International Journal of Power System Operation and Energy Management

Volume 2 | Issue 1 Article 4

January 2013

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Abstract - Global energy consumption is increasing at a dramatic rate due to the increase in the world's population and the quest for improvement of living standards. Most of our energy comes from fossil fuels which cause the problem of global warming due to the emission of greenhouse gases (GHG). As a result, there are many harmful effects such as rise in sea level, drought in tropical regions near the equator, an increase in hurricanes, tornadoes and floods, and the spread of disease. Renewable energy is the energy generated from natural resources such as solar heat and light, wind, rain, tides, waves, and geothermal heat, which are replenished naturally. This paper highlights in particular the impact of power electronics in solving or mitigating the global warming problem and supporting the generation of renewable energy.

Keywords - *Renewable Energy, Global Warming, Power Electronics.*

I. INTRODUCTION

Global energy consumption is increasing dramatically due to our quest for higher living standards and an increasing world population. Most of our energy comes from fossil fuels, and burning these fuels causes global warming. Global warming raises the sea level, brings drought to tropical regions near the equator, increases hurricanes, tornadoes and floods, and spreads disease. These consequences are serious and will eventually bring tremendous unrest in the world. Various measures to solve or mitigate global warming are outlined in the paper.

Power electronics help improve the energy efficiency of apparatus, and helps the generation of environmentally clean or green energy. Renewable green energy sources will constitute the bulk of our energy sources in the future. It has been estimated that widespread energy efficiency improvement, by power electronics and other methods with the existing technologies, can save 20% of global energy demand, and another 20% can be saved by preventing waste, i.e., by various conservation methods. "Global warming problem is solvable by the united effort of humanity".

II. GLOBAL WARMING PROBLEM

Undoubtedly, energy is the lifeblood of the continued progress of human civilization. Per capita energy consumption is the barometer of a nation's prosperity. Global energy consumption has increased dramatically to accelerate our living standard. The USA with 5% of the world's population, consumes 25% of total energy. Japan with 2% of the world's population consumes 5% of total energy. China and India with 35% of the world's population consume only 3% of total energy. But this scenario is changing fast. The Earth's atmosphere accumulates solar heat due to GHG concentrations and raises the temperature. This causes:

- melting of glaciers and polar ice caps
- inundation of low-lying areas
- adverse effect on world climate
- severe drought in tropical countries near the
- equator that damages agriculture and vegetation
- hurricanes, tornados, heavy rain and floods
- spread of disease
- extinction of some animal species
- acidity increase in seawater

According to UN predictions, some example scenarios due to global warming are:

- 50% of Bangladesh will be under water in 300 years displacing 75M people
- Several island nations in the Pacific will be under water within 100 years.
- India's agricultural production will decrease by 38% by 2080 due to drought, but CO2 fertilization will offset it by 9%

- Melting of ice in Antarctica and Greenland will cause ocean level rise by 200 ft.
- Melting of all the ice in the world will cause ocean level to raise by 210 ft.
- Arctic regions will be virtually free of ice by 2070

If fossil fuel burning is completely stopped today, ocean level will rise by 4.6 ft. in next 1000 years

Table I presents the top six emitting countries.

Country	Share GHG 2005 %	Share CO_2 %	Share CO_2 %
China	17	20	26
USA	15	20	17
EU-27	11	14	12
Russia	5	6	5
India	5	4	5
Japan	3	5	4

TABLE I

TOP SIX EMITTING COUNTRIES

Note that human beings and other animals exhale GHG, but the trees absorb CO_2 by photosynthesis (called the carbon fertilization effect). Some CO_2 is washed away by rain and dissolves as carbonic acid in the ocean. In normal conditions, different natural sources and sinks of GHG maintain the ecological balance that maintains the stable atmospheric temperature.

III. THE IMPACT OF POWER ELECTRONICS

The modern era of high density solid state power electronics started with the invention of PNPN triggering transistor by Bell Labs (1956), which was later translated into the commercial thyristor (1958) by GE. Since then, there has been a vast expansion in the technology with the R&D radiating in different directions (power semiconductor devices, converter topologies, analytical & simulation techniques, estimation, control techniques, control hardware and software). It is interesting to note that the name "Power Electronics" emerged systematically from the early 1970s. Earlier, it was included as a part of Industrial Electronics. Power Electronics is an exciting, but complex technology, because of its multi-disciplinary nature. It is currently the most active discipline in electric power engineering, as indicated in Figure 1.

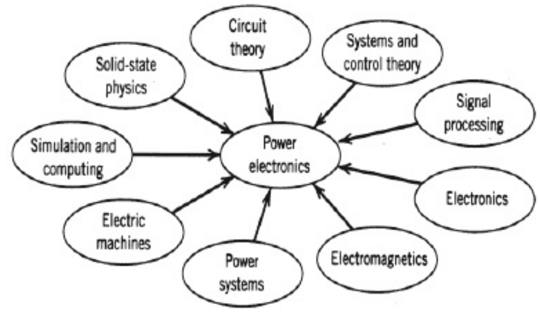

Fig. 1: Multi-disciplinary Nature of Power Electronics

Power electronics is the interface between electronics and power, as shown in Figure 2.

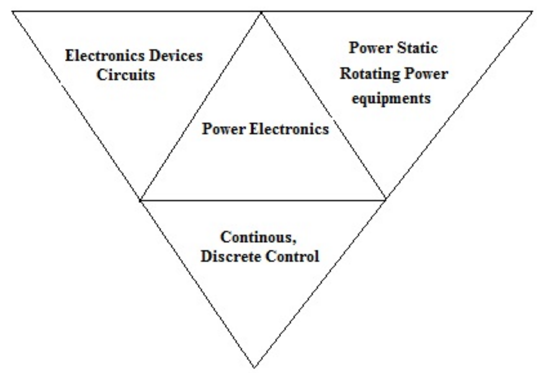

Fig. 2 : Interface between Electronics and Power

The applications of power electronics may include dc and ac regulated power supplies, uninterruptible power supply (UPS) systems, electrochemical processes (such as electroplating, electrolysis, anodizing, and metal refining), heating and lighting control, electronic welding, power line static VAR compensators [SVCs, static VAR generator, or static synchronous compensator (STATCOM)], active harmonic filters, high voltage dc (HVDC) systems, photovoltaic (PV) and fuel cell (FC) power conversion, solid state dc and ac circuit breakers, high-frequency heating, and motor drives. The motor drive area may include applications in computers and peripherals, solid state starters for motors, transportation (electric/hybrid electric vehicles (EV/HEV), subway, etc.), home appliances, paper and textile mills, wind generation system, air-conditioning and heat pumps, rolling and cement mills, machine tools and robotics, pumps and compressors, ship propulsion, etc. In addition to applications in energy systems and industrial automation, power electronics is now playing a significant role in global energy conservation that is helping environmental pollution control indirectly, i.e., solving the global warming problem. It is also an important player enabling the better utilization of renewable energy sources by implementing maximum power point tracking (MPPT) function (for wind and photovoltaic), ride-through capabilities, etc. Power converters are capable of seamlessly transferring variable frequency power to the fixed frequency grid (ac-dc-ac). It is critical for wind energy and hydro-energy. Economical storage solutions can increase the capacity factor of renewable energy sources like wind and PV and increase their penetration in the grid. Distributed power generation systems will provide solutions to avoid energy crises in the future. It will increase the power production in the vicinity of the consumption centers. In the long-term, it will decrease the power volume at the transmission level and make the central grid control very complex. Local grid control will be necessary in order to avoid grid instability and blackout. New control methods appear to improve performance. The future distributed generation is able to run in on-grid and off-grid modes. Advanced control of grid converters, including grid impedance estimation, adaptive current control, are emerging. Monitoring and advanced diagnosis will also be integrated.

The solutions to solve global warming problems include:

- Widespread promotion of renewable energy
- Applying advanced emission control standards to fossil fuel based power generating stations
- Promotion of Electric Vehicles (The ICE vehicles will be replaced by electric vehicles with the intermediate step of hybrid vehicles
- Widespread mass transportation (as in Japan and Europe)
- Promotion of energy efficiency in the generation, transmission, distribution and utilization of electrical energy

A. *Variable-frequency drives*

In a variable frequency drive, converter-machine efficiency can be improved further by machine flux programming at light load and reduced speed. Power electronics-based load proportional speed control in air-conditioning can save as much as 30% of energy, compared to the traditional thermostatic control. The additional cost of power electronics can be recovered by saving energy in a period depending on the cost of electricity.

B. *Lighting*

Power electronics-based high frequency compact fluorescent lamps (CFLs) can, typically, be four times more efficient than traditional incandescent lamps, besides giving much longer life. Light dimming control of CFL can further improve energy efficiency. The CFLs are expected to completely replace the incandescent lamps in the near future. Solid state LED lamps with higher efficiency and longer life are becoming more popular.

C. *Wind Energy*

One of the best sources of renewable energy is wind energy. Wind energy has the biggest share in the renewable energy sector. Over the past 20 years, grid connected wind capacity has more than doubled and the cost of power generated from wind energy based systems has reduced to one-sixth of the corresponding value in the early 1980s. Early versions of wind turbine generators consisted of fixed-speed wind turbines with conventional induction generators. This class of machines was rugged but was limited to operation in a narrow wind-speed range. In addition, the conventional induction generator, which was connected directly to the electrical grid, required that reactive power support be provided locally to achieve the desired voltage level.

Advances in power electronics have revolutionized wind turbine technology and led to the development of the doubly fed induction generator (DFIG). Figure 3 depicts this variable speed wind energy conversion system in a block diagram. Most modern wind farms have DFIGs and are available in ratings that range from 1.5 megawatts (MW) to 4.5 MW. Newer generations of wind generators, which have permanent magnet synchronous generators and fully Wind turbine Electrical generator PE Interface grid Mechanical energy Unconditioned electric power Variable Speed Operation for optimal power extraction Voltage, frequency, active/reactive power control rated converters, have a range of control over both real power and reactive power for varying wind speeds.

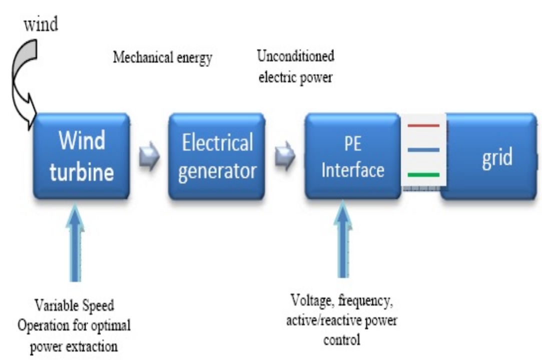

Fig. 3: Variable speed wind energy conversion system

D. Renewable Energy through Micro Inverters

A relatively new option for optimizing solar system efficiency and reliability is use of micro-inverters that connect to each individual solar panel. Equipping each panel with its own micro-inverter allows the system to accommodate its changing load and atmospheric condition, which provides optimal conversion efficiency for both the individual panels and the entire system. Power inverters are the critical electronic component in a solar power system. In commercial applications, these components interface with the photovoltaic (PV) panel, the batteries that store the charge and the local power distribution system or the public utility grid.

Figure 4 shows a typical solar inverter, which takes a very low voltage from the dc output of a PV array and converts it into some combination of dc battery voltages, ac line voltages and distribution grid voltages.

It should be noted that in Figure 4, the microcontroller (MCU) block, TMS320C2000 or MSP430 microcontrollers typically include such critical on-chip peripherals as pulse-width-modulation (PWM) modules and A/D converters.

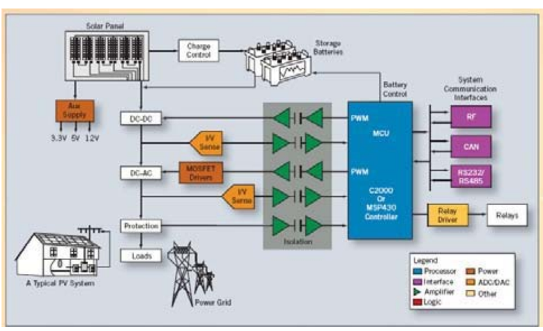

Fig. 4 : Conventional power converter architecture

Furthermore, in a typical solar energy-harvesting system, multiple solar panels are connected in parallel to a single inverter that converts the variable dc output of multiple PV cells into a clean sinusoidal 50-Hz or 60-Hz voltage source. This is usually done by MPPT algorithms and other techniques which increase efficiency and maximize conversion efficiency.

On the other hand, using a micro-inverter for each individual solar panel instead of using a single inverter for the entire system can prove beneficial in reducing different control requirements, such as the ability to adjust conversion parameters on each panel using a high resolution PWM.

Micro-inverter architectures employ a dedicated MCU for each panel to manage energy conversion. However, these additional MCUs can also be used to improve both system and panel monitoring. Besides, the MCU is integrated on-chip communication peripherals (CAN, SPI, UART, etc.), in order to simplify interfacing with other micro-inverters in the solar array.

E. Solar Energy

The use of solar energy is heavily dependent on power electronics. The conversion of solar energy to electricity is currently accomplished mostly in two ways: by direct conversion using photo-voltaics (PVs), or by solar thermal conversion. These are briefly described below.

In the direct-conversion method, PVs generate a direct current (DC) output that is converted to alternating current (AC). This conversion is achieved by a power electronic device called an inverter. Most PVs are rooftop units, and PV-based solar energy primarily has limited distribution and capacity. However, some large commercial PV-based solar facilities of up to 60 MW have been built recently.

F. Solar Thermal Conversion

In solar thermal conversion, the sun’s rays are directed by mirrors to heat a thermal exchange agent (e.g., mineral oil) to a sufficiently high temperature. This agent then exchanges the heat generated via a conventional steam cycle and runs a steam turbine that drives a synchronous generator. The solar thermal method also has the capability of storing energy using a thermal phase-transition approach. This is commonly achieved by using molten salt to store heat for up to six hours; the stored heat is used to run a conventional steam cycle when energy from the sun is not available. Although solar thermal facilities have plant capacities in the range of several hundred MWs, they also require significant quantities of water for cooling and steam generation.

IV. CONCLUSION

In recent years, the increasing importance of power electronics has been realized for energy saving. The high efficiency of power electronics-based energy systems has been discussed in the literature. Saving energy gives a direct financial benefit, particularly where the energy cost is high. The extra cost of power electronics in energy saving can be recovered within a reasonable period depending on the cost of electricity. In addition, reduced consumption means reduced generation that indirectly mitigates the environmental pollution or global warming problem. In general, the integration of renewable energy resources is still not satisfactory. The significance of power electronic was discussed to make the role of power electronics more clear in terms of advancement in inverters, microcontrollers.

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