International Journal of Precision Engineering and Manufacturing-Green Technology (2019) 6:669–670
https://doi.org/10.1007/s40684-019-00150-0

Online ISSN 2198-0810
Print ISSN 2288-6206

PREFACE

Preface for the Special Issue of Energy Harvesting

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Energy Harvesting, broadly speaking, refers to the activity of capturing ambient energy and converting it to electricity in a useful form. In this broad sense, almost all electrical power generation could be called energy harvesting. However, most recent research uses a somewhat narrower definition. Usually Energy Harvesting refers to capturing ambient energy for use by untethered (i.e. wireless) devices at the point of operation of the devices. The goal is usually to eliminate, or at least reduce, the reliance on batteries and the attendant need to periodically replace them. In this context, it is one of the technologies, actually a fairly broad family of technologies, enabling the emerging Internet of Things. Specifically, it is hard to imagine many hundreds of billions, or trillions, of sensors gathering data and wirelessly communicating that data if each end node must have its battery periodically replaced. Thus, the ability to harvest enough energy to support its own operation, is a key supporting technology for many wireless nodes that make up the Internet of Things.

Many types of energy are available to harvest, including thermal gradients, light, mechanical motion or vibrations, wind, etc. However, in the specific environment of a wireless sensing node, the range of options may be quite limited. Thus, it is important to develop basic understanding and technological solutions for a wide range of options. This Special Issue will provide a snapshot of recent research across a broad range of ambient energy sources and emerging technologies.

Energy Harvesters could, of course, be applied in a very broad range of applications, really any application in which networks of wireless devices need to operate. One of the most prevalent applications is in large scale manufacturing. Smart factories, for example, rely on large amounts of real-time sensing. These sensors are often wireless and ubiquitous. The need to regularly replace or recharge batteries in many thousands of devices throughout a large operation represents a very real maintenance and reliability concern. Furthermore, some sensors may be in locations in which battery replacement is either impossible or prohibitively difficult. Energy Harvesting, is therefore, highly relevant to smart manufacturing operations. It is, furthermore, a green technology in that the energy being harvested rarely if ever consumes fossil fuels or releases carbon to the atmosphere. However, it is also true that the amount of energy harvested in the applications and by the technologies discussed in this Special Issue is not likely to make any significant difference in reducing greenhouse gas emissions. Rather, these technologies could enable more intelligence in large scale operations, such as manufacturing, which could, in turn, result in improved efficiency. Thus the effect of energy harvesting technologies in reducing greenhouse gas emissions reaches far beyond the immediate energy harvested by the devices themselves.

From about the year 2000, there has been an impressive increase in research activity, and thus scholarly publications, related to energy harvesting. This was driven by the emergence of wireless sensor networks, sometimes called ambient intelligence, and now often referred to as the Internet of Things. Thus, the research was driven more by a need than by the enabling features of any specific base technology. Nevertheless, energy harvesting has made use of many novel materials technologies, and has spurred the development of new power conditioning circuit topologies. Furthermore, new theory has been developed to both enable the ability to predict power generation from excitations (i.e. machine vibrations, thermal gradients, etc.) occurring in a variety of application environments and to optimize device structures and material properties specifically for the purpose of harvesting energy. This special issue will provide a snapshot

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of recent research on many energy harvesting technologies. Specifically, the following topics will be covered:

- Piezo energy harvesting.
- Energy harvesting textiles.
- Triboelectric energy harvesting.
- Thermoelectric energy harvesting.
- Energy harvesting from fluid oscillators.
- Thermal energy systems.
- Electromagnetic vibration energy harvesting.
- Fuel cells.

We would like to express our sincere appreciation to all the authors and editorial members for their valuable time and effort, and to Ms. Sung Gyung Lee and Ji Young Oh of the Korean Society for Precision Engineering (KSPE) for their dedicated effort during the review and production process. We sincerely hope that you enjoy this Special Issue on Energy Harvesting.