Introduction

In the world today, everyone is at risk to environmental problems, and global warming. Although many people think that they have nothing to worry about, this is not the case. Carbon emissions are growing rapidly due to all of humans industries and energy. Coal and oil, with which we make things that we use daily, are very bad for the environment when they are burned. These coal and oil plants are major contributors to pollution, and we have to find a green substitute if we want to keep living the lifestyle that we have grown used to over the last couple of decades. Our cars pollute, and this substitute will need to be able to power cars efficiently and cleanly. If we want to protect our Earth, and make sure that our kids do not pay for our mistakes, we have to do something. We have many power sources as candidates, such as geothermic energy (which captures heat from the ground then creates energy), hydroelectric energy (which uses water to turn a turbine to create energy) or even energy from biomass (where organic materials are burnt and the heat is changed into energy). But the source of energy that really interests me is nuclear energy. Great scientists such as Albert Einstein have worked out these principles, and this science is very interesting. When people talk about nuclear energy, they are talking about the splitting and merging of atoms. Throughout this project, you will learn how nuclear energy works, and brief histories of different kinds of nuclear transportation.

Nuclear Mechanics

Introduction

The Earth has limited supplies of both oil and coal, but Nuclear energy is unlimited. According to Bellows (2006), nuclear energy is clean, safe and cheap. While coal and oil plants pollute the Earth, nuclear energy does not, save radiation which can be controlled (Smith 1996). Nuclear energy is the way of creating heat light and energy through fission and fusion (NRC 2007).

Fission

According to Energy Quest (1994), fission means to split apart. In Nuclear terms, fission is a way to get energy by splitting atoms (Smith 1996). In order to split an atom, scientists like the late Albert Einstein have figured out that you have to shoot a neutron at an atom to split it; the easiest atoms to split are uranium and plutonium (NRC 2007). This process creates two or three new atoms out of one (NRC 2007). When an atom is split, it

releases energy in the form of light or heat (Energy Quest 1994). A small amount of matter can contain huge amounts of energy. If it is let out slowly, it can be harnessed, and if it is let out all at once, it makes a huge explosion, like an atomic bomb. For harnessing purposes, uranium is the easiest element to split (Smith 1996). If a uranium atom is split, its neutrons are shot around, causing further atoms to split and ultimately creating a chain reaction (Smith 1996). The first time a chain reaction occurred was when Enrico Fermi created one in 1942. Nuclear power plants create these, and try to get all the power they can from the atoms by using reactors (NRC 2007).

Fusion

In the fusion process, the nuclei are fused together instead of being split apart (Smith 1996). This fusion joins smaller atoms together and merges them to make one nucleus (Energy Quest 1994). Although scientists do not completely understand how fusion works, they do know that it makes less radioactive material then the fission process (Energy Quest 1994). According to Smith (1996), the fusion process requires immense amounts of heat. The supply of fuel in fusion lasts much longer, and is much more efficient then fission, which is why scientists are trying to figure out how to use it (Energy Quest 1996). According to Energy Quest (1994), the sun and other stars run on fusion nuclear energy. Smith (1996) further states that, in the sun's case, it fuses hydrogen molecules to create helium, and in the process creates energy, which we can perceive as light and heat.

Power Plants

Machines called nuclear reactors create 16% of the world's energy (Smith 1996). At Nuclear power plants, the energy is produced by fission reactors (NRC 2007). According to Smith (1996), the first major nuclear plant opened in England in 1956. While other coal and oil power plants burn these resources to make energy, nuclear plants do the same thing, but turn the heat into electricity by using steam turbines (NRC 2007). In order for the power plants to maximize the heat given off by the fission, the uranium has to go through a process. Uranium is an element on the periodic table, and it is dug out of the ground before being enriched, and processed into tiny pellets (Energy Quest 1994). These pellets are then loaded into long rods, which are loaded into the reactor (Energy Quest 1994). To turn a steam turbine, the fission process gives off heat to water in the reactor, this water turns into steam which turns the turbine, and creates electricity (Energy Quest 1994). There are two kinds of reactors, the first is a PWR. A Pressurized Water Reactor keeps the water under pressure so

that it heats, but does not boil, whereas the BWR, Boiling Water Reactor, lets the water boil (NRC 2007).

Conclusion

Although nuclear energy is very efficient, and very green, making nuclear energy can lead to radioactive by-products (Smith 1996). According to the NRC (2007), radiation can damage human cells, and can even cause cancer. There is also the risk of nuclear meltdowns, which can make an area radioactive for hundreds of years, thus making it unlivable and the fallout can kill people (Smith 1996). The mechanics of nuclear power apply to warfare as well, and are the main science used to develop the atomic bomb (Energy Quest 1994). Smith (1996) states that the U.S. and Russia have over 50,000 nuclear weapons between them, and that that is enough to kill every person on earth.

Ford Nucleon

Introduction

At the time (1950) Nuclear power was a big concept for the world, and this Atomic energy had the potential to give clean, safe, and cheap power to the entire world. The Ford Nucleon was a nuclear-powered concept car built by the Ford Motor Company. A 3/8 scale of the Ford Nucleon was unveiled in 1957 by Ford. According to Bellows (2006) the Nucleon concept was received with a great amount of enthusiasm from the public.

Nuclear Reactor

The Ford Nucleon was designed not to have an internal-combustion engine within it. In fact, Bellows (2006) and Wikipedia (1998) state that it was intended to have a small nuclear fission reactor in the rear of the car. The nuclear fission reactor was planned to work like a mini submarine reactor (Bellows 2006). The Ford Motor Company (1998) declared that the reactor would be located in rear of the vehicle. It was designed to use Uranium fission, which would create heat that would in turn super-heat water, which would generate steam. This steam would turn the turbines and would generate electricity for the car to move, the steam would then be condensed into water to restart the process. These engines could work as long as they had a source of uranium as fuel. According to the Ford Motor Company (1998) the reactor was an interchangeable unit that could be changed or modified at any time. The reactor would have a radioactive core that would have to be handled very delicately. Bellows

(2006), Wikipedia (2007) and the Ford Motor Company (1998) all concur that the engineers of the era envisioned recharging stations, where old reactors could be swapped for new ones, would eventually replace gas stations. These reactors would be suited to different people's needs, and would vary depending on the driver's needs and the distance to be travelled (Ford Motor Company 1998).

Features

The reason why the Ford Nucleon received so much attention was because of its unique energy source. According to Bellows (2006), it was the most energy-efficient car ever built. Depending on the type of reactor, it was estimated that the Ford Nucleon would be able to drive up to and exceeding 5,000 miles a charge (Ford Motor Company 1998). Since there was no combustion unit in the car, the automobile would have been virtually silent, an idea relished by many at the time. Unlike the pollution problems of today, the Ford Nucleon did not emit any harmful vapors to the environment, other then radiation, which is controllable (Bellows 2006).

Design

The Ford Nucleon was the icon of the Atomic Age (1950s). According to the 3/8 scale of the Nucleon released by Ford in 1958, the Nucleon had tail fins and had a sleek, futuristic look to it. The car resembled a space-ship, and was the inspiration for the De Lorean in the movie "Back to the Future". The windshield was one piece of glass, and did not have any pillars, but curved around the door. The roof was built in the same manner as a cantilever, and air intakes were made on the edge and base of the roof (Ford Motor Company 1998).

Conclusion

Ford never produced a working proto-type of the Nucleon. The naïve optimism of the public at the time led to misunderstanding of nuclear power, and, when the dangers of atomic energy became fully aware to the public, the Nucleon project was abandoned. According to the Ford Motor Company (1998), one of the reasons why the Nucleon was never built was because the design had depended on the development of lighter reactors, and

better shielding from the reactor. The slightest accident, like a fender-bender, could result in a major melt-down, and become a radioactive disaster.

A Short History of Nuclear Ships

Reactors

The first pressurized water reactors built in submarines was by the Russians for the USS Enterprise, which is still in service (Australian Uranium Association 2008). These PWRs, as they are called, were basically heat engines (The National Museum of American History 2000). Rolls-Royce built the PWR-2 reactor for the Royal Navy (Australian Uranium association 2008). It used uranium fission to release energy which would heat pressurized water, which would steam up, and the steam would turn a turbine (The National Museum of American History 2000). There have been four generations of PWRs, the last one being developed in 1995 (Australian Uranium association 2008). These reactors would turn the propellers on the sub, as well as providing an electricity source for living (The National Museum of American History 2000). Because of the incredible efficiency of these PWRs, nuclear submarines can operate submerged for months at a time (The National Museum of American History 2000). The safeties of the reactors are enhanced by internal neutron shields, this leads to long core lives. Old submarine reactors need refueling every ten years while new reactors will only need to be serviced every fifty years. Work on nuclear marine propulsion systems started in 1940 (Australian Uranium Association 2008). The Navy experimented with several different propulsion systems, but finally decided to go with closed-circuit systems, because they did not need any oxygen to work, and did not cost a lot, which is one reason why some European Navies use them (Harris 2006).

American Ships

Both Harris (2006) and the Australian Uranium Association (2008) agree that the Nautilus was the first nuclear-powered submarine to go to sea. It was put to sea in 1955, and could put up speeds of 25 knots for weeks on end (Australian Uranium Association 2008). It was 323 feet and 3,674 tons with a surface-speed of 18 knots, and so fast that on its first exercise, it outran the homing torpedo (Harris 2006). The USS Triton was built in 1955, and was the next nuclear-powered submarine, it was 447 feet long, and weighed 5,963 tons (Harris 2006). It was the largest US sub built to date, but became the first nuclear submarine to be retired in 1969. Another milestone in submarine history is the USS Skipjack, built in

1959; it was the first sub to use nuclear power plants, and the high-speed Albacore hull (Harris 2006). The USS Enterprise was the first nuclear aircraft carrier, it was powered by eight nuclear reactors, it was put to sea in 1960, and it still remains in service. The USS Long Beach was the first nuclear cruiser, and was put to sea in 1961 (Australian Uranium Association 2008). There have been two major US submarine that have sunk (Harris 2006). The first is the USS Thresher. It sank April 10, 1963, no one knows what happened, but it was on trials when something went wrong (Harris 2006). It sank 8,300 feet and took 128 crew members with her (Harris 2006). The USS Scorpion is the second nuclear sub lost, and was probably the victim of one of her own torpedoes (Harris 2006). By 1962, The Navy had already 26 nuclear submarines with 30 new ones under construction. Nuclear power revolutionized the Navy, and although there have been some mistakes, the US Navy has an almost impeccable safety record, and has almost 5500 of accident-free reactor years (Australian Uranium Association 2008).

Russian Ships

According to Harris (2006), the Soviets created their first nuclear sub in 1958; apparently, they copied the American subs, and were so fast that five years into their program they had 24 subs, but the Soviets did not understand problems like radiation, so they accumulated a less then stellar safety record. The earliest power reactor failure for the Soviets was in 1961, when their first nuclear powered missile carrying sub was on its maiden voyage (Broad 1993). There had been a loss of coolant, and after emergency repairs, ten crewmen died of radiation (Broad 1993). It would seem that the Echo-class was the worst class for the Soviets, there has been three different mistakes in this model. On May 24, 1968, there was a major meltdown, due to a liquid-metal coolant failure. No one realized for several hours, and nine crew members eventually died. In June 1970, an Echo-class crashed into an American submarine off the coast of the Kamchataka Peninsula, the ship was carrying nuclear-tipped missiles and torpedoes, on impact, the sub started to sink, but resurfaced, the propeller shaft was damaged badly, but the sub returned to port (Broad 1993). On August 10, 1985, there was a huge reactor explosion which killed 10 people, and exposed people on several square-miles out to high doses of radiation (Broad 1993). The Alfa-class submarine was a Russian built ship with a Liquid metal cooled reactor, and was very fast (Australian Uranium Association 2008). The Typhoon-class was the biggest Russian ship, weighing 26,500 tons, and was powered by twin 190 Megawatt PWR reactors (Australian Uranium Association 2008). The second biggest were the Oscar-2-class, also known as Kursk, which had the same

power plant as the Typhoon, and weighed 24,000. Although the early Soviet subs had many accidents, by the third generation of PWRs (1970), the subs have fared much better. All Russian ballistic missile subs have had double reactors since the Enterprise.

British and French Ships

The Russian, US and British Navies have always relied on steam turbine propulsion whereas the French and Chinese use the turbine to generate electricity to move. The French Rubis class does not need to be refueled for thirty years, and generate 48 megawatts. The French aircraft carrier, Charles de Gaulle, was commissioned in 2000, and has two PWR units can go 25 knots for five years before refueling (Australian Uranium Association 2008). Finally, the French barracuda classes are commissioned to be built in 2014; they will use the same reactor units as the Charles de Gaulle. The British Vanguard class can last over a lifetime without refueling, and are 15,400 tons while only needing one PWR2 reactor (Australian Uranium Association 2008).

Numbers

At the end of the Cold war there were over 400 submarines that were working, or being built, and at least 300 of them have been scrapped (Australian Uranium Association 2008). The Russia and the US have over 100 each in service, the UK and France have less then twenty each, China has six, and overall, 47 nations operate more then 700 subs, 300 of them are nuclear powered (Harris 2006).

A Short History of Nuclear Aircraft

Introduction

In the late 1940s, the ideas of nuclear fission and the development of aerospace propulsion systems were bigger then ever, and when the government decided to merge the two together, it was the dawn of a new nuclear aeronautical age (Schulin 2003). The driving force behind these nuclear powered aircrafts was the silent war in the US and Soviet Russia (Wikipedia 2008). These new planes had the potential to keep nuclear weapons in the sky for months at a time, which would dissuade the other country from attacking (Everything.com 2003 and Wikipedia 2008). The US and Russia conducted long experiments, but over time

both countries cancelled their programs, and no models were ever actually made in production numbers (Schulin 2003, everything.com 2003 and Wikipedia 2008).

NEPA

The United States started its nuclear aircraft program in 1946 with a program called the NEPA. The NEPA stood for the Nuclear Energy for Propulsion of Aircraft. It was started by the Royal Air Force in 1946, and by 1948, ten million dollars had been spent in the program (Everything.com 2003 and Wikipedia 2008). The NEPA's goal was to do research on the feasibility of nuclear aeronautics, and most of this research was done at the Oak Ridge National Laboratory (Schulin 2003). It was ended in 1951, when it joined with another group to create the ANP (Wikipedia 2008).

Transition

The other group that joined the NEPA was started in 1948 and was called the Atomic Energy Commission and was created by students at the Massachusetts Institute of Technology (MIT) to test the feasibility of nuclear aeronautics, when the two joined together, they created another group called the ANP (Everything.com 2003). This group from MIT came up with a final report called the Lexington report which stated that nuclear powered flight was possible, but would take over fifteen years to develop and would cost over one billion dollars (Schulin 2003).

ANP

The ANP stands for Aircraft Nuclear Propulsion program. While the NEPA's goal was to do research in the nuclear field, the ANP's goal was much more ambitious, and they wanted to develop a proto-type (Everything.com 2003). In order to create this proto-type, the ANP had to find information on reactor materials for shielding, and had to create designs for reactors in three to five years (Schulin 2003). Funding issues slowed down these programs, but most of these goals were still achieved.

Pratt and Whitney

The ANP studied two types of Nuclear Powered jet engines. Two companies were charged with the task of building two different engines (Everything.com 2003). Pratt and Whitney's Aircraft Company was the first corporation to be contracted by the NEPA, and

started their work in 1953. This engine used an indirect cycle system, which used nuclear fission to melt metal, the liquid metal heats air which turns a turbine (Schulin 2003). By the end of the ANP, Pratt and Whitney never made a working indirect-cycle system reactor.

General Electric

The second reactor was made by General Electric, it was a direct-air cycle systems, and was very successful (Wikipedia 2008). The reactor works by heating air directly with nuclear fission, and the heated air turns a turbine. The first working nuclear jet engine was a General Electric modified J-47 Turbojet (Schulin 2003). It was created in 1956, and the reactor was called the Heat Transfer Reactor Experiment No.1 (HTRE-1), several others were developed later. It eventually operated for more than 120 hours including 65 hours. The HTRE-1 was later followed by the HTRE-2, and the HTRE-3 could power two turbojet engines (Schulin 2003).

Convair B-36 bomber

The United States' goal was to build a supersonic manned bomber, but due to technical and financial problems, they decided to convert an existing Convair B-36 bomber. A small reactor was installed in the bomb bay, and the plane was re-named the X-6. The bomber was used for shield development and radiation tests, and is known as the Nuclear Test Aircraft (NTA). The NTA was fitted with a one megawatt reactor in order to simulate radiation. According to Everything.com (2003), the nose section of the bomber was rebuilt with twelve tons of lead and rubber, shielding was added around the reactor, and water jackets were placed around the fuselage of the aircraft (to absorb radiation) all as little things to help take away radiation from the crew members. The aircraft completed 47 flights from 1955-57, and stopped being tested when the ANP shut down (Schulin 2003 and Everything.com 2003).

Tupolev

Although the focus of the report is mainly on the American Air Forces, the Russian Air Force did create several nuclear dependant aircraft, one of them being the Tupolev TU-95 LAL. The Soviet nuclear program was experimental and it was estimated that it would take twenty years to complete a working model, and it started on August 12, 1955. Much like the B-36, a small reactor was put into a working Tupolev bomber, and the Soviets conducted 34 research flights to see radiation levels. Although the experiment looked promising, it was

shut down because of advances in other fields which led nuclear aeronautics to become useless for the Russians (Wikipedia 2008).

ANP Program Cancellation

President Kennedy shut the ANP down on March 28, 1961. The shielding of the reactor for radioactive purposes was never completely finished due to the fact that the shielding weighed too much for the plane to carry (Schulin 2003). The ANP had spent over one billion dollars of 1957 value, and no working proto-type had been created yet. Schulin (2003) further states that the building materials of the plane and reactor could not handle the intense heat created by the fission process, and it was not powerful enough at the time to completely protect the crew members from radiation. The Lockheed study was created to find the design differences that would need to be calculated within nuclear bombers compared to other ones. The first recalculation needed would be the landing weight of the plane, and the effect it would have on the landing gears because a normal plane loses about half of its weight to fuel consumption, but a nuclear plane would land with the same weight that it took off with, which meant that better landing gears would be needed (Schulin 2003). The second issue of radioactivity led to the concept of divided shielding, which would focus the shielding on the cockpit and the reactor, the only problem with this was that radiation was free to go anywhere within the aircraft, and some could get lost in the environment. Thirdly, the reactors would weigh huge amounts, and while the aircraft would be able to hold it, the focus of weight in one area would take a lot of structural consideration into the design of the craft Schulin 2006).

Nuclear Powered Mars Rover

Introduction

The Mars Science Laboratory, or MSL, is the product of NASA's desire to get a nuclear powered rover on Mars. It will be the third rover sent by NASA to land on the moon, since the landing of the Spirit and the Opportunity, but it will be the first nuclear powered one (NASA 2008). According to David (2006) and Chang (2008), this end-of-the-decade project could be considered as a stepping-stone into the next decade of nuclear spatial aeronautics, and this rover, in addition to its other goals, will be investigating the possibility of long-term missions which include sending humans to Mars. The program is projected to cost over 1.8 billion dollars, already over 165 million over budget (Chang 2008). The rover will stay on the planet

for 687 Earth days, which is one Martian year, and the project is managed by the NASA's Jet Propulsion Laboratory in Pasadena, California.

Launching and Landing

The rover will launch in September of 2009, onboard the spacecraft Atlas Five form the Cape Canaveral Air Force Station in Florida. The rover will reach Mars on or around July 10, 2010, where it will be released from the space shuttle (David 2006). The rover will be let go above its destination, and a few minutes before impact, it will release a parachute and deploy rockets to ensure the landing. This landing method will ensure that the craft will land in a radius of twenty kilometers (David 2006 and NASA 2008).

Reactor

According to David (2006), the reactor on the rover will be Plutonium powered rather then the traditional uranium powered reactors. Berger (2006) states that NASA will use a multi-mission radioisotope thermoelectric generator for its rover (MMRTG). This type of reactor converts Plutonium-238 atoms that are in the process of decaying into electricity which will power the craft (Berger 2006). This power source will give the rover greater mobility then solar powered rovers, because it will be able to travel at different latitudes, where there is less sun, at night, and when it is cloudy (NASA 2008).

Design

According to Berger (2006), the rover will be the approximate size of a compact car. It will be about nine feet long, which is twice as long as the Spirit and the Opportunity (Chang 2008 and NASA 2008). It will weigh about 1,708 pounds, which is three times heavier, then the Spirit and the Opportunity. It will have six wheels and a mast where several instruments will be set up. Thanks to its rocker-bogie suspension system, the rover will be able to roll over anything that gets in its way under 25 inches high, and will be able to travel about 660 feet per day on the Martian landscape.

Instruments

The rover will be carrying state-of-the-art instruments to help it analyze the data that it collects (David 2006). It will be equipped with ten different mechanisms, which will be controlled by people from Earth. Of the instruments, several gadgets have been provided by alternate space programs including a hydrogen-based water detector from the Russian Federal Space Agency, and a spectrometer (a device that measures wave lengths and angles

in between faces of an object) from the Canadian Space Agency (NASA 2008). Among other devices, the rover will be using a laser in order to vaporize the surface lair of rocks to see the inside, Chemical make-up readers to analyze the compositions of different rocks, using the arm to pick up whatever they need investigated, and a central mast camera that would be mounted at eye-level to store all video taken, and would be the main use of navigation for the scientists back on Earth.

Goal

The previous Martian rovers have found evidence that there was once water on the planet, so the Mars Science Laboratory's mission is to determine whether this environment was or still is containing microbial life (Chang 2008 and David 2006 and NASA 2008). Over the next Martian year, the rover will be charged with the task of completing a twenty kilometer journey to collect data. During this time, it will collect samples of Martian soil and rock, and will analyze them with its instruments to determine if they contain any organic compounds that could be the building blocks of life. It will try to assess what has happened to Mars over billions of years, and will try to uncover the water and carbon dioxide cycles, and try to see if they are frozen, liquid or gaseous.