Future role of power Semiconductors: From “Silicon vs. WBG” to “Silicon and WBG”
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1. Efficiency: Key to reducing future CO2 emission

“Efficiency” is the key issue for power electronics and power device technologies toward future reduction of CO2 emission by reducing energy consumption. Information and communications technology (ICT) industry is a good example to show the importance of improving the efficiency. (In a data center ([1]), total energy efficiency is less than 30 percent.) The potential of energy efficiency improvement in end-use-energy is listed at the highest among the other options in IEA report ([2]) as measures for reduction of CO2 emission.

2 “Efficiency” as renewable energy resource “Negawatt”

One of the most important role of power electronics technology in the future advanced electrification are as “efficiency improvement driver” in electric and electronic systems. Once efficiency is improved in a system, a part of the wasted heat energy in the old system is converted to electricity equivalent to energy generated without CO2.

If we accept energy efficiency improvement as energy resource, the generated energy by the efficiency improvement is equivalent to renewable energy which can be use by another load. This concept is called “negawatt” ([3], [4]). Once negawatt concept is accepted, power electronics as the technology of efficiency improvement driver can be categorize as renewable energy resources, and the cost of technology can be compared with photovoltaic (PV) and wind turbine generators.

Let us calculate the negawatt cost. The cost of negawatt by installation of 2.8kW high efficiency air-conditioner, which are one of the most committed application of the power electronics technology, replacing inefficient air-conditioners can be calculated about 10-20 cent/kWh. Although the power electronics related “negawatt” cost is couple of times higher than that of the coal steam generation system, the cost is comparable to PVs and wind firms([5], [6]) if the “negawatt” is considered as renewable energy resources.

3 “Installation” with better progress ratio of “Cost per Negawatt”

The assessment with the experience curve had been often used in policy making and long term marketing to promote new technologies in renewable energy source. Progress ratio (propagation rate) is defined as reduction in cost for every doubling of cumulative installation (production). The progress ratio in the PV module production was calculated to be about 80 percent and learning investment was 60 billion dollars which include government measures to promote PVs, incentive cost for commercialization and recouping of research and development cost([7]).

An investigation shows that progress ratio of inverter is higher than 90 percent which means cost reduction of the power electronics system is rather slower than the other
renewable energy systems([8]). Both the initial cost ($/kW) and overall lifecycle cost ($/kWh) reduction with better progress ratio is required to make “Negawatt” break even for the installation without governmental investments.

4. Future Role of Power Semiconductors

The “ideal” characteristics of the wide-bandgap (WBG) power semiconductors shows advantage to open new applications in power electronics industry while competitive silicon power technology is characterized as “progressive” toward future volume applications[9]. Among the silicon technologies, CMOS platform becomes very strong once it meets huge volume applications [10, 11]. Based on this analysis, silicon power device industry challenges to prepare future volume demands for end use owned by many people while WGB power semiconductor challenges to open new application of power electronics technology and core power electronics systems (Fig. 5, [12],modified).

Paradigm of electronics technology has spread from hardware to service for reduction of CO2 emission (Fig. 6). The role of power semiconductors have been re-defined as the key segment for the future environmental technology.

References