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Impacting Energy Utilization: the Role of Thermoelectrics

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The dawn of the 21^{st} Century has starkly illuminated new challenges in the area of energy production and use: a rapidly increasing worldwide demand, dwindling supply, and the overarching threat of environmental damage due to energy utilization. These are not temporary inconveniences but rather harsh realities of a new world: energy reserves whose creation took millions of years are being depleted by an increasingly energy-hungry global society. How can science respond to these new challenges? To answer this question it is useful to think in terms of both short-term and long-term strategies. In the long term, we must develop sustainable carbon-free energy technologies. In the short-term, we must impact *utilization* of traditional sources of energy, especially in terms of increasing the efficiency of energetic processes. Here we note that in terms of overall energy usage in the United States, more than half of the energy produced by traditional energy sources is lost, mostly in the form of heat. This "lost" energy, which arises due to the inefficiency of thermal processes, represents a vast amount of energy that can be made available for usage now. *Increasing the efficiency of industrial processes* thus should be a major goal of a short-term energy research effort. A very promising approach to this problem is the development of new semiconducting thermoelectric materials capable of efficiently converting heat to electricity. A better understanding of the electronic and thermal transport properties of solids, new synthesis methods, and the use of nanotechnology have brought fresh and exciting progress to this old problem. We describe some of the materials science successes and remaining challenges in thermoelectric energy conversion and how these materials might be implemented in future devices and systems.