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Ancient Days and Modern Times

> *But I [Zeus] will give men as the price for fire an evil thing in which they may all be glad of heart while they embrace their own destruction.*
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> Hesiod, *Works and Days* c. 800 B.C.

In the mythology of ancient Greece, fire was enshrouded in the legend of Prometheus, who stole its secret from Zeus and gave it to mankind. Because fire was not intended for us, humanity was punished for accepting it by the advent of Pandora, who opened the great box of woe, releasing disease, toil, and sorrow upon the world, saving only the gift of hope. This legend strikes a chord even now, as our use of energy expands seemingly without limit even as consequences begin to appear. Prometheus suffered greatly for giving fire to humanity, and we may yet suffer greatly from our overwhelming dependence upon it. Only time will tell if the gift of Prometheus turns out to be the blessing in the future that it has been in the past.

There is no limit to the amount of energy humanity may want. But there are certainly limits to the amount available from fossil fuels. Through the rise and fall of successive civilizations and empires, the energy needs of the ancient world were supplied by renewable sources, including food, firewood, wind, flowing water, draft animals, and slaves, with only tiny amounts from coal and oil. The 18^{th} century witnessed the invention of steam engines that could turn heat into useful work. Because of this advance in technology, energy usage for the first time began to grow faster than population. The heat from burning coal powered the industrial revolution. Soon afterward it was discovered that devices such as steam engines are limited in the fraction of heat they can convert into work. By immutable laws of thermodynamics, steam turbines like those used in power plants typically waste more than half the energy they consume. Although work can be converted completely into heat, the reverse is not true. Heat cannot be converted completely into work, no matter how many engineering advances are made.

Now, at the beginning of the third millennium, the world's average annual energy consumption per person is about 100 times higher than it was 2000 years ago, when there were only perhaps 200 million people in the world. Presently, there are more than 6 billion souls on the face of the Earth. Over the last two

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millennia, world energy usage has risen by a factor of more than 3000 and has been increasing at a rate of around 2% per year. This 2% increase per year is all by itself 60 times more energy than the total annual energy consumption of the ancient world. The amount of energy used per person varies enormously from country to country. If all countries consumed as much energy per person as the richest do, world energy usage would be an order of magnitude higher than it is. Such an increase in energy may be unachievable with fossil fuels alone and, in any case, is not sustainable.

Almost everyone wants a higher standard of living. Energy and living standards go hand in hand. How can continuously increasing demands for energy be satisfied? Can energy use double in the next 40 years and keep increasing with no end in sight? Right now human energy needs are met primarily through the gift of Prometheus, from fires fed by fossil fuels. But all fossil fuels contain carbon, and burning it produces carbon dioxide. As the amount of carbon dioxide in the air increases, so does the Earth's average temperature, because carbon dioxide acts to slow down Earth's heat loss. Changes in global weather accompanying increasing planetary temperature will become greater as energy production from fossil fuels goes up.

Beyond fossil fuels, the energy contained in certain atomic nuclei can also be set loose, as was proven dramatically by the detonation of the first atomic bomb at Alamogordo, New Mexico, on 16 July 1945. Of more peaceful potential was the earlier proof that energy locked inside uranium atoms could be released controllably. It did not take long to demonstrate that the controlled release of nuclear energy can be used to generate electricity. Heat from the reactor built in 1943 in Oak Ridge, Tennessee, to demonstrate the production of plutonium from uranium, was used to generate electric power before the first nuclear weapon was detonated. (This reactor has long been decommissioned but still exists as a museum.) Although the amount of electric power produced was only symbolic, this test did prove the principle of the concept. Before the hazards and costs associated with nuclear reactors were fully realized, extravagant claims were made about the ability of this new energy source to supply electricity cheaply, notably the claim in the 1950s that electricity from nuclear reactors would become too inexpensive to meter. New technologies inevitably generate new problems as well as new possibilities, and the balance, if there is one, is always between cost and benefit.

The production of electrical energy using the heat from nuclear fission has increased far less rapidly than first expected. The combination of complex engineering, serious concerns about radioactive waste, and the role of reactors in making nuclear weapons have all inhibited the growth of nuclear-powered electricity generation. Where and how to store radioactive waste for millennia is not a simple problem. The politics of nuclear weapons are not simple either.

The impact of worldwide climate change needs scarcely to be emphasized. To understand why such climate changes are underway, it is important to know the scientific facts that determine our planet's temperature. While the details of this issue are extremely complicated, the fundamental principles are straightforward. The next chapter gives an overview of why ice ages and global warming cycles come and go. What happens if glaciers start growing again, the next ice age begins, and we're out of fuel?

Recommended Reading

Eberhart, Mark E. *Feeding the Fire: The Long History and Uncertain Future of Mankind's Energy Addiction*. New York: Harmony House, 2007.

Thirring, Hans. *Energy for Man: Windmills to Nuclear Power*. Bloomington, IN: Indiana University Press, 1958. (This book was one of the earliest to evaluate quantitatively humanity's energy situation, and much of its information is still relevant.)