Alternative Energy Sources Including Bioethanol as a Fuel

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Abstract

This article details alternative energy methods; the likelihood only alternative energy can be used and the correlation between non-renewable energy use and climate change. The usability and effectiveness of bioethanol was also tested through research of experimentation. The rest of the report was comprised of other research from relevant sources in order to gain a further understanding of alternative energy sources. It was found that though bioethanol is slightly more environmentally friendly it does not produce the same results as regular, non-renewable fuel. Other findings also stated that though it is not entirely impossible to live off renewable energy, the cost and time scale leaves too much to chance. Instead, the best option seems to be to live off these in tandem with more focus on the renewable sector as non-renewable fuel has shown to have a severe impact on climate change. A group of pupils completed a survey after watching a presentation of these findings and classed the information as useful and relevant to their course.

I. Introduction

What is energy? Energy, by definition, is the measure of work needed for a system to produce something or change and is used everyday by the population of the world, without a second thought. Energy comes in many different forms: heat, sound, kinetic, electrical, chemical etc and is used to heat our homes, power our cars and even to cook our food. Energy is not something that can be created. In fact, through the conservation of energy we have found that energy cannot be created or destroyed, but instead only transferred from one form to another.

Due to the numerous forms of technology; increasing numbers of cars on the road and the rapidly growing industry sectors, the demand for energy has grown in the past few decades. For example, average electrical energy consumption of the world has increased from 1200kWh per capita in 1971 to over 3000 kWh per capita in 2013 (Bank, 2014).

As shown in figure 1.1, the world’s electrical energy demand is rising (Bank, 2014), this energy must be supplied somehow and since their discovery, fossil fuels have been the world’s leading suppliers of energy. Fossil fuels are fuels from natural sources and are in the form of coal, gas and oil. They are the remains of living
organisms and are a result of millions of years of high pressure and temperature conditions.

As shown in figure 1.2, fossil fuels play a crucial role in many countries source of energy, but how is energy released from fossil fuels such as coal, gas and oil? In order to release energy from fossil fuels they must be burned. As these fossil fuels are burned, pollutants are emitted along with the useful energy. Combustion is an exothermic reaction meaning that energy is released from the reaction. There are two forms of combustion, complete combustion and incomplete combustion. In complete combustion, the reactant is completely burned in oxygen and the products are water and carbon dioxide (CO$_2$, a greenhouse gas), in incomplete combustion, the reactant is not completely burned in oxygen and the products are water and carbon monoxide (CO). Water vapour is actually a greenhouse gas, meaning that is has a significant impact on the climate crisis. CO$_2$ and CO are also products of these reactions, both are able to cause significant damage to the ozone and even cause respiratory problems. The major problem with CO$_2$ is that it is a greenhouse gas, which contributes to climate change.

Another problem we face with burning fossil fuels is the natural traces of sulfur present in these hydrocarbons such as coal. This means that when combustion takes place, the Sulfur is oxidised (gain of oxygen bonds) making sulfurdioxide (SO$_2$) (Bitesize, 2011). This by-product has an extreme environmental effect through its creation of acid rain. This happens as SO$_2$ is a soluble non-metal oxide and therefore when it reacts with water in the atmosphere, H$_2$SO$_4$ is created and the water turns acidic. Sulfurdioxide also plays a large role in human respiratory problems. Another contributor to acid rain is NO$_x$ which is created when nitrogen and oxygen react at a high temperature. This creates NO which is release into the atmosphere from the likes of car engines and burning fossil fuels. When in the atmosphere, the NO reacts with oxygen to become NO$_2$, which forms acid rain and causes respiratory problems (BBC, 2014). Due to fossil fuels releasing these pollutants, greenhouse gases, soil and water have been tainted by acid rain, natural crop production is becoming increasingly difficult and the temperature of the earth is rising. One final problem with fossil fuels is that they are finite and so will eventually run out.

So how do we fix these problems? How do we ensure a greener future whilst also guaranteeing that our energy needs are satisfied? Perhaps our answer lies in renewable energy. Renewable energy is energy produced by utilizing natural occurrences such as wind, waves and sunlight unlike fossil fuels these are not finite and will last until the sun dies. By harnessing these, no harmful by products are formed, except in the production of receptors such as wind turbines.
Renewable energy is incredibly important. Climate change is becoming a growing problem, to put this in perspective; many governments have placed the threat held by climate change next to that of terrorism. Is it possible to live without fossil fuels though? Dr. David McKay of the University of Cambridge considered a point in time where we are without fossil fuels. In his conclusion, Dr. McKay decided that, in theory, it would be possible to live off of sustainable energy alone however the cost and vast changes may cause problems (Engineering.com, Online). Through this, we know that there is still a way we can live on sustainable energy creating a greener future, jobs and security in the energy industry.

II. Wave Power

Wave power is a form of renewable energy which transforms the natural occurrence of waves into energy. Due to the lack of emissions from this process, it makes it an incredibly green way of energy production. There are several methods of harnessing waves for energy. The first is using a chamber and a generator. A chamber is built half in the water half out. When a wave hits the chamber the water in the chamber is forced to rise as well as the air in the chamber. When the air is forced up it has nowhere to go but through a turbine powered generator. The force of the air causes the turbine to turn as well as the generator. From there the generator transforms the kinetic energy into electrical energy (Resources, Online).

Another method used in harnessing wave power is that of the Pelamis wave energy converter. In design it looks like a giant snake in the water. The Pelamis wave energy converter works through the use of pistons inside it. Hinges that attach different sections of the “snake” are connected to pistons which sit inside a cylinder. When the wave moves the snake the hinges and pistons also move. The pistons move hydraulic fluid through to a motor which is attached to an electrical generator. The electricity from the generator is then sent to the shore through a sub-sea cable, allowing the electricity to be used by the national grid.

These are the two main sources of wave energy, both of which are incredibly promising. However the question remains, how much energy is wave power capable of producing? The World Energy Council, a UN approved body that looks to inform large organizations and countries on energy strategies and statistics, estimates that around 2 terawatts of power can be produced from the Earth’s oceans solely from wave power. To put this in perspective, this figure is roughly twice the world’s
current electricity production (Green, Online).

Another factor that needs to be taken into account when discussing wave power is how cost effective and efficient the system is. There is no point in spending millions of pounds on a project which does not deliver a suitable amount of electricity to put into the grid. Not many studies have been conducted into the chamber method; however the Pelamis wave snake had immense results with an efficiency level of roughly 70% (index, 2011). This is promising as it shows that the work and money put onto this device delivers satisfactory results.

Though the pros of wave power as a green source of alternative energy production are extensive, the cons must also be analysed. One of the main problems many companies and governments run into when discussing wave power is the large upfront cost. Though wave power is one of the less pricey alternatives in terms of running cost and maintenance, it does take a large sum of money to initially produce. Pelamis launched the wave snake first in Portugal with the initial cost of the project reaching a staggering €9 million (website, Online), equivalent to around £7,650,000. Due to this large cost many are reluctant to implement this source.

Another possible issue that wave power poses is a threat to marine life. With the presence of these devices in the water or on the shoreline, marine life is disturbed. There are many points that can have an impact on sea life. The receptor itself; the cable that attaches it to the sea bed or the anchor within the seabed itself. The construction of the receiver on the shoreline, and the alternative routes that boats may need to take meaning that more surface are on the sea is used, rather than just a small amount for transport. The hydraulic fluid present in the snake can seep into the sea if anything were to break the snake, causing a severe environmental impact. Another possible downside of wave power, is the by-products and emissions present in the actual production of these receptors. For the shoreline wave power receptor, construction crews and equipment will need to be present; therefore the fumes from work vehicles will have an impact on the environment. The production of the Pelamis wave snake will also produce greenhouse gases due to the large amount of metal and plastic used.

Many of these problems are similar to that of any energy source, i.e. the building of power stations. However, some of these problems are fairly severe, so how can we ensure that the problems are avoided in the future?

In terms of the hydraulic fluid, using a water soluble alternative may be the answer. Therefore, in the case of a spillage or a snake breaking, the marine life is not harmed.

Other than this, there is no obvious fix for the impact wave energy has on marine life, or the cost to produce products such as the Pelamis wave snake. Due to these severe implications wave energy is perhaps not the first choice for an alternative energy source.

### III. Wind Power

The world’s most common method in the production of green energy is wind power. For centuries wind has been used from grinding corn to pumping water however the more recent application is of that to produce
electricity. A typical wind turbine is made up of three rotors which sit atop a tower that is anchored in the ground. In order for the rotors to spin, they must act opposite to the wind. The force of the wind pushes against the rotors and causes them to turn, this then causes the shaft-which is connected to the rotors-to turn as well. The shaft is connected to a gearbox which turns when the shaft does, this is then connected to a generator which converts the mechanical energy of the gearbox to electrical energy (Layton, Online).

**Figure 3.1**  (TurbinesInfo, 2011)

There are a few different types of wind turbines; the most common is the Horizontal Axis Wind Turbine or HAWT for short. The typical design is that of a propeller which spins on the horizontal axis as the wind catches it (Meyers, Online). In order to stop the turbine’s blades from catching the tower as they spin the blades are made stiff and are sometimes pointed slightly upwards away from the tower.

An advantage of the HAWT is that it can withstand strong winds due to its strong tower, and therefore can be placed in areas of higher wind speeds increasing the energy output of the turbine. HAWT is one of the most efficient wind turbines to date, this is due to the blades rotating perpendicular to the wind and therefore the wind pushes the blades through the whole motion meaning that the blades never need to act against the wind (Meyers, Online).

Another type of wind turbine is the Vertical Axis Wind Turbine or VAWT which has the rotors arranged in a vertical state. A main advantage of this is that unlike the HAWT, the VAWT does not need to be pointed into the wind and can harness the movement from any angle (Meyers, Online). The main mechanical components of the VAWT are not positioned at the top of the tower, but instead at the base meaning that maintenance is slightly easier than on the HAWT.

An advantage of VAWT is that unlike HAWT they are positioned closer to the ground and can therefore be mounted on rooftops in order to benefit from the high velocity winds many of these tall structures receive. By doing this the efficiency of the VAWT is greatly increased. Another advantage of the VAWT systems is that is does not need as high a wind speed to startup as HAWT. This allows energy to still be produced even from low wind speeds (Meyers, Online)

**Figure 3.2**  (SRM, 2012)

One disadvantage of wind power as a whole is the image it can tarnish a landscape. Many people describe wind turbines as an eyesore, and feel that it can ruin the image of a country side. Many projects to further develop wind
power have failed due to public opposition, with petitions and meetings being called for across the country in order to stop more wind turbines being built in certain areas. Due to the lack of public support it can be hard to find funding for these projects and thus the price can become too much.

As mentioned previously the cost to build and maintain wind turbines can be a big problem. With limited funding the likelihood of more wind farms are small, even though they seem to be popping up everywhere.

Another issue with wind power is the environmental impact it has. Yes, it is a renewable source of energy, however the wildlife the building of these structures disrupts is immense. Not only are the animals living in the ground where these structures are being built in danger, but the rotor blades also pose a danger to birds and bats. The threat is so extreme that in Australia, the Tasmanian wedge-tailed eagle faces threat of extinction due to the presence of wind turbines (Hambler, 2013).

Another possible disadvantage of wind power is the turn off speed for wind turbines. When winds around a wind turbine reach a certain speed, the turbine turns itself off for self-preservation. There have been many broken and damaged wind farms due to high winds. The typical speed for a large wind turbine to shut itself down is around 56mph (mpoweruk, Online). The turbine can be shut off in a number of ways, the main ones of course being through mechanical and electrical brakes (mpoweruk, Online).

Though this is a disadvantage, in a way it is also an advantage. The turbine shuts off in order to protect itself; if it were to continue to run it may get damaged. This would mean that repair work would need to take place or in extreme cases, the turbine would need to be replaced.

There are two other methods however which stop the turbine and allow it to be completely shut off; these are called stalling and furling. Stalling occurs when the wind speed becomes too great and the stress put onto the rotor blade is becoming too much, therefore the flat edge of the rotor faces into the wind. Furling is when the pitch angle is used to decrease the angle of attack and thus in turn, reduce the lift. This method also means that the flat edges of the blade is facing onto the wind, in order to slow the turbine down and reduce damage (mpoweruk, Online).

Figures 3.3 and 3.4 both showing stalling and furling. (ONLINE, 2013)
then the turbines will also shut off. This is because there is no point in keeping a turbine running if the same energy output from the turbine is the energy needed to run it. The typical wind speed for this to happen is 9mph (mpoweruk, Online). Wind turbines have an optimum working speed, usually of around 25mph. The reason for this is because this usually produces the marked voltage output of the generator. When speeds exceed this, the angle of the rotor blades needs to be altered in order to protect the generator. Though a wind turbine can continue to function at speeds up to that of the cut off speed, the higher the winds, the less efficient the system is.

These are all relevant problems and ones that can perhaps be holding back wind power as being a more prominent figure in our energy sector, so how can we fix them?

In terms of expense, though the initial cost of wind power is expensive, the actual output from it is cheaper than that of fossil fuels (Crew, 2015). Over the years, the price of non-renewable energy has been increasing, however due to the lack of energy input needed to convert renewable energy into electricity; the price of renewable energy has fallen. Therefore in the long-term, wind power is actually cheaper due to its lack of needed man power in harvesting it and its lack of necessary energy to run.

In terms of harm to wildlife, one solution may be to introduce more off shore wind farms. On land many animals are seeing the adverse effects of wind farms, however studies are showing that marine life is doing exceedingly well around off shore wind turbines. Marine biologists have even been finding new species of fish in areas where wind turbines are present (Hill, 2012).

IV. Bioethanol
A much discussed subject over the past few years has been “Is there a more eco-friendly way to power my car/motor”. This has sparked many questions about the abilities, advantages and disadvantaged of different biofuels such as bioethanol.

In the US, bioethanol is fairly common. In fact, due to ethanol’s high octane rating, a measurement of performance for a vehicular fuel (ONLINE, 2016), it has replaced lead as a fuel enhancer (Bioethanol?, What is Bioethanol?). The E10 blend is used in most cars and does not require any vehicle specifications for a car to run on this fuel. It is comprised of a mixture of 10% ethanol and 90% petrol. As the ratio of ethanol to petrol increases, a certain type of car must be used. As the blend reaches E85 (85% ethanol and 15% petrol) a “flex-fuel” vehicle must be used (Bioethanol?, What is Bioethanol?).

E10 has made a significant environmental impact already, with emissions being lessened so much that it is equivalent to taking 7 million cars off of the road (environment, 2009).

V. Production
Bioethanol is simply ethanol produced by either the fermentation of sugar or by the reaction of ethene with water. The reason why ethanol is becoming such a popular fuel source is due to the fact that it can be produced from biological sources such as corn, maize and fruits. The production of ethanol starts with biomass which is predominantly made up of cellulose (a chain of sugar molecules); hemicellulose (like cellulose but of a
simpler structure) and lignin (an organic polymer found in many plants). This does not however contain the necessary concentration of sugars needed to produce ethanol so these carbohydrates must be treated with various enzymes or acids in order to extract and breakdown the plant walls into sucrose and glucose. This happens when the hemi cellulose and the cellulose are hydrolysed. The lignin however is still leftover and can later be used in order to power the boilers for the ethanol production (Bioethanol?, What is Bioethanol?).

Unlike petrol, it is readily available in many countries and does not need importation due to its vast production possibilities. Therefore countries that usually have to import petrol such as India will have a more readily accessible alternative to fuel. For example, one possible method for producing bioethanol can be from fruit. Many fruits are high in sugars, making them ideal candidates for fermentation into ethanol. There are many different factors that affect how large a percentage yield of ethanol someone can attain from fermentation of fruit. A group of researchers from the University of Malaya conducted an experiment into bioethanol produced from bananas to see how effective the production was in terms of fuel and reducing agricultural waste. In the experiment they also detailed how the highest yield of ethanol can be attained. Their results showed that by using a higher temperature; more water; longer shaking hours; rotten fruit and more enzymes the concentration of ethanol increases (Hossain, 2011).

**VI. Fuel Results**

So how effective is ethanol as a fuel? The answer is, not very. As shown in figure 6.1, ethanol has a much smaller enthalpy of combustion, meaning that the energy given out per mole when completely burned in oxygen is smaller than that of gasoline.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Enthalpy of combustion (kJ mol(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>-29,676</td>
</tr>
<tr>
<td>Gasoline</td>
<td>-48,201</td>
</tr>
<tr>
<td>Diesel</td>
<td>-45,700</td>
</tr>
<tr>
<td>Propane</td>
<td>-49,973</td>
</tr>
</tbody>
</table>

Figure 6.1 (TutorVista.com, 2016)

This therefore means that the mileage ethanol gives is not as good as that of the mileage diesel or gasoline gives.

A company called Edmunds compared E85 to regular gasoline. They did this by driving from San Diego to Las Vegas, a 333 mile run in a Chevrolet Tahoe. Their plan was to drive to and from Las Vegas on the first day on regular gasoline and then do the same the next day on E85. In order for the test to be fair, the team hired a mechanic to completely drain the Tahoe the next day so no residual gasoline would be left over. The team found that on regular gasoline to and from Las Vegas, they spent $124.66 on 36.5 gallons however on E85 they spent $154.29 on 50 gallons of fuel. From this the team found that E85 was 26.5% worse in fuel economy compared to regular gasoline (Edmunds, 2009). Perhaps in this sense then, E85 is not the best blend since it costs more and gives less miles per gallon (mpg).

Another issue that many consumers have experienced with using ethanol laced fuels, is car damage. Ethanol’s ability to retain and attract water compared to that of gasoline is much higher. This is due to ethanol’s hydroxyl group as it attracts water
from moisture in the air through hydrogen bonding (Stefan.V, 2015). Due to the absorption of water from any moisture within the tank, the ethanol can be rendered useless at any point in the car’s lifetime (Lapine, Online). Another problem motorists have found when using ethanol fuels, is that when left for a period of time, the ethanol and water can actually separate and thus when the engine is eventually, the water is sucked in through the intake valve and into the cylinder, flooding the engine.

Again, another recurring issue especially with older vehicles is the damage ethanol causes to small parts of the car. Ethanol has corrosive properties and therefore can damage and deform small plastic and metal parts of a car (Lapine, Online).

VII. Conclusion
After extensive research, it is clear that renewable energy, though theoretically possible, should not be the only form of energy we live on. Yes, it is more environmentally friendly to produce and burn, however it is not nearly efficient enough to feed the continuously growing need for energy.

Nevertheless, we cannot continue to live off of fossil fuels to the current extent that we are as the Earth’s temperature is rising, hurricanes are becoming more intense and the sea level is predicted to rise to as much as 1.2 meters in the next century.

From this we can safely conclude that the best option in moving forward is that of fossil fuels and renewable energy working together. Neither is the perfect solution on its own, however if we were to focus mainly on renewable energy, whilst also incorporating non-renewable energy in the process an effective balance can be reached. This gives us the cost of non-renewable energy as well as reducing the amount of greenhouse gases.

VIII. Relevance
In order to test how useful this information is, a class presentation took place in which a group of National 5 pupils volunteered their time in order to try and learn more on alcohols and alternative energy. The class were preparing for an upcoming assignment on a similar topic. They completed a questionnaire before and after the presentation in order to gain an idea of how much the learned. The presentation was made up of information from this report. The questionnaire was comprised of three questions before and four after, all on a scale of 1-10. The results were as follows.

1. How knowledgeable are you on alcohol as a fuel?

<table>
<thead>
<tr>
<th>Scale 1-10</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or Under</td>
<td>77%</td>
<td>0%</td>
</tr>
<tr>
<td>Over 5</td>
<td>23%</td>
<td>100%</td>
</tr>
</tbody>
</table>

2. How knowledgeable are you on the production of bioethanol?

<table>
<thead>
<tr>
<th>Scale 1-10</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or Under</td>
<td>100%</td>
<td>15%</td>
</tr>
<tr>
<td>Over 5</td>
<td>0%</td>
<td>75%</td>
</tr>
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3. How knowledgeable are you on its effects on the environment?

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<tr>
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<tr>
<td>Over 5</td>
<td>0%</td>
<td>100%</td>
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This shows that the information given from this report in the presentation was useful.
The fourth question from the questionnaire asked how suited to the year group the presentation was, 84.6% of pupils rated it a 10.

Overall, each pupil’s knowledge on the production and environmental impacts of bioethanol was furthered through the presentation. The class all found that it was well suited to their year group and found the information relevant to their course.

IX. References


Hambler, C., 2013. Wind farms vs wildlife. [Online] Available at:


