Nuclear Fusion:
An Alternative for Energy Production

Michael Olson
Meteo 3100
Kevin Perry
25 April 2006
Abstract

With decreasing availability of fossil fuels, another source of energy is needed. Among many other possibilities, Nuclear Fusion has many good qualities. Fusion is based on the principle of capturing energy from Hydrogen atoms by joining it with another atom. This is the same process that occurs in the sun. Nuclear sources of energy have been researched since the decade of 1930. Today, this energy is used much more than the general public realizes. For instance, NASA's Martian rovers, Spirit and Opportunity, are powered by nuclear means, and England has a probe orbiting the moon powered by an ion engine. An extremely large amount of energy is available from such a source. This paper looks into the benefits of Nuclear Fusion as well as current problems, difficulties, or issues. The production and harvesting procedure of energy from a fusion reaction is also discussed, as well as different methods of extraction.
Nuclear Fusion: An Alternative for Energy Production

The beginning of the year 1999 was a wonderful time. It meant easy travel. It meant more money in savings. The price of gasoline was extremely low, such as $0.87 per gallon in Butte, Montana, for example. But those times have passed. Current prices have risen by over $2.00 per gallon, and in some cases, nearly $3.00 per gallon. Many people around the world are worried about high prices. But of even more concern is the shortage of oil and the environmental effects of its use. Scientists have predicted that the reserves of oil will be depleted within 50 years. Others are concerned that because of the current use of oil and its resulting increase in harmful chemicals, the world's problems of global warming, acid rain and smog are increasing. Research has been done on possible alternative sources of energy in order to reduce the use of fossil fuels, relaxing the pressures on the economy and environment. One of the cleanest, most efficient, and most reliable sources of energy in question is Nuclear Power.

Of the two types of Nuclear Power (Fusion and Fission), Fusion is very possibly the better. One form of production is the Thermonuclear reaction, which works on the same principle as the sun. This basic principle is the combination of deuterium and tritium, releasing an alpha particle (a helium nucleus) and a neutron.

Deuterium is an isotope of Hydrogen having one neutron, and tritium an isotope with two neutrons. Both elements are abundant here on earth. Deuterium is found plentifully in the oceans. Tritium is also found in the oceans, but is also found in Lithium, which is plentiful in Earth's crust.
The reaction is called Thermonuclear because of the extremely high temperatures required for it to occur. In the sun, temperatures of tens of millions of degrees Celsius are required for the reaction to take place. Here on Earth, the lower pressure changes the requirements. A reaction here requires hundreds of millions of degrees Celsius. Researchers in this field have developed the ability to produce these high temperatures. One current difficulty, however, is producing a sustained, or continuous, reaction. As a result, the reaction chamber has to be cooled after each reaction and reheated before the next reaction can start. This is a very costly procedure, so researchers are doing all they can to develop the technology to produce a sustained reaction.

The products of the reaction, an alpha particle and a neutron, have an extremely high amount of energy. These materials are pumped into another chamber where the energy is transferred to another material, which in turn evaporates water. The steam turns a turbine and generates electricity.

Other procedures for Nuclear Fusion are being tested. Dr. Martin Fleischmann, a professor in the Chemistry Department at the University of Utah, developed a procedure called "Cold Fusion," which produces its energy from the fusion of two deuterium atoms. (ZPEnergy, Para. 2) This reaction does not have the same temperature requirement as Thermonuclear reactions. Yet when other scientists attempted to reproduce the reaction, they were unsuccessful. Critics instantly rejected his theories. Since that time, however, it has been discovered that such a reaction has multiple variables. One variable is the use
of the element Palladium. Palladium is used to react with the hydrogen in the reaction. Only in recent years did scientists discover that the Palladium has to be 90% saturated with water. Anything less will cause the reaction to not occur. Research is beginning again to investigate Cold Fusion.

With Cold Fusion back on the line for a possibility, groups have looked to it as a possibility to ease the demand for energy. A group in California called "D2Fusion" has hired Dr. Fleischmann to do research for them. D2Fusion is looking at possibilities to use Cold Fusion for heating homes. If this and others similar experiments succeed, then the high demand will be eased, meaning cheaper energy. In addition, the pollution that is produced by coal plants and other generators of power will decrease significantly.

How much energy does Nuclear Fusion offer, though? Estimates show that we have enough deuterium for nearly 10 trillion Quads of energy. One Quad is one quadrillion BTUs (British Thermal Units), which is equal to 1.055 Exajoules (1.055 * 10^{18} Joules). So we have enough deuterium to produce 1.055 yottaJoules (1.055 * 10^{34} Joules) of energy. In 1998, the U.S. consumed approximately 94.27 Quads. Therefore, there is enough deuterium to produce that same amount of energy for 100 billion years!

Many concerns have been expressed about nuclear energy. One of the largest arguments is against its nuclear waste. During the decades after World War II, the nations of the world began to develop nuclear power. Up until more recently, the primary focus was on Nuclear Fission, which does create a significant amount of waste. This waste takes thousands of years to decay. Fusion, however, is a different story. The
material used in the production chambers is a strong material that resists a significant amount radioactivity. The decay of such materials ranges from 50 to 100 years. In addition, the amount of waste is significantly less. After 100 years, the amount of waste amounts to 1 m$^3$. Scientists are aware of all these concerns. Many experiments are underway to resolve them. 

NASA and other space programs around the world are also experimenting to find better propulsion systems. The probes that NASA sent to Mars in 2004 are powered by nuclear energy. The English space program has also recently developed and sent a rocket in orbit around the moon by use of an ion engine very similar to that being tested by NASA. 

Nearly fifty years ago, a person walking through a major city would have been shocked to see the condition of the environment. The sky was constantly gray with a continuous stench and low-quality light. Imagine leaving a doorstep and looking to see the stars, yet never being able to see them. All those natural wonders that we enjoy would no longer be enjoyable, being dulled by the thick haze. But today, many of those cities have been cleaned, and its citizens can enjoy these wonders as much as rural villages. Why? Those cities have undergone a change that helped clean the air by reducing the production of harmful chemicals. One of these major changes is the transfer from fuel-based energy to nuclear power. Through years of studies and experiments, this efficient power has come into our hands to use. We cannot afford financially or economically to throw this knowledge away. Nor can we afford to use it carelessly. Yet through wise usage, we can see a change in our cities, in our nation, and in the whole world.
Illustrations

Illustration 1: Fusion Reaction   Illustration by Princeton Plasma Physics Laboratory.
Located: http://www.pppl.gov/fusion_basics/pages/fusion_reactions.html

Illustration 2: Nuclear Power Plant   Illustration by Princeton Plasma Physics Laboratory.
Located: http://www.pppl.gov/fusion_basics/pages/fusion_power_plant.html

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