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ROLE OF POWER ELECTRONICS IN NON-RENEWABLE AND RENEWABLE ENERGY SYSTEMS

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Abstract- **In today and also in future the impact of greenhouse gas emissions and the accelerated augmentation in global energy consumption have swift the transition towards greener energy sources. For this the renewable energy system has been using very frequently. The non-renewable and renewable energy systems are the categories of Distributed Energy Resources (DER). As the coupling technology for DERs, the major advantages of power electronics will be the potential for improving efficiency and the introduction of new control possibilities for providing ancillary services to the electric grid. This paper reviews most non renewable and renewable DER systems, and discusses the power electronics as the coupling technology in the light of the prospects and possible trends in the future.**

Also briefly describes the attributes of distributed generation (DG). A qualitative description of the role of power electronics in Non renewable energy system (Internal combustion engine, Micro turbine & Fuel cell systems) and Renewable energy system (Wind, Solar & Photovoltaic systems) has been presented.

Keywords**: On-site Generation, Distributed Energy Resources (DER), Renewable Energy Sources (RES), Power electronics, Ancillary services, combined heat and power (CHP).**

I. INTRODUCTION

According to International Energy Agency (IEA) data from 1990 to 2008, the average energy use per person increased 10% while world population increased 27%. And as of 2010, about 16% of global final energy consumption comes from renewable but at the same time the fossil fuels (liquid, coal and natural gas) have been the primary energy source for the present day world which is of non-renewable energy system. So the renewable as well as non-renewable energy system both is important for human development.

Distributed generation (DG) applications today are primarily for niche markets where additional power quality is desired or local onsite generation is desired. In some cases, the distributed energy resource (DER) is designated for backup and peak power shaving conditions. Power electronics currently are used to interface certain DER such as fuel cells, solar cells, and micro turbines to the electric power grid to convert high-frequency ac or dc voltage supplied by the DE source to the required 60-Hz ac voltage of the grid. In case of DG systems, the power electronic interface has to regulate the voltage, frequency, and power to link the energy source to the grid. The focus will be on high power density, robust dc-ac and ac-ac modules with complex control and safety requirements.

This paper makes a review of DER systems which includes both renewable and non renewable energy technologies with a focus on the coupling power electronics to the utility grid. It discusses needs for future research and points out some possible directions for the future. This paper presents some of the requirements of the power electronic interface as applicable with respect to both renewable and non-renewable power generation units and qualitatively examines the existing power electronic topologies that can be employed. Energy storage is also very important for DG; however, this paper focuses on the power electronics aspects of DG.

II. RENEWABLE & NON RENEWABLE SYSTEMS AND THEIR POWER ELECTRONICS COUPLING

In this paper the renewable and non-renewable systems are under DER and both of them are further classified as follows:

Renewable generation units

- Wind energy system
- Photovoltaic system
- Wave energy system

Non-renewable generation units

- Internal combustion engine systems
- Micro turbine systems
- Fuel cell systems

For all above systems the power electronic devices can be used in place of traditional power devices such as switches, capacitors, inductors etc. and can perform several of these functions with a single device. The power electronic coupling accepts power from distributed energy sources and converts it as desirable power with frequency and voltage. In below the required power electronics coupling discussed for each of the application.

Wind energy system:

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power.

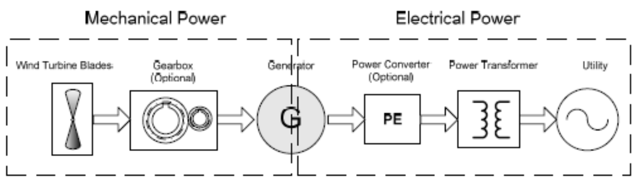

Fig1: Generalized diagram of a wind energy system

Here by the diagram of the wind energy system, the mechanical power this is wind through the wind turbine blades converted to the electrical power and used for the other purpose. The gear-box is optional as multi-pole generator systems are also possible solutions. Between the grid and the generator a power converter can be inserted. The electrical output can either be AC or DC. In the last case a power converter will be used as interface to the grid.

High frequency direct AC-AC conversion has also been proposed as coupling of wind energy conversion systems to the grid. Matrix converters have also been proposed for wind energy generation systems, both with partially rated and full scale converters for variable speed mode of operation.

Additionally, the presence of power converters in wind turbines also provides high potential control capabilities for both large modern wind turbines and wind farms to fulfill the high technical demands imposed by the grid operators such as: controllable active and reactive power (frequency and voltage control); quick response under transient and dynamic power system situations, influence on network stability and improved power quality

Photovoltaic energy system:

Photovoltaic energy systems consist of arrays of solar cells which create electricity from irradiated light. The designed system includes PV cells as the main source of energy, electric storage (battery), maximum power point tracking (MPPT) and protection circuitries. An MPPT algorithm based on measuring the slope of the PV power-voltage curves is presented which can be implemented with simple analog electronic circuits.

PV panels are formed by connecting a certain number of solar cells in series. Since the cells are connected in series to build up the terminal voltage, the current flowing is decided by the weakest solar cell.

By the figure, PV modules are connected in series and/or in parallel and then connected to a centralized DC/AC converter. There are also string-array PV systems in which series of PV panels are connected in the form of a single string and connected to the grid with one inverter per string. There exists also a configuration where PV strings have a DCDC converter plus and inverter offering the possibility of maximum power point tracking for maximizing the power production of the PV system.

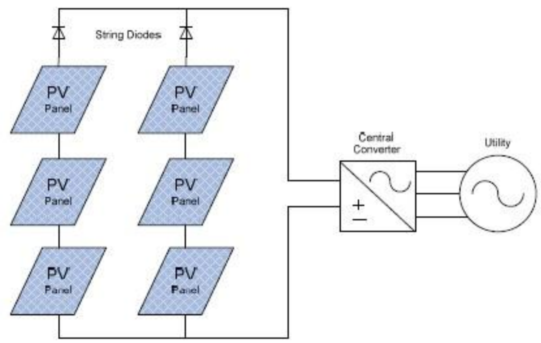

Fig2: PV configuration with a centralized power electronic coupling

Wave energy systems:

Wave energy is the transport of energy by ocean surface waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). Machinery able to exploit wave power is generally known as a wave energy converter (WEC). Waves are generated by wind passing over the surface of the sea. As long as the waves propagate slower than the wind speed just above the waves, there is an energy transfer from the wind to the waves. Both air pressure differences between the upwind and the lee side of a wave crest, as well as friction on the water surface by the wind, making the water to go into the shear stress causes the growth of the waves.

The primary advantage of most power electronic coupling is the possibility to integrate energy storage units such as super capacitors, or superconducting magnetic energy storage (SMES) in the DC link of converters and provide additional support to the grid. There are other possibilities that are emerging now but still at the level of research based on direct AC-AC link conversion technology that has been reported and used for lower power level applications such as UPS.

Internal combustion engine systems:

The internal combustion engine system firstly converts chemical energy into mechanical energy which in turn spins a shaft to convert the mechanical energy into electrical energy. The energy can be converted in DC as well as AC. With power electronics as interface, the combined efficiency of engine-generator can be optimized and provide the flexibility of adding energy storage systems for islanded mode of operation. Fig. 1 shows a variable speed IC engine-generator configuration that allows for integration of synchronous or asynchronous generators to the grid.

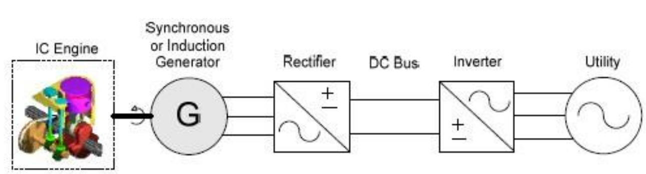

Fig3: Variable speed internal combustion engine configuration with power electronics coupling

Microturbine system:
Microturbine system has shafts spinning at up to120.000 rpm driving a high speed generator. The high frequency output from the generator is first rectified and then converted to grid frequency AC power. Microturbines are appropriately sized for commercial buildings or light industrial markets for combined heat and power (CHP) or power only applications. In high speed microturbine applications the generated three phase high frequency voltage, typically in the range of 1000 to 3000 Hz must be converted to line frequency before it becomes usable for the consumer and/or utility.
The power electronics can also be designed to provide ancillary services to the consumer or power grid such as voltage support, load following, operating reserve, backup supply. The most common power electronics topology used to connect microturbines to the grid is the one shown in Fig. in which the high frequency power from the generator must be converted to DC first by using a diode bridge or an active rectifier.

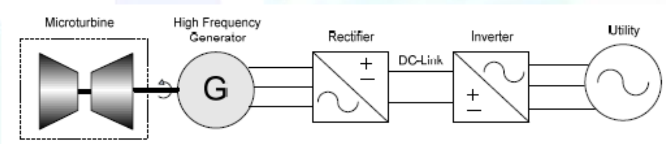

Fig4: Typical power electronic coupling for a microturbine system

Then a DCAC inverter is used to build up three phase voltages at the frequency of the grid. Another interesting power conversion system is the high frequency AC link converter illustrated in Fig. 3.

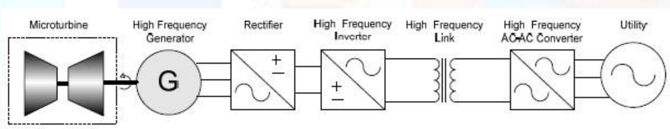

Fig5: High frequency AC link coupling for a microturbine system

The microturbine generator feeds three phase power into a rectifier and the DC is then fed into a high frequency single phase inverter so that a compact high frequency transformer can be used. The secondary of the transformer feeds an AC-AC converter that takes the single phase high frequency voltage to produce a three phase voltage at the frequency and phase needed to make a connection to the grid. No manufacturer is presently marketing this high frequency link system but it is a configuration of future interest. Matrix converter can also be a solution for coupling the microturbine to the grid with the disadvantages of higher number of switches and the lack of a DC or AC link to store energy that will make fluctuations at either side of the converter directly visible to the other side.

Fuel cell systems:
These are electrochemical devices that produce electricity without any intermediate power conversion stage. The advantage is the energy density that is nearly 10 times that of a battery. Fuel cells like PV systems produce DC power and thus power conditioning systems are required to be able to couple them to the grid. Fig. 4 shows the simplest configuration of a fuel cell system coupled to the grid. If isolation or high ratio of voltage conversion is required a transformer is integrated into the system. The main drawback of this system is that a line frequency transformer placed at the output of the inverter makes the system bulky and expensive.

III. POWER ELECTRONICS COSTS AND OTHER COSTS FOR DER's SYSTEMS

By the figure which compares the average power electronics costs in percentage of total costs for four DERs systems. In the figure we can see that the power electronics costs significantly less than the other capital costs.

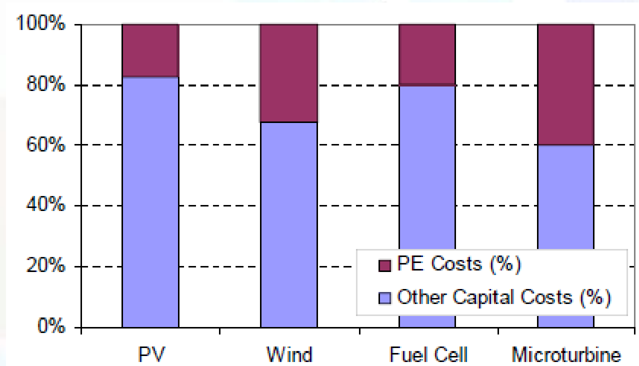

Fig: Power electronics costs compared to total capital costs for distributed energy systems

Power electronics account for 20-40% of the total system cost. In order to see widely spread distributed energy systems in the future, cost of the coupling power electronics must be given a serious consideration. Power electronics can amount for a significant part of the total cost of a typical DER application.

IV. CONCLUSION:

The importance of renewable energy, renewable energy based energy conversion systems, and distributed power generation as well as non-renewable energy, non-renewable energy based energy conversion has been reiterated.
The unique advantages of using power electronic couplings have been discussed throughout the paper and can be summarised in the following features:
- Flexibility to integrate energy storage units in the

converter DC link to provide power quality support and ancillary services such as reactive support by generating units and loads,

- Maximum power point tracking for PV and wind energy systems,
- Dispatching capabilities with energy storage units,
- Improved efficiency,
- Variable speed operation ability allowing for fuel usage optimisation.

In order to make possible all the potentialities mentioned in the paper, intensive research and development in the power electronics technology is strongly needed.

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