Project Number: MH - 1201

Alternative Renewable Energy

~Future of Energy in Japan and Korea~

An Interactive Qualifying Project Report submitted to the faculty of Worcester Polytechnic Institute, in partial fulfillment of the requirements for the Degree of Bachelor of Science

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IQP

Abstract

The objective of this IQP is to investigate the current status of alternative renewable energy technology, including Bio-mass, Wind Energy, Solar Energy, Quantum-dot Solar Energy, Geothermal Energy, Hydro Energy, Wave and Tidal Energy, and Ocean Thermal Energy; to develop a vision of future energy production in Japan and in South Korea, and to provide ideas of the feasibility of renewable energy.

Executive Summary

This Project explores the feasibility of current alternative renewable energy and the impact of new ideas for renewable energy. Then, it investigates the details about the applicability of the alternatives in Japan and South Korea.

For the current alternatives, Bio-mass, Wind Energy, Solar Energy, Quantum-dot Solar Energy, Geothermal Energy, Hydro Energy, Wave and Tidal Energy, Liquid Fluoride Thorium Power (LFTR), and Ocean Thermal Energy are examined. The obtained evidence shows that solar energy and wind energy are the two most advanced alternatives we have today. Also, these two are improvable in terms of their efficiency and cost.

For the futuristic alternatives, focus is put on Space-based Solar Power (SBSP) and Air Fuel Synthesis. The feasibility of the SBSP system is investigated through calculations of required space for the system. A thermal issue that SBSP might have is also discussed.

The current Japanese approach to energy production issues is inspected and, based on the direction where it goes, a novel idea for future energy production is made by the author. The main goal to achieve is to have a nuclear-free electric generation system. In detail, energy source contributions in 2030 and 2050 are proposed. Without the political and financial views, it is obtained that having no nuclear power plant in Japan is probable. The necessity of the idea is also discussed.

South Korea is using much renewable energy such as: solar, wind, tidal, bio-mass, and geothermal energies. The renewable energies in South Korea are similar to the ones in Japan, but Korea focuses more on solar and tidal energy than other renewable energies. After research we concluded that renewable energy alone cannot sustain South Korea's energy consumption. The renewable energy percent compare to the total energy consumption in Korea is less than 3 percent, which means sustainability is far behind the goal of self-sufficient energy country. However, Korean government is positively looking forward for renewable energy research and exploration. Besides, the government is planning to construct villages or town even city along with green energy. The Solar City Sangdo is a city designed and constructed with green energy, mostly energy supplies by solar power. Another green energy had mentioned in the project is Uldolmok Tidal Power Station, which is the largest tidal power station in East Asia. The energy generated from the power station is enough to supply 5000 homes. Although with government is looking forward to renewable energy due to financial, policies, and technology; the goal of "sustainability" is difficult to approach. Therefore, I consider the technology wise and come up with this suggestion that we made is multi-green energy, which is a combination of tidal, solar and wind. Basically, both Japan and South Korea are aggressively looking for renewable energy due to the restrictions coming from their geology and increasing population. Lastly, we predicted the future vision of energy. Two cases had been discussed and the first is installing mirrors at the geocentric orbit so that solar energy is increased. Second case is minimizing the energy consumption by creating robots that can do all the work for us, assuming that technology advanced enough to support the energy of robots exists. True, alternative energy is needed, but sustainability comes before it.

Life styles also considered as potent issues. There are two main situations: first case with lack of energy resources and second case with abundant energy sources. We will also examine how these two cases affect transportation, education, and our lifestyles. For lack of energy resources case, the transportation would be minimized, so people rather work at home than report to office every morning. Also the Education, many people could not afford the tuition for high school or colleges. Therefore, in this case government should be responsible for the tuition problem and support online education. Simply, our Lifestyle is dependent to the energy, and the development

1-Introduction

1.1-Overview

"Sustainability" refers to a quality and system of life that allows people to meet their current needs without compromising the resources available for future generations to meet their needs. There are limited energy resources for people, and if we cannot find a solution for alternative energy in near future, we cannot sustain. Price, environment, health, safety, and lifestyle are taken into account as the elements needed to be sustainable with this project. Then we discuss the energy situation in Japan and Korea and suggest what could be done.

1.2-Motivation (environmental and health)

In this alternative energy project we also consider environmental and health as our motivation. People should start planning energy saving, or innovation, ahead for at least 40 years afterwards. As medical service and technology improves, there will be a tremendous increase of population, as the population increases energy consumption will be positively proportional to the population growth. And why is it for 40 years? Since the closest shortage of oil is around 4o years; natural gas is 60 years and coal is another 150 years. I assumed the next generation will face a shortage of oil and natural gas. This is not the only problem to deal with but if we keep using our energy resources like oil, nuclear, coal, and natural gas nowadays, this shortage will become a reality. Fossil fuels are the largest greenhouse gas emitters in the world, contributing 3/4 of all carbon, methane and other greenhouse gas emissions. The U.S. consumes more than 20 million barrels of oil per day, with more than one million tons of coal consumed annually as well. These power plants will keep emitting a huge amount of greenhouse gases and damage our atmosphere, resulting in 3.2 billion tons of additional carbon dioxide annually. More than 2.5 million metric tons of carbon is produced by power plants. Besides, nuclear power plants cause many health issues due to radiation. Radiation sickness doses amounts to that of about 200 rems. If all our power came from nuclear plants we would receive an extra 2/10 of a millirem a year. The three major effects of radiation (cancer, radiation sickness and genetic mutation) are nearly untraceable at levels below about 50 rems. So, why don't we use green and renewable energy instead? Although the technologies we have today have less efficiency and higher cost, if you consider the next generation, environmental and health issues, innovation of renewable energy is one of the best ways to solve the problem. Therefore, we have decided to use bio-mass, solar, wind, thorium and fusion reaction energies to improve the future environment and health. Most importantly, through this alternative energy project, we want to change the concepts of energy in the minds of people who only think in the short-term instead of the long term.

1.3-Motivation (New Business)

Our motivation for this project is to offer new business ideas. I predict that the alternative energy industry will be one of the biggest industries to be invested in. Knowing the issues today and exploring the remedies to the issues would expand my view of the particular subject. For examples, by using the knowledge of quantum mechanics, I could come up with a new way of making quantum dots or predicting which business will be the best for society and myself and start a new business.

1.4-Health and environmental issues

People realize the seriousness of environmental effects due to certain energy usages which lead to health problems. Air and water pollution were already issues in the past. Greenhouse gasses could also harm us through global warming, ozone depletion, and climate change. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide. Outdoor and indoor air pollution cause respiratory and other diseases, which can be fatal. Water pollution is an undesirable change in the state of water, contaminated with harmful substances. It is the second most important environmental issue next to air pollution. Any change in the physical, chemical and biological properties of water that have a harmful effect on living organisms is water pollution.[1]

Polluted water also contains viruses, bacteria, intestinal parasites and other pathogenic microorganisms. Using polluted water for drinking purposes is the prime cause for waterborne diseases such as diarrhea, dysentery and typhoid.

1.5- Lifestyle

People's life and energy are closely related. For examples, transportations, heating, and cooling use energy, also even what people wear was made using energy. Innovation of technology change people's lifestyle and this is directly proportional to energy cost. For example, early 18oo's before light bulb introduced people use candles or oil lamps at night. However, since Edison invented light bulbs, human's lifestyles had tremendous change by working until late night and had more activities during night time. The problem is how people could maintain the light bulbs, which requires electricity to keep the light. Therefore, in order to keep using electricity people built electricity power plants. Due to the convenience of electricity people start to depend on the energy. So, people live where power plants can reach. Naturally, town forms as population increase and then city forms where the most concentrated place within the town. Energy also changes people's lifestyle by commuters, transportation. During 1500's, people use horses as most common transportation. People trade, and travel within the range where horses can reach. However, when steam engine is invented by James Walton, the concepts of commuter changed. People started to build railroad and extend the route to other towns, cities, even to other countries. In order to run the steam engine, coal energy is the key point. Therefore, people started digging mine and so, mine industry expended tremendously. Eventually coal becomes valuable energy sources and many people become miners. Coal energy provides new jobs for society and various trades for business. Oil is the same case just different time periods and more efficiency compare to coal energy. Therefore, energy has two major effects on human's lifestyle. First, energy like electricity change people's activities and living locations. Second, energy changes commuters, provides new jobs, and new trades. Now, let us consider two extreme situations: the world with just a little bit of limited energy and the world with unlimited energy.

1.5.1-Unlimited Energy

If we have unlimited energy which are very cheap, our life style would definitely change dramatically as well. To think what would happen with this situation, there are too many factors we need to take in account. It is even hard to consider if it is good for us or not. What we can think about is the possibility we gain from this; with unlimited energy we could try things that we could not because of the expenses toward energy. For example, everyone goes to work by helicopters, or we even, we can live on the sky by making a floating land. These possibilities with unlimited energy would fasten the technology innovation.

One big change we can imagine if we had unlimited energy is change in our business basis. The only possible unlimited energy situation is when we use the solar energy. Therefore, oil companies will not have as much customers. Also, cars will be battery based, not engine based, so engine making factories will be needed far less. Demands of materials will change due to such changes, which leads some materials more expensive and others not. As the business basis changes, I predict that, the value of goods changes. We do not need energy saving products anymore. This means, for instance, an advertisement for a light bulb which only uses a third of energy per year compare to others would not mean anything.

Even when we have unlimited energy, if the population increases our food production cannot meet the demand within Earth. We might have to expand our agricultural spaces by go into other planets, which is a possible option when we have unlimited energy. This innovation might make our traveling style a little bit different; we might be able to go to Mars with a price of domestic air flight.

When we have these possibilities, I think that education and recreation will be very significant in our life. Education and recreation are correlated to each other. For some people, education is a pleasure and is the main purpose of life. Some people educate themself to make money to buy what they want to have fun. Rapid technology growth and change in our society could make the difference in rich and poor bigger. I the difference get bigger and bigger then only the rich will have the control over society. To prevent this from happening, a strong education system would be very affective. Educating people from young age can encourage studying independently. This would give anyone a chance to try one’s best equally.

The above is just a prediction in the situation I made. However, it is sure that we will be needing energy in the future, and we need to come up with alternatives to replace our limited energy source. When we consider the danger of nuclear energy, green energy seems the best choice we can choose now for the future.

1.5.2-Limited Energy

On the other hand, what will happen if the energy cost is too expensive that most of the citizens cannot afford it? This situation is totally opposite from the situation I mentioned above. In this case, there will be two results will happen. First result is that people give up the lifestyle they have been living and turn back to the nature. And second result is innovation of new energy sources.

For turning back to nature, basically people change their lifestyle so they plants, and hunts; instead of go to works, or cook at houses. Since we had been living in the nature and we could sustain our life living in the nature. Therefore, less dependence of energy sources like oil, coal, natural gas or nuclear is a way leading to this result. For innovation of new energy, people invest and research for new energy source to sustain and compete with current energy sources they have been using. This will be a challenge for governments, and many leading technology companies. Even there is new energy source is invented if there is no effective policy for it, this will not be successful. Oppositely, if there is good policy for the new energy but technology do not support the basic needs, will leading to failures eventually. According to current situation, we seem like head toward second result, which is innovation of technology. People start research and invest more and more on green renewable energy like wind, solar, biomass, and wave. Once again, energy is a like keychain and people are keys that hanging on the keychain. Our life style is limited and sustained by the energy sources we have.

Furthermore for second situation if we are under limited energy sources how people's lifestyle change? There three main aspects to consider, which are transportation, environment, and education.

1.5.3-Transportation

Life style also could be also dependent on transportation. Let's say one person uses 308 million Btu per year in US. And about 40 percent of the energy is use in transportation according to EIA, 2009. For example, if a person has to drive one hour from Worcester to Boston for work, this causes about two gallons of fuel. From the example we could tell if the person work at home instead of driving all the way to Boston will save two gallons of fuel and one hour of time. How much energy could be created by two gallons of gas? According to Maine Public Services one gallon of gasoline could generated 125000 Btu's, so if there are two gallons than it generates 25000 Btu's. Furthermore, this is just a person could save by working at home instead of driving for work. Considering the population of US is 311,591,917, and 30 percent of population have work with driving distance. This will give a number of people 93,477,575 and multiply with 25000 Btu's which will give us 2.34*10^12 Btu. And how much electricity could be generated by this huge amount of energy? 3412 Btu equals 1kWh and so if we divide 3412 Btu than the result come out to be 685814771 kWh. This is about 0.02 percent of the total US electricity consumption. This result seems not very effective but if we consider global population and global energy consumption this 0.02 percent from one country is a huge different.

Besides, working at home is more productive than going to offices for work. The recent interview of Freakonomics Radio's Stephen Dubner had discussed the benefit of working home. He explained that a recent experiment by a company named Ctrip shown that people working home are more productive and less risk for health issues. The company required half of their employees to work at home while the other half of them reported to offices. The study revealed that people who worked from were 13 percent more productive than people working in an office. The study also showed that people working from home were more efficient. Stanford economist Nick Bloom, who conducted the experiment with Ctrip, says there may be a reason for this.

"In the office it's very noisy, you can hear the guy next to you on the phone or the person across the desk crying because their boyfriend just split up with them. It's very distracting," said Bloom.

“For the health problems, other studies show that commuting into the office is bad for you as well. A study from the Washington University shows that people who commute long distances have higher blood pressure than people who have short commutes.” [43]

(Marketplace for Wednesday, Aug 22, 2012)

1.5.4-Environment

Environmental issues also closely related to life style of human. Nowadays, the emission of carbon dioxide increases rapidly. Global warming is one major threat that 21 century mankind facing now. Therefore, we are looking forward for various renewable energies. Once again this lead us back to technology development. However, we could also decrease the carbon emission by changing our life style such as, taking quick shower instead of long relaxing bath, study or read newspaper with sunlight instead of electric lamp or light and taking bike to work place instead of driving. Taking bike as an example, if driving distance with one gallon of gasoline by normal passenger vehicle would produce 8887 gram of carbon dioxide, which means bike could save up to 8887 gram of carbon emission. Therefore, by living near the work place (biking distance) could reduce the carbon emission. Overall, reducing the usage of water, electricity, and gasoline also decrease the carbon emission.

1.5.5-Education

Education is one of major issues that government should be considered. Most of the school education focuses on literature, and sciences. How to get good grade on tests? How to get a better job in the future? Most of people learn and teach how to use up energy but how to gain energy. Parents teach their child how to turn on the light, how to flush the toilet, and how to turn on the microwaves. But they don’t teach child where all these energy come from and how they do work. Why parents do not teach these kinds of method are because of the education they had been troughed do not contain energy. And now the energy issues are getting more realistic and troublesome to society nowadays. If governments do not take energy education more seriously, the energy wastes will be increased and have terrible effect to the earth. Therefore, what energy education should government focus is how to save energy and list more regulations about building waste, and prefer all the new buildings to use green energy. The problem is that governments are also people and if they do not have energy education, they would not get the point of energy education. So, in order to maintain or sustain energy longer what should we do is the generation nowadays to teach their parents and their children.

We have the most responsibility to tell other people and through people we tell government why energy education is important.

What should we do if there is limited energy? How should we sustain our education system with least energy consumption? The idealistic education system I thought of is free online education system. There are already some online educations running such as: course sera, Udacity, and Edx. So, you stay at home or somewhere internet is available to take the courses that you are interesting. The best part of these online educations is either really cheap or free tuition. Therefore, people who could not afford the regular college tuition are also able to learn college courses. However, these education systems would cause some problems such as: diplomas, degrees, and policies. Since, the system is free which will contradict many existing colleges' policies. And the contradiction will cause law issues of legal or illegal. Therefore, what I have thought of is make the online education system as official governmental web systems and set up new laws. The online education systems cooperate with governments instead of each person. The government pays the tuition for citizens. Also, makes the degree official and consents the diplomas from the online educations. Set up an examination for each field who ever passes the exam will be acknowledged. By learning online at home could save transportation energy, time, and money. Although, internet needs electricity by then most of buildings will be self-energy sufficient and provide major electricity needs for the houses.

1.6-Safety

Safety is another issue we need to consider. The Fukushima nuclear accident in 2011 showed us the gravity of safety needs. However, as of May 2012, 30 countries worldwide are operating 436 nuclear reactors for electricity generation and 66 new nuclear plants are under construction in 14 countries. And nuclear power plants provided 13.5 percent of the world's electricity production in 2010.[2] Radiation can cause death in the worst case scenario.

Approximately 1Sv of radiation causes human nauseas, and 10Sv cause death. In 1999, two workers at nuclear fuel facility died of radiation after an accident, in Japan. There is a difference in radiation above 1Sv in once and radiation of 0.3Sv for a long time. Radiation tends to accumulate inside human body, so less radiation does not mean good when you expose your body long time to it. Major long-term effects of radiation are cancer, leukemia, and cataracts. It seems that the price of nuclear energy defeats the safety concerns.

1.7-Price

According to Community Solution, the production of gasoline will be reduced rapidly in the next 40 years, which will put many businesses in financial trouble and cause transportation havoc due to the heavy current dependence on petroleum. When gas prices increase, people tend to use less transportation that requires gas, which would make it hard to sustain our lifestyle today. The other solution is-to find other energy that exists cheap. Natural gas is a good option for the replacement of petroleum. Natural gas has a price of $2.3 per MMBtu. However, when the shortage of natural gas happens in the far future, this will bring the result back to previous situation, such as a shortage of petroleum. And this could happen to any other non-renewable energy. The best way to prevent a shortage of energy is innovation of new renewable energy resources. But the renewable energy we have now, such as solar energy, is 25¢/kwh, which is little bit more than double the price of natural gas. It defeats the argument of price versus efficiency.[3] With governmental and private support, engineers need to improve the technology to lower the price of renewable energy. In this way, people will not have to suffer in the future due to the increasing price of gasoline or shortage of energy sources.[4]

2-Back-ground

2.1-Current energy pros and cons

First of all, the most common and plentiful energy source that we use is coal. Coal is a fossil fuel that results from the decay of primeval forests over time. This energy source is considered as one of the world's most plentiful energy source, according to National Center for Policy Analysis in Dallas, Texas. About 25 percent of world's known coal is reserved by United States. Another good thing about the coal is cheaper price compared with other energy sources like: oil, and natural gas. Industry lobbyists say the free market policy will mean lower energy bills for consumers and businesses. Last advantage of coal is versatile of physical states. Coal could be burned directly, and it could also be transformed into liquid or gas forms, which means there are more ways to use coal energy.

There are also three cons about coal energy. First, coal-fired power plants are a major source of air pollution, according to the Environmental Defense Fund. Burning coal is also the main cause of acid rain and releases large amount of carbon dioxide. Another con about coal is health issue. The air pollution by burning coal poses a health hazard. Especially for those whom with respiratory diseases have more significant effects by the air pollution. The third disadvantage of coal energy is nonrenewable. After burning coal releases carbon dioxide and other chemicals that could not be restore.

Fossil fuels (oil) have three major pros and cons. First of all, fossil fuel is very efficient energy source, which has an average of 45% efficiency for fossil-fired power generation for electricity; compare with coal is about 35% and other left over 65% is wasted on heat and pollution through cooling towers and smoke stacks. On average the share of electricity production from fossil fuels in OECD countries is 61%. Oil is another form of fossil fuel. It produces energy when it is burned. And this is another advantage about the oil. Petroleum can be refined for uses such as generating electricity, powering automobiles, industries and heating homes. Third, oil energy has developed technologies for production, process, and commercialization. In other words, it is always considering as more convenient energy source for costumers.

However, gasoline also has environmental damages like coal. When it burns, it produces carbon dioxide and nitrous oxide and sulfuric acid, which contribute to acid rain. The other con about this energy is that price will rise long before fossil fuels run out because the fossil fuels remaining in the earth will become more expensive to collect. The last disadvantage is like coal energy, which is nonrenewable energy. Eventually, the supply will run out after 40 years. And this is one of the major reasons the price will increase rapidly.

Nuclear energy is clean burning and does not contribute to greenhouse gases like oil and coal. The other advantage about this energy is cost-effective, as a small amount of uranium can produce large of energy. One ton of natural uranium can produce more than 40 million kilowatt-hours of electricity. Worldwide, there are 441 nuclear power plants that supply about 16% of the world's electricity. The third advantage of nuclear energy is that the power plant only need small amount of fuel to the reactors since uranium is evenly distributed around the world. Once the nuclear power plant is installed, it is considered stationary power supplier.

The one of the major cons of the nuclear energy is safety. Radiation doses of about 200 rems cause radiation sickness, but only if this large amount of radiation is received all at once. The three major effects of radiation are cancer, radiation sickness, and genetic mutation. And the other disadvantage is waste disposal. The byproducts of the fissioning of uranium-235 remain radioactive for thousands of years, requiring safe disposal away from society until they lose their significant radiation values. During transportation of the waste is also risky, as many unknown variables may affect the containment vessels. If one of these vessels were compromised, the results may be deadly.

Natural gas is another fossil fuel that commonly used for power generating worldwide. In 2005, United States has 43% of Efficiency of Electricity Production from Natural Gas. For Korea, it has 49% of electricity production from natural gas; and Japan produced 45%. It is widely used, contributes 21% of the world's energy production today. The other pros about natural gas is that emits 45% less CO_2 than coal and 30% less than oil. And the abundant supply in the US. DOE (Department of Energy) estimates 1.8 trillion barrels reserved.

The pro about the natural gas is the large amount of reservation. Mostly about 40% of natural gas (2658 Tcf) is reserved in Middle East and little bit more than 4% (304.6 Tcf) is reserved in US compare with worldwide natural gas reservation. There are 0.74 Tcf in Japan and 0.25 Tcf in South Korea. Overall, worldwide natural gas reservation is about 6609 Trillion Cubic Feet. "Today, natural gas powers over 112,000 vehicles in the United States and roughly 14.8 million vehicles worldwide. Natural gas vehicles, which can run on compressed natural gas, are a good option for high-mileage, centrally-fueled fleets that operate within a limited area." [50]Although, when natural gas is burnt it still produced carbon dioxide but it is much less and harmless to the environment.

The cons about natural gas are nonrenewable, dangerous, environmental harmful. Like the other two fossil fuels, coal and oil. It is nonrenewable energy, which means there will be one day that will meet the shortage of it. Natural gas is very dangerous (explosive) when liquefied form is used to transport over water, in tanker ships. Lastly, it still emits carbon dioxide when it burns. Besides, it contains about 85% of methane, which is a potent greenhouse gas.

2.2- Overview of "2011 the Outlook for Energy" by Exxon Mobile

To understand what the issues are and what are capable of doing in terms of making our energy green we looked at a document made by Exxon mobile in 2011 and summarized it.

In this document, Exxon attempts to predict the energy related tasks in the future up to the year 2030. *Outlook* shows that ExxonMobil expects the global energy demand in 2030 to be almost 35 percent higher than in 2005, even accounting for the recent recession which dampened energy demand in 2009. Other key findings include these following:

• Growth will be led by rapid expansion in non-Organization for Economic Co-operation and Development (OECD) countries such as China and India, where energy usage will rise by about 65 percent.

• Demand will be particularly intense for electric power, which will comprise 40 percent of global energy demand by 2030.
• Oil and natural gas will remain essential, but other sources including nuclear and renewables (e.g., wind, solar and biofuels) will play an expanded role.

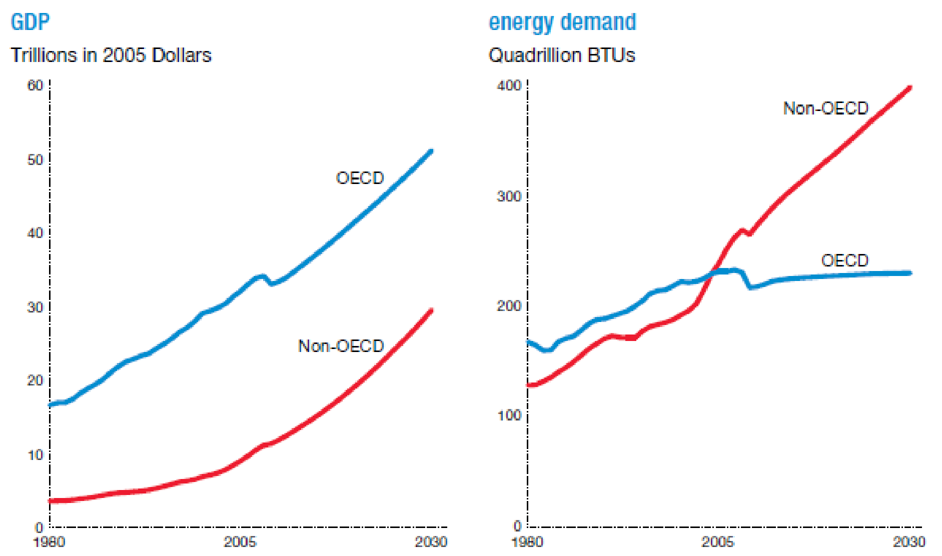
ExxonMobil believes that meeting future energy needs while also reducing environmental risk will require an integrated set of solutions that includes:
• Accelerating energy efficiency, which tempers demand and saves emissions
• Expanding all economic energy sources, including oil and natural gas
• Mitigating emissions through the use of new technologies and cleaner-burning fuels such as natural gas, nuclear and other renewable sources.

More details are discussed below.

Exxon claims "New energy technologies will open up new energy sources and new end-use technologies will reshape demand patterns, just as they have for the last 150 years. Change in energy use and technology development is an evolutionary process, but one that often has revolutionary impacts".

Considering the difference between the old energy/technology and new energy/technology, it will be even harder for us to adapt to the changes. This prediction by Exxon seems reasonable to many factors. That change in energy cannot happen rapidly is shown by its history. There is direct and indirect consumption of energy. Interestingly, indirect use forms a large proportion of daily energy use in the world. Exxon makes a point that we have to consider not only the energy we use in our daily lives, but also the tremendous energy being used behind the scenes that makes our modern lives possible. Just considering one aspect is not enough.

As the global energy demand increases we need to make more energy. But at the same time we need to sustain our live styles. To succeed, we will need an integrated set of solutions that includes expanding all economic energy sources, improving efficiency and mitigating emissions through the use of cleaner burning fuels such as natural gas.



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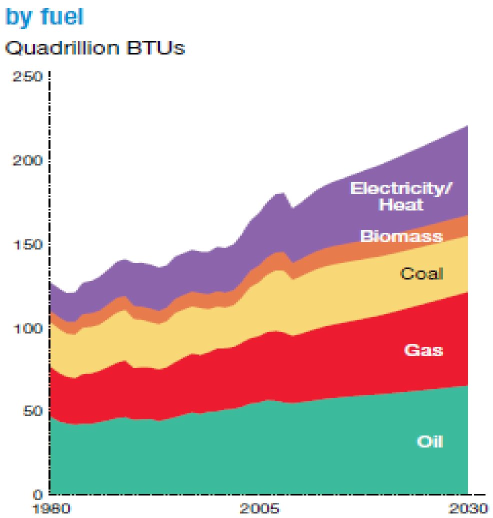
These graphs show the amount of GDP and energy demand in the world. They divide them into Organization for Economic Co-operation and Development (OECD) and non-OECD to show how they are different. Through 2030, the economies of non-OECD countries, while still relatively smaller, will grow at a much faster rate than those of the OECD. By 2030, these developing economies will have reached close to 60 percent of OECD economic output. In non-OECD countries, rapid economic growth is expected to produce a steep climb in energy demand. In fact, we expect that between 2005 and 2030, non-OECD energy demand will grow by about 65 percent. However, even with this rapid growth, per-capita energy demand in non- OECD countries still will be much smaller than in OECD countries. By contrast, in OECD countries, energy demand is actually expected to be slightly lower in 2030 versus 2005, even though their economies will be more than 50 percent larger on average. How is this possible? The main reason is efficiency. ExxonMobil continues to project substantial improvements in efficiency in OECD countries. In non-OECD countries, we also see efficiency improving, but faster growth in GDP and personal incomes will continue to drive demand higher there.

Anyone asking how the world will meet its energy and environmental goals must consider electric power generation; by 2030, this sector alone will account for about 40 percent of total primary energy demand, and its largest energy source will continue to be coal, the fuel with the highest carbon intensity. In each sector, demand would be growing much faster without improvements in efficiency. Efficiency improvements in each sector will add up to significant energy savings each year – reaching 300 quadrillion BTUs in 2030. Transportation is one of the fastest growing energy demand sectors. Commercial transportation demand will grow in all regions, but far more rapidly in non-OECD countries. By 2030, these fast developing nations will have overtaken the OECD as the largest source of commercial transportation demand. Heavy-duty vehicles such as commercial trucks will soon overtake personal vehicles as the largest source of transportation-related energy demand. At the same time, as the population grows and developing countries grow, the need of personal vehicle grows, as well. China today has only about 27 vehicles per 1,000 people, compared to 780 per 1,000 in the United States. Rising incomes in China and other developing countries will produce strong growth in the number of global vehicles through 2030.

Efficiency is a key to reduce the demand growth. Gains in energy efficiency through 2030 will reduce global energy-demand growth by approximately 65%. Taking sensible steps to improve energy efficiency is a "triple win" it saves money, reduces energy demand and curbs CO2 emissions. Through 2030, the amount of energy saved through improved efficiency will be greater than the energy consumed from any single supply source.

Making vehicles more efficient is a goal of automakers, governments and consumers around the world. Many technologies already have been developed to substantially improve the fuel efficiency of conventional vehicles. These are not far-off innovations; they are available today, and there is a lot of positive news in this area. This innovation is very close held to us, especially in the US where almost everyone owns a car and hoping not to pay too much for the gas.



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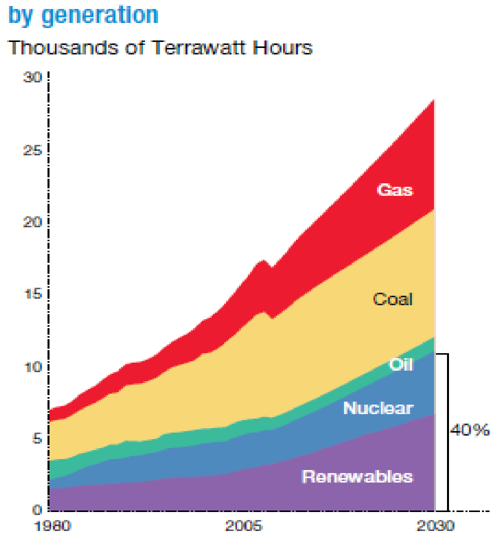
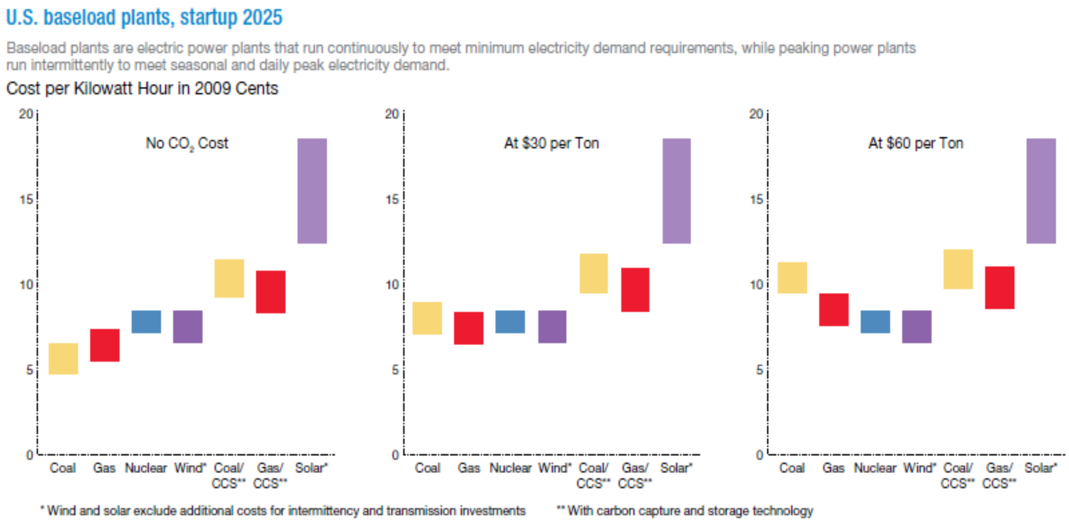
This graph shows the global industrial demand by types of fuel. Oil remains the largest industrial fuel through 2030 due to growing non-OECD demand. We see natural gas and electricity gaining share while coal declines, reflecting the shift to less-carbon intensive energy sources.



[7]

Looking at electricity use in the world by generations, we see that by 2030, we expect that 40 percent of the world's electricity will be generated by nuclear and renewable fuels. This seems very bright to us. I personally think this is not too realistic; this is what should happen and what we need to aim at for now. I say it is not realistic because of the electricity generation cost. You can see the prices from these graphs clearly:



[8]

In the United States, absent any policies that impose a cost on CO2 emissions, we would expect coal and natural gas to be the lowest-cost options for future, newly-built power plants. But policies that impose a cost on carbon would sway these economics. Coal, being the most carbon-intensive fuel, would increase in price more than natural gas. At $30 per ton of CO2, natural gas would become the most economical alternative for new-build power plants. This is where we expect CO2 costs may evolve over the next 10 years. As the CO2 price increases, we would expect to see fuel switching from coal to natural gas. This will happen by running existing natural gas plants at higher load factors, as well as by building new natural gas plants and retiring old coal plants.

Natural gas seems helpful for us today. Since it can burn easily and cleaner than what we use now such as coal and gas. Natural gas will provide a growing share of the world's energy through 2030. Affordable and abundant, natural gas can help provide the energy needed for economic and social progress. And because it burns cleaner than oil and much cleaner than coal, natural gas is a powerful tool for reducing the environmental impact of energy use. Natural gas used for electricity can reduce CO2 emissions by up to 60 percent versus coal, which today is the most popular fuel for power generation. It also has fewer emissions of sulfur oxides and nitrogen oxides. Yet, I think it is a temporally solution for next few decades. Curbing greenhouse gas emissions while also meeting rising energy demand will require a tremendous global effort, sustained over decades. Compared with a cap-and-trade system, a carbon tax by being predictable, transparent, and comparatively simple to understand and implement - is a more effective approach for creating the conditions necessary to achieve emissions-reduction goals.

With the growth of natural gas needs, the demand of liquid fuel supply will increase. Through 2030, total liquids demand increases steadily to 104 Million Barrels per Day Oil Equivalent (MBDOE) – about 24 percent higher than in 2005. Meeting this demand in an economic and environmentally sound manner is an ongoing task of the global energy industry. It will require large investments to maximize yields from mature fields as they naturally decline, and develop new sources of supplies in existing development areas as well as promising new regions.

Innovation of technology seems like the solution ExxonMobil has. Cleaner and more efficient ways of generating energy would provide enough energy to the demand and yet sustainable. Balancing the demand, supply and emissions will be needed to us in the future.

Exxon is strongly suggesting gas as next major energy source. All indicators predict it. However, we need to remember that gas is not renewable. We might have gas for a long time but there will be end to it. Gas is better than coal and other current major burning materials used today, yet gas still emits carbon gasses.

3-Overview of Alternatives

First of all, the following is a list of the costs for electricity come from alternative energy sources: Solar, Fuel cells, Wind, and Biomass.

Energy Source	**Cost (¢/kWh)**
Solar Energy	20-40
Fuel cells	10-15
Wind Turbines	5-10
Biomass generator	5-10

[9]

3.1-Bio-mass:

Microalgae are considered one of the most promising feedstock for biofuels. Algae range from small, single-celled organisms to multi-cellular organisms, some with fairly complex and differentiated form. It contains 40% of lipids by weight. Algae are usually found in damp places or bodies of water and thus are common in terrestrial as well as aquatic environments. Like plants, algae require primarily three components to grow: sunlight, carbon-dioxide and water. Photosynthesis is an important bio-chemical process in which plants, algae, and some bacteria convert the energy of sunlight to chemical energy. There are three main advantages about microalgae. First, due to the simple cellular structure, it converts solar energy more efficiently, and it can also access to water, Carbon dioxide, and other nutrients more effectively. For this reason, microalgae are capable of producing 30 times the amount of oil per unit area, compared with other oilseed crops. Secondly, microalgae have much faster growth-rates than terrestrial crops. The per unit area yield of oil from algae is estimated to be from between 5,000 to 20,000 Gallons (18,927 to 75,708 Litres) per acre, per year; this is 7 to 31 times greater than the next best crop, palm oil (635 Gallons *or* 2,404 Litres). Lastly, growing microalgae need carbon dioxide, which provides greenhouse gas mitigation benefits. Therefore, microalgae are one of the best remedies to the energy sources.

3.2-Wind

Wind energy is well known alternative renewable energy. There are many types of them exist: vertical ones to horizontal ones and small ones to large ones. Well known types are propeller turbine windmill, savonius windmill, and durries type windmill. Each type of wind generator has different advantages and disadvantages. Propeller turbine windmills have the best efficiency but makes noise when rapidly moving. Savonius and durries windmills have less efficiency than propeller windmills but they have capability of running even when the wind is weak. Also, they are quieter than propeller windmills. So, you can put them almost everywhere you want to. Wind generators can be separated in two categories: off shore wind power plants and small types of wind turbines. We are for both of them. We predict that off shore wind power would be the key to success of wind power generators but small types of windmills help the innovation of them. We discuss the ways how we can make them better in terms of efficiency and price. It is really hard to set the place and the size of wind turbine since there are so many factors that have to take into account. Based on how wind turbines work, we know that more wind let the generator produce more electricity. To have more wind, we need stronger wind or larger surface area of the turbines. Wind energy increases by third power respects to its speed. If wind speed increases from 2m/s to 3m/s the 2.2 times more energy is gained. The weight of a turbine is proportional to its diameter by power of three. And the energy gained by wind is proportional to the diameter of turbine by power of two. Therefore, to gain twice the electricity from a wind turbine, we need to make the diameter 1.4 times bigger.

Some people find building wind turbines on the ocean as solution to all the issues wind turbines have. There is not enough data to mass produce offshore power generators today. The reason for this is because wind turbines are expensive, 1.5 to 2 times more, to be built. 60% of it is from the maintenance fee. Simply, technology innovation is needed to make this cost cheaper. In order to do so, we need to have more data on winds, waves, and geological features, etc. Japan is struggling with this issue more than other countries because of the environment they are in; there are many typhoons and earth quakes. There are 3 offshore wind power plants and total of 14 wind turbines in Japan. When the US tried to make offshore wind power plan on Cape Cod, another issue was raised: the citizens' view of having wind turbines in their vicinity. People in Cape Cod did not want to see wind turbines on the ocean.

Our idea to innovate technology on offshore wind power plants in the US has two key considerations: Navy and civilian investment. Money is always a problem to technology innovation. US spend lot of money on naval force. If all the energy needed by navy is generated on the ocean it would be good for them, and also it would be easier to get more funds towards the technology innovation of offshore wind power. Also, if we could find ways to combine, for example, wave power and solar power to offshore wind power generator, we can minimize the impact to the environment.

We also prefer small types of wind turbines for reasons suggested earlier. Just to spin a big wind turbine needs fairly strong wind. However, you do not need strong wing to spin a small wind turbine. You can put small wind turbines on the top of your house and it can generate electricity. Innovation on small wind turbines cost much less than innovation on the big ones. Kyushu University in Japan made a new type of small wind power generator. This is how it looks:


10

This type is good in many ways: compact, high efficiency, less sound (45 decibels), easy installation, distinguishable by birds etc. The disadvantage of this model is the price. The cost of it is about $35,000 while other companies make the same sized ones for about $5,000.[11] Wind blows from the smaller side of the cone which is placed around the turbines. As the wind blows, it creates less pressure to the end side of the turbine by aerodynamics. This can increase the speed of wind by 1.4 times more. Kyushu University has made 5kW and 3kW turbine both has the height of 13.4m and propeller diameter of 2.5m. Since the blades are surrounded by the cone, birds can distinguish it as an object, so they do not accidently fly into the turbines. This is just an example of many new clever types of small turbines.[12]

I would like to propose that focusing on these two, offshore wind power farms and small versions of wind power generators, is one of the best ways of developing wind power generators.

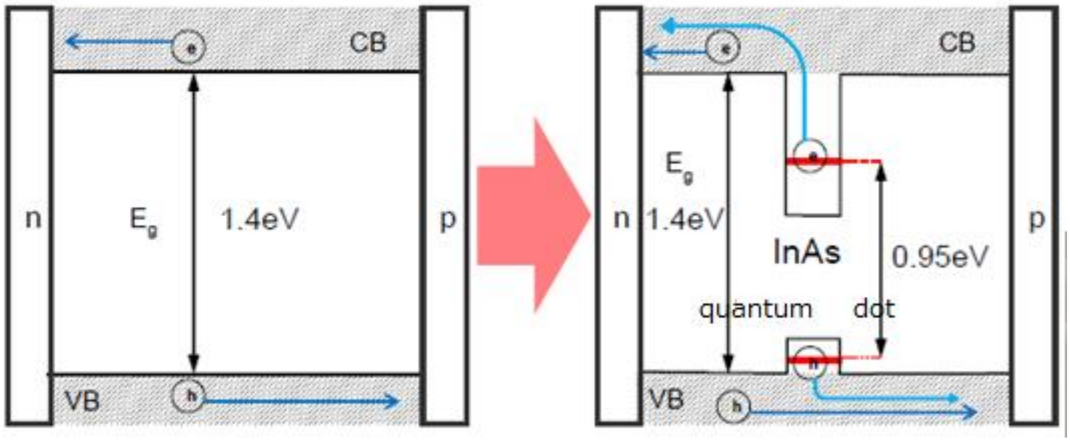
3.3-Solar

Solar energy has a long history, yet world's energy comes from solar power plants is less than a percent. There are several different ways to change the solar energy to electricity; solar power, solar thermal, and solar chemical. We think that quantum dot solar cell and CSP have a huge potential. In theory, quantum dot technology can make the efficiency of a photovoltaic to 60% which is 3 times more than the efficiency we have today. Concentrated solar power (CSP) is a technology that uses solar resource to generate electricity while producing very low levels of greenhouse- gas emissions. Therefore, this could be the key technology to overcome the climate change. Besides, the flexibility of CSP plants enhances energy security. CSP has an inherent capacity to store heat energy for short period of time for later conversion to electricity; unlike photovoltaic technologies. In addition, when combined with thermal storage capacity, CSP plants can continue to produce electricity even when clouds block the sun or after sundown. There are three major types of CSP systems such as: Parabolic Trough System, Power Tower System, and Dish Engine System. A single CSP plant can generate enough power for about 90,000 homes. For the environmental effects, compare to fossil-fueled power plants, CSP power plants generates significantly lower levels of greenhouse gas and other emissions. In addition, CSP is clean, non- polluting and has no carbon emission that contributes to climate change.

3.4-Quantum dot solar energy

What is meant by the efficiency of solar energy? What is needed to be improved to increase its efficiency? Life time of the solar panel is one of them and size of the panel is also one of them. But most importantly considered is how much of the sun energy a panel can convert in to electricity.

Photovoltaic solar energy can only use 20% of the sunlight due to its energy. When the wavelength is too high, it becomes heat and when the wavelength is too short the light cannot be absorbed. However, when quantum dot is used, it can help the electrons to transfer easily. When the energy gap is 1.4eV in a P-N junction, less than that energy cannot change the energy level. Quantum dots (QDs) are artificial clusters of semi conductive atoms that have the ability to confine the electrons motion due to their small size. One of the most important properties of Quantum Dots is the ability to tune their band gap and therefore control their light absorbance and emission frequencies. This is done through the quantization of their energy levels. In this way it is possible for their optical and electrical properties to be adjusted according to their purpose of use. Therefore, when quantum dot is used, 0.95eV is enough to let the electron go to the other band. With quantum dot, the efficiency can be increased to 60% in theory with today's technology.[13]



(Picture made by ASEP)

By applying this technology, solar panels can be more compact. This will allow houses to have smaller size of a solar panel to have enough energy needs. Also, for an electric car with $3m^2$ of roof would be able to generate 1.8kw. This means that the car can run about 500km/day on a sunny day without any gasoline. Or, it can make the battery in the car smaller, which makes the car lighter and this lead the car to have better mileage.

Quantum dot cell technology is still in progress of its innovation. The price of quantum dot cell panels is unknown now. However, scientists say that by increasing the efficiency so significantly the net price would go down. A way of making quantum dot is patented. This way of making it is not too stable because of the size of it. Mass production of quantum dot with good accuracy is needed to be innovated to have quantum dot cell cheaper and more efficient. Another thing which needs to be improved is manufacturing of blue quantum dots; blue quantum dots are difficult to manufacture due to the timing control during the reaction. Since, sunlight contains roughly equal luminosities of red, green and blue.

Life time of a photovoltaic solar panel is said to be 15~25 years. We do not know the life time of quantum dot cell but scientists assume that the lifetime of quantum dot is longer than the lifetime of photovoltaic solar panels.

Quantum science has been changing quite a lot of old technologies. For example, quantum dot TV made the TV resolution much better, and quantum science also dramatically changed the way of medication. The old solar technology is having hard time increasing the efficiency and decreasing the price. Quantum science is something which even scientists think that a lot of it is still unknown. Using quantum dot technology to solar cell is a bright potential and we are close to make it usable. In a short future, quantum dot solar cell could be a main source of our electricity.

3.5-Some Issues on Solar and Wind Energy

We all know green energies, such as wind and solar energy, are good for the environment, and we need to be thinking of adapting these in our lives. However, the proportion of them among whole energy sources being used today is very low. Price, land space, greenhouse gasses, etc. need to be taken into account when we consider it.

Prices of solar and wind energy are very high. Cost of solar energy is about $0.22kwh and the cost of wind energy is about $0.08kwh. On the other hand, the cost of nuclear and coal energy is around $0.04kwh. These numbers include decommissioning, production, and construction fees. Consumers of electricity care more about the price of the electricity over how good it is to the environment if the differences are big like these. However, solar energy is getting cheaper and cheaper. Increase of life-time, efficiency, and demand of solar panels make them lower cost. 20 years ago, solar energy was 7 times as expensive as it is today. So, we can hope that they would catch up with the prices of coal and nuclear energy.

Huge land space is needed for solar and wind energy generators. While nuclear energy needs 4,200 hectares and coal energy needs 3,800 hectares to provide power to San Jose, California, wind energy needs 53,000hecters and solar needs 7,500 hectares. The size of San Jose is 46,000 hectares, so wind energy generation cannot fit in there. These numbers are approximately in ratio, nuclear: coal: solar: wind=1:1:2:11. But not everything is bad about it. Unlike a coal mine, a wind farm could be used to grow crops at the same time.

CO_2 is known as one of the green-house gasses. Comparing the CO_2 output per kilowatt-hour of coal, solar and wind power, the ratio of them is: 76:4:1. It is clear that solar and wind energy is much cleaner than coal energy.

One of the main problems often argued against wind generators is the sound problem. Many people who live near wind generators complain about the sound made when blades are spinning. Some people hear the loud noise from them and some people experience the effects of infrasound due to human bodies. Infrasound can cause nausea, headache, etc. This issue makes wind generators hard to build in a residential area.

Considering these points, I think solar and wind power should be used on a small scale, such as per house. If we try to make a style of power self-sufficiency, solar and wind would be great sources to generate power. This way, we can minimize the cons of wind and solar generator and the use of coal and nuclear power.

3.6-Geothermal

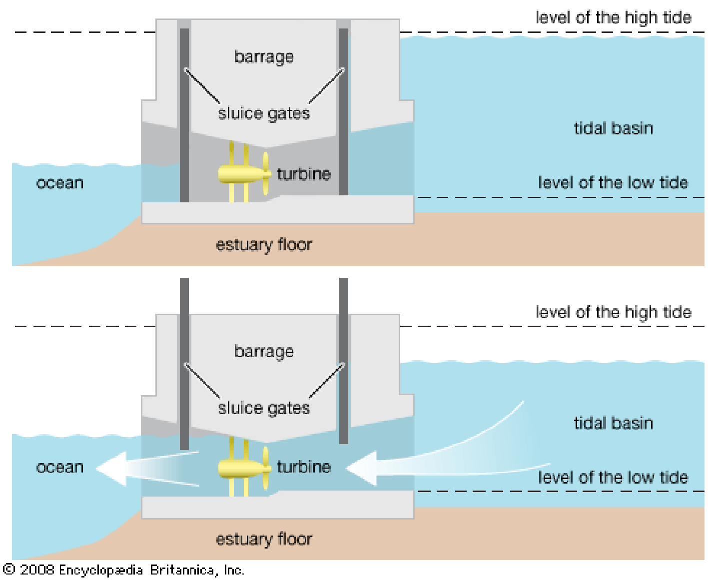
Geothermal electricity is generated using the geothermal energy about 3km deep in the ground. Other than geothermal generators, hot springs and heaters use the geothermal. These places are found near activated volcanoes. In Ireland, where there are 33 active volcanoes, 15% of their electricity production comes from geothermal.[14]

3.7-Hydro

There are several types of hydroelectric generators, but they all use gravity to have a kinetic energy to run the generator. Hydroelectric generators do not emit any greenhouse gasses when in operation. However, many trees are cut down and a lot of greenhouse gasses are emitted while constructing a hydroelectricity generators. And it takes about a decade for hydroelectricity generators to be beneficial in terms of cost and net amount of greenhouse emitted.

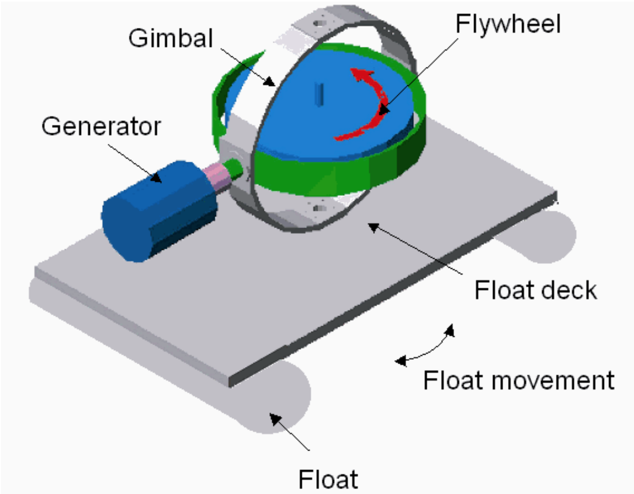
3.8-Wave and Tidal Power Generator

Wave activated and tidal power generations are not as renowned as solar or wind energy. I think it is because they could not have the technology innovation as much as solar and wind power due to difficulty of making things in and on the ocean. However, they have potential to be one of the leading alternative renewable energy soon. Simply put, wave activated power generators use the movement of waves of ocean. There are two types of movement occur in ocean. One type is the flow of the water which is horizontal movement, and the other type is the up-down movement of sea. Types of wave power generators can be divided into two; floating and fixed. There are many kinds of wave power generators. Tidal, on the other hand, do not have many types. This is an example of tidal power generator:



Famous active tidal power generator is in Bay of Fundy. The UK Carbon Trust estimates the cost of tidal electricity at about 35cents/kWh which is about 15cents more expensive than solar energy.

There is a wave power generator that seems really promising to us, which is called a“gyroscopic wave generator”. This is the basic mechanism of how a gyroscopic wave generator works:



15

1. Waves excite the float.
2. The float gets angular velocity.
3. The gimbal of gyro gets the angular velocity.
4. The gyro produces large gyro moment.
5. The gyro moment drives the generator in synchronized and phase locked condition.
6. Electric power is generated.

Since it does not need to convert the wave movement to other energy such as air, it directly changes to mechanical energy, it can have a good efficiency.

My idea of using wave power generator is to combine it with wind generators. Off shore wind firm and wave/tidal power generator could both be put in a same place. And by having them in a same place there would be less impact to the sea nature. This idea can be expand to have ocean thermal energy with the above.

3.9-LFTR

A power generator that attracts my attention is Liquid Fluoride Thorium Power (LFTR). R.P. Siegel (an author) provides a list of concerns about traditional nuclear and pros and cons of LFTR. Concerns about traditional nuclear:

1. Proven risks of dangerous meltdowns
2. Very long time required for approval and construction.
3. Potential terrorist target.
4. Too big to be liable; taxpayers will likely pick up the cost of an accident.
5. Highly centralized and capital intensive.

6. Non-renewable and rare fuel source: Uranium (much of it controlled by indigenous tribes).
7. High level of embedded CO2 in concrete and steel.
8. Dangerous radioactive waste lasts 200 – 500 thousand years.
9. No operating long-term waste storage sites in the U.S.
10. Shipping nuclear waste poses an increased potential risk of spills or interception by terrorist groups.
11. Fissile material can be converted into nuclear weapons.
12. High construction costs generally requiring subsidies and loan guarantees.
13. Competes with renewable for investment dollars.

Pros:

- Carbon-free operation
- Inherently far safer than conventional light water reactors
- Abundant fuel (thorium)
- Chemically stable
- Currently being developed in China and by US companies like Flibe
- Very small amount of low-level radioactive waste. Should be much easier to manage.
- Concentrated energy source, requiring far less land than solar
- Runs round the clock, good base-load and load-following source
- Less suitable for weapons proliferation that conventional nuclear
- Relatively low cost and scalable
- Could potentially be used in a distributed manner
- Technology is currently at the demonstration phase
- LFTR requires less cooling water than conventional reactors

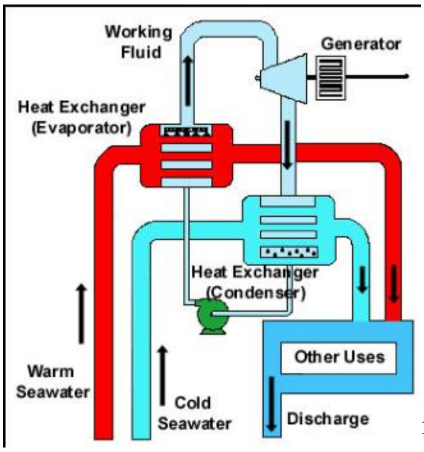
Cons:

- Non-renewable fuel
- Still produces hazardous waste (though far less)
- Can still facilitate proliferation of nuclear weapons
- Quite different than current technology
- Primarily conceived as a centralized plant
- Like all big plants, could be a terrorist target
- Technology not ready for prime time yet
- Competes with renewable for investment dollars

It is not a renewable energy. The easiest way of thinking about LFTR is the replacement of nuclear energy but safer, where nuclear fission supply 16% of the world's electricity. Siegel also makes a point that he consider thorium to be ultimately unsustainable in the very long term. I do agree to his point. LFTR is still in progress of its development. Therefore, we need to consider if this solution is just better than others, or it is actually good. LFTR need more time and money to actually get support from the public and scientists.

3.10-Ocean Thermal Energy

The temperature on the surface of ocean is 10~15℃ warmer than the deep ocean(600m-1200m) water. Using this temperature difference can vaporize and cool down gasses by itself to run turbines. The following picture shows the basic mechanism:



16

4-Case in Japan

4.1-Japan's approach to environmental issues

Japan has made four basic environmental regulations in the past. This project started 18years ago. The fourth regulation came out on April 27th, 2012. To have low carbon emission, circulation of resources and coexisting with the environment is the basic idea behind these regulations. Safety is also considered strongly. There are nine priority fields which are the focus of this regulation.

1. Make the economy and the society green and propel the green innovation
2. Help other countries with the high technology that Japan possesses
3. Encourage all the citizens to endeavor to create a sustainable society
4. Slow global warming
5. Create a good environment for animals
6. Recycle and innovate new methods of waste treatments
7. Secure a water regime
8. Reduce the air pollution problem
9. Treat chemical effluents

There is, also, a special entry specifically on the nuclear reactor disaster. Recovering the environment and cleaning the radiation have been occurring in many places since last year. However, more efforts are needed. The regulations show the detail procedures for these remedies.[17]

The Japanese government presented a survey about nuclear power to Japanese citizens in July, 2012. About 88,000 people answered the survey. The survey asked: In 2030 what percentage of nuclear reactor usage do you want?. Figure 1 shows the result of this question.

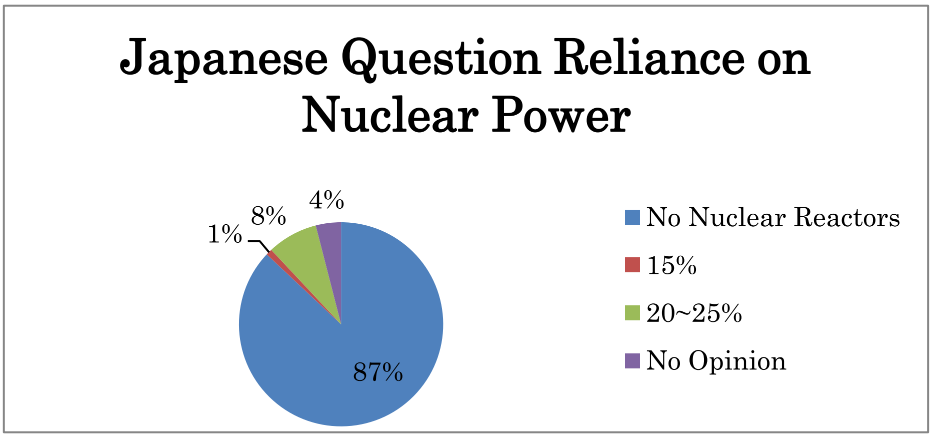


Figure 1[18]

To accomplish having zero nuclear reactor use, we need some alternatives to provide enough electricity. The Japanese government predicts that Japan would need 1trillionkWh in 2030. A plan that the government has shows 65~70% of it comes from thermal energy and the rest comes from renewable energy. The government does not provide the specific numbers of which types of energy are to be used. However, for solar and wind energy, it gives the specific numbers. For solar energy, in 2030, the government plans to have 72.1billion kWh, and 90.3billion kWh from wind energy. These numbers are almost 20 times more than what Japan uses now.

I think it is very important to think about human health in the first priority. However, in real life there are direct damages and indirect damages. Therefore, we need to look at overall safety. What kind disadvantages are there with zero reliance on nuclear power? The scenario for zero reliance on nuclear power for 2030 shows that a massive amount of thermal power would be used. Nuclear reactors become weapon when something happens; this means that when people think about nuclear reactors and say they are dangerous, they assume that there will be some kind of accidents. But, then it is the same for thermal energy power plants. When some kind of accidents occurs, it would be dangerous, but it is just not as bad as nuclear accidents. Moreover, air pollution occurs with thermal energy plants even when they are running properly, which might affect human health in some ways. Also, we need to consider the amount of pollutants and energy that were emitted and used when those 54 nuclear power plants were built in Japan. Not using any of the plants anymore means that energy and money put into them would become nothing but a waste. Was the earthquake in Japan the main reason why Fukushima had such a critical accident? I personally think that the earthquake was not the main cause of the tragedy. There were many human factors to the accident. I personally think that if the Tokyo Electric Power Company had been maintained and prepared well, the accident would not have been as bad.

According to the survey that Japanese government gave, the majority of citizens of Japan do not want nuclear power. Now, I consider the plan to meet the energy needs for Japan without any nuclear power in 20 years. When thermal power plants are used to provide 70% of Japanese power, coal, natural gas, peat, and oil would be used much more than ever. Using natural gas is cleaner than using coal, peat, and oil. Natural gas is not renewable, so even after 2030, we would need to increase renewable energy and decrease the use of natural gas. Some say shale gas can help to be the replacement for natural gas. I prefer not using shale gas because of the safety and environmental issues.[19]

To extract shale gas, drill a well of about 2000m deep and splash high pressured water with some sand-like matter to the shale to fracture the shale. The water contains about 0.5% of chemicals, such as gelling agents, surfactants, acid, aldehydes, and scale inhibitors which can harm flora and fauna. Almost 7500 to 25000 tons of water is needed for a well of shale. Even though the chemicals are used with water about 2000m deep, there is a chance that they come up to the ground, which can cause well water to become cloudy, and it also might cause a fire when gas is ignited as it is coming from a water faucet. For these reasons, shale gas plants cannot be placed near where people live. Moreover, the shale gas extraction process might cause environmental pollutions. When digging a well for a shale plant, heavy metals such as mercury, cadmium, and arsenic come out.[20]

These factors make us realize how important it is to move on to renewable sources of energy. The ratio of proven reserves for the production of natural gas is about 60 years.[21] Using mainly natural gas as a link to today's energy sources and to the next generation's energy would be an approach I consider to resolve the energy production dilemma.

However, even though no nuclear plants is the best choice for our safety there would be many more factors come in play when it is actually done. On 09/14/2012 the Japanese government announced a plan for the energy for next few decades. Public reaction to this is not too appealing. In the plan it says the government will spend $12.2trillion consist of $8.4trillion for energy-saving and $3.8trillion for renewable energy, but it does not mention anything about how much more the citizen would need to pay and other details about the plan. In our life, we can consider something in theory but they are not always the same with the actual. To build wind and solar energy generator that can cover the need of Japanese electricity use, with today's technology; it costs approximately $4.5 trillion.[22] I would like to consider what the possible options Japan has in theory and then discus their feasibility.

4.2-Energy consumption reduction

It is as important to reduce the energy consumption as using green energy to achieve the goal. Electricity consumed for home use takes about 27% of the total electricity consumed in Japan.[23] And about 60% of this is from air conditioners, refrigerators, and lights.[24] Assuming that replacing light bulbs to LEDs can save electricity by 50%, and then this replacement of home-use lights can roughly save 2.2% of the total electricity use, or 22 billion kWh per year. When same is done to manufacturing industry, it can save 1.9% of total electricity use in Japan. Moreover, just 5% of increase in the efficiency of machines that are used to manufacture in manufacturing industry can save 1.2% of the total electricity use. This is just an example but we can clearly see how big the effect of low electricity consume products are.

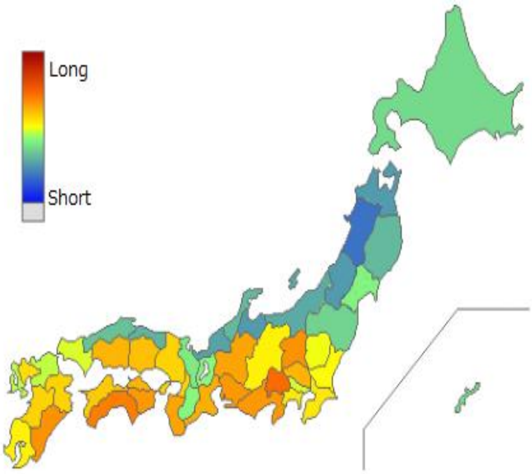
4.3-Solar and Wind Energy

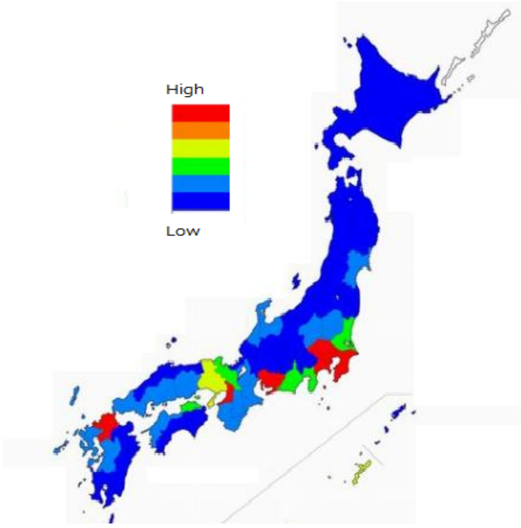
To provide 10trillion kWh just by photovoltaic solar energy with efficiency of 20%, we would need about $23784Km^2$. This is 3.2% of Japanese land, where 66% of Japanese land is forest and only about a third is flat land.[25] To provide the same amount of electricity by on-land wind energy, it would need 10.9% of Japanese land. Off-shore wind farms would need about $27600Km^2$.

4.4-Photovoltaic Solar Energy

A 10% increase of photovoltaic solar energy efficiency would make the size of the land needed to be 67%. If quantum dot solar panels are made, and they work as the theory predicts, then the size needed would be a third of what we need with today's technology. This shows how much the innovation of technology helps.

When installing solar panels, one of the biggest issues would be where to put them. Since 16.7% of land use in Japan is building estate[26], it is possible to produce electricity for non-populated household use by putting solar panels on each roof. However, Japan has few cities which are very populated. For example, in Tokyo, about 50 million Kw is needed and this requires about $2250Km^2$ while Tokyo only has $2188.67Km^2$. [27] You can see the hours of sunlight and the density of population in the figure below.





[28] [29]

Ideally, the places where we want solar energy farms are in the area where the hours of sunlight are longest. Looking at the figure of hours of sunlight, we see that the southern part of Japan has more sunlight then northern part. Populated cities would need other prefectures' help in order to have enough electricity. Even though, it looks unrealistic only to have solar energy to provide electricity.

4.5-Wind Energy

It is said that for wind energy, for on-land at least average wind speed of 6m/s and for off-shore 7m/s is needed in order to gain a good amount of electricity. There is a total of about 15,000km^2(4% of Japanese land) good for on-land and 61,000km^2 for off-shore.[30] Using 2% of the on-land and 7% of the off-shore, these two can, in theory, provide 162 billion Kwh in a year (about16% of electricity consumed today).

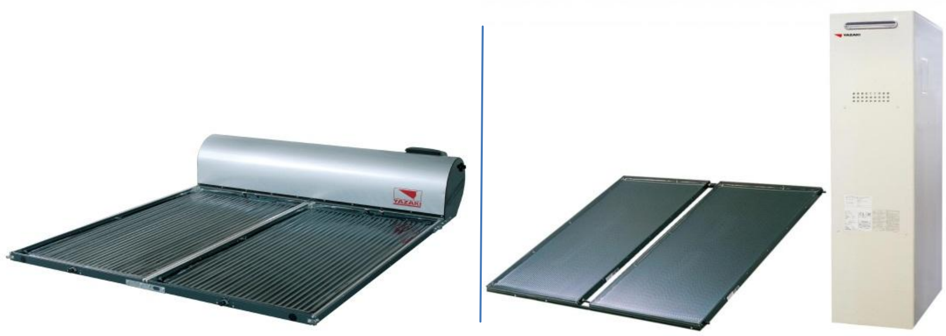
4.6-Solar Water Heating

Along with the idea of using natural gas for a link to change the energy sources gradually, a solar water heating system can be helpful as well. Solar heating systems can be installed with about $200-300 for a house. In China, the prevalence of solar water heating is 76%.[31] Assuming the gas fee for taking shower is 55￠, one spends $200 a year, a large saving. This means if you use it for more than one year you are saving money, overall. However, Japan is an exception.

4.7-Solar Water Heating In Japan

Solar water heating systems have a long history. Solar water heating became popular in Japan after the oil shock in the 1970s. In 1980, over eight hundred thousand of them were bought in Japan. However, the drop in gas prices and the introduction of photovoltaic solar energy have led to the number sold being decreased to less than a half of what was sold in 1980s; in 2007, only 35 hundred thousand of them were sold. In the world, China and Israel have the highest diffusion of solar water heaters. In China, the diffusion of solar water heating systems is 76% while Japan only has 25%.

There are basically two types of solar water heating systems; one that has a tank with a panel, and one that has a tank separated from the panel. The combined type could be installed cheaply; it can be installed for about $1,500 for a $9m^3$ sized one. Also, this type lets the water go through naturally, therefore, there would not be any extra fees for either gas or electricity. However, this type weighs heavy, so it cannot be installed to weakened houses such as old houses; commonly sold ones weigh about 350Kg. This is a critical issue to Japan since there are many old houses. Other than this problem, there are problems which limit the use of the combined type such as in this case: The combined type might not work well in winter, might only be used for filling a bath tub, and might not be able to gain enough pressure for a shower. On the other hand, the separated type lets the water circulate with a pump and the separation of the tank makes the water heater much lighter. Because of this, the tank could be bigger and by using the separated type, it is possible to keep water warm for a longer time. Also, the pump makes it possible for the water to be used for a shower. This can be done at almost a 40% saving of the gas price. The negative part of this type is the initial investment fee; it can cost about $80,000 to $100,000 for a $9m^3$ sized one with a tank. When there are photovoltaic solar panels with similar price range, it does not sound too promising. Following are the pictures of the combined (left) and separated (right).


[32]

4.8-Electricity consumption reduction by using solar water heating

Assuming the total shower time for a family is two hour/day and the average original water temperature is 10℃ before heating, the family takes showers with a water temperature of 37℃. This family spends about 16494 kWh in a year. In Japan, about 261,000 houses use electricity for heating their water. Therefore, electricity consumption for heating water for showers is 2billion Kwh in a year. This is about 0.4% of the total electricity consumed in Japan. This is equivalent to what a photovoltaic solar power can produce with a space of approximately $63.5km^2$.

4.9-Reasons why Japan cannot adapt solar water heating

Then why aren't more solar water heating system from Chinese companies imported? One reason is simply because Japan does not want Chinese products dominating the whole solar water heating system market. It is hard to adopt solar water heating systems due to the strength of houses in Japan. It is the lack of water pressure. There are many two-storied solitary houses in Japan. However, many of them do not have a water supply brought up to the second flower. Therefore, to bring water up to the roof, where the tank is usually placed, if you have the combined solar water heating system, you need to install a motor in order to use it. Water pipes in Japan are already very old, so if it is considered, it would be a huge national project. Considering this point the numbers of houses that can put solar panels are limited. There is another reason, which is not scientific, but some people say that it is due to the appearance, or its esthetic value. People are throwing away their solar water heating systems because they do not look good.[33]

4.10-Hydro

There are quit a few hydroelectric generators in Japan; about 8% of total electricity in Japan is from hydro. If Japan could use all the rain water to create electricity, Japan can provide 373TkWh a year.[34] This is obviously impossible but we can see how much potential Japan has in terms of hydro energy.

4.11-Geothermal

In Japan 119 active volcanoes and has potential of providing more than 164billion kWh a year. However, today, Japan only has 20 geothermal generators which providing net amount of 30 billion kWh a year.[35] One of the reasons why there are so few of them is because of hot springs. People misunderstand that if we use the heat to provide electricity they would run out of hot spring water. This is shown to be not true because the deepness they use for the hot springs, are different from the deepness of what geothermal generators use. Also, near the hot spring areas are usually a sightseeing spots and people think the generating plants would distract the visitors view. However, this is a solvable problem; the generator can be hidden somehow or placed little bit away from the sightseeing places.[36] Letting people know more information would be the first step of adapting more geothermal generating plants.

4.12-Bio-mass

A 0.2% of total electricity in Japan comes from bio-mass which is very small. With just what Japan have now, 4.5billion kWh could be provided from bio-mass if there are generators.[37] If new types of bio-mass, such as Algae, are developed, this number could go up. Also, these could be used in many other ways such as for cars and for heating water.

4.13-Wave

The amount Japan provides electricity from wave and tidal energy is close to zero. However, Japan has a rich environment to have wave power generators. According to Ocean Energy Association in Japan, to have 2 hundred million kWh for 2020, 7.5hundred million kWh for 2030, and 20 billion kWh from wave power is a good estimation for a goal.

4.14-Ocean Thermal Energy

In theory, if all the ocean thermal energy in seas around Japanese is used, ocean thermal energy can provide 10^{14}kWh per year. This means that it can save 8.6billion tons of oil or 10 times more than what Japan need for a year. The cost it takes to provide enough electricity needs in Japan with only ocean thermal costs about $700 trillion. The price of the electricity generated my ocean thermal is roughly 35~50cents/kWh with prototype. Currently there is no active commercial use ocean thermal energy generator, because of several issues. One thing that I think is a waste of energy is the energy that pumps up the cold water from the deep sea. Also, obviously it needs to be in the ocean so inland countries cannot use them while island countries such as Japan are a great place to use them.

Ocean thermal energy is a clean alternative renewable energy, though; similar to other green energy sources it needs technology innovation to use commercially. Ammonium is one of the major chemical used to run the turbine because of the efficiency and the price. However, it is bad for the materials used in turbines. Another thing that has to be improved is the pipe which pumps up the water. Sea creatures tend to stick on the pipe and they get bigger, so the pipe needs to be cleaned once in a while.

4.15-Conclusion

After considering these different types of green generators, it seems Japan has a lot of potential of using clean energies. I have come up with some ideas for Japan's electricity generation. I first assumed, because of the population decline and also due to saving energy technology, the total amount of electricity consumption could be about 90% in 2030 and 85% in 2050 of what Japan use today. Therefore I calculated things with maximum percentage of 90% in 2030 and 85% in 2050. The chart shows the idea I have for 2030 and 2050.

<table>
<tr><td>Year</td><td>2012</td><td>2030</td><td>2050</td></tr>
<tr><td>LNG</td><td>30%</td><td>39%</td><td>0%</td></tr>
<tr><td>Hydro</td><td>8%</td><td>10%</td><td>14%</td></tr>
<tr><td>Wind</td><td rowspan="6">1.1%</td><td>16%</td><td>26%</td></tr>
<tr><td>Solar</td><td>15%</td><td>25%</td></tr>
<tr><td>Bio-mass</td><td>1%</td><td>2%</td></tr>
<tr><td>Geothermal</td><td rowspan="2">1%</td><td>1.5%</td></tr>
<tr><td>Wave</td><td>1%</td></tr>
<tr><td>Ocean thermal</td><td>8%</td><td>15.5%</td></tr>
<tr><td>Total</td><td>39.9%</td><td>90%</td><td>85%</td></tr>
</table>

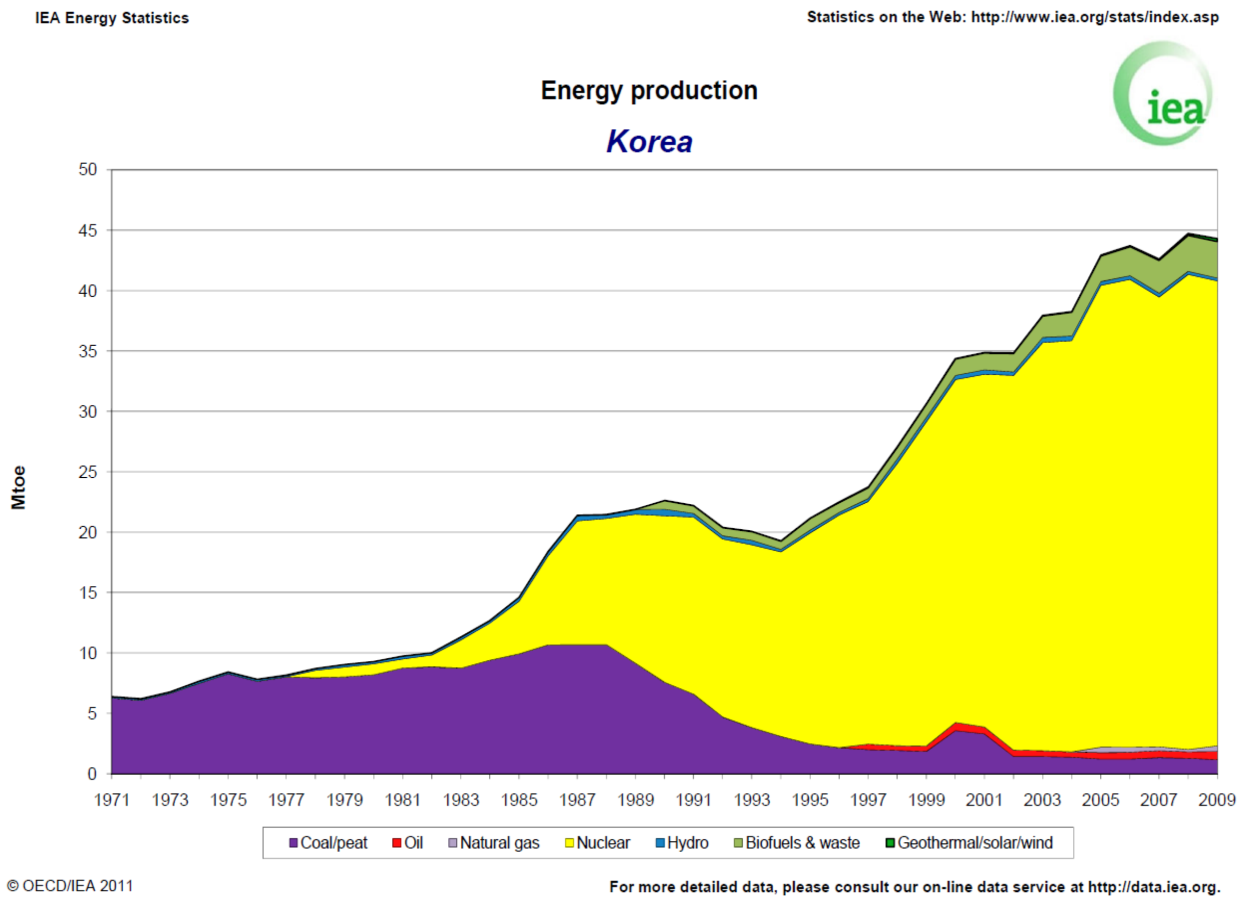
By 2030, there would be only natural gas and renewable energies and by 2050 there would be only renewable energies. The hydro generators would be built mostly in the mountains where rains a lot. Wind power farms would be placed both on-land and off-shore. For the on-land ones, northern area such as Hokkaido is one of the best places to place. The off-shore ones could be placed mainly on the coast of Pacific Ocean, and the Sea of Japan. Solar energy is suitable in southern parts of Japan where there are longer day time than others. Bio-mass plant can be built almost anywhere in Japan. Also bio-mass technology could be improved in many ways such as innovation on fermentation methods which leads to higher efficiency of converting to bio-energy to alcohol. Geothermal generators are best to be placed near active volcanoes or hot spring places where the temperature difference is as big as possible. Since oceans around Japan do not have high difference of tides, using the stream of the ocean is better. There are many places that have constant high ocean flow near Japan, also these places are not gathered at one place; they are spread around the oceans. This is good because many places are able to use them. Ocean thermal farms are best placed in southern part of Japanese ocean. The southern part has bigger difference in temperature on the surface water and the deep sea water.

This approach is necessary to Japan. One reason is due to public opinion. As we can see from the survey, what Japanese citizens want for a first priority is safety and many people realized the danger of nuclear reactors when accidents happen such as earth quakes which occur over 4000 times a year in Japan including small ones.[38] This approach would make Japan nuclear reactor free. Also, this approach is good for air pollution problems. After finish building renewable energy plants almost no greenhouse gasses are emitted. Throughout the whole process, from building them and using them, in a long term net pollutants are emitted much less than using nonrenewable energies such as a thermal energy.

Another reason is for the dependency of energy. It cost more than buying fuels from other countries for the power plants, to construct renewable energy farms in a short term. However, in a long term, because this plan does not depend on any fuels when operating, it pays back plus save a lot of money. From these reasons, I think this approach is great for future of Japan.

5- Case in Korea

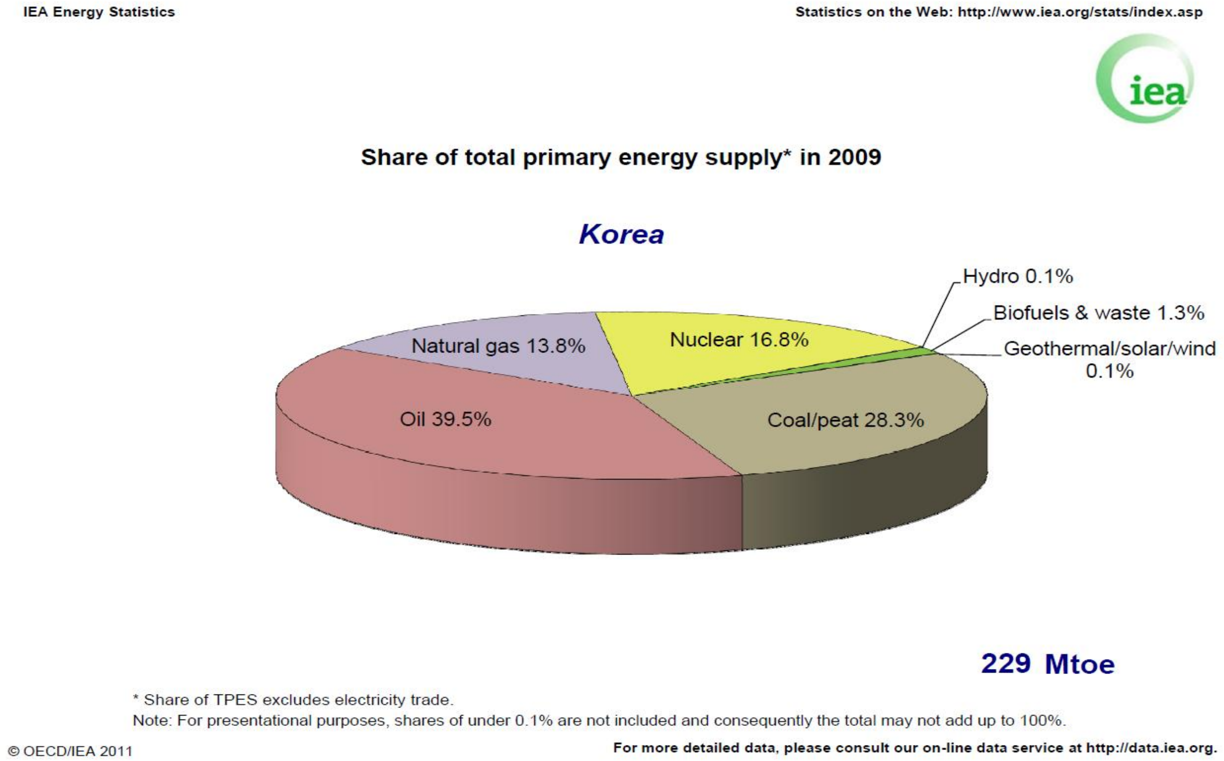
Energy production statistics for South Korea



From the statistics above we can tell Korea started with coal energy from early 1970's and it increased slightly up to 1988. However, after 1988 the energy production from coal reduced rapidly but energy production of nuclear increased relatively high. For the nuclear energy, which is the major energy supply of South Korea nowadays and coal is still the base of the energy production. From the graph, biofuel and waste introduced late 1980's but due to technical issue and efficiency of the energy production it has very small portion compare to other energy like coal and nuclear. Furthermore, there are same problem with the hydro and oil energy.

In my assumption for next coming decade, the nuclear energy will be the base of the production. The biofuel, waste, and hydro energy will increase tremendously in the future. Since, oil is getting more and more expensive as time goes by; and coal produces too much negative combustion waste to atmosphere, which has negative effects to the environment and atmosphere. Besides, the solar energy will be the next most intentional energy to be used. Although, the energy efficiency is still lower than nuclear or oil; there are many scientists and engineers trying to improve the efficiency and usage of it. Therefore, I predict the alternative energy resource in Korea will be solar and hydro energy in the future.

Primary Energy supply in South Korea



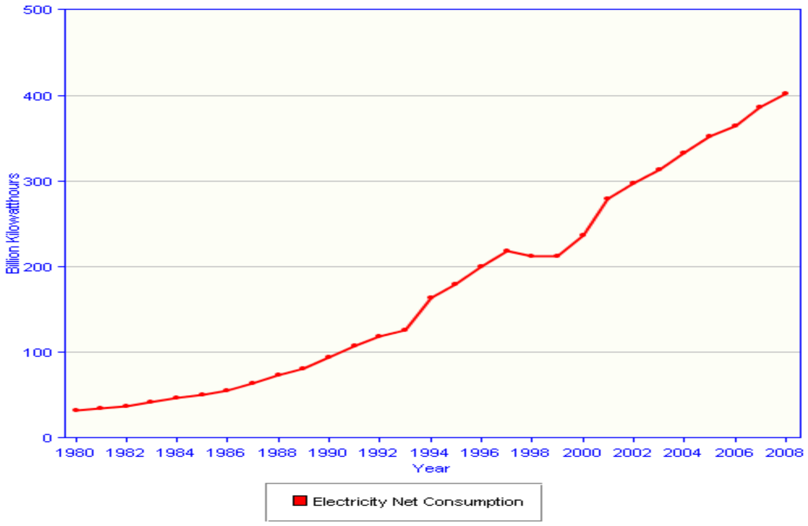
The total primary energy supply in Korea, South is still based on oil which is about 4o percent of the total supply. Next major supply is coal and peat which is about 28 percent of the total energy supply. For natural gas and nuclear have about the same percentage out of the total 13 and 16 which add up to 30 percent. The supply energy percentage of coal and peat are similar to sum of the energy supply of natural gas and nuclear. And lastly, the least energy supply from biofuels, waste, hydro, wind, and solar energy; all of them add up to about one percent of the total energy supply.[39] [40]

Energy states of South Korea

Korea is one of the top energy importers in the world. The country is the fifth largest importer of crude oil, the third largest importer of coal, and the second largest importer of liquefied natural gas (LNG).

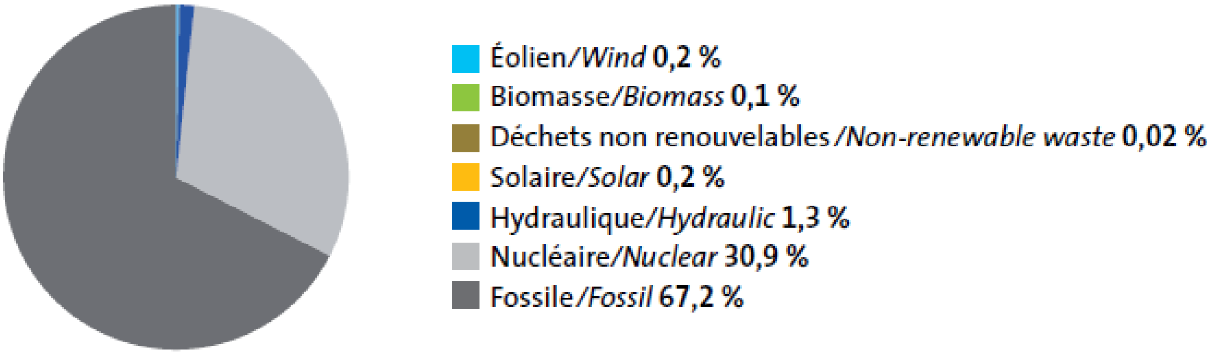
1. South Korea is a major energy importer, including oil, natural gas, and coal.
2. South Korea has a large refining sector, but relies on crude imports for all of its oil needs.
3. South Korea is the second-largest importer of liquefied natural gas in the world behind Japan.
4. Nuclear power accounts for more than one third of South Korea's electricity generation.

Population: 48 million
Electricity Consumption: 408 billion kWh
Electricity Consumption (Per Capita): 8900 kWh
Electricity production from nuclear sources (% of total) in South Korea: 31%
Electricity production from nuclear sources in South Korea: 154753000000 (kWh)



Renewable energy in South Korea

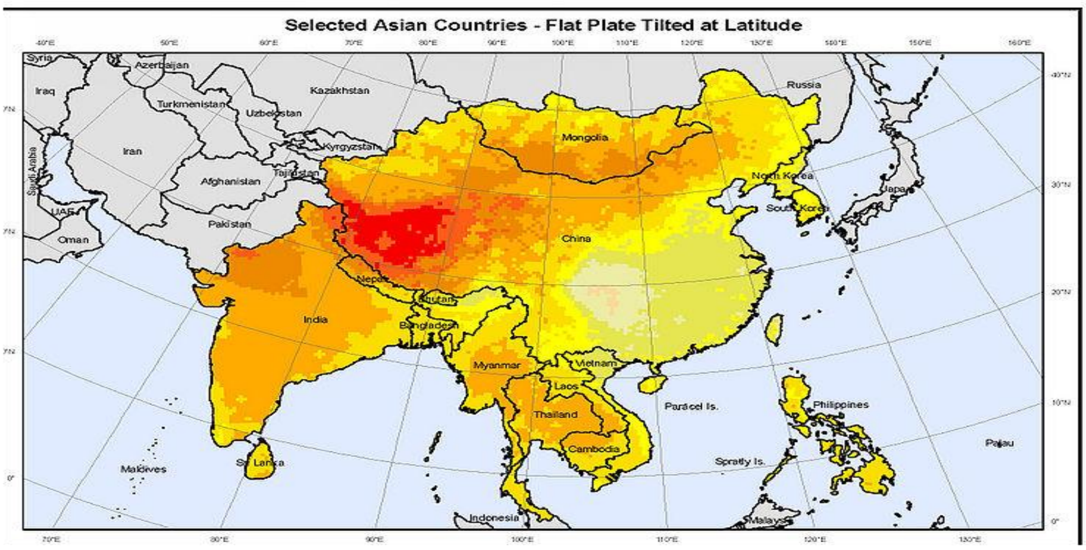
Renewable electricity production is paltry 2% of the total and is split between hydropower, solar power, wind power and biomass.



Hydro: 1.3% (of the total), Solar: 0.2%, Wind: 0.2% and Biomass: 0.1%.

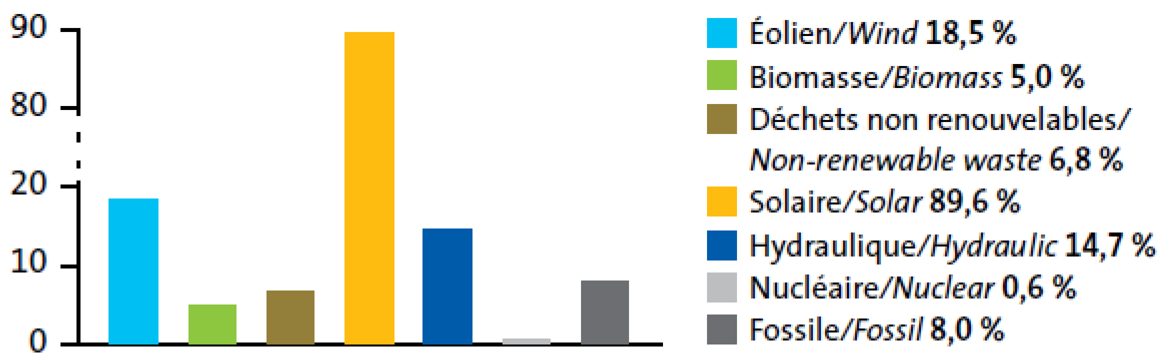
Hydropower is the major renewable energy of South Korea, which consist of 71.8% of all renewable production. There are two major hydropower stations, Uldolmak tidal power station has capacity of 1 megawatt and generates 2.4 GWh annually. The South Korean government plans to increase this capacity of 1 MW to 90 MW by the end of the year 2013, increasing the demand cover to 46,000 households. Second station is Sihwa lake tidal power station generates 260 megawatt and the energy produced by the station will be enough for a city with population of 500,000. This tidal power station is the world's biggest tidal power station. This station was opened in 2011.

Solar potential of South Korea is 250,682,398 MWh/year.



Photovoltaic solar power sector put on the fastest growth in 2010 with 1073GWh. Korean government planned to set up 100000 roofs with PV panels by 2012, at private and public establishments. The country aims to install 1.5-3 GW of solar capacity in 2013.
South Korea's total installed wind turbine fleet capacity is 379 MW in2010. The governments are interested to invest more on wind farm at offshore. There is project constructing for 500 wind turbines at west coast site of Jeolla Province. These turbines have capacity of 2500MW, should be able to supply enough electricity for population of Busan (3.7 Billion)

Taux de croissance 2009-2010/*Growth rate 2009-2010*



Renewable Policy in South Korea

South Korea aims to increasing renewable energy to 11% by 2030. This is compared with a current figure of 2.4%. Therefore, achievement of these targets would more than triple energy from renewable in 20 years.

South Korea already has fits in place for wind and solar power; however, from 2012 these will be replaced by a Renewable Portfolio Standard (RPS), approved by the South Korean Assembly in March 2010. This RPS will require 14 state-run and private power utilities with capacity in excess of 500MW to generate 4% of energy from renewable sources by 2015, increasing to 10% by 2022. This program, which will become effective in 2012, will mandate 350MW/year of additional RE to 2016, and 700MW/year to 2022.

A large part of this challenge is the lack of space to showcase and test their green technology products such as wind turbines. South Korean companies are also having a hard time attracting customers from the domestic market. However with that being said, this provides a great opportunity. South Korean green technologies can focus on exporting their products abroad if the domestic market is lacking demand. The government is trying to boost domestic demand to by requiring all companies to generate 2 percent of their energy from renewable sources by next year. This figures goes up to 10 percent by the year 2022. (Young Il Choung, 2010)

Tidal energy in Korea

The Uldol-muk Strait produces maximum tidal water speeds that exceed 6.5 m/s and the width of the strait is around 300 meters. In short, it is the ideal location for a tidal power plant. Uldolmak tidal power station has capacity of 1 megawatt and generates 2.4 GWh annually. The South Korean government plans to increase this capacity of 1 MW to 90 MW by the end of the year 2013, increasing the demand cover to 46,000 households. According to the Korean government the Uldolmok Power Plant is a step towards achieving its goal of generating 5,260 GWh hours using tidal power by 2020.

41

Sihwa lake tidal energy

Sihwa lake tidal power station generates 260 Mw and the energy produced by the station will be enough for a city with population of 500,000. This tidal power station is the world's biggest tidal power station. This station was opened in 2011. The government says the plant will save the resource-scarce country more than 860,000 barrels of oil or about $93 million a year. also new plant would reduce South Korea's carbon emissions by 320,000 tons.

Solar city in Korea

Dae gu is one of the best city suitable for solar energy due to its sunny weather. Korean government has been planning to make Daegu as solar city by building: solar houses, village, park, and parking lots. Solar thermal system will be used for commercial buildings like: elementary school, public library, and convention center. Besides, it uses solar heating system to keep the greenhouses' temperature, since Daegu is one of the best areas for fruits, and vegetables in Korea. "In addition to securing investment in research and development as well as manufacturing of renewable energy technologies, the city encourages active integration of these technologies in the private sector. For example, Korean companies based in Daegu have entered voluntary agreements to meet certain energy efficiency and renewable energy use requirements"

Solar power plant built in 2011. Its capacity is 200kW, consisting of 60m tower and 400 solar mirrors.

Daegu will host the next World Energy Congress conference in October 2013.[42]

Green City Songdo, Korea.

Songdo city is considered the greenest business hub in the world. The district project will be completed by 2015. This project expects to cost about 35 billion dollars, is one of the most expensive development projects ever undertaken in the world. Built on 1500 acres of reclaimed land, this Free Economic Zone is meant to become a major business hub between Japan, China and South Korea.

The energy efficiency and environmental considerations start with construction phase. The city plans to recycle 75% of waste that has generated during the construction process. Besides, for transportation Songdo city built 25 km network of bike lanes within the city. The city is designed in a way that city dwellers should not walk more than 12.5 minutes to reach shops, parks, or public transportation. Furthermore, 5 % of the parking spots will be reserved for low-emissions vehicles with an additional 5 % for carpool vehicles in offices and commercial buildings.

On the other hand, 80% of the buildings in Songdo expected to use LEED- certified, and Songdo is actually the largest private LEED development site in the world. Its buildings should use 20 % less water and 14 % less electricity than a typical city of the same size. For other energy saving, every residential building in Songdo has smart meter, which could measures the energy consumption at home to control rooms regulating traffic via traffic/crossing lights, the combination of real-time data and reflexivity should indicate the smartest possible use of resources in the public space.[43] [44]

Figure 2. Songdo City in 2015

Figure 3. Bridge with 7.5 mile connecting Inchon International Airport

How much electricity could be saved by installing solar heating water tank in South Korea?

Assumption:

150 Liter per capita, we assume there the average of three people in a family

-450 Liter for a family to take shower per day

-Heating water from 20 C to 40 C

-electricity cost 2.2 cent per kWh

So basic heat transfer equation: $Q = mC_p\Delta T$

=1000g*4.1813(J/gK)*20= 83626 J

83626 J = 0.0233 kWh

0.0233 kWh * (150*3) = 10.485 kWh

There are 158624 houses in South Korea use electricity to heat the water.

10.485 *158624= 1663172.64 kWh

1663172.64 * 365 day= 607058013.6 kWh per year = about 600 million kilowatt per hour per year

So, approximately South Korea could save about 600 million kilowatt per hour per year of electricity, if install solar heating water tank for all the houses that use electricity to heat the water.

Besides, by installing the solar heating water tank could save $ 13355276.30 per year.

The calculation followed below:

2.2cent *10.485 kWh = 23.067 Cent

23.067* 365 day * (158624) number of houses = 1335527630 cent = $13355276.30

The conclusion:

The total electricity consumption of Korea is 455 billion kWh and so if we compare the saving by installing solar heating water tank which is 600 million kWh. 600/455000 = 0.0013 = 0.13 %. Therefore, 0.13% could be saved out of the total electricity consumption of South Korea.

Comparison and Assumptions:

There are approximately 33% of house in South Korea use natural gas to heat the water. The total number of houses in South Korea is 17,574,067. And so, if we can install solar tank to rest of 33 percent then there will be an obvious improvement for renewable energy in Korea. The calculation follows:

17574067*0.33= 5799442 ~ 5800000 (houses use natural gas to heat the water)

10.485 kWh * 5800000 = 60807150 kWh

60807150 kWh * 365 days = 2.22 E^{10} kWh ~ 2200 million kWh

Percent change of total:

2200 million kWh/ 455000 million kWh = 0.4%

0.4 %(natural gas heat) + 0.13 %(electricity heat) = 0.5%

However, we should also consider the installation fee and weathers in Korea. First of all, the average price of solar water heating is $800. If government installs for all the houses in Korea, the total price will be around 14 billion. This is an amount of money that Korea cannot response yet to research on renewable energy. The Maximum the government had spent for renewable energy recently was about 3 billion. Is it really worthy to spend this amount of money to save 0.5% of electricity consumption? I would say “No” for sure. Besides, the weather in South Korea, there is minimum three months that temperature goes below freezing point every year. In the other words, this cause the pipe lines crack and freezes the water. Therefore, government needs to spend extra money installing anti freeze pipe lines for solar water heating.[45] [46]

6-Futuristic Technologies

6.1-Space-Based Solar Power Generation (SBSP)

A calculation shows that Earth receives 5.7×10^{24}J of energy from sun in a year which is 1.6thousand quadrillion kWh a year. On land, it is hard to have solar panels everywhere. The idea of SBSP is to collect solar power in space and send it to Earth. A solar panel on earth gains only a small portion of its potential due to night, weather, and seasons. However, SBSP can overcome this. SBSP today is placed about 36000km high, this orbit is called the geostationary orbit (GSO). GSO is the best place to have SBSP because at this point, it rotates at the same coordinate with respect to Earth. It can be calculated by parameters Universal gravity G, Mass of Earth M, Mass of SBSP m, Distance from the center of Earth L, Rotational velocity ω. We have a condition:

$$\mathrm{mL}\,\omega^2 = GMm/L^2.$$

This gives L=42200km. This means at 35800km high, it has same orbital period as the Earth surface has. The collected energy at this height is sent to Earth's surface either by microwave or laser.

There are many technological issues that are needed to be solved. The disadvantage of a laser beam transmission is that the beam tends to widen as it travels a long distance. This makes the receiver base to be much bigger than when microwave is used. Microwave transmission also has disadvantages. We do not know biological effects associated with the wireless transmission of electricity due to the high frequency microwave signals. Also, the efficiency of microwave transmission now with the technology that the Japan Aerospace Exploration Agency (JAXA) has is about 30-40%. Of course, the cost is another issue with building an SBSP. To build an SBSP, which has the same capacity as a nuclear reactor, total cost, including lunching, for one is about $15billion with JAXA estimation. We need to remember that development and maintenance fee would add up to this amount. In the past, the JAXA planned to shoot an experimental SBSP in 2010 and 2011. However, none of those actually happened. Now, JAXA aims 2020-2030 to make a SBSP for commercial use with a cost of 8¢/kwh. It is not known how realistic this is, but here are the details: The size of the SBSP is $2.5km^2$, and the capacity is about a million kilowatts. It will be placed 36000km high above the Earth surface.[47][48]

When something happens to the SBSP, it is different from fixing something on Earth. We might have to have robots doing this work for safety. And to do this, SBSP needs to be an easily fixed structure without losing efficiency and increasing the cost.

SBSP sits in space; they are placed on an orbiting satellite. This means that it rotates with Earth, which creates "night time". With the height given, an SBSP is exposed to sun fifteen hours a day. This is more than double what an average day-time is on the Earth surface. But does it overcome the energy loss while being transported? Tom Murphy, a physics professor at University of California, mentions that "our 3.6 km diameter collecting area would generate about 40 GWh of energy in a day, at an assumed reception/conversion efficiency of 70%. By comparison, a flat array of 15%-efficient PV panels occupying the same area in the Mojave Desert would generate about a fourth as much energy averaged over the year". I calculated this in my way and it shows that on-land would generate a sixth of what SBSP generates over a year. However, the point here is whether the amount of money we invest is too much or reasonable. I think it is impossible to have the price/kwh the same as in nuclear power in the near future, though. SBSP has the biggest potential among the renewable energy ideas we have today. If the idea of SBSP becomes reasonable, we would not have to worry about energy anymore. Indirect advantage is that without any worry towards fuels for energy, we would not have any more wars or disputes caused by energy issues.

6.2-Seeking the applicability of SBSP through numbers

At $36000km$ above the surface of the Earth, we have a total of about 5.7 billion km^2 of area. Only approximately 100 thousand km^2 is needed to meet the world's electricity needs; this is less than 1% of the area of Earth's geostationary orbit. However, SBSP requires receivers, which are on Earth, as well. A ball park figure that is needed for the world's electricity requirement is about $204270km^2$, which is 0.1% of the land on Earth. In the case of Japan, it would need to use 3% of Japanese land to produce enough electricity within Japan. And Japan is a very populated country, and also the energy use per capita is very big. This 3% tells us how applicable the SBSP is: Compared to wind energy, solar energy, or ocean thermal energy, this number is far less than what others need. Until we make the SBSP able to be used commercially, it will need money and energy. Yet, this is a very bright idea which might change our concept of energy completely.

6.3-Issues with SBSP

One thing I consider with the idea of SBSP is the thermal issues we might have. Earth receives the sunlight with its surface. The size of which and greenhouse gas we have make the average Earth temperature stable at reasonable temperature for humans to live. However, my concern is that when we increase the area of the surface which receives the energy from the sun onto Earth, would it make the temperature too high for us. In one year, if SBSP produces enough energy for the world, about 20 trillion kWh extra $7 \times 10^{19} J$ comes onto Earth. One theory that I can think of is a decrease in greenhouse gas.[49] When we only use SBSP, and no longer use thermal energy on Earth, the amount of greenhouse gas will decrease. This makes the energy that comes onto Earth escape better from it. The temperature of the Earth without greenhouse gas would be an average of about 33℃ (59℉) colder than the present average of 14 ℃ (57 ℉). This is just a theory. It is complicated to predict what would happen with this issue, but this is something we might need to consider as we start using SBSP.

6.4-Air Fuel Synthesis

My vision about alternative energy is simple and it brings back the issue of sustainability. The primary energy resources are like fossil fuel, coal, and nuclear; these are limited by natural restriction. The common restriction is that all of them come from underground. According to IME, there are an estimated 1.3 trillion barrels of proven oil reserve left in the world's major fields, which at present rates of consumption will be sufficient to last about 40 years. So, my point about the alternative energy and the vision is how to continue all the things that generate and run by those primary energy as they approach the insufficiency. People are used to the all the things that generate or run by fuel. For example, most of the fuel has been using for run the transportation such as: automobiles, ships, train, and airplanes. Besides, I think transportation is one of the most important issues about the energy, lifestyle, and future vision. Transportation could change people's life style completely. Let's imagine the life without cars, motorcycles, ships, or an airplanes nothing that work as transportation. Our life will be restricted and of course we consume less energy. Transportation is positively proportional to the energy consumption. In the future, the scale of transport will expand to outer space and this will change our life style completely. But before we get to that point; how do we sustain the energy for the transportation from now to the future? Therefore, the simple vision about this problem is new energy resource that could continue the transportation we have now. Basically, the new technology development could be the vision for energy.

Air Fuel Synthesis is the process of turning carbon dioxide and hydrogen in the water into a sustainable fuel. Why this could be new vision of energy? The responses to declining fossil fuel sources must be completely sustainable, yet also easily replace the many uses of fossil fuel. By producing synthetic hydrocarbon liquids by AFS method helps to reduce human dependence on fossil oil with benefits: global warming, energy security, sustainability, and economy.

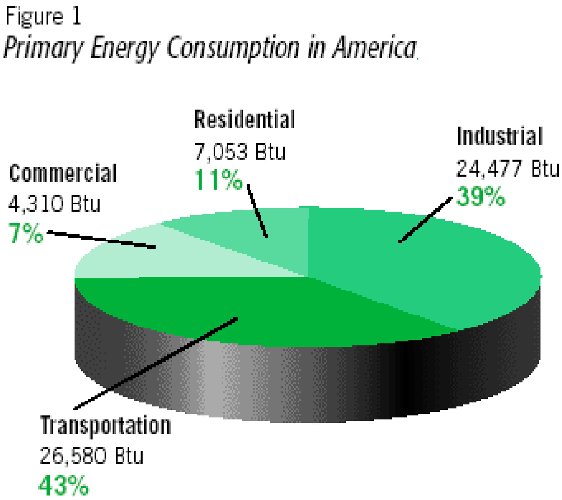


Figure 4. wikispace transportation + energy

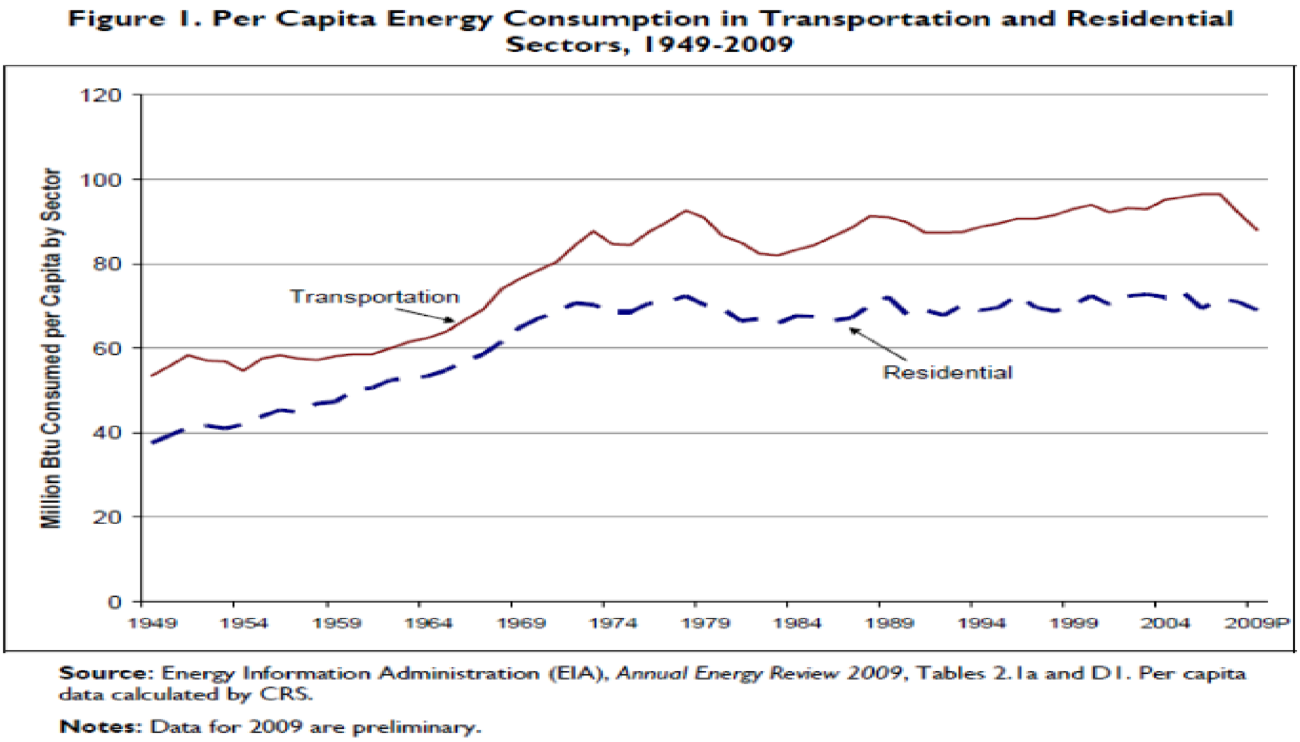
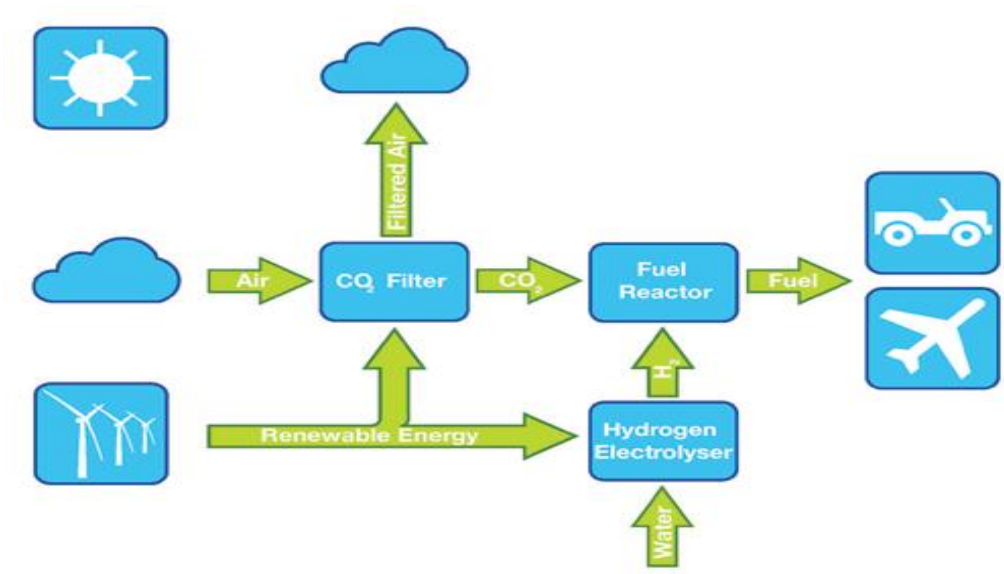


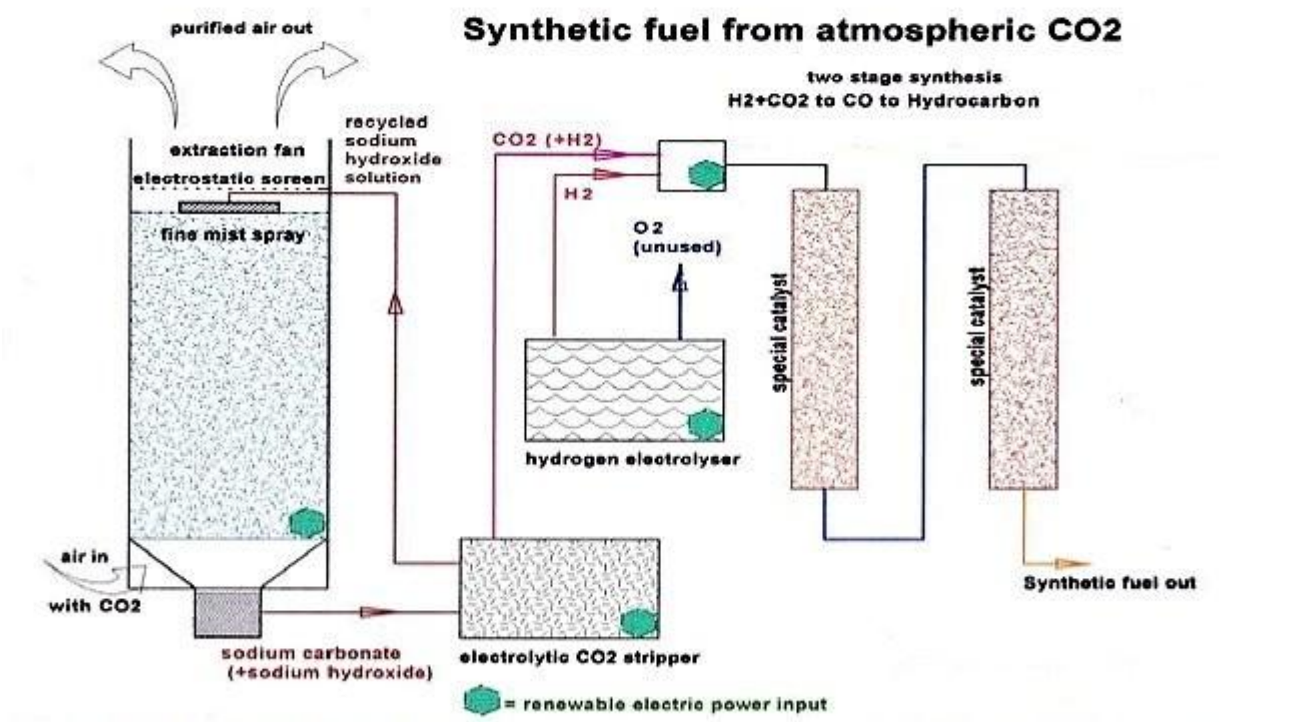
Figure 5. Energy consumption in transportation

6.5-Technology



“Air Fuel Synthesis system uses renewable energy to capture carbon dioxide and water from CO2 point sources, though we have also proved our ability to take CO2 from air. We electrolyse the water to make hydrogen react the carbon dioxide and hydrogen together to make liquid hydrocarbon fuels.” [43](AFS Ltd, 2011)

Furthermore, the process required energy to run AFS system, as the graph shown above the energy need to run the system come from wind mills and solar panels. Most importantly, AFS fuels are unrestricted by the price of raw materials, geo or local politics and avoid the land use or food availability issues that affect biofuels. According to AFs Ltd the fuel production costs are low and predictable for the life of the plant.



-Remove carbon dioxide from air by blowing air through a mist of sodium hydroxide solution, converting CO_2 to sodium carbonate
-Remove CO_2 from sodium carbonate by electrolysis
-Make hydrogen gas from water by electrolysis
-Convert the carbon dioxide into carbon monoxide using the “reverse water gas shift reaction.”
-Convert hydrogen and carbon monoxide into gasoline using the “Fischer-Tropsch process.”

6.6-The Reverse Water Gas Shift

The reaction has been known to chemistry since the mid 1800's. This provides a source of hydrogen at the expense of carbon monoxide.

$$CO_2 + H_2 \rightarrow CO + H_2O$$

This is a collection of chemical reactions that converts a mixture of carbon monoxide and hydrogen into liquid hydrocarbons. For Fischer–Tropsch plants that use methane as the feedstock, another important reaction is steam reforming, which converts the methane into CO and H_2: $H_2O + CH_4 \rightarrow CO + 3\ H_2$

6.7-Efficiency of AFS

Liquid hydrocarbon fuels, particularly with a 15 percent energy storage ratio for synthetic gasoline. (The energy storage ratio is the amount of energy generated by burning a fuel divided by the amount of energy required to produce that fuel.) In AFS this will be a precise assumption since the process of producing liquid hydrocarbon fuels are similar. So, in automobile the efficiency for conversion of gasoline's heat energy into motive power is in the neighborhood of 15 percent, compared to an efficiency of about 80 percent for an electric car. This means a synthetic-gasoline-powered car will require about 35 times more electric power from a utility source for a given trip than will an electric car. Overall the efficiency of the AFS is way too low to be commercialized now. However, as time goes by the technology improvement may find a better way to increase the carbon capture rate. There is still plenty of space to improve the efficiency of AFS.

6.8-Comparison

Currently, there are other eco-friendly transportation technologies such as: electricity, hydrogen/fuel cell, bio fuels, and synthetic fuel from air. All of these responses to the shortage of fossil fuels although the AFS process avoid the conflict with land use for food or with deforestation (bio fuels), and also this avoid the additional replacement of existing infrastructure and vehicles as there is with electric or hydrogen fuel cell technologies. AFS fuels could simply replace the usage of current fossil fuels and it is also carbon neutral, less land take up, and low material prices. "It means that people could go on to a garage forecourt and put our product into their car without having to install batteries or adapt the vehicle for fuel cells or having hydrogen tanks fitted. It means that the existing infrastructure for transport can be used," Mr. Harrison said. *Peter Harrison is the Chief Executive of Air Fuel Synthesis.*

6.9-Vision

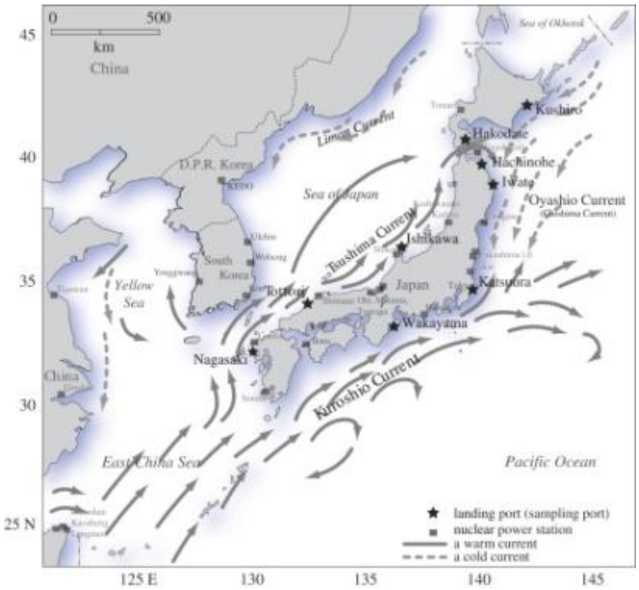
The vision of renewable energy should start from sustainability. Although, we have solar, wind, tidal, and other renewable energy. These energy resources could not sustain our energy consumption nowadays. Therefore, the energy vision I thought of start from transportation and using renewable energy to produce new energy resources like air synthesis fuels to sustain human life. Basically, use renewable energy to independent from energy resources. Furthermore, this AFS could be expending to run ground base turbine for more electricity production.

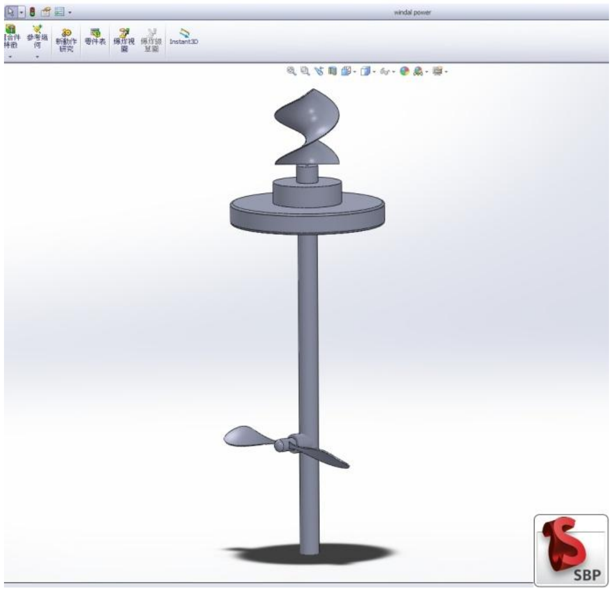
“AFS wishes to develop relations with technology partners to establish large scale supply capabilities to support uptake of the AFS approach. The key commercial feature of the process is its independence from oil price and availability.” [44](AFS Ltd, 2011)

"We are converting renewable electricity into a more versatile, useable and storable form of energy, namely liquid transport fuels. We think that by the end of 2014, provided we can get the funding going, we can be producing petrol using renewable energy and doing it on a commercial basis," he said. [45](Independent, 2012)

6.10- Future vision of renewable energy for South Korea

Since South Korea is a peninsular all the three sides of country is surrounded by ocean except the north part, which is connect to North Korea. Besides, Korea has such a strong ocean flow, Peak tidal currents among the shores of western Korea are often 1 to 1.5 m/s and reach a maximum in the passage of the southwest tip of the peninsula of 4.4 m/s. [53] Therefore, I have determined to use more tidal power energy to increase the renewable energy of South Korea. However, I think one type of renewable energy could not reach the max energy efficiency but combining solar, wind, and tidal all together into one power supply station. This is the Multi Power Generator that I have designed below.





First, the Wind Turbine is on the very upper part of the device looks like a spiral shape. One major advantage of spiral shape wind turbine is that does not matter what direction the wind blows it will spin as long as there is wind passing through it. This spiral shaped wind turbine could produce up to 30% more electricity compare with the traditional horizontal propeller shaped wind turbines. [55] It operates under low wind velocity with 4mph and sustains with sharp storm wind about 105mph. The material of the turbine is 40% fiber glass and 20% carbon fiber and another 40% with aluminum steel. With spiral shaped wind turbine it could generated about 25W~30W with 7mph wind. I am optimistic about this low-friction high-speed drive mechanism. [56] (We first neglect the gear friction). If we assume the average wind speed is 20mph then the wind turbines could produce 788kW/yr. On the other hand the spiral shape wind turbine is comparably quiet than the horizontal axial turbines; and it is also less harmful to the birds. Since, the location is close to ocean surface and the blade area is small.

Second part is the solar panel which is installed beneath the wind turbine. Although, it could not change the focus and direction like dual axis solar panel, which follows the intensity of the sunlight. Still, this one meter square area could produce (160*hour of sunlight*365) assume 8 hours of

sunlight then 467200 kwh/yr. The efficiency is relatively low compare with dual axis solar panel the best solar panel manufactory (SunPower) [57] with 17% efficiency so; I assume 11% for the solar panel that I have designed under ideal condition.
Lastly, the bottom part of the device is horizontal propeller type tidal turbine. This is the major energy sources of the device. Mainly this device is designed for strong ocean current under 10m depth with average flow velocity of 2.5m/s. The annual energy capture of open channel horizontal propeller type:

$$P \propto V^3$$

$$V = [K_0 + K_1 \cos(\frac{2\pi t}{T_0})] \cos(\frac{2\pi t}{T_1})$$ (Equation developed by Fraenkel, 2006) [54]

"The tidal cycle has been approximated by a double sinusoid; one with a period of 12.4 h representing the diurnal cycle, and the other a period of 353 h representing the fortnightly spring-neap period." With current speed of 2.5m/s the ratio of maximum spring to maximum neap tide was 2.0. Since the maximum spring tide occurred at t = 0, an equation in terms of K_0 and K_1 could be derived:

$$V_{spring} = 2.5 = K_1 + K_0$$

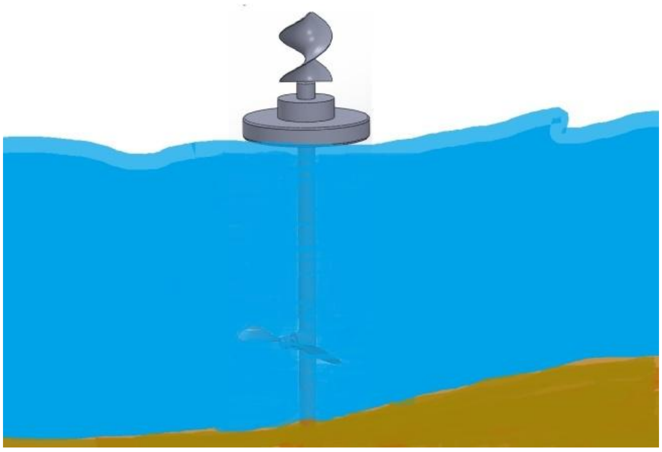
From plotting the sum of the two tidal variations it could be seen that the maximum neap tide occurred at approximately: $\cos\left(\frac{2\pi t}{T_1}\right) = 1$ and $\cos\left(\frac{2\pi t}{T_0}\right) = -1$

A second relationship was derived as: $V_{neap} = 1.25 = K_1 - K_0$
The two simultaneous equations could then be solved to give $K_0 = 1.875$ and $K_1 = 0.625$, and a final relationship for flow velocity variation with time of:

$$V = \left[1.875 + 0.125\cos\left(\frac{2\pi t}{353}\right)\right] * \cos(\frac{2\pi t}{12.4})$$

Therefore, with average of 2.5m/s tide current velocity; the tidal turbine could produce 15.6 watt/s. For the annual energy production is 480.6 MW/yr. Besides, the two blades tidal turbines are less harmful to the fishes because of the larger gap in between and I have considered the smoother finish at the edges of the turbines.

For the efficiency of the device there is no actual experiment to measure but I assume the idealistic efficiency of it by 11% from the solar panels, 40% from the tidal turbines and 30% from wind turbines which give us the sum of the efficiencies equation: Wind turbines with average wind speed 20mph could produce about 90 W/h. Therefore, the capacity of wind turbines is 0.79 MW/yr * 30% efficiency = 0.24MW/yr. For the solar panel the capacity is 0.053MW/yr * 11% efficiency = 0.0058 MW/yr. The tidal turbine's capacity is 480.63 MW/yr * 40% efficiency = 192.24MW/yr. Therefore, the average efficiency of the system is (0.24 +0.0058 +192.24) MW/ (0.79 +0.053+480.63) MW = 40%. I would install this multi energy device near the south cost of the Korea in between Jeju Island and South Korea where the maximum current and sunlight intensity. In the conclusion, the total power production of the power generator is 192.5MW/yr, considering the each section of wind, solar, and tidal efficiency in ideal situation. I believe this would be the good first step of combing renewable energy by increasing the energy efficiency and energy production for South Korea to approach "Sustainability."



7-Human as an Energy Source

We, humans, create energy through eating food. 1 kcal is equivalent to 1.16Wh. An exercise is a process of using energy. When we go to a gym to lift weights, we use the energy we gain from food to do so. The energy is conserved within the process. When we make a campfire, the fire is creating the heat by using the energy stored in the wood. As we get close to the fire we feel the heat and warm us up. The way how we exercise today is like burning the woods but not getting close to it. We can use the energy used in the process of exercising to other form of energy such as electricity. Assuming there is a fitness gym with 60 light bulbs, where operates 300 days a year 12h a day. This gym consumes about 8730 kWh per year for lights. If all the weights for the machines at the gym were motor base, creates electricity as we exercise, the electricity consumed would be decreased. The capacity of an average size bicycle generator is 100 W.[50] This is about 363 kWh a year when used 10h a day. Also, when the weights for dumbbells were motor based, 20 kWh a year is generated. Assuming this is done by five people, about 2000kWh is generated in a year. This is 23% of the electricity used for the lights at the gym. A 2000 kWh of electricity might be a small amount; however, there are 26831 gyms in the US, therefore about 53million kWh is saved every year in the US.[51]

While this is a big scale project, we shall take the basic idea of this and make it a smaller scale project. There are ideas which use heat from a body and vibration made while we move. BBC news reports that "At Stockholm's busy Central Station, engineers use heating exchangers to convert body heat into hot water and then pump that water to an office building next door, providing it with environmentally friendly and cost effective heating. The process can reduce energy costs by up to 25%". Also, Mr. Kohei Hayami in Japan makes floors with a vibration-powered generator (an example shown below). On this floor, as we walk, the LEDs on the signs lights up in dark.

[52]

At places like stations, stadiums, and air ports where a large amount of people move around, such systems of generating electricity can help reduce the total energy consumption. These types of ideas which make wastes into energy have potential of making a big amount of electricity in net. Not only humans do such waste but do factories and car engines also make heat and many kinds of transportation like train, vehicle, and subway makes vibration on the roads.

8-Conclusion

The study of alternative renewable energy teaches us about its necessity and capability. In detail, Bio-mass, Wind Energy, Solar Energy Geothermal Energy, Hydro Energy, Wave and Tidal Energy, Liquid Fluoride Thorium Power (LFTR), and Ocean Thermal Energy are discussed. Depending on the geology, each of these has pros and cons.

The main issues of these alternative forms of energy are the cost and the efficiency. We have not achieved them in reality; yet the capabilities of these alternatives are shown theoretically. For example, quantum-dot solar can increase the efficiency of using primary PV three times more and that less than 1% of the area of Earth's geostationary orbit can produce enough energy for the world with SBSP.

The LFTR generation system is not a renewable energy. However, it seems that this system is a good replacement for nuclear plants in countries making plans to build more due the safety of LFTR and its raw material. On the other hand, for a country like Japan, which is trying to get rid of nuclear plants and move on to renewable energy, it seems that LFTR is not a welcoming solution to the Japanese energy problem.

To "sustain," people know that renewable energy is the solution. Nevertheless, when we question the priority of what to consider in energy, the answer varies; it might be price, environment, health, safety, or lifestyle. This drives us to the controversy of continuing to use nuclear and thermal energy or going to green energy.

In my opinion, it is a good time for Japan to rethink energy after the accident in the Fukushima nuclear reactor. Both for the safety and for the environment, it is not too early to start building up the base for renewable energy. With this action toward green energy, Japan might be able to show other countries an example of how it can be done. This can lead to speeding up the innovations of renewable energy, which decreases the cost. It might take decades to have a "green society." However, I think that, in the long run, the effort and money we put in now would be worth a lot more.

South Korea is a small country with a population of 48 million. The country has neither fossil fuel nor coal, which makes Korea energy-dependent. Since the most of the energy is generated by coal and fossil fuel, in order for Korea to be independent from foreign energy resources, it must use innovation in various renewable energy sources and advanced technology to improve the existing green energy infrastructure. Korea's solar energy is restricted by geology, and so is the wind energy. The remaining hydro energy is the best alternative energy since South Korea (peninsular) is surrounded by oceans. However, this energy also could not sustain the energy consumption of the country. Therefore, I have a theoretical solution for this problem. The multi-green energy in the ocean will be the best solution. Basically, a turbine motor run by tidal forces under the sea is located between a huge plate at the bottom of the ocean and a wind turbine run by wind above the surface. Above the surface, where the wind turbine is located, there is also a plate that is designed with solar panels that can create solar energy. This complex multi-green energy generator is my best solution to the energy problem in Korea. Due to the limitations set by time, sponsor, and environment, I was unable to conduct advanced research or create an actual construction to present my solution. Overall, the main problems of South Korea are controlling its population and reducing the usage of the primary energy, which is environmentally unfriendly. Therefore, South Korea must keep improving their technology to create a better cost-effective renewable energy and also explore new energy sources that can sustain the energy needs of the entire country.

Next study of this project needs to investigate the feasibility of these approaches proposed for Japan and South Korea in other countries. Including the financial needs and international relation issues, how the world changes due to the shift of the energy sources to renewable energy has to be analyzed. International regulations and treaties that support achieving to have a world with only green energy are also greatly required to be considered.

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