously.

1.11 VARIABLE SPEED DRIVES

The availability of power electronic devices has introduced variable speed drives. Control of DC motor, induction motor and synchronous motor has become very simple. Variable speed drives lead to saving in energy costs also.

1.12 FACTS CONTROLLERS

Facts controllers are being increasingly added in the power systems for control of active and reactive power. Facts controllers assure fast control of active and reactive power thus helping in maintaining system stability and voltage profile. Thyristor controlled series capacitor, static phase shifting transformer, static synchronous series compensator and unified power flow controller are being increasingly used in all power systems throughout the world.

Previously one electricity utility was responsible for generation, transmission and distribution of electrical energy. However this system has been found to be incompatible with present day requirements. The power players in deregulated market include generating companies (Gencos), Transmission companies (Transco), Distribution companies (Discom), Retail companies etc. Benefits of deregulation include improved and efficient operation of generation, transmission and distribution systems, elimination of subsidiaries, improved services to consumers and lower tariffs. Power sector reforms have been undertaken in many advanced countries. USA, Canada, UK, Germany, Australia, Russia and many other countries have undertaken this exercise. Power sector reforms have been undertaken in India also. Central Electricity Regulation Commission (CERC) was set up about 10 years back. Many states have set up State Electricity Regulatory Commissions (SERC). Electricity boards have been unbundled in many states and Gencos, Transcos and Discoms have been set up. This process is likely to speed up in the years to come.

V. TRANSMISSION LINE CONDUCTORS

ACSR conductor has been in use for overhead lines for past many decades. These conductors can be operated at about 75 C and are manufactured in a variety of sizes from about 5 mm diameter to about 40 mm overall diameter. However many new conductors have been developed and are being increasingly used in many countries including India. It has been reported that these conductors can withstand very high temperature (200 C) and thus have very high current carrying capacity as compared to ACSR. Some of these conductors are:

ACSS Aluminium Conductor Steel Supported

ACSS/TW Aluminium strands are formed to produce trapezoidal wave thus increasing the aluminium cross-section area for the same diameter.

ZTAC/R Special Zirconium alloy aluminium conductor invar steel reinforced

GTAC/R Gapped TAL alloy aluminium conductor steel reinforced

ACCR Aluminium conductor composite reinforced

ACCC Aluminium conductor strands over a low thermal elongation polymer matrix composite core.

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