



# Power Electronics, Smart Grid and Renewable Energy Systems

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**ABSTRACT** | The paper is basically an introduction of power electronics and its applications with emphasis on renewable energy systems and smart grid. The advent of modern power electronics has brought tremendous impact on power systems, besides the usual industrial applications to improve productivity. Power electronics is possibly the most important element in modern smart grid and renewable energy systems. The discussion in the paper will include modern power semiconductor devices and applications of power electronics in energy saving, electric vehicles, renewable energy systems, and grid energy storage. Finally, the basic elements of smart grid will be reviewed.

**KEYWORDS** | Energy; energy storage; power electronics; renewable energy systems; smart grid

## I. INTRODUCTION

Power electronics, smart grid and renewable energy systems constitute the basic content of this introductory paper of the special issue. Energy and environmental issues are extremely important nowadays and almost everybody is talking about these. It is well known that the modern age of solid-state electronics or “First Electronics Revolution” was ushered by the invention of the transistor in 1948 by Shockley, Bardeen and Brattain of Bell Lab. The same lab also invented the thyristor (also called P-N-P-N transistor) in 1956 which was commercialized by GE in 1958. This started the modern power electronics age which is often called the “Second Electronics Revolution”. Then gradually came the integrated circuits (ICs), microcomputers, digital signal processors (DSPs) and field programmable gate arrays (FPGAs). The advent of modern power electronics brought significant impact on energy systems.

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Since the dawn of the 21st century, we have been witnessing a kind of industrial revolution due to tremendous impact of power electronics in our society. Truly speaking, we can define the 21st century as the golden era of power electronics applications. It is bringing significant impact to exploring the various renewable energy resources (such as wind, photovoltaic and ocean energy systems), variable speed drives in transportation systems (such as electric and hybrid vehicles, ship propulsion, etc.), bulk energy storage systems (such as battery, flywheel, etc.), energy saving applications in electrical systems, high efficiency energy systems [such as high voltage dc (HVDC), flexible ac transmission system (FACTS), static VAR compensators (SVC), uninterruptible power systems (UPS)], etc., besides the usual role in industrial automation for productivity improvement. Many of these applications come under the emerging smart grid system. As energy price increases and environmental regulations are tightened, power electronics applications will proliferate everywhere in industrial, commercial, residential, transportation, aerospace, military and utility systems. The Electric Power Research Institute (EPRI) of USA estimates that more than 70% of U.S. electrical energy now flows through power electronics, and this will eventually grow to 100%. The role of power electronics in this new era will be as significant as computers, communications and information technologies.

The objective of this paper is to give a simple but comprehensive review of power electronics and its applications in smart grid and renewable energy systems. It will help the readers to have a background and motivation for the special issue and launch successfully to the advanced and specialized papers.

## II. POWER ELECTRONICS

What is power electronics and why is it so important today? Power electronics uses power semiconductor devices that operate in switching mode to convert and control electrical power. The conversions may involve