Missouri S&T's Peer to Peer

Volume 1 | Issue 2 Article 10

May 2017

Nuclear Fusion as a Primary Energy Production Method

Joshua Eiswirth

Joshua Eiswirth
Nuclear Engineering at Missouri University of Science and Technology

NUCLEAR FUSION AS A PRIMARY ENERGY PRODUCTION METHOD

Abstract

In this paper, the possibility of using nuclear fusion as a primary energy producer will be analyzed. A brief overview of nuclear fusion is given as well as the drawbacks of nuclear fusion today. The human species, need to find a more abundant and renewable means to produce energy, because the non-renewable resources relied on today will be completely used up in as little a 100 years. Nuclear fusion, if perfected, offers a reliable and extremely abundant energy source. With commercial nuclear fusion plants more energy would be available than ever before. While no efficient fusion reactor design exists today, many steps are being taken towards efficient fusion and a few will be outlined in this research paper. The sources used come from accredited academic sites written by the organization as a whole or individual authors with degrees that pertain to the information collected. Nuclear fusion is often described as "always 15 years away", but many innovations exist today that were often thought of as impossible. Any given day a breakthrough could occur in one of the many fields related to nuclear physics that serves as the missing piece to efficient fusion power generation.

Nuclear Fusion as a Primary Energy Production Method

The world's biggest producers of electricity in 2013 were China, with 5422.2 billion kWh, and the United States, with 4286.9 billion kWh produced (The World Bank). This accounted for 41.6% of the entire world's electricity production, and both of these super-powers rely on non-renewable resources as their main sources of power. If no alternative energy sources are adopted, in 110 years the world's coal supply will run dry according to the World Coal Association. If this happens, over 40% of the world's energy production means will disappear along with it. The best way to fix this problem is to avoid it altogether. It is crucial that a clean, reliable energy source be developed to replace the non-renewable sources relied so heavily on and cut back on the carbon emission that are proven to hurt the environment. There are many options when it comes to renewable energy production; however, none are without their drawbacks. Solar energy can only be collected when the sun is shining, wind turbines require a windy day, and nuclear fission leaves behind fission fragments that take years to decay and require special storage. The biggest drawback to nuclear fusion is that it cannot be done efficiently at this point in time. Nuclear fusion is a strong contender for the world's primary energy source if mastered. Efficient fusion power may still be impractical, but any day a major breakthrough could catapult the world into an age of cheap, plentiful energy for all.

Methods

As a student in the Nuclear Engineering field much of the information presented in the following research paper falls under "general knowledge", meaning that a source was not necessary as the information is taught in fundamental Nuclear Engineering classes. While attending the American Nuclear Society national student conference, I was able to speak with many student researchers about my research proposal. Unfortunately, it is not possible for me to give credit to these people because the presentations given at the conference are not publically available. However, all statistics and numerical data are properly cited and come from accredited sources, either organizations in the energy production field or authors with degrees pertaining to my research.

Because the topic of this paper is theoretical in nature, some information is estimated. using mathematical formulas or computer simulations.

Basics of Nuclear Fusion

Nuclear fusion is the process of combining the nuclei of two lighter atoms to create a heavier atom. During this process a small amount of mass is converted into a large amount of energy, by the famous equation E=mc^2. This energy must either be contained by strong magnetic waves generated with a superconductor, or by compression forces generated by a powerful laser (Carlton, 2017). A massive amount of energy is needed to force two atoms close enough to fuse, as well as a temperature in excess of 180 million degrees Fahrenheit (Carlton, 2017). With current methods, much more energy is required to achieve fusion than is obtained from the reaction. However, scientists all over the world are working to make this process more efficient in hopes that one day fusion will be what powers the world.

Commercial fusion will most likely use deuterium and tritium, two isotopes of hydrogen, as fusion components. The fusion cross section between these two atoms is high, so they are easy to fuse. The product of the fusion reaction is a helium nucleus and a 14 MeV neutron. Deuterium can be distilled from seawater making it readily available. Tritium however, is not naturally occurring and must be produced by other means. A major problem which stood in the way of fusion research was finding a way to deal with the extremely powerful neutrons that are produced during the Deuterium-Tritium (D-T) reaction. Fortunately, the problem concerning the extremely powerful neutron can be used to solve the problem that tritium is not naturally occurring. The fast neutrons produced from the D-T reaction can be directed towards and absorbed by lithium, which can also be distilled from seawater, resulting in the reaction n + Li6 -> He4 + T + 4.8 MeV where T is tritium and n is the neutron from the D-T reaction. Essentially, everything needed for fusion can be obtained from seawater, making it an extremely abundant energy source.

The State of Fusion Today

Major efforts in the fusion power production field are being made by people all over the world, from research labs at MIT, to multi-billion dollar projects. The direction fusion research is heading in right now is a good starting point, but research must continue. As other technologies improve, they may be able to be applied to fusion. The International Thermonuclear Experimental Reactor (ITER) is multi billion dollar international project that looks to build a massive fusion reactor. In theory, the reactor will output more energy than is put into it. Until concrete data is collected from the reactor, it is unknown how well it will truly perform, but it is likely that ITER will be the closest thing to efficient fusion ever achieved. This is a huge step towards making fusion an effective energy producer. However, there are some issues with the ITER. The production cost has nearly tripled since proposed in 2006 and some countries are no longer as optimistic about the success of the project. For example, the US is considering retracting financial support for the project after estimated contribution raised by nearly $3 billion (Lucibella, 2014). Backing out now could mean even further setbacks to the project and may doom it entirely. Regardless of the costs, the ends will always justify the means if the secrets to fusion are discovered and fusion power can be shared throughout the world. ITER should be looked at as a stepping stone towards commercial fusion and template for smaller, more efficient, reactors in the future. The two easiest ways to make fusion more efficient are to decrease the amount of energy that is required to start the fusion reaction, and increase the amount of energy obtainable from the reaction.

A World Powered by Fusion

Once perfected, the Department of Energy estimates that "One gallon of seawater would provide the equivalent energy of 300 gallons of gasoline; fuel from 50 cups of water contains the energy equivalent of two tons of coal." According to the U.S. Department of the Interior 97% of all of the water on the planet is seawater. The volume of all water would be about 332.5 million cubic miles, and every cubic mile is more than 1.1 trillion gallons. This means that there is 3.548*10^(20) gallons of seawater on the planet. If every 50 cups (3.125 gallons) of water contains the energy equivalent of two tons of coal, the energy equivalent of all of the seawater in the oceans is around 454,144,000,000,000,000,000,000 pounds of coal. Having energy production means on this scale would mean energy for countless years, and the ability to get power to places in the world that have never had power before.

According to The World Bank, 15.4% of the population did not have access to electricity in 2012. For some, life without electricity is something that is impossible to even imagine. In many places readily available electricity is something that is taken for granted, but there are over 1 billion people on the planet who do not know this luxury. A world with fusion power is a world that is capable of providing energy to every single person; once the stigma of nuclear energy is no longer an impediment, scientists could devise a plan for rolling it out globally. Fusion promises a means to produce zero-carbon emission energy cheaply and abundantly, andshould be looked at as a way to get power across the globe.

Conclusion

Matthew J Moynihan, a so called "fusion expert" with a PhD in Inertial Confinement Fusion, has made many attempts to explain fusion to the masses. Moynihan started a Wikipedia page called "Teaching Fusion to the Public" and has written many articles on fusion for magazines.

Moynihan made an comparison in an article written for *Forbes Magazine* saying “I argue that fusion development is about where human powered flight was in the early 1890’s”. The author argued that when human powered flight was first being discussed there were many similarities in the way people view fusion power today. Fusion is often considered impossible or improbable, but considering the current state of human powered flight , humanity should not give up on trying to make fusion realistic. Even if it takes 100 years to perfect fusion power generation, the results will be well worth the wait. Energy costs could drop to all time lows, everyone on the planet could have access to power and clean drinking water, and scientists could turn their focuses to other applications of fusion.

References

Nordhaus, T. (2014, June). How To Make Nuclear Cheap. Retrieved April 17, 2017, from https://thebreakthrough.org/images/pdfs/Breakthrough_Institute_How_to_Make_Nuclear_Cheap.pdf

Carlton, P. S. (2017). Harnessing the Energy of Nuclear Fusion Reactions with Superconductors and Lasers. Retrieved April 19, 2017, from http://www.cas.org/news/insights/science-connections/nuclear-fusion

The World Bank. (n.d.). World Development Indicators: Electricity production, sources, and access. Retrieved April 13, 2017, from http://wdi.worldbank.org/table/3.7

Lucibella, M. (2014, September). Congress Divided Over Future of U.S. ITER Contributions. Retrieved April 13, 2017, from https://www.aps.org/publications/apsnews/201409/iter.cfm

Perlman, U. H. (n.d.). How much water is there on, in, and above the Earth? Retrieved April 19, 2017, from https://water.usgs.gov/edu/earthhowmuch.html