Energy Resources in the UK: A Critical Assessment and Analysis

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1.0 Introduction:

The UK government is working at home and abroad to adapt to the effects of climate change and reduce greenhouse gas emissions by investing in low-carbon energy sources, improving fuel standards in cars and increasing energy efficiency wherever possible. In 2012, the nations of the United Kingdom is endowed with vast and varied renewable energy resources. However, UK leads the world in offshore wind, with more than 700 turbines already installed, and is accelerating the deployment of onshore wind with the biggest projects in Europe already operating and under construction in Scotland and Wales. Taken together onshore and offshore wind provide enough power for more than two and a half million homes. [2]

In 2008, UK established the world’s first legally binding climate change target. The aim was to reduce the UK’s greenhouse gas emissions by at least 80% by 2050. The UK government was set up national policies and strategy to fulfil the target. [3] The actions were as follows:

- Carbon budgets to limit the amount of greenhouse gases the UK is allowed to emit over a specified time.
- Using statistics on greenhouse gas emissions and further evidence, analysis and research to inform energy and climate change policy.
- Using the EU Emissions Trading Scheme (EU ETS) to meet over 50% of the UK’s carbon emissions reduction target between now and 2020.
- Using a set of values for carbon to make sure project and policy appraisals account for their climate change impacts.
- Using the 2050 Calculator to let policy makers and the public explore the different options for meeting the 2050 emissions reduction targets.

In fact, there is a lively ongoing public debate about the role of onshore wind energy in meeting the UK’s future electricity needs and environmental targets. Particularly, in January 2012, more than 100 Members of Parliament expressed their concerns over onshore wind subsidies in a letter to the Prime Minister. He responded by defending the role of the renewable technology as a key part of the UK’s future mix of energy sources. [4]

The background to this debate is the UK’s twin commitment to reduce greenhouse gas emissions and to increase the proportion of energy generated by renewable sources, such as wind and solar. The Climate Change Act (Her Majesty’s Government, 2008) commits the UK to reducing its annual greenhouse gas emissions by at least 80 per cent by 2050 compared with
1990 levels. The initial four carbon budgets set by the Government, and passed by Parliament, require emissions to be cut by 34 per cent by 2020 and by 50 per cent by 2025. At the same time, the European Union Directive on Renewable Energy (2009/28/EC) requires the UK to obtain at least 15 per cent of its gross final consumption of energy from renewable sources by 2020.

In order to achieve these objectives and move towards a low-carbon economy, the UK must undertake a shift in its energy supply towards much less carbon-intensive sources. Renewable energy, such as onshore wind, is central to this ambition.

However, there are several forms of low-carbon energy, and it is not trivial to determine the right combination of renewable sources and other low-carbon technologies. Several environmental, economic and social considerations need to be carefully taken into account in order to identify the most desirable energy mix.

### 2.0 Aims and objectives:

This report aims an overview of various renewable and non-renewable energy resources and their availability in the UK. It is also involved a virtual analysis of advantages and disadvantages of numerous renewable and non-renewable energy resources in the UK. Consequently, the critical appraisal research will be associated on the Climate Change Act (2008) of an 80% of CO2 reduction by 2050. The first case study is life cycle costing (LCC) of particular renewable technology. On the other hand, 2nd case study is environmental impact assessment one of the renewable technology using Life Cycle Assessment (LCA) based on UK energy resources.

### 3.0 Literature Review:

In 1997, the Kyoto protocol set up an obligation on countries to reduce carbon emissions within 2008 to 2012. In year of 2002, World Summit on Sustainable Development in Johannesburg saw obligation from several countries to make this internationally binding agreement. In 2009, Copenhagen maintained the momentum of Kyoto protocol to reduce further carbon emissions. In particular, UK and EU countries had decided to go through more than Kyoto targets; and UK government has proposed 20% of CO2 reductions by 2010. Unfortunately, it has not been
achieved by 2010. On the other hand, the Royal Commission on Environment Pollution (2000) specified the requirement of 60% reduction by the middle of century. In fact, it was adopted as the formal UK target in the energy White paper in 2003 and 2007. Finally, the UK government set a target the Climate Change Act (2008) of an 80% of CO2 reduction by 2050. There are number of instruments and strategies taken for long term CO2 reduction. The UK government is speeding up planning decision on renewable and low carbon energy use such as offshore wind power, tidal power, nuclear and so on.

The UK government has been developed Climate change program’s policy measures such as Climate Change Levy (CCL), the Renewable Energy Obligation (REO) and the Emissions Trading Scheme (ETS). In fact, CCL applies for all non-domestic energy use but major energy user can be released up to 80% of the levy by Climate Change Agreements.

4.0 Analysis:

“An overview of various renewable and Non Renewable Energy resources and their availability in the UK”

4.1 Renewable Energy:

In 2011, 77.1% of renewable energy sources used in UK, most of energy comes from hydro and wind generation. However, wind (with a 15.4% share) accounted for around three times the shares of large scale hydro (4.9%) in primary input terms. “Of the 8.7 million tonnes of oil equivalent of primary energy use accounted for by renewables, 6.3 million tonnes was used to generate electricity, 1.2 million tonnes was used to generate heat, and 1.1 million tonnes was used for road transport.” [1] The various renewable energy sources are:

4.1.1 Hydroelectric power:

Hydroelectric power is the energy derived from flowing water. This can be from rivers or man-made installations, where water flows from a high-level reservoir down through a tunnel and away from a dam. Turbines placed within the flow of water extract its kinetic energy and convert it to mechanical energy. This causes the turbines to rotate at high speed, driving a generator that converts the mechanical energy into electrical energy. The amount of
hydroelectric power generated depends on the water flow and the vertical distance (known as ‘head’) the water falls through. [6]

Figure 1 : Hydroelectric Power Energy sources in the UK. [7]

“The UK currently (2011) generates about 1.5% of its electricity from hydroelectric schemes. Although further large-scale development potential is limited, there is scope for exploiting our remaining small-scale hydro resources in a sustainable way”. [6] There are 3 main categories used to define the output from hydroelectric power:

- Large-scale capacity: hydro plant producing more than 5 megawatts (MW).
- Small-scale capacity: hydro plant producing less than 5 megawatts.
- Micro-scale capacity: hydro plant producing less than 50 kilowatts.

“The total hydroelectric installed capacity in the UK at the end of 2011 was approximately 1676 megawatts, which is around 1.9% of the current total UK generating capacity and 14% of renewable electricity generation capacity.”[6]

United Kingdom has the opportunities to use hydroelectric technology on a large scale are now limited, not only because of environmental also because many of the most economically
attractive sites for schemes have already been used. However, it is important to exploit UK’s remaining small-scale hydro resources in a sustainable way. However, recent studies estimate there is a remaining viable hydro potential of 850 to 1550 megawatts in the UK. This represents approximately 1 to 2% of current UK generating capacity and so would make a modest but useful contribution to UK renewable energy and emission reduction targets. There are a number of steps that have to be considered before a scheme can be built, eg scheme economics, environmental permits, planning consent and connection to the local electricity network. [6]

### 4.1.2 Tidal Wave:

Wave and tidal stream energy is electricity generated from the movement of wave and tidal flows. However, wave power is much more predictable than wind power – and it increases during the winter, when electricity demand is at its highest. Tidal and current stream energies are also predictable and consistent. [8] There is a potential for Tidal Wave energy resources in the UK. In the UK interest has been devoted to the River Severn estuary, lying between South Wales and the South West area of England.

“It is estimated the UK has around 50% of Europe’s tidal energy resource, and a study in 2004 estimated the UK’s technical resource at around 16 terawatts per hour per year (TWh/year) (4% of overall supply).” [8]

Wave and tidal stream energy has the potential to meet up to 20% of the UK’s current electricity demand, representing a 30-to-50 gigawatt (GW) installed capacity. Between 200 and 300 megawatts (MWs) of generation capacity may be able to be deployed by 2020, and at the higher end of the range, up to 27GWs by 2050. [8]
The UK is currently seen as a world leader and focal point for the development of wave and tidal stream technologies because it has an abundance of marine energy resource. With its excellent marine resource and its expertise in oil and gas exploration, the UK is in a unique position to benefit from this type of renewable energy – and to develop related wave and tidal services. The industry is still in its early stages however, and further research is needed to determine how best to exploit these assets.

4.1.3 Wind Power:

Wind power technologies transform the kinetic energy of the wind into useful mechanical power. The kinetic energy of the air flow provides the motive force that turns the wind turbine blades that, via a drive shaft, provide the mechanical energy to power the generator in the wind turbine.

Wind power is currently one of the most developed and cost-effective renewable electricity technologies. The UK has the largest potential wind energy resource in Europe. While offshore wind is more technologically challenging and more expensive than onshore wind, it has a larger potential due to a stronger and more consistent wind resource out to sea, leading to higher
power outputs per turbine and more hours spent generating each year. “The UK leads the world in offshore wind, with more than 700 turbines already installed, and is accelerating the deployment of onshore wind with the biggest projects in Europe already operating and under construction in Scotland and Wales. Taken together onshore and offshore wind provide enough power for more than two and a half million homes. But we could do so much more. Our challenge is to bring costs down and deployment up.” [1]

At the beginning of 2013, the installed capacity of wind power in the United Kingdom was 8445 megawatts (MW), with 362 operational wind farms and 4,158 wind turbines in the United Kingdom. The United Kingdom is ranked as the world's eighth largest producer of wind power. [1]

By 2020 a total of at least 13GW of onshore wind and 18GW of offshore wind should be operational, according to the Government’s delivery plan published in 2011. At that point nearly a third of UK demand could be met by wind energy. Given the steady reduction and decommissioning of coal fired and some nuclear power stations, wind farms as a source of grid power would be on par with nuclear, and second only to CCGT power stations. [1]
4.1.4 Biomass and Bio-fuel:

Biomass is plant matter used to generate electricity and produce energy from heat. Biomass usually refers to living or recently dead plant material that can be used for fuel purposes. Although biomass can be used to mean plants grown specifically for bioenergy, or any biodegradable natural waste that is used for fuel. Fossil fuels such as coal and oil are not considered to be biomass as they are not recently dead, nor were they produced especially to become biomass. In fact, biomass is a very versatile form of renewable energy and the technology and applications are improving. As interest in global warming, reducing the use of fossil fuels and reducing carbon footprints becomes more significant, biomass will become a more important and widespread form of energy in the future.

Biomass is expected to make a significant contribution to delivering the UK’s 15% renewable energy target in 2020. However, we must ensure that our support for biomass under the Renewables Obligation (RO) represents value for money for the bill payer. Analysis carried out to inform the Government’s 2012 Bioenergy Strategy indicates that, compared to offshore wind, dedicated biomass electricity is a costly way of saving carbon. This is why the Government Response to the Renewables Obligation Banding Review Consultation, published in July 2012, announced our intention to focus biomass support on transitional technologies such as enhanced co-firing, full conversions of coal generating stations to biomass, as well as energy from waste technologies, and combined heat and power (CHP) projects. In the Government Response to the follow-up RO consultation on biomass affordability and value for money, published on 18 December 2012, we announced our intention to introduce a new dedicated biomass capacity cap. The cap will be set at 400MW of new build dedicated biomass generating capacity and a notification process will be used to allocate places within the cap. Once the 400MW cap is triggered, we will consider consulting on proposals to exclude any further new build dedicated biomass deployment from our grandfathering policy. [14]

“Since 1 April 2011, biomass electricity generators over 50KW have been required to report against the following sustainability criteria:

- minimum 60% GHG emission saving for electricity generation using solid biomass or biogas relative to fossil fuel
- general restrictions on using materials sourced from land with high biodiversity value or high carbon stock – including primary forest, peatland, and wetlands
Following a 2-year transition period, we intend that from October 2013 generating stations of 1 megawatt (MW) capacity and above will be required to meet the criteria in order to receive Renewables Obligation Certificates (ROCs) under the RO.” [10]

4.1.5 Geothermal:

Geothermal power generation is a well-established and relatively mature form of commercial renewable energy. However, one of its important characteristics is a high load factor, which means that each MW of capacity produces significantly more electricity during a year than a MW of wind or solar capacity. Geothermal energy is stored in the form of heat beneath the Earth’s surface. Deep geothermal for direct heat can be used the source of the heat tends to be hot water aquifers, which are rock strata containing groundwater at depths where temperatures are considerably hotter than the surface. This water can be extracted and will naturally replenish. At temperatures of over 60°C the heat can be used for local heat networks or for cooling through the use of absorption chillers. Consequently, Deep geothermal power is generally created when cold water is pumped down one borehole, heated up as it moves through fractures in hot rocks (at temperatures over 120°C) and returned to the surface via another borehole to drive an electricity-generating turbine. One advantage of deep geothermal energy is that, aside from the initial drilling, geothermal plants have little visual, noise or air quality impact. They can also run almost continuously, providing base load energy, and are not affected by changes in the weather. [15]

“The International Energy Agency predicts that by 2050 geothermal electricity generation could account for around 3.5% of global electricity production, with deep geothermal heat meeting 3.9% of projected final energy demand for heat.” [15]

“Geothermal capacity grew by just 0.8% (88 MW) in 2011, to reach 11 GW. Geothermal capacity has now been overtaken by solar power capacity, but geothermal power runs at a much higher load factor solar. So geothermal still produces significantly more electricity than solar.”[11]
“Only two major projects were completed in 2011, in Iceland (90 MW) and Costa Rica (42 MW), while Mexico shut down an old plant (78 MW). The US has the largest geothermal capacity, now just over 3.1 GW (28.3% of the world total), followed by the Philippines (2.0 GW), Indonesia (1.2 GW) and Mexico (0.9 GW).” [11]

4.2 Non Renewable Energy:

Over the last 200 years an ever-increasing proportion of our energy has come from non-renewable sources such as oil and coal. In UK main non-renewable resource is nuclear plant. However, when gas and oil burn they produce mainly carbon dioxide and water, releasing the energy they contain. Crude oil is a mixture of different chemicals and is usually separated out into fuels such as petrol, paraffin, kerosene and heavy fuel oils. When these fuels are burned they produce the gas carbon dioxide, which is a greenhouse gas and is a major contributor to global warming.

4.2.1 Fossil Fuels:

Fossil fuels are compounds made from the chemical elements carbon and hydrogen. Fossil fuels formed millions of years ago, during the Carboniferous Period, from the remains of plants and animals. As the plants and animals that inhabited the swamps died, they were buried under sand and mud which stopped them from decaying. Over time, more sediments covered the remains and pressure, together with heat, turned them into coal, oil and natural gas deposits. Fossil fuels are mostly found deep underground. To extract coal, mine shafts are dug into the
ground. Drilling rigs are used to bore into the ground or seabed to obtain oil or natural gas. The Industrial Revolution, in the 18th century, saw the development of steam-powered machines that used coal to heat water and produce steam. Steam-powered machines largely replaced the use of manual labour, horse power, wind and watermills and allowed goods to be manufactured in larger quantities than before. The UK present situations are as follows: [15]

- 74% of the UK’s electricity is generated from fossil fuels.
- Most of the world’s oil (13%) comes from Saudi Arabia.
- Russia is the main producer of natural gas, extracting nearly 22% of the total produced each year. The UK is 5th with 3.2%.
- China leads the way in coal production, mining 38% of the world’s coal.

### 4.2.1 Nuclear Power:

The Government is committed to delivering a low carbon and affordable energy mix of renewables, new nuclear and clean gas and coal, which will provide reliable low carbon electricity generation and reduce the UK’s dependence on fossil fuel imports. “Two of the Government’s principal aims in its energy policy are to provide energy security and to decarbonise the UK economy to an 80% reduction on 1990 emissions of greenhouse gases by 2050, as required by the Climate Change Act (2008).” [16]

The global nuclear renaissance provides a multi-billion pound opportunity for those industries involved in the supply of goods and services required for the construction, operation and maintenance, as well as decommissioning, of nuclear power stations and fuel cycle infrastructure.

The Government is aware of the important role that nuclear Research and Development (R&D) plays in the civil nuclear industry for the UK, helping to underpin the performance and safety cases of operational plants, inform government policy, develop innovative solutions and provide industry and regulators with a cadre of skilled people. The potential growth of the nuclear sector in the UK will not be driven by technology alone. A complex mix of Government policy, relative cost of nuclear power to other sources of energy, market decisions and public opinion will influence the rate and direction of growth in the decades to come. It is this level of complexity that obliges Government to keep a wide range
of technological options open for the future and therefore to maintain an agile and flexible R&D capability. [16]

“Comparative Analysis of advantages and disadvantages of various Renewable and Non-Renewable Energy Resources.”

4.3 Renewable Energy and Non Renewable Comparative Analysis:

All renewable and non-renewable energy resources have some advantage and disadvantages too. In fact, Hydroelectric Power has huge power capacity and cheap to run; consequently wind power is provided less power and very expensive to run. By way of comparison, the UK has around 65,000 MW of conventional electricity generating capacity. Less than a third of the UK's electricity now comes from coal fired plants, over a third now comes from natural gas fired combined cycled gas turbines. The nuclear element provides around 25% of UK electricity supply, although as the older plants reach the end of their operating life, this will progressively fall. Now that the bulk of the nuclear industry is privatised, it seems unlikely that any new nuclear plants will be ordered in the UK.

It seems likely that renewable energy technology will continue to develop in terms of performance and reliability, and become more cost effective. For example the costs of electricity from wind turbines has fallen by around 70% within a decade or so, and similar reductions for photo voltaic solar cells have taken place.

However, there are obviously some technical constraints. Some renewable energy sources of course are intermittent e.g. the winds and waves, and of course, the sun! However it has been suggested that intermittency need not be a major operational problem, if the electricity from these devices is fed into the national power grid network. So long as the total contribution from the various intermittent renewables does not exceed around 30-40% of the total electricity on the grid, the grid can in effect 'even out' local variations, so that the net overall power available from the grid remains more or less constant, without the need for expensive storage systems.

Although renewables generally have much less environmental impact than conventional sources, no technology can be totally benign, and they have varying degree of local impact. The development of some renewable energy technologies is therefore also likely to be
constrained by local environmental, planning and land use factors. Indeed there have already been some local planning disputes and local opposition in relation to the spread of wind farms in the UK: see 'the Wind power Debate in the UK'.

Equally however, the deployment of renewables may be stimulated by increasing environmental concerns over the generally much more significant global impacts of using conventional energy technologies e.g. global warming from the emission of greenhouse gases like carbon dioxide produced when fossil fuels are burnt. The local and global impacts have to be traded off against each other. [16]

4.4 The Critical appraisal of the effectiveness of Policy and Regulatory:

“The critical appraisal of the effectiveness of policy and regulatory instruments to influence energy use in the UK, reducing dependency of fossil energy and meeting the target in the Climate Change Act (2008) of an 80% of CO2 reduction by 2050.”

“The UK is committed to reducing its greenhouse gas emissions (GHG) by at least 80% by 2050, relative to 1990 levels. For this to happen, we need to transform the UK economy while ensuring secure, low carbon energy supplies to 2050.

The 2050 calculator and analysis helps the public engage in the debate about how to do this. It also lets us make sure our short- and medium-term planning for this transformation is consistent with achieving the long-term aim.” [12] In 2008 Renewable Transport Fuel Obligation (RFTO) policy says, “Administered by the Renewable Fuels Agency and requires suppliers of fossil fuels to ensure that a specified percentage of UK road fuel supply is from renewable fuels. The target for 2010–2011 is 5% of fuels by volume. Suppliers may buy out their obligation for 30 pence/litre. The obligation also requires companies to submit reports on the carbon content and sustainability of the biofuels used”. [16]

In particular, three major recent legislative and institutional reforms have further driven climate change policy in the UK: (1) promulgation of the Climate Change Act; (2) establishing the Committee on Climate Change; and (3) establishing the Department of Energy and Climate Change. These reforms have made it significantly harder to reverse ambitious climate change policy targets and further driven roadmaps that outline a long term trajectory for emissions mitigation in the UK such as the Low Carbon Transition Plan and the Carbon Plan. [17]
The critical appraisal 2050 pathways also show an ongoing need for fossil fuels in our energy mix, although their precise long term role will depend on a range of issues such as the development of carbon capture and storage. Pathway Alpha illustrates “a pathway with largely balanced effort across all sectors, based on physical and technical ambition. In this pathway, there would be a concerted effort to reduce overall energy demand; an equivalent level of effort from three large scale sources of low carbon electricity (renewables, nuclear, and fossil fuel power stations with carbon capture and storage); and a concerted effort to produce and import sustainable bioenergy”.[17]

In fact, UK deployment of fossil fuelled power stations, and particularly coal, has tended to cluster in a limited number of locations (for example, the Thames estuary, Humberside, Tyne-Tees, Forth estuary, Merseyside, South Wales). This could encourage the development of regional infrastructure for the collection and transport of carbon dioxide. The Government is considering how the CCS demonstration programme could help establish such networks.

4.5 Wind Power Life Cycle Costing (LCC):
“A case study of the Economic Assessment in form of life cycle costing (LCC) of 1 (one) particular renewable energy technology of your choice that might be applicable in the UK, even in a smaller scale.”

Life-Cycle Cost is defined as the sum of all costs incurred during the lifetime of an item, including total earning and ownership costs. In a wind farm context, a simple way of explaining the relevance of the LCC concept is knowing that a specific wind turbine model with the lowest initial cost may not be necessarily the one which also costs the least amount of money in the long run. Operations and maintenance costs come to mind, as they can even exceed the acquisition costs.

In particular, life cycle costing is very important for any renewable technology. However, most of the energy comes from offshore wind farm in UK. “Financial constraints which limit greater deployment of renewable technologies. This barrier lies in the perceived risk associated with investing in renewable energy technologies, which is generally higher than competing in conventional technologies and the effects of this higher perceived risk on a technology's market.” [4] The key to successful life cycle costing is identified the cost during the life cycle is
Initial Investment Costs: Cost for Acquiring Equipments /facility

Operational Costs: Annual Cost Related to operation of facility/equipment (EXCLUDING Maintenance and Repair costs) utility e.g. Gas, Electricity, Water.

Maintenance Costs: Scheduled or periodic costs associated with the upkeep of the equipments to maintain it in good working order.

Replacement Costs: anticipated expenditures to major components required to maintain the operation of the equipments.

Residual Value (RV): (Salvage Value), it is remaining value at the end of the study period, or at the time it is replaced during the study period. RV can be based on value in place, resale value, salvage value, or scrap value, net of any selling, conversion,

Disposal Cost: Residual values can be based on value in place, resale value, salvage value, or scrap value, net of any selling, conversion.

Suppose UK offshore wind farm has three alternative tower structures to satisfy a 50 years design life. In fact, wind turbine failure one of cause is tower vibration. The alternatives are
A. Wind Turbine materials steel with an initial cost of £195,000 and projected service life of 40 years. At the end of 40 years, rehabilitation will be required to extend service life by at least 10 years.

B. Wind Turbine materials welded Steel with an initial cost of £214,500 and an estimated service life in excess of the 50 year project design life.

C. Wind Turbine materials composite steel with an initial cost of £230,000 and an estimated service life in excess of the 50 year project design life.

**Maintenance:** The periodic cost for inspecting and maintaining each of the three alternates is considered to be about equal. Since the effect on all alternates is equal, these recurring costs need not be included in the calculation.

**Rehabilitation:** The material service life of alternative A is less than the required 50-year project design life. The service life can by extended by at least 15 years with a lining that is estimated to cost £48,750, or 25% of the initial cost, in currency dollars.

**Discount Rate:** All cost estimates are expressed in current pounds, inflation is ignored. The owner agrees that a real discount rate of 7% is appropriate.

In this case, among three choices, only Alternate A needs to be analysed to determine the present value of the invert rehabilitation projected in year 40. The present value of alternative B and C is equal to their initial cost since there are no significant future expenditures. In the case of A, at a discount rate of 7% the present value is as shown below:

General Present Value (PV) Formula:

\[ PV = S \times DF \]

\[ DF = \frac{1}{(1 + i)^n} \]

Where:

- \( S \) is the value of cash flow in \( n \) years time (£).
- \( DF \) is the Discount Factor
- \( i \) = Interest Rate/Charge (%)
Table 1: LCC Present Value Calculation of case study.

<table>
<thead>
<tr>
<th>Year</th>
<th>Currency (£)</th>
<th>Discount Factor @ 7%</th>
<th>Present Value(PV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-initial cost</td>
<td>195,000</td>
<td>1</td>
<td>195,000</td>
</tr>
<tr>
<td>Post 40 years to Rehabilitation</td>
<td>48,750</td>
<td>.0668</td>
<td>3,255</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>198,255</td>
</tr>
</tbody>
</table>

Table 2: The alternative material for wind turbine.

<table>
<thead>
<tr>
<th>Alternative material for wind turbine</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total PV @ i=7%</td>
<td>198,255</td>
<td>214,500</td>
<td>230,000</td>
</tr>
<tr>
<td>Ranking</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

4.6 Wind Power Life Cycle Assessment (LCA):

“A case study of the environmental Impact assessment of 1 (one) of your chosen Renewables Energy Technology using Life Cycle Assessment (LCA) that might be applicable in the UK, even in a smaller scale.”

Climate change, or global warming, refers to the increase in the average temperature of the Earth’s surface. This is caused by emissions of greenhouse gases including carbon dioxide, nitrous oxide and methane. Direct emissions from waste management contribute to all of these, and when emissions from the whole life of materials and products are included, the contribution of waste management, including prevention, becomes significant.

“Climate Change is an issue of global concern. In the UK, the Climate Change Act 2008 sets out an objective to reduce carbon dioxide emissions 80% by 2050 against a 1990 baseline.” [13]
Life cycle assessment is a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). Here, Horns Reef offshore wind farm renewable technology is taken as a case study of the environment impact assessment. The specifications are as follows:

### Table 3: Horns Reef Offshore Wind Farm Basic specifications. [20]

<table>
<thead>
<tr>
<th></th>
<th><strong>OFFSHORE TURBINE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>160 MW</td>
</tr>
<tr>
<td><strong>Tower</strong></td>
<td>165t (78 m high)</td>
</tr>
<tr>
<td><strong>Nacelle</strong></td>
<td>61t materials</td>
</tr>
<tr>
<td><strong>Rotor</strong></td>
<td>37t materials</td>
</tr>
<tr>
<td><strong>Foundation</strong></td>
<td>832t materials</td>
</tr>
</tbody>
</table>

### Table 4: The wind farm’s turbine and transmission materials quantity. [20]

<table>
<thead>
<tr>
<th>Materials</th>
<th><strong>Offshore turbine</strong></th>
<th><strong>Transmission</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Steal</td>
<td>349.240</td>
<td>1488.186</td>
</tr>
<tr>
<td>Stainless steel</td>
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<td>Cast iron</td>
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<td>131</td>
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<td>Glass fibre</td>
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<td>Plastic</td>
<td>3.879</td>
<td>822.158</td>
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The life cycle process has 4 life cycle stages. The offshore wind power life cycle process tree is illustrated below:

**Figure 7: Offshore Wind Farm Life Cycle Process tree. [20]**

**Manufacturing stage:** In the manufacturing phase of the wind turbine each component has been looked at separately. The manufacturing processes used in each case have been carefully analysed, as well as the amounts of raw material required and the energy used in their manufacture. With regard to the manufacturing phase, the impact categories with the greatest relevance are those related to inorganic respiration, climate change and the reduction of mineral resources. In the case of inorganic respiration, those components whose manufacture
has the greatest impact are the foundation and the rotor. Conversely, if we analyse the contribution of each raw material in the wind turbine manufacturing processes as a whole, prepreg is the element which has the greatest impact in the GWP category, while steel and copper are those which most affect the reduction of mineral resources.

**Transportation stage:** To complete the transport phase, we have first looked at transport from the various component manufacturers to the assembly workshops of the company which builds the wind turbine. We have also included the transport of the wind turbine to its final emplacement in the wind farm. Transport processes include the impact of emissions caused by the extraction and production of fuel and the generation of energy from fuel during transport.

**Use stage:** In this phase the categories which have the greatest impact are inorganic respiration and the reduction of mineral resources. This is basically due to the replacement of components during the time the turbine is in operation.

**Disposal stage:** In the decommissioning phase we have assessed the materials directed to landfill such as concrete. The metals extracted are taken for recycling and the oil is incinerated. According to the decommissioning plan established for the wind farm, the foundations will not be removed but rather left in place and covered with a 30 cm layer of organic soil. In this way it is hoped that any contamination that would be caused by using heavy equipment, such as diggers, trucks, etc., can be avoided, although this entails a considerable loss of materials.

### 5.0 Conclusions:

Renewable energy is so called because it relies on natural energy flows and sources in the environment, which, since they are continuously replenished, will never run out. The UK is well placed: it has amongst the world's largest resources of wind, wave and tidal energy. There are lots of renewable energy resources in UK such as wind power, tidal wave, hydroelectric power, solar power, geothermal, biomass and so on.

Obviously the future of renewables will depend on a wide range of technical, economic, environmental and political factors, as well as other policy concerns and political developments, nationally and internationally. Some of the key issues are the question of whether nuclear power can be relied on in the future, the security of supply and balance of
payment problems that may face the UK when and if it has to import natural gas from overseas, the role of energy conservation, and the wider environmental issues relating to greenhouse gas emissions, acid rain and so on.

The UK is fortunate in having relatively large reserves of oil, gas and coal, and this, and the relative cheapness of gas, has, arguably, led to a degree of complacency, not least on energy conservation. But, quite apart from the fact that these fossil fuel reserves are finite, the question remains whether all of them can be used without producing unacceptable environmental problems, most notably in terms of global warming. New technologies are emerging which use fossil fuels more efficiently, thus reducing net emissions.

Obviously in the short term energy conservation and the potential for energy saving via the introduction of more renewable energy technology would merit top priority. After all, cost effective savings of between 50-80% are claimed as feasible in many end-use sectors, and it would seem to be foolish to consider any new supply options unless we were also tackling energy waste. However, although much can be done to avoid energy waste, the UK will still need new sources of energy, as old plant is retired. Given that nuclear power seems unlikely to revive in the UK at least, the renewable energy based technologies represent the most promising non-fossil options.

6.0 References:


### 7.0 Gantt Chart:

The assignment has started from 7th of February, 2013. The approximate action plan of activities for my assessment is shown below on the Gantt chart.

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</table>
Task 1 = Research the background.
Task 2 = Renewable and non-renewable energy resources in UK study.
Task 3 = Stage1 Report writing.
Task 4 = Climate Change ACT (2008) legislation study.
Task 5 = Case Study on LCC
Task 6 = Case Study on LCA
Task 7 = Information gather from government sites
Task 8 = Stage2 Report writing