WEDC

Water, Engineering and Development Centre
Loughborough University UK

Energy and development in developing countries

by

N R Curd

A research project submitted in partial fulfilment of the requirements for the award of the degree of Master of Science of Loughborough University

August 2011

Loughborough University

Table of Contents

List of figures

List of tables

1.0 Executive Summary

This research aimed to look at the relationship between energy use and development in developing countries, to establish thresholds of energy provision for policy makers. An extensive literature review provided the basis of knowledge for the analysis in this study.

Pearson correlations coefficients in this study were used to find the strength of the relationship between energy use per capita, and various indicators of development, including education, population (including urbanisation), infrastructure, health and gross domestic product, in a sample of 12 representative countries (7 developing, 5 developed). The strongest relationships between energy and the indicators were found in developing countries, and in particular between both urban population and energy use per capita, and under 5 mortality rates and energy use per capita. Indicating that energy use per capita is most strongly influenced by urbanisation, and increased in energy use per capita is related strongly to decreased under 5 mortality rates.

The threshold analysis in this report found a general trend in data, which showed that countries with energy use per capita of 600kg of oil equivalent or more were able to meet the majority of basic human needs. Therefore this is seen as the target amount of energy per capita, which should be achieved in order to create an enabling environment for development.

The findings of this report lead to three main recommendations, which include;

1. Specific Energy Access Targets
    - Developing countries should establish energy targets. This report recommends a short term minimum access target of 600kg of oil equivalent per capita to create an enabling environment for basic development
2. Strategic Service Provision
    - Due to the links between urbanisation and increased energy use per capita, rapid urbanisation should be discouraged. Therefore providing basic levels of

energy to surrounding rural locations may help increase opportunity and standards of living, whilst discouraging rapid urbanisation.

3. Energy Source Analysis
    - Understanding local energy situations is key to improvement. Therefore an extensive energy survey of existing energy situations can be used to find problematic areas in terms of quantity, quality, cost and sustainability. An energy source analysis can be carried about to find renewable or cleaner sources of energy, which can then be implemented into phasing out strategies of unsustainable or harmful sources.

This study concludes that various links can be found between increased energy and development, therefore increasing the quantity of energy available to the poorer communities would be beneficial. However, this increase could cause adverse affects in the long term, due to the problems associated with energy use and climate change. Therefore the global population have a responsibility to provide assistance for sustainable energy growth such as utilising renewable energy sources, which will limit detrimental environmental affects.

1.1 Introduction

This research aims to explore and analyse the complex relationship between energy and development in developing countries. It will use existing literature and data as a basis for a comparative energy analysis between countries relating to development. The results from this comparative analysis will then be used in a threshold analysis, aiming to discover energy provision thresholds that aid development. The specific aims of this project are;

- To investigate the magnitude of energy poverty globally
- To discover the relationship between energy and various indicators of development
- To look for trends in existing data analysis
- To establish thresholds of energy provision for development.

These objectives will be the primary focus of this research, and how they were met throughout the course of this research will be discussed in the conclusion of this report.

2. Literature Review - Introduction

Energy is one of the major challenges of the modern world. It has been said to influence people's lives, and to be central to almost all aspects of human welfare, such as, access to water, agriculture productivity, health care, education, job creation, climate change and environmental sustainability. However, millions of households in developing countries lack access to affordable, clean, reliable and safe modern energy services. Many households in developing countries pay high prices for poor-quality substitutes, leading to poverty, damaged health, constrained delivery of local services, increased vulnerability to climate change, limited opportunities, decreased environmental sustainability and negative impacts on education and health (UNDP, 2009). This literature review aims to contrast and compare literature surrounding the topic of energy provision in developing countries.

2.1 Current Energy Situation in Developing Countries

2.1.1 Access

Energy access varies across developing countries, and is much lower in poorer developing countries, placing them at a huge disadvantage (UNDP,2009). It is seen as 'unacceptable that a third of humanity has no access to modern energy services and a half of humanity has to rely on traditional biomass for meeting their basic needs' (AGEC, 2010).

One of the most pressing challenges of the development community is improved energy services for poor households. Whilst there has been much attention focusing on this problem, there seems to be limited progress towards tackling it. The world's poor generally do not have access to safe clean fuels, and subsist on traditional sources, including dung, crop residues and wood. Relying on these forms of energy, poses major dis-benefits such as a substantial and increasing time and effort spend on their collection, a possibly higher price per unit for energy services, and severe widespread health impacts associated with indoor air pollution from their inefficient burning (Sagar, 2005).

As access to modern energy services is said to have multiple benefits, even basic levels of electricity access or modern fuels can replace tradition sources of fuel for energy needs including, lighting or motive power, which can allow for communication, healthcare and education. These improvements can substantially benefit a community or household. Modern energy services need to reach beyond the wealthy cities, as progress in health, education and economic growth depend on it. Nations could gain from fulfilling their commitments to the poorest and also will benefit from their newfound productivity (UNDP, 2010).

An energy ladder has been developed, and it refers to the phenomenon of households and businesses progression from low efficiency fuels to high efficiency ones in relation to income growth per capita. Biomass fuels like wood fuel are found at the lower end of the ladder, and electricity is found at the top end of the ladder (The World Bank, 2008). The diagram overleaf depicts the energy ladder.

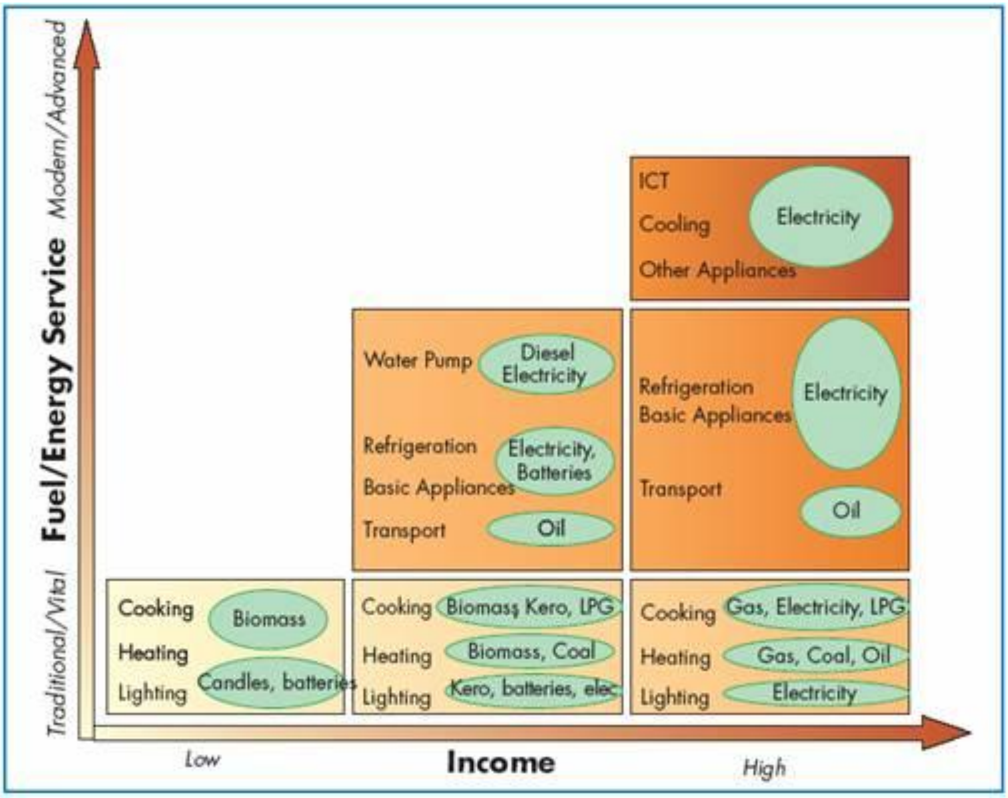


Figure 5 - The Energy Ladder (Source IEA, 2002)

The more efficient fuels are located at the top end of the ladder, and they tend to be cheaper per unit of energy consumed. However, the poorer households are often the least able to afford these more efficient fuels due to the connection charge barrier (The World Bank, 2008). Therefore whilst in theory access to these more efficient fuels would have benefits for the poorer communities and households they often are not in a position financially to obtain them.

Energy is generally not considered as one of the basic human needs, however it is necessary for the delivery and provision of these basic needs, such as food security, clean water, shelter, health and education (Kemmler, 2007). AGEC (2010) also believe that current energy systems are proving inadequate to meet the demands of the world's poor and are severely jeopardising the achievement of the Millennium Development Goals (MDGs). Both Kemmler (2007) and AGEC (2010) consider the elimination of energy poverty as important in eradicating poverty.

The energy ladder highlights the progression from basic level energy access to electricity access, which is cheaper per unit cost. However despite the cheaper cost per unit, one third of the world's population, which amounts to around two billion people have no access to electricity (Nayar, 1991), and half of this population live in Africa (Pereira, 2010). Much of the energy required by these 2 billion people is met by traditional and non-electrical sources, including human and animal power, fire-wood, kerosene and animal waste (Nayar, 1991). Sub-Saharan Africa (SSA) is the least electrified area of the world, with rural electrification levels around 5% (Karakezi, 2007). SSA is currently home to around 13% of the world's population (Kebede, 2010), with around 68% of its population living in rural locations (Karakezi, 2007). What is probably the most alarming figure however is that in SSA, less than 10% of schools, hospital and clinics in rural areas have access to electricity (Brew-Hammond, 2010). Commercial energy use in SSA is very limited, where electricity is available it is often produced as a social amenity, and is heavily subsidised by the government (Kebede, 2010).

As a result of limited access to modern energy, there is a high dependency on the traditional fuel wood by rural households in developing countries, and it is usually utilised by burning in inefficient cooking stoves (Kanagawa, 2006). It is not necessarily the use of these traditional sources that is undesirable, however the arguments against the use of these sources are relating to efficiency, environmental burden, gender, environment and health (Kebede, 2010). The general efficiency of burning traditional sources is said to be around just 10% (Kebede, 2010). Whilst there are alternatives available, it is difficult for households to adopt an alternative such as a gas stove, over the readily available wood stove (Kanagawa, 2006). In particular, SSA region compares poorly with others in terms of the reliance on traditional energy sources for cooking, with countries such as Burkino Faso and Tanzania have more than 95% of their population relying on them. In addition to this the number of people in SSA relying on these sources for cooking and heating is expected to increase in the next 25 years or so (Brew-Hammond, 2010).

In addition to the energy ladder, there is also an energy ladder in the pattern of electricity use. At the lower end of the scale is electrical use for illumination, showing that the most common use of electricity is lighting. The next most common use of electrical power is for entertainment through the use of a television. It is estimated that close to half of rural homes with electricity own a television. Interestingly electricity is only used for cooking in a small minority of homes in poorer developing regions , less that 1%. These findings come from a wide range of data from a variety of countries. One reason is cost, however tradition plays a strong part in this, with people generally preferring to continue to cook with wood and charcoal because they prefer the taste (The World Bank, 2008). These findings really put a question mark over a couple of aspects of energy provision. Firstly, the health related motivation for expanding modern energy access, as it appears just providing electricity for example is not necessarily enough to stop people from cooking with open fires and therefore increasing risk of disease. Secondly, modern energy provision has been linked to an increase in income generating activities, however with the introduction of items such as television, it might not necessarily be the case that it leads to income generating activities.

2.1.2 Issues

As a result of the reliance on traditional sources and the low level of energy use by the world's poor, there is a lack of motivation for policy makers and NGOs to focus on this issue (Sagar, 2005). This is an area which requires attention, as Africa itself boasts the widest range of potential energy resources, which exceed energy demands, however the power sector in severely undeveloped. Put into context with the developed world, the average person living in Africa is still using less energy than the average person in the UK over a century ago (Wolde – Rufael, 2005). Access to modern energy for developing countries is about energizing human development. It is necessary for ending poverty, empowering women and generating opportunities (UNDP, 2010).

A prominent issue surrounding energy is related to equality. In vast contrast to many discussions surrounding the issues of equity between countries and generations there have been few discussions related to the issues of equity within countries. In developing nations there are generally large disparities between the affluent richer population and the poorer communities, these disparities can even reach the magnitude of those between industrialised and developing countries. There is a need for more focus to close the gaps between developed and developing countries, but also to set out steps to close the gaps within developing countries (Siddiqi, 1995).

The ‘energy gap’ which exists between the poor and more affluent areas of developing countries is not simply a quantitative gap, but also a qualitative gap. A representation of this qualitative gap is in the quality of the fuels that are used in the respective areas. Richer more affluent areas are closer to the inhabitants of developed countries; they make use of electricity, refined petroleum and natural gas, whereas the poorer communities still heavily rely on traditional fuels as their primary source. Another manifestation of this gap is the exposure of households to air pollutants resulting from energy use. Poorer households are exposed to substantial levels of pollutants as a result of their biomass use, and also from living or working in heavily congested areas, resulting from increasing emission from vehicular traffic (Siddiqi, 1995).

2.2 Future Energy Predictions in Developing Countries

2.2.1 Predicted Access

An estimated 1.4 billion people will not have access to electricity by 2030. A further 2.6 billion people will not have access to improved energy situations for cooking and heating by the same year. This lack of energy will cause adverse effects on the socio-economic conditions of rural people. Improving energy access can potentially make improvements for these people’s lives (Kanagawa, 2006). These figures are quoted in various articles, therefore the source of these predictions appears important. Many articles have quoted figures surrounding these 1.4 and 2.6 billion marks. The source of the data from the quoted reference is the World Energy Outlook, which is published yearly, and these specific numbers were calculated in the 2002 report. They are based on a ‘reference scenario’, which is a scenario whereby the future predictions are made on the basis that there will be an ‘absence of major government initiatives’ (IEA, 2002) during the predicted period. The reference scenario does not include possible, potential, or even the most likely initiatives, on the basis that major new policy initiatives will inevitably be implemented during the projection period, however it is near impossible to predict precisely which ones will be adopted in this period. Therefore it is suggested that the reference scenario is not seen as a forecast but as a baseline scenario (IEA, 2002). Therefore quoting these numbers in the context shown above is a little misleading. The 2009 report estimates 1.5 billion people will lack access to electricity in 2030, which is an increase of 1 million from the 2002 prediction. The 2009 report does contain predictions further to the reference scenario, called the 450 Scenario, and this scenario reduces the number of people without electricity in 2030 by 2 million to 1.3 billion. The 450 scenario depicts an idealistic world where collective policy action is taken to limit long-term greenhouse gas concentrations to 450 parts per million of Carbon Dioxide equivalent. Whilst this objective is gaining widespread support around the world it is unlikely that all nations will act accordingly in this idealistic scenario. Therefore at best guess the author would predict that the actual projections should fall somewhere in-between the reference and the 450 scenarios, however projecting future trends is highly dependant on assumptions relating to incomes and electricity pricing. Therefore a high degree of certainty cannot be placed around any future prediction. Adding further complication to any future projections, the global financial crisis and resulting recession have had a dramatic impact on the energy markets, in particular in the short term. The world energy demand in aggregate has fallen, and how quickly it recovers is largely dependant on how quickly the global economy recovers (IEA, 2009). This would prove very difficult to accurately predict as a basis for the projections.

Another prediction is that in the year 2030, most of the people without access to electricity will be in SSA (650 million) and in South Asia (680 million). Using the current rate of connections for future projects, it is estimated that it will take over 40 years to electrify South Asia, and just under double that time to provide electricity for SSA (Wolde-Rufael, 2005). Wolde-Rufael (2005) discussed that whilst the provision of electricity is not a cure for all socio-economic problems, such supply would be a requirement for economic and social development. This theory is supported by Pereira (2010) who sees access to electricity as a key aspect for the increased economic development (in particularly a rural setting) and therefore a decrease in poverty. Ebohon (1996) admits there are huge doubts over Africa's ability to achieve sustainable economic growth and development due to its energy structure.

2.2.2 Predicted Demand

Currently developing countries consume a limited share of global commercial energy, due to the expected income growth of their economies'; there are suggestions that they may soon consume the majority of the world's energy (De Vita et. al, 2006). The energy needs of developing countries may not only be affected by a rising residual energy demand as a result of a growth in income, but also by an increased industrial energy as their economics grow in the long run (Sari, 2007). As the energy use in developing countries is growing rapidly, it is affecting the world's energy resource reserves, along with accelerating climate change (Urban et.al, 2007). Many of the current patterns of energy use are unsustainable, as a result there is an increasing pressure to acknowledge developing countries energy use on a global scale (Urban et. al, 2007), especially since many areas of the world have no reliable and/or secure energy supplies (Vera, 2007). Findings of research by Kebede (2010) show that an emphasis placed on energy efficiency in both industrial and agricultural sector can reduce the overall energy demand and therefore improve economic growth. In order to meet current and future energy demands of a growing population, each region must introduce diverse sources of energy, suited to their local situation. It therefore seems that a mixture of energy efficient technologies and diverse energy sources would set a stage for the better economic development of developing countries.

2.2.3 Future Targets

Just under half of developing countries have set targets for access to electricity, with many if these located in Sub-Saharan Africa. This shows a significant increase from an earlier UNDP study based on 2005 data, which showed that only 21% of national MDG reports highlighted energy targets (UNDP, 2009). Therefore a growing focus has been placed upon energy access. However, in vast contrast to this, very few countries have targets relating to access to modern fuels, improved cooking stoves, or access to mechanical power. In addition to this is appears that given the importance, a large number of countries are still lacking specific energy access targets, and especially those which are deemed essential for poverty reduction (UNDP, 2009). Therefore the main focus and drive has been placed upon access to electricity, and other forms of energy use have been overshadowed, regardless of the improvement potential they bring.

2.2.4 Issues

The World Summit on Sustainable Development in 2002 discussed energy, where the present international community confirmed that energy is important for the success of the millennium development goals (MDGs) aim to half the population living in poverty by 2015 (Vera, 2007). There is much debate surrounding the achievability of the MDGs, especially in relation to Africa which has the lowest electrification rates globally. The World Bank's

APEA suggests that 50% by 2015 will probably not be achievable, however a more realistic target is around 35% electrification by 2015, and rising to 48% by 2030. They also suggest that in order to fulfil this revised target by 2030, this will require an annual investment of US$4 billion (Brew-Hammond, 2010).

2.3 Development Indicators

This section will highlight findings from literature relating to various development indicators in developing countries.

2.3.1 Urbanisation

Urbanisation and high-density living have the potential to influence wide patterns of resource use. The indirect and direct energy requirements of urban living will contribute significantly to adverse environmental impacts, such as increased carbon dioxide emissions (Parikh, 1995). As a result the adverse affects, sustainable development should be considered. Sustainable development involves developing in a way that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (P.del Rio, 2008). Without the arrival of adequate energy services, many people may be driven into migrating in search of a better living condition, therefore inadequate energy services encourage rapid urbanisation (Kebede, 2010). Providing rural communities with small scale renewable projects can help them gain access to energy services and expand livelihood opportunities, which contribute to poverty alleviation and a better standard of living (Lloyd, 2009).

The diagram overleaf shows how urbanisation can cause increased energy use, and all the elements including population, income, consumption patterns, industrialisation and urbanisation are all intrinsically linked together.

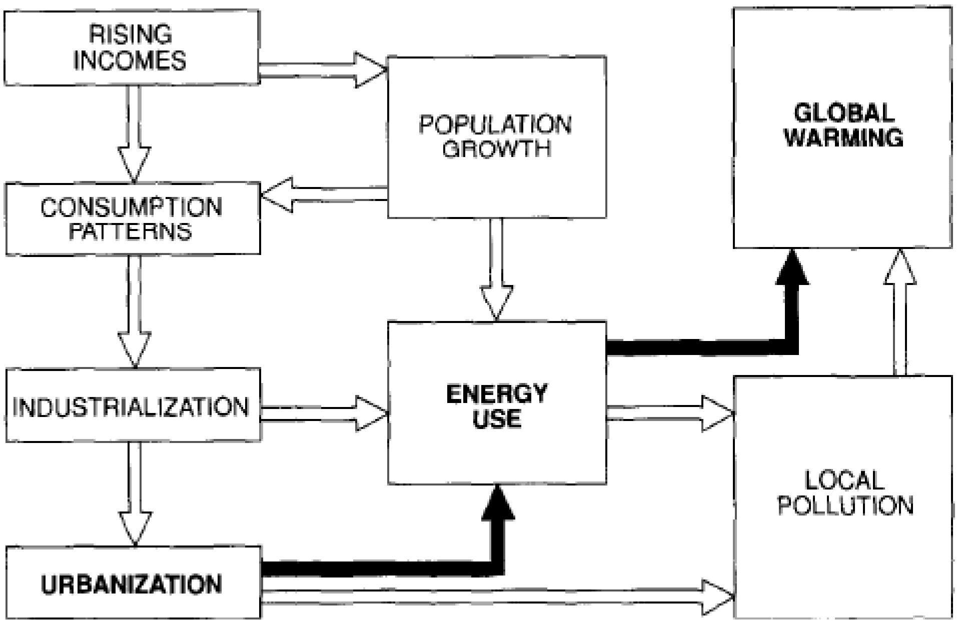


Figure 6 - Energy Use Links (source Parihk, 1995)

The main identifiable types of energy use which can be associated with urban growth and urban lifestyle and these are (Parikh, 1995);

- Indirect energy consumption such as goods producing or transporting
- Direct energy consumption such as personal transportation, or changes in domestic usage

Jones (1991) supports the notion that urbanisation can affect energy use in in developing countries in many ways. Indirectly by, separating food producers from consumers, which is in contrast to traditional agriculture where farmers consume a majority of what they produce, and they produce a majority of the food they eat. Therefore, the structure of traditional agriculture practise needs to be adapted to support urbanisation. Often to support larger crop sizes agricultural operations mechanise, commercial fertiliser is increasingly used, and more of the output is processed so that it can travel further to the urban areas. These factors contribute to energy use that is not associated with traditional agricultural practise
Another energy use change occurs in changes in individual activities, therefore direct energy consumption changes, supporting once again the findings of Parikh (1995). People living in urban areas have been found to be more likely to travel using fuel related transport, than those in rural locations. In addition to travel changes, households in developing countries use between 40-90% of all fuels, so any changes in domestic energy use can be an important factor in the overall energy situation (Jones, 1991).

However it is argued that, in some countries, whilst urbanisation can be seen to increase energy use, once urbanisation reaches a certain level, emission effects turn out to be negative, thus reducing environmental damage (Martinez-Zarzoso, 2009). Madlener (2011) suggests that urbanisation has nearly reached saturation in more developed countries, so therefore the future urban growth will mainly come from less and the least developed countries. Following this theory, if the saturated urbanisation in the more developing countries have crossed the 'certain level' whereby emission effects is negative, this suggests the global focus of emissions control should be on the less developed countries. Whereas, there has been much focus and emphasis on reducing emissions in the developed nations.

2.3.2 Poverty

Poverty can be defined as a low attainment of social condition, such as education, health, and nutrition (Kanagawa, 2008). Therefore poverty alleviation can be defined as the improvement of living conditions, moving closer to the achievement of a minimum level of basic human needs (Silva, 2009). Poverty is and has long been a major obstacle of sustainable development in both developing countries and the entire world, it has therefore proved to be a main target of the donor community including the World Bank (Kanagawa, 2006).
Whilst energy itself is not considered to be a basic human need, it is seen as a necessary component to conduct activities and provide basic services for human life such as heat for both cooking and warmth, and illumination (Silva, 2009). It is important to promote opportunity to overcome poverty, and such opportunities include the access to modern energy such as electricity (Kanagawa, 2008). It is acknowledged that access to reliable and affordable energy has an essential role in the achievement of the Millenium Development Goals. As a result, a minimum level of energy consumption can be associated to a condition of living which is situated above the poverty line (Silva, 2009). The poverty line is based on a set of poverty measures to diagnose the extent of poverty, and there exists a form of measurement in the form of a line, below which you're considered living in poverty. A poverty line is considered arbitrary and can be set using two main approaches, the first is placing the line where the definition of absolute poverty lies, which is, people who cannot purchase or obtain a fixed amount of basic goods for human life, and the second method is establishing the line in relation to a broadly accepted standard of living at a specific time and place, meaning that the line is determined using the identification of those who are excluded from living a certain quality of life which is the social norm (Kemmler, 2007). These methods are often criticised for placing a monetary value on poverty, as is it considered too

narrow. This is due to the fact that monetary figures cannot capture essential aspects of well-being (Kemmler, 2007).

A direct relationship has been established between the absence of adequate energy provision and poverty indicators such as infant mortality, illiteracy, and life expectancy (Kebede, 2010). Wolde-Rufael (2005) concurs that poverty and energy use may be intrinsically related, and went on to say that solving the needs of the poor will be crucial for poverty alleviaton. Kanagawa (2006) also sees energy as a fundamental requirement for development, and one of the main components of poverty reduction in developing countries.

Absence of a commercially supplied energy such as electricity, can lead to an increase in poverty, lack of development opportunity, migratory flow to large cities, and a society's disbelief in its own future. The arrival of electricity can acquire a higher degree of economic sustainability and a better quality of life (Pereira, 2010).

However, it is argued in a paper by Wamukonya (2001) that electrification and increased energy use does not have a significant impact on expanding income generating activities, and is therefore not a critical stimuli for such activities, and other factors such as access to finance and markets are more important. This paper however discusses that the majority of people living in electrified houses consider their social status to be elevated, and that it has improved their quality of life. Energy services for poverty reduction are often less about technology and more about the understanding of the role that energy can play in these people's lives, and responding to the specific constraints that these people are subject to in improving their livelihoods. Energy can have an important input into water supplies, communication, local health, education, and many forms of transport (Kaygusuz, 2011).

As of 2000, 1.6 billion people had no access to electricity, and 99% of these were situated in a developing country. Four out of five of these people were living in rural areas, and the majority of them also living under the absolute poverty line (Silva, 2009). A principle benefit of rural electrication is considered to be better lighting. This is considered to achieve improve security, and the ability to study at night (Wamukonya, 2001). This therefore links to the idea that education is one of the most essential components for poverty reduction.

2.3.3 Health and Healthcare

Around 87% of households in Ghana use woodfuel as their source for cooking and heating, this is fairly representative also of a large proportion of households in developing countries.

Therefore every day there is smoke exposure in the indoor environmental (Arthur et. al, 2011). The world health organisation believe as many as 1.6 billion women and children die each year as a result of indoor smoke pollution from traditional energy sources (Silva, 2009). Therefore a significant reduction in exposure to indoor smoke pollution could be achieved by replacing these traditional sources with clean renewable ones, such as solar. The main beneficiaries of this improvement in the household would be women and children (Kanagawa, 2006).

A lack of access to clean, efficient and modern energy in the home can impact health in many ways. The most important direct health affects are the result of air pollution from burning solid fuels on open fires and simple stove indoors (UNDP, 2009). Just under 2 million deaths worldwide occur as a direct result of solid fuel use, and more than 99% of these deaths occurring in developing countries, which is equivalent to 3.3% of all deaths globally (UNDP, 2009).

In additional to health effects of indoor smoke from incomplete combustion, other health-related impacts arise such as burns and scalds from open or semi open fires, risk of injury and violence to women collecting firewood, and missed time from school for children involved in fuel collection (UNDP, 2009).

Healthcare benefits can also be achieved through increased energy access. A majority of rural clinics in Namibia, have no light, no communication, and no sterilisation equipment, and this is fairly typical of the poorer developing countries. Increased energy provision can allow clinics to have the energy for lighting, refrigeration for vaccines, communications, sterilisation, heating and cooling systems, and educational outreach, which could bring around dramatic increases in healthcare (Yaron, 1994).

Therforefore health benefits can be seen through increased energy access in many ways, including (adapted from IEG, 2008);

- Health care facility improvements, leading to better healthcare.
- Cleaner air in indoor environments from reductions in open fire cooking, lighting and heating, leading to improved health.

- Improvements in health education through increased access to television and radio services.
- Greater nutrition from improvements in knowledge and access to refridgerated storage facilities.

It is said that there is a causal chain for health impact caused by increased access to energy in the form of electricity and it is as follows. Access to electricity increases access to television and radio, and increases time spent watching and listening to these. This in effect increases the access to media awareness campaigns regarding health issues. Increased awareness leads to greater understanding of behaviour, therefore leading to changes in behaviour where possible. These changes therefore improve health (IEG, 2008).

2.3.5 Education

Energy access improvement and in particular the access to electricity can have a huge impact on education. It reduces drudgery, therefore allowing children time to attend school. It also as mentioned previously illuminates the house allowing for study, however in addition to this it allows for the utilisation of TV, radio and information technology for educational purposes (Kanagawa, 2008). Research shows that children in electrified households have higher levels of education than those children living in households without electricity (IEG, 2008).

In rural areas in particular, children typically return from school and then have various household chores in the afternoon. Therefore time for schoolwork or homework is typically limited to the evening hours, so lighting would allow them to carry out homework or reading in the evening hours (Yaron, 1994). Primary education shows the highest return of investment, as a lower literacy rate leads to a lack of employment opportunities. In addition to employment opportunities, gaining an education allows the poorer households to have positive effects on confidence, sociality, concern for society, participation for social activity, the resistance to oppression and the possible involvement in the political process, possibly leading to a better quality of life for themselves and others in their situation. Therefore by allowing the opportunity to gain an education, advantages are available for both the individual and the broader society, towards poverty reduction. (Kanagawa, 2008). Looking beyond primary education, lighting would also allow for adult educational classes to be run in the evening out of working hours if there was sufficient community interest for this (Yaron, 1994).

Looking specifically at electrification, there are two main ways which it can help improve education in developing countries. Firstly, it can improve the quality of schools either directly through the provision of equipment such as lights, tv, computers which are all electrically dependant, or indirectly by electricity access causing opportunity in that area and thus movement causing increased teacher quality and quantity. Secondly, as discussed in the previous section, it allows for increased hours in which study can occur, i.e into evening hours. However, it is also possible that electrification also causes decreased study hours, where televisions are installed into the home (IEG, 2008). Therefore showing that whilst benefits can be achieved through increased energy use and electrification, the solution is not just simply providing electricity as other factors have affect.

2.3.6 Economic

Throughout literature, there appears to be no general consensus on either the direction or the causality between energy consumption and economic growth (Ozturk, 2009). Wolde-Rufael (2005) supports this theory after carrying out a co-integration test, and a modified granger causality test. He concluded that whilst there was a evidence of a long run relationship in 8 out of the 19 countries tested, a definite stand on the existence or non-existence for the relationship between energy use and economic growth could not be established. Wolde-Rufael (2005) suggested that there may be a number of factors which differ from country to country at work, which could account for differing directions of causality detected in the study. The role of energy is economic development is suggested to be contentious, due to the variations in literature. Some authors argue a complementary relationship, whilst others indicate variable results and other factors being involved (Ebohon, 1996).

Ebohon (1996) infact carried out a study following his remarks, and following his analysis concluded that his findings ‘strongly uphold’ the theory that energy is complementary to national income growth. In line with these findings, Lee (2005) believes it is clear in general that for developing countries energy is important for economic development, and that energy conservation measures may harm economic growth. Sari (2006) contradicts this point, suggesting that the promotion of energy efficiency and decreased energy intensity has the potential to have positive impacts on economic growth, with the added benefit of less pressure on the environment.

Kebede (2010) supports the views of Sari, saying that Sub-Saharan African countries' economic development depends on energy consumption. Therefore it is important to diversify energy sources and to introduce energy efficiency measures to improve GDP growth at all levels of the economy (Kebede, 2010).

Further supporting the relationship between energy and economic growth. Energy can be seen as a good measure of economic activity and development according to Siddiqi (1995). As a good correlation has been identified between GDP and energy use in various countries, so therefore inequities from country to country can be explained by energy use per capita differences (Siddiqi, 1995).

2.3.7 Socio – Economic

Literature tends to focus upon the direct employment effects of an energy project as the most important contribution to development locally. There are additionally a wide array of other benefits that are often overlooked. These include, income generation which ultimately diversifies the source of income of the local population, and therefore the creation of a development alternative. This ends up providing people with brighter future prospects which can have a significant positive psychological effect on an isolated communities (P.del Rio, 2008). Various major social issues have been linked to energy use, including poverty, quality of life, education, demographic transition, indoor pollution, health, gender and age related implications. Therefore using energy indicators of the social dimension are an important indicator for the socio-economic effects energy can have on the community (Vera, 2007). Kanagawa (2006) implies that energy access improvements in rural areas can improve the health of the inhabitants, along with mitigating the environmental burden, therefore having significant socio-economic impacts on local and global scales.

2.3.8 Women's Empowerment

Women are increasingly recognised as both the producer and managers of energy (Farhar, 1998), as women for the most part do the household cooking, and collect the fuelwood for the energy supply (Arthur et.al, 2011). Women spend a great deal of time collecting wood for energy, often three mornings a week, and whilst this activity does not cost them in literal monetary terms, it is time wasted which could be spent doing more productive activities (Arthur et.al, 2011). Farhar (1998) reinforces this concern by recognising that women's time is often overlooked, but it is an essential part of sustainable development. Farhar (1998) suggests that even a simple photovoltaic device or solar powered lighting or access to the electricity grid would save these women time and energy. However with women carrying the majority of this burden, without empowerment, they are unable to be the voice of change in their communities (Farhar, 1998). Further to this, decision makers often have a lack of understanding in the complex relationships between gender roles, energy availability and social welfare, and are often falling to the false assumption that welfare increases directly with energy consumption (Farhar, 1998).

2.4 Issues relating to Energy

This section will highlight the main issues and adverse effects which can be related the energy.

2.4.1 Climate Change

The greenhouse effect which is the ability of gases such as carbon dioxide and water vapour to trap some of the re-emission of solar energy by the plant, is an essential component of life on earth. Without this process, the planet would be too cold to support life. Without human intervention the concentration of these gases would change slowly, however human activities are rapidly increasing the concentration of carbon dioxide in particular, along with other greenhouse gases, which raises concern regarding the impact of this. The changing concentrations of carbon dioxide in the atmosphere have the potential to warm the earth by 1-5°C (Wuebbles, 2001).

Sinyak (1994) suggests that a general consensus exists that further environmental pollution and specifically climate change could be prevented if the emissions from energy systems throughout the globe are reduced. However energy is currently, and will remain the dominant active driving force of both social and economic progress over the 21st Century. Therefore as a result, Murota (1996) believes that global warming is a problem that must be addressed globally in the 21st century.

2.4.1.1 Development in relation to climate change

Murota (1996) recognises that rapid development in developing countries causes concern for the increased demand for energy. Rapid development will increase the carbon dioxide emission and accelerate the rate of fossil fuel exhaustion, such as the heavy use of coal combustion in India and China, which is expected to result in a significant contribution of carbon dioxide in the atmosphere within the next 30 years (Williams, 1993). This will ultimately lead to the problem of global warming and resource depletion becoming uncontrollable (Murota, 1996).

The necessity for a change of approach to human development can be explained by a growing crisis in the interaction between humanity and nature (Sinyak, 1994). We have long taken for granted the moderate and stable climate which facilitated the evolution of natural systems that feed and sustain human life along with the evolution of modern society. However in light of recent trends in climate changes, caused by increasing levels of carbon dioxide in the atmosphere and the resultant global warming, the climate is now of major concern (Sinyak, 1994). Zidansek et al (2009) reinforces this belief by portraying climate change as 'one of the most dangerous problems to the contemporary world', and suggests that humans must either adapt to the corresponding climate changes, or attempt to reduce the impact by significantly reducing the burning of fossil fuels. However, Sinyak (1994) questions the latter, suggesting that in spite of radical steps being taken to prevent the impact of energy systems on the global climate, the accumulation of carbon dioxide in the atmosphere cannot be stopped, we can at best aim for postponing the doubling of this concentration over the next couple of decades.

The burden of global energy problems will shift from developed to the developing countries by 2050, when developing countries are predicted to have a 55-60% share of the world energy demand, this will create new tensions in the global energy scene if actions are not taken (Sinyak, 1994). For example, the smoke from cooking fires in Africa will release around 7 billion tons of carbon dioxide in the atmosphere by 2050 (Arthur et.al, 2011). Despite this, Sagar (2005) believes is likely that the world's poor are going to remain excluded from the climate discussions. This is unfortunate as the benefits of international cooperation are likely to flow to current or future emitters to help them reduce these emissions. This leaves the low emitting individuals or households, who by their own use patterns contribute to the achievement of the United Nations Framework Convention on climate change will continue to get ignored. However, Rong (2010) believes that no serious solution to the climate change problem can be formulated without the involvement of developing countries. Reinforcing this point, Sagar (2005) suggests that more attention needs to be paid to the world's poor, despite how little emissions they may produce currently. However Lloyd (2009) believes that this is a two way street, suggesting that climate change issues are not a sufficiently pressing issue for the sustained attention of developing countries, given the more urgent issues such as access to clean water and food security, poverty alleviation, and equitable energy access. So is it that more attention needs to be paid to these countries, or is it that they themselves need to obtain the motivation for change, or both?.

Sagar (2005) expects that the links between energy use and climate change will be a motivator for widespread deployment of devices to ease this burden, however admits that so far this is yet to happen, or at least on a wide enough scale to really make a difference. Further to this, Sinyak (1994) believes that whilst global energy systems have started the transition from fossil fuel and exhaustible resource based systems, to renewable energy resources, it is difficult to foresee the length of the transition period.

Poorer countries tend to be hotter and as a result closer to their temperature tolerance limits, however there are suggestions that temperatures will rise faster towards the poles than near the equator. This being said however with these countries near their tolerance limits and very often having livelihoods very exposed to climate change, which creates a dangerous prospect (Tol et al, 2004). Therefore the adaptive capacity, which is the ability of the community or country to alleviate the negative consequences and take advantage of the positive changes, is an important factor (Tol et al, 2004). Whilst we cannot be certain of the exact effects and how developing countries will adapt in future, what we can be almost certain of is that the poor will lose the most relative to their income as a result either directly or indirectly of climate change (Tol et al, 2004). The various effects of climate change are discussed in sections below.

2.4.1.2 Agriculture and climate change

Rong (2010) suggests that agricultural potential will most probably reduce rather than increase as a result of global warming. However Wuebbles (2001) considers the geographical factors surrounding this issue, by suggesting that in some areas over the next few decades crop yields and productivity are projected to increase, however significant decreases can be expected in the tropic and sub-tropics. This is alarming due to the high population of this area, which boasts a majority of the world's population. Wuebbles (2001) believes this decrease could be so severe that it will increase the risk of hunger and famine in areas where already some of the world's poorest people reside. Differing from the geographical approach Hitz (2004) considers the extent of the temperature rise as a factor in the effects. Hitz (2004) expressed some uncertainty about whether globally agriculture experiences increases, decreases or no has effect in the event of a temperature rise of up to 3-4^{o}C. However above this threshold Hitz (2004) estimates adverse impacts globally, such as crop yield declines. Further to this Hitz (2004) discussed that whilst geographic change such as growing crops at a higher latitude and altitude to maintain optimum temperatures could maintain crop production, eventually this geographical shift will be counteracted by temperature rises. Productivity losses in agriculture will lead to additional effects such as price increases for grain. This in turn could lead to a reduction in livestock production due to the price increases of grain (Wuebbles, 2001). This is only a simple example to scratch the surface of the knock on effects of the predicted decreases in agricultural productivity, the full effects of such cannot be accurately formulated.

2.4.1.3 Climate change effects on Sea levels

Global warming will result in a sea level rise for two reasons. The first being thermal expansion, as the climate heats the water in the ocean expands, and secondly the melting of both snow and ice from mountain glaciers and polar ice caps increases the volume of water in the ocean (Wuebbles, 2001 & Rong, 2010). This last century has seen the global sea level rise by around 10-25cm (Wuebbles, 2001), and this is expected to reach 1m by the end of this century, and if this melting accelerates further a 3m rise seems plausible (Rong, 2010). This 3m figure is alarming, and the magnitude of risks should this occur in developing countries is large. For example in China a 3m sea level rise could affect over 50 million people with a potential economic loss of US$260 billion (Rong,2010). Reinforcing this, Wuebbles (2001) also recognises sea level rises could have detrimental effects on low lying coastal areas, highlighting the risks as 'direct flooding and property damage or loss, coastal erosion, increased frequency of storm surge flooding, salt water infiltration and therefore pollution of irrigation and drinking water, destruction of estuarine habitats, and damage to coral reefs'. It appears that adverse impacts will rise linearly with sea level rises, the higher the rise the higher the risk (Hitz, 2004).

2.4.1.4 Climate change effects on Water Resources

Climate change has the potential to lead to an intensification of the global hydrological cycle. This will lead to major impacts on regional water resources. Some areas will see reduced rainfall and increased evapouration, which will significantly decrease the availability of water. Whereas other areas rainfall is likely to increase, and where the use of artificial fertilisers is prominent this may lead to runoff related drinking water pollution (Wuebbles, 2001). This is however disputed in a paper by Hitz (2004) where the relationship between water resources and climate change are said to appear inconclusive, and various studies have not found a trend. However the paper by Hitz (2004) recognises that an argument can be made that a high magnitude increase due to climate change will probably result in an adverse impact on the availability of safe drinking water. Whilst some regions may see benefits brought around by climate change, the majority of the world's population will not see improved conditions, as water systems are optimised for the current climate state (Hitz, 2004).

2.4.1.5 Climate related natural disasters

Climate change brings about predictions of increased extreme weather events. Historically many of the developing countries have seen huge losses from climate related disasters such as drought, flood, storm, cold wave, and wild fires (Rong, 2010). Developing countries are particularly vulnerable to extreme weather events (Mirza, 2003), and it is reasonable to assume that countries who suffered more historically from weather related disasters will in future be more vulnerable to future climate change (Rong, 2010). For example in the last 10 years an average of 8% of China's population have been affected yearly by such events, therefore they are at high risk of future events (Rong, 2010). Putting this all into context, the last decade has seen costs incurred by developing countries twenty times greater than that of the developing world, totally US$35 billion a year damages from natural disasters (Mirza, 2003). Mirza (2003) discusses that the magnitude of vulnerability varies in terms of geographical location, seasonality, exposure of the population, and the current infrastructure. The frequency and magnitude of extreme weather events may increase, and also people's vulnerability to these events may also increase in the future due to climate change facts (Mirza, 2003). The table below shows some of the predicted dangers for various developing countries.

Selected impacts of climate-related extreme events in developing regions

Region	Expected regional impact of extreme events
Africa	Increases in droughts, floods, and other extreme events will add to stress on water resources, food security, human health, and infrastructure, and would constrain development in Africa (*high confidence*) Sea level rise would affect coastal settlements, flooding and coastal erosion especially along the south-eastern African coast (*high confidence*) Desertification, exacerbated by reductions in average annual rainfall, runoff, and soil moisture (*medium confidence*) Major rivers highly sensitive to climate variation: average runoff and water availability would decrease in Mediterranean and southern countries in Africa, affecting agriculture and hydro-power systems (*medium confidence*)
Asia	Extreme events have increases in temperate Asia, including floods, droughts, forest fires, and tropical cyclones (*high confidence*) Thermal and water stress, flood and drought, sea-level rise, and tropical cyclones would diminish food security in countries of arid, tropical, and temperate Asia; agriculture would expand and increase in productivity in northern areas (*medium confidence*) Sea-level rise and increase in intensity of tropical cyclones would displace tens of millions of people in low-lying coastal areas of temperate and tropical Asia; increased intensity of rainfall would increase flood risks in temperate and tropical Asia (*high confidence*) Climate change increase energy demand, decrease tourism, and influence transportation in some regions of Asia (*medium confidence*)
Latin America	Loss and retreat of glaciers would adversely affect runoff and water supply in areas where glacier melt is an important water source (*high confidence*) Floods and droughts would increase in frequency, higher sediment loads would degrade water quality in some areas (*high confidence*) Increases in the intensity of tropical cyclones would alter the risks to life, property, and ecosystems from heavy rain, flooding, storm surges, and wind damages (*high confidence*) Coastal human settlements, productive activities, infrastructure, and mangrove ecosystems would be negatively affected by sea-level rise (*medium confidence*)
Small Island States	Projected sea-level rise of 5 mm per year for the next 100 years would cause enhanced coastal erosion, loss of land and property, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion into freshwater resources, and high resource costs for adaptation (*high confidence*) Islands are highly vulnerable to impacts of climate change on water supplies, agricultural productivity including exports of cash crops, coastal ecosystems, and tourism as an important source of foreign exchange for many islands (*high confidence*)

Source: IPCC (2001a). *Note*: The IPCC uses the following words to indicate judgmental estimates of confidence: *very high* (95% or higher), *high* (67–95%), *medium* (33–67%), *low* (5–33%), and *very low* (5% or less).

Figure 7 - Impacts of climate change (source Mirza, 2003)

2.4.1.6 Climate change effects on Health and Human Infrastructure

Climate change related factors can affect human health by changes in weather, sea level, water availability, and ecosystem changes such as those that affect food security, or the geography of vector borne diseases. Direct health effects by climate change include increased frequency of cardio-respiratory illness and death which is caused by increased frequency of heat waves for example. An example of an indirect effect could be malnutrition and hunger caused by decreased agricultural productivity which reduces food security (Wuebbles, 2001). However, health impacts are complex as their causes after often owed to multiple factors, therefore we may see increases in morbidity and mortality for some causes, and decreases for other causes (Hitz, 2004).

Many studies show an increase risk of Malaria with an increasing climate temperature. Suggestions are that the risks increase linearly with temperature rise, and that a global increase in the seasonal potential Malaria transmission zones into areas formerly free of the disease can be expected, along year round transmission increases. However, interestingly, the risk of a Malaria epidemic is reduced, as this decreases gradually with a temperature rise (Hitz, 2004). Haines et.al (2006) reinforces these concerns, indicating that a climatic change would cause an increase of around 57% of the population at risk of Malaria in Africa, and that the lengthening of the transmission season could cause an increase of 16-28% in the total number of person-months of exposure.

Vector-borne diseases are not the only concern, as mentioned previously increased rain fall in some areas could lead to the pollution of water sources, and findings highlight that water-borne disease risk increases with temperature rises. For example higher temperatures are usually accompanied by a higher occurrence of diarrhoeal disease (Hitz, 2004). Water borne diseases mainly affect younger age groups; therefore an increase in this type of disease will be mainly borne by children in developing countries (Haines et.al, 2006).

2.4.2 Fossil Fuel supplies

Global demands for more energy to fuel economic development has resulted in exponential growth in the use of fossil fuels since the start of the industrial revolution (Lloyd, 2009). Fossil fuels account for 79% of the world's primary energy consumption (Kumar et.al, 2010). The ever increasing gap between demand and supply will generate challenges to modern living (Lloyd, 2009). The world energy forum predicts that fossil fuel reserves will be exhausted in less than 100 years. The current rate of exhaustion and the predicted future increased demand is forcing planners and policy makers into looking for and considering alternative sources years (Kumar et. al, 2010). In contrast in a paper written by Shafiee (2009) discusses oil and gas reserves, suggesting that predictions stating that reserves are diminishing are not reliable and that over the last few decades these reserves did not decline. Further to this, Sinyak (1994) discussed that the problem is not the supply of energy, the problem is how to supply it in an optimal way. Regarding the supply side, Inexhaustible energy sources do exist already or at very least they are known in principle. Their development depends on costs and time, therefore they require motivation or a need to develop further. Once cheaper and limited energy sources such as fossil fuels are exhausted, these new technologies utilising inexhaustible resources will find application. This suggests that mankind will not suffer from a lack of energy in the foreseeable future, mankind will simply have to learn how to provide this new resource in an optimal way with minimal risks to economy and the environment

It is suggested that fossil fuels will keep a prominent role for a long time yet, due to resource availability and economics (Sinyak, 1994). Jin-ke et. al (2009) justifies this notion, explaining that long term economic growth will not be achieved without adequate and affordable energy supplies, which requires the continuing and significant contributions of fossil fuels currently. Shafiee (2009) also recognises that fossil fuels currently play a crucial role in energy markets globally, and are currently worth US$1.5 trillion in the marketplace.

2.4.3 Pressures relating to energy provision

Energy is considered ‘the vital basis of the development of human society’, and it can be associated with many aspects of social development and everyday life (Wang, 2003). With an increasing world population and rising living standards, the result is an increasing demand for energy globally. Therefore developing countries are facing high pressures in terms of economic growth and environmental issues in the 21st century (Wang, 2003). However whilst electrification is often justified on the basis of the resultant economic development, this is not automatically the case in practise. Electricity is a necessary component of economic development however it is now generally accepted that it is not a sufficient catalyst for it (Wamukonya, 2007)

Electricity is often used as a symbol of progress, and allegedly politicians who promise electricity win votes. As a result political pressures to fulfil normally outweigh any economic rationales of providing electricity. Further to the suspected local political agenda, global economics and political instability have contributed to the rising attention of limited fossil fuel resources, and resulting terrorist attacks of late have been used in support of distributing renewable sources of electricity on a global scale (Wamukonya, 2007). Utilising Africa's energy potential will limit the dependency on imported energy, and may also help to reinstate much needed foreign exchange (Wolde-Rufael, 2005).

2.5 Summary of Main Findings

The main findings from literature will now be summarised below;

1. **Current Energy Situation in Developing Countries**

- Energy access varies across developing countries and is much lower in poorer areas (UNDP, 2009). One third of the world's population have no access to modern energy, and half rely on traditional biomass for meeting basic needs (AGEC, 2010).
- More efficient fuels tend to be cheaper per unit of energy consumed, however poorer households are generally unable to obtain these due to a connection charge barrier (The World Bank, 2008).
- Energy is not considered a basic human need, but is necessary for provision of basic needs (Kemmler, 2007).
- Tradition is an important consideration as even where electricity is provided, les than 1% use it for cooking, as they prefer to cook with wood and charcoal because they like the taste (The World Bank, 2008).
- Energy inequity within developing countries between poor and rich communities, can reach the same levels as the inequity between developed and developing countries (Siddiqi, 1995).

2. **Future Energy Predictions for Developing Countries**

- A baseline scenario predicts that 1.4 billion people will have no access to electricity, and 2.6 billion people will not have access to improved cooking and heating by 2030 (Kanagawa, 2008). However this prediction is based on the assumption that no major government initiatives will be implemented in this period, therefore putting the reliability of these figures in doubt.
- The world energy demand has decreased as a result of the global financial crisis, and how quickly it recovers is largely dependent on when the economy recovers (IEA, 2009).
- Due to expexted income growth of economies in Developing Countries it has been suggested that they might soon consume the majority of the world's energy (de Vita et.al, 2006).

3. **Development and Energy**

- Urbanisation influences wide patterns of energy use. Direct and indirect energy requirements of living in urban areas will contribute significantly to adverse environmental impacts and increased energy use, not associated with traditional rural living (Parikh, 1995 & del.Rio, 2008).
- Poverty is defined as the low attainment of social condition, whilst energy is not considered a basic human need it is seem as a necessary component for basic services such as cooking, heating and illumination (Kanagawa, 2008). A direct relationship has been established between energy provision and poverty indicators such as infant mortality, illiteracy and life expectancy (Kebede, 2010).
- The use of traditional inefficient sources of energy causes indoor smoke exposure which is harmful to health, and is said to be responsible for as many as 1.6 billion women and child deaths annually (Arthur et.al, 2011 & Silva, 2009). In addition healthcare benefits can be associated with increased energy access, due to increased lighting refrigeration, communication, sterilisation and, heating and cooling access (Yaron, 1994).
- Energy access improvements can have a huge impact on education. In particular, electricity access allows for illumination for evening study, and the use of television or other education aids such as computers (Kanagawa, 2008).
- There is no general consensus in literature surrounding the links between energy use and economic factors (Ozturk, 2005).
- Women are both the managers and producers of household energy, and they carry the burden of collecting fuelwood, when other more productive activities could be carried out. However without empowerment, these women are unlikely to be the voice of change to more efficient sources of energy use in their communities (Farhar, 1998).

4. Issues relating to Energy Use

- Global warming is a problem that must be address in the 21st century, as rapid development in developing countries causes concern for increased energy demand, which will increase carbon dioxide emission (Murota, 1996).
- The burden of global energy problems is predicted to shift from developed to developing countries by 2050, when they will have the majority of the worlds energy demand share, creating new tensions in the global market (Sinyak, 1994).

- Global warming has the potential to affect agriculture, sea levels, water resources, natural disaster frequency, and health if action is not taken the remediate the release of carbon dioxide into the atmosphere.

3.0 Methodology

This section of the report aims to explain the methodological methods used to investigate the research questions arising in this report. It will also highlight the historical methods used in similar studies.

3.1 Introduction

There are huge doubts surrounding the ability of developing countries to develop and grow without adequate access to energy. The specific research questions that will be investigated surrounding this issue are:

- What is the magnitude of energy poverty in various developing countries?
- Is there a relationship between energy and various indicators of development?
- Can trends be established from existing data?
- Can thresholds of energy provision be established?

Research questions arising from literature review include;

- Is energy poverty alleviation the key to poverty alleviation?
- Does inadequate access to energy place countries at a disadvantage?

3.2 Research Design

The research aims to expand upon existing studies relating to energy use and provision. Therefore it is important to understand the methods used in similar studies which may be adopted for this analysis. The table overleaf summarises the various analysis methods used in similar energy studies;

Table 1
Summary of empirical studies on energy consumption–growth nexus for country-specific studies.

Authors	Period	Country	Methodology	Causality relationship
Kraft and Kraft (1978)	1947–1974	USA	Granger causality	GDP→EC
Akarca and Long (1980)	1950–1970	USA	Sim's technique	GDP- - - -EC
Yu and Hwang (1984)	1947–1979	USA	Sim's technique	GDP- - - -EC
Abosedra and Baghestani (1989)	1947–1987	USA	Co-integration and Granger causality	GDP→EC
Hwang and Gum (1991)	1961–1990	Taiwan	Co-integration, error correction	EC←→GDP
Yu and Jin (1992)	1974–1990	USA	Co-integration and Granger causality	GDP- - - -EC
Stern (1993)	1947–1990	USA	Multivariate VAR model	EC→GDP
Cheng (1995)	1947–1990	USA	Co-integration and Granger causality	GDP- - - -EC
Cheng and Lai, 1997	1954–1993	Taiwan	Granger causality	GDP→EC
Cheng (1998)	1952–1995	Japan	Hsiao's Granger causality	GDP→EC
Cheng (1999)	1952–1995	India	Co-integration, ECM, Granger causality	GDP→EC
Stern (2000)	1948–1994	USA	Co-integration, Granger causality	EC→GDP
Soytas et al. (2001)	1960–1995	Turkey	Co-integration, Granger causality	EC→GDP
Aqeel and Butt (2001)	1955–1996	Pakistan	Hsiao's version of Granger causality Method, Co-integration	GDP→EC
Fatai et al. (2002)	1960–1999	New Zealand	Granger causality, ARDL, Toda and Yamamoto test	GDP- - - -EC
Glasure (2002)	1961–1990	Korea	Co-integration, error correction, variance decomposition	EC←→GDP
Hondroyiannis et al. (2002)	1960–1996	Greece	Error correction model	EC←→GDP
Altinay and Karagol (2004)	1950–2000	Turkey	Hsiao's version of Granger causality	GDP- - - -EC
Ghali and El-Sakka (2004)	1961–1997	Canada	Co-integration, VEC, Granger causality	EC←→GDP
Paul and Bhattacharya (2004)	1950–1996	India	Co-integration and Granger causality	EC←→GDP
Oh and Lee (2004)	1970–1999	Korea	Granger causality and error correction model	EC→GDP
Wolde-Rufael (2004)	1952–1999	Shanghai	A modified version of Granger causality (Toda and Yamamoto)	EC→GDP
Lee and Chang (2005)	1954–2003	Taiwan	Johansen–Juselius, Co-integration, VEC	EC→GDP
Ang (2007)	1960–2000	France	Co-integration, VECM	Energy use→GDP (in the short run)
Lee and Chang (2007a)	1955–2003	Taiwan	Granger causality, co-integration, VECM	EC→GDP (only where there is a low level of energy consumption in Taiwan)
Jobert and Karanfil (2007)	1960–2003	Turkey	Granger causality test	GDP- - - -EC
Ho and Siu (2007)	1966–2002	Hong Kong	Co-integration, VEC model	EC→GDP
Zamani (2007)	1967–2003	Iran	Granger causality, Co-integration, VECM	GDP→Total energy
Lise and Van Montfort (2007)	1970–2003	Turkey	Co-integration test	GDP→EC
Karanfil (2008)	1970–2005	Turkey	Granger causality test, Co-integration test	GDP→EC GDP- - - -EC (when unrecorded economy is taken into account)
Ang (2008)	1971–1999	Malaysia	Johansen co-integration, VEC model	GDP→EC
Erdal et al. (2008)	1970–2006	Turkey	Pair-wise Granger causality, Johansen co-integration	EC←→GDP
Bowden and Payne (2009)	1949–2006	USA	Toda–Yamamoto causality test	EC→GDP
Halicioglu (2009)	1960–2005	Turkey	Granger causality, ARDL, co-integration	GDP- - - -EC
Payne (2009)	1949–2006	USA	Toda–Yamamoto causality test	GDP- - - -EC
Soytas and Sari (2009)	1960–2000	Turkey	Toda–Yamamoto causality test	GDP- - - -EC
Belloumi, 2009	1971–2004	Tunisia	Granger causality, VECM	EC←→GDP (in the long run) EC→GDP (in the short run)
Zhang and Cheng (2009)	1960–2007	China	Granger causality	GDP→EC

Note**: EC→GDP** means that the causality runs from energy consumption to growth.
GDP→EC means that the causality runs from growth to energy consumption.
EC←→GDP means that bi-directional causality exists between energy consumption and growth.
EC- - - -GDP means that no causality exists between energy consumption and growth.
Abbreviations are defined as follows: VAR=vector autoregressive model, VEC=vector error correction model, ARDL=autoregressive distributed lag, EC=energy consumption, GDP=real gross domestic product. ECM=error correction model, and GMM=generalized method of moments

Figure 8 - Methods uses in similar studies (Source: Ozturk, 2010)

As you can see from the table common methods for comparing energy to a development indicator such as GDP include co-integration, Granger Causality, Johansen, ARDL, VEC model and Toda-Yamamoto causality test.

The ARDL model was viewed at the most attractive approach for modeling energy relationships as it reflected the pattern seen in energy consumption where adjustments in demand take time to fully materialize, until co-integration techniques were formulated (De Vita, 2006). One of the more widespread co-integration methods is the Johansen (1988) method, and it holds the advantage of allowing estimation of multiple co-integrating vectors where and if they exist. In addition, Granger causality techniques are also widely used. The test is said to be relatively simple and straightforward. It works on the theory that a time series X is said to Granger-cause another time series Y if it can be shown that the values of X can provide statistically significant predictive information about the future values of Y. In order for Granger causality to be adopted, a series of variables used is required to be stationary, as non-stationary data in such causality tests can produce causality results, which are not valid (Jin-ke, 2009).

Non-stationary data is considered generally as not predictable to any real degree of certainty, therefore taking into account earlier concerns of our ability to predict future trends of energy use or development, and the various external factors involved. The data used within this study is deemed to be non-stationary data. The purpose of this research is to give an indication of the strength of a relationship between two measured variables, as a result using a Granger causality test, may lead to misleading causality results. With this in mind, correlation tests can be carried out to simply obtain the strength of the relationship between these two measured variables whilst overcoming the problems associated with future predictions. Whilst co-integration and various energy modeling techniques have been historically used for similar studies, such complex analysis is not required nor is suitable for the data sets used in this study. Therefore more basic comparative analyses were adopted for this project as explained in the next section (3.2.1). The analysis is split into two main sections, which are;

- Comparative analysis of 12 countries with energy use per capita spread (including developing and developed countries)
- Threshold rankings using sub 1000kg oil equivalent per capita countries

3.2.1 Comparative analysis of 12 countries

A representative sample (as explained in sampling method 3.5) of 12 countries with a spread of energy use per capita was examined to identify any correlation between energy provision and chosen indicators of development. The chosen indicators of development for the purposes of this study were;

- Education
    - Literacy rate
    - Females out of school
    - Males out of school
- Population
    - Urban population
    - Rural population
- Infrastructure
    - Urban access to safe drinking water
    - Rural access to safe drinking water
    - Total Population access to sanitation facilities
- Health
    - Mortality rate (under 5s)
- Gross Domestic Product

Comparative analysis method

For this analysis parametric data assumptions were made. There are four assumptions relating to parametric data, and these are;

1. Normally distributed data
2. Homogeneity of variance
3. Interval data
4. Independence

The data used for this report has been analysed by the following normally distributed data check, to ensure that it is distributed in such as way that the correlation coefficients will be meaningful.

The best way to assess the shape of the distribution is through the use of a frequency distribution. A graph can be plotted called a probability-probability plot (P-P Plot). This shows the cumulative probability of one variable against the cumulative probability of a particular distribution. The data is therefore ranked and sorted, and for each rank a corresponding z-score is calculated. This z-score is the expected value which it would have in a normal distribution. Once this is done the z-score itself is converted into a z-score, and this actual z-score is plotted against the theoretical expected z-score. If the data is normally distributed then both z-scores will be the same, and will be represented by a straight diagonal line on the P-P Plot (Field, 2009, P134).

Many of the indicators which are compared in this study are on differing measurement scales which cannot simply be compared to one another. Therefore to overcome the problem of measurement scale dependence, the indicators were converted to a standard set of units, in a process called standardisation. Therefore the unit of measurement which any scale of measurement can be converted is standard deviation. All of the indicators and energy use data were converted to units of standard deviation by dividing the distance from the mean by the standard deviation. This gives us the data in standard deviation units from the mean. In the comparisons there will be two variables and therefore two standard deviations. In the analysis these are multiplied and then divided by the product of this multiplication. This standardised coverance gives us the correlation coefiicent and it is defined by the following equation, where s_x is the standard deviation of the first variable and s_y is the standard deviation of the second.

$$r = \frac{cov_{xy}}{s_x s_y} = \frac{\sum(xi - \frac{\sum x}{N})(yi - \frac{\sum y}{N})}{(N-1)s_x s_y}$$

This specific equation is know as the Pearson product-moment correlation, or the Pearson correlation coefficient (Field, 2009, P169-73).

This Pearson correlation coefficient was adopted to determine any relationship between energy use per capita and the chosen indicators of development. The relationship strength between the two variables is interpreted by the size of the correlation coefficient, however the significance of the correlation is important. The correlation coefficient is tested to find the difference from a zero relationship, to ensure that any relationship found is statistically meaningful (Field, 2009, P169-73). The SPSS package used calculated the significance of the one tailed tests, and any significant scores of over 0.05 highlighted that the null hypothesis, i.e no relationship, could not be rejected and therefore the relationship was statistically insignificant, and this relationship was subsequently not used for discussion. Going back to the interpretation of the correlation coefficient of statistically significant relationships. SPSS produces a Pearson correlation coeffient which ranges from -1 to +1. The positive and negative sign indicates the direction of the relationship, with a positive sign showing energy use per capita and the indicator covert in the same direction, i.e increases in both. In contrast, a negative relationship shows that energy use per capita and the chosen indicator covert in opposite directions, i.e as one increases, the other decreases. A correlation coefficient of 0 indicates no linear relationship, whereas a correlation coefficient of 1 indicates a perfect linear relationship (Kerr, 2002).

To summarise, the comparative analysis aims to discover the strength of any relationship between energy use and development indicators, and this was carried out using Pearson correlation coefficients on SPSS.

3.2.2 Threshold Rankings

All developing countries averaging less that 1000kg of oil equivalent per capita energy were collated and ranked by the following development indicators;

- Rural safe water access
- Urban safe water access
- Sanitation facility access
- Under 5 mortality rates
- Female to male ration in primary education
- Happiness

These rankings were then analysed and compared, taking into account the strength of the correlations from the previous analysis. The aim being to look for trends In development indicators which could relate to energy use per capita, and thus used as energy provision thresholds in policy making.

3.3 Setting/Context

The context of this report will mainly be set in developing countries. However for comparative purposes a representative sample from both developing and developed will be analysed in terms of energy use per capita and development indicators as a part of this study. The countries considered as developing countries in this report are taken from the World Bank 2011 developing countries list (as shown in section 3.5.1).

3.4 Data Source

The data analysed in this study was published by the World Bank and can be found at http://data.worldbank.org/indicator [accessed last 30.07.2011]. The data was downloaded from the World Development Indicators (WDI). The WDI include data from around 210 countries from 1960 to 2008, due to a two year publishing lag. The data has been collated from the statistical systems of the member countries, and therefore the quality of the data depends on the efficiency of these national systems. However the World Bank helps to improve the capacity, efficiency and effectiveness of national statistical systems, for the use in these data sets. The World Bank strive for high quality data by adopting internationally accepted standards, methodologies, sources, definitions, and classifications including, General Data Dissemination System (GDDS) and Data Quality Assessment Framework (DQAF).

3.5 Sampling

There are two main sampling methods to be adopted in this study. The first being purposeful quota sampling, whereby the researcher targets specific data based on characteristics required for the study, to initially narrow down the vast quantity of data (Bryman, 2001).
The second sampling method includes the use of Stratified sampling. This involves selecting a sample in a way which ensures that subgroups in the population are represented. The main steps included in the stratified sampling are as follows (adapted from Gay, 1996);

1. Identify and define study population
2. Determine sample size
3. Identify the basis of the subgroups, to ensure equal representation
4. Classify the sample into members of the subgroups
5. Randomly select required number of members of the subgroups for analysis

To summarise the sampling for this study will be carried out in two phases which are;

- Phase One – Quota Sampling
- Phases Two – Stratified Sampling

3.5.1 Phase One – Quota Sampling

The initial sampling will be used to narrow down the data from the 209 available countries to those who have detailed and historical data on energy use. This is due to the focus of the study being placed upon the relationships with energy use per capita, therefore this information is of paramount importance for the analysis In developing countries this data is from 1970-2008, and in developed countries from 1960-2008. The countries considered as developing for the purposes of this study where specified by the World Bank in 2011, and the following countries (overleaf) are included;

1. Angola
2. Armenia
3. Bangladesh
4. Belize
5. Benin
6. Bhutan
7. Bolivia
8. Burkina Faso
9. Burundi
10. Cambodia
11. Cameroon
12. Cape Verde
13. Central African Republic
14. Chad
15. China
16. Comoros
17. Congo, Dem. Rep
18. Congo, Rep.
19. Côte d'Ivoire
20. Djibouti
21. Ecuador
22. Egypt, Arab Rep.
23. El Salvador
24. Eritrea
25. Ethiopia
26. Gambia, The
27. Georgia
28. Ghana
29. Guatemala
30. Guinea
31. Guinea-Bisau
32. Guyana
33. Haiti
34. Honduras
35. India
36. Indonesia
37. Iraq
38. Jordan

39. Kenya
40. Kiribati
41. Korea, Dem Rep.
42. Kosovo
43. Kyrgyz Republic
44. Lao PDR
45. Lesotho
    Liberia
46. Madagascar
47. Malawi
48. Maldives
49. Mali
50. Marshall Islands
51. Mauritania
52. Micronesia, Fed. Sts.
53. Moldova
54. Mongolia
55. Morocco
56. Mozambique
57. Myanmar
58. Nepal
59. Nicaragua
60. Niger
61. Nigeria
62. Pakistan
63. Papua New Guinea
64. Paraguay
65. Philippines
66. Rwanda
67. Samoa
68. São Tomé and Principe
69. Senegal
70. Sierra Leone
71. Solomon Islands
72. Somalia
73. Sri Lanka
74. Sudan
75. Swaziland
76. Syrian Arab Republic
77. Tajikistan
78. Tanzania
79. Thailand
80. Timor-Leste
81. Togo
82. Tonga
83. Tunisia
84. Turkmenistan
85. Tuvalu
86. Uganda
87. Ukraine
88. Uzbekistan
89. Vanuatu
90. Vietnam
91. West Bank and Gaza
92. Yemen, Rep.
93. Zambia
94. Zimbabw

3.5.2 Phase Two – Stratified Sampling

Detailed and historical data was found for 136 countries. The researcher then ensured a representative spread of energy use per capita samples using the following method:

- The countries were then ranked in order of least energy use per capita, to most energy use per capita.
- They were then assigned to one of the following energy use per capita intervals;
  1. 0-100kg (of oil equivalent)
  2. 101-200kg (of oil equivalent)
  3. 201-300kg (of oil equivalent)
  4. 301-400kg (of oil equivalent)
  5. 401-500kg (of oil equivalent)
  6. 501-600kg (of oil equivalent)
  7. 601-700kg (of oil equivalent)
  8. 701-800kg (of oil equivalent)
  9. 801-900kg (of oil equivalent)
  10. 901-1000kg (of oil equivalent)
  11. 1001-2000 kg (of oil equivalent)
  12. 2001-3000 kg (of oil equivalent)
  13. 3001-4000 kg (of oil equivalent)
  14. 4001-5000 kg (of oil equivalent)
  15. 5001-6000 kg (of oil equivalent)
  16. 6001-7000 kg (of oil equivalent)
  17. 7001-8000 kg (of oil equivalent)
  18. 8001-9000 kg (of oil equivalent)
  19. 9001-10000 kg (of oil equivalent)
  20. 10001-11000 kg (of oil equivalent)
  21. 11001-12000 kg (of oil equivalent)
  22. 12001-13000 kg (of oil equivalent)

23.13001-14000 kg (of oil equivalent)

24.14001-15000 kg (of oil equivalent)

25.15001-16000 kg (of oil equivalent)

26.16001-17000 kg (of oil equivalent)

27.17001-18000 kg (of oil equivalent)

28.18001-19000 kg (of oil equivalent)

- The frequency of the intervals was then plotted on a graph to show the spread of data
- From the frequency graph the following sample groups where chosen. Where a high frequency of countries were shown a small range group was formed to ensure the sample is representative of the overall picture.
  - Group 1 (0-1,000kg)
  - Group 2 (1,000-2,000kg)
  - Group 3 (2,000-3,000kg)
  - Group 4 (3,000-4,000kg)
  - Group 5 (4,000-5,000kg)
  - Group 6 (5,000-10,000kg)
  - Group 7 (10,000-15,000kg)
  - Group 8 (15,000-19,000kg)
- The following equation was then used to identify the number of countries which should be randomly selected from each of the groups (sample size for study is 12), and the results shown in the table below;
  - $$no.\ of\ samples\ taken\ from\ group = \frac{number\ of\ countries\ in\ group}{total\ number\ of\ countries\ in\ all\ groups\ (total)} \times sample\ size$$

    The results of this calculation is shown in the table below:

Group	Number taken from group
1	5
2	2
3	1
4	1
5	1
6	1
7	0.5 (1 sample taken from 7 & 8 combined)
8	0.5 (1 sample taken from 7 & 8 combined)
total	12

- The number of samples from each group as above, were then chosen at random from each of the groups and the countries identified for the comparative study were;

Group	Country	Status
1	Bangladesh	Developing
1	Sudan	Developing
1	Ghana	Developing
1	Guatemala	Developing
1	Indonesia	Developing
2	Iraq	Developing
2	China	Developing
3	South Africa	Developed
4	United Kingdom	Developed
5	Germany	Developed
6	United States	Developed
7 or 8	Iceland	Developed

These 12 countries were then used for the comparative analysis, using Pearson correlation coefficients.

3.6 Data Analysis Method

This analysis of data in this study was a quantitative analysis. Quantitative research involves large-scale and representative data sets, which are often presented or perceived as being a gathering of 'facts' (Blaxter, 2006). The research is being employed within this study as measurement which provides a basis for more precise estimations of the relationship between two things (Bryman, 2001).

The data storage and analysis for this research project was carried out using SPSS version 18.0 licensed to Loughborough University. It allows for large amounts of data to be processed quickly and accurately, it has been used in many quantitative studies.

3.9 Limitations of research methods

Bryman (2001) suggests that there are various limitations and criticisms of quantitative research, including;

- Failure to distinguish people and social influences affecting the way they interpret the data from the real world;
- Heavy reliance on the instruments and methods employed, thus removing the connection between the research and everyday life;
- Researchers may analyse the relationships between the variables creating a view of the social life, without taking into account the subject. Therefore creating theories which are independent from the individual;
- There is a false sense of precision and accuracy from the view that there is 'measurement' involved.

The researcher has considered these criticisms, and the findings from the literature review will be considered alongside the findings of the quantitative study in order to minimise any effects.

The specific limitations of this study could include;

- The use of secondary data, therefore the author has no means to validate or check any of the data used
- Other variables not measured may influence the relationships found/not found
- Lack of causality, correlations do not show causality
- Data used does not distinguish between the rich and poor members of society, they are viewed as a whole

3.10 Summary of Methods used

To summarise there are two main sections of analysis in this report, and they are;

1. Comparative analysis
    a. 12 countries providing representative sample to be use to compare the relationship between energy use per capita and various indicators of development.
2. Threshold analysis
    a. All developing countries using under 1000kg of oil equivalent per capita ranked by various development indicators to establish a threshold of energy provision to achievement basic human needs.

4.0 Findings and Discussion

In this section of the report, the main data analysis findings will be shown and discussed in relation with the findings from the literature review at the beginning of this report. Causality will not be fully explored as it cannot be ascertained from this method, however discussion will take place regarding possible reasons behind the correlations found/not found. This section of the report is split into 3 main sections, and these are;

- Exploration of Energy use trends and patterns in the chosen countries
- Analysis and Discussion of Correlations between Energy Use and the indicators of development
- Threshold Analysis

The exploration of energy use trends and patterns will allow for a more detailed understanding of the energy situation in the chosen countries for the analysis. This will form the basis of the correlation comparison, as the rate in which energy use is increasing or decreasing in the chosen countries is essential to fully understand the meaning of the correlations.

Once the exploration of energy use trends is complete, the analysis and discussion of correlations between energy use and the indicators of development begins. The author will be looking for the strength of correlations in relation to findings from literature. In addition the strength of these correlations will have an influence on the third section of the analysis, which is looking at thresholds. Any indicators that are found to have a high correlation with energy across all countries will be held in high regard in the threshold analysis.

The threshold analysis section will be looking at all developing countries, which currently have energy use per capita 1000kg of oil equivalent or less. These countries will then be ranked based on development indicators, and the energy use per capita analysed in order to formulate a threshold of energy provision that must be met to allow best chance of reaching adequate levels of development and growth. Figure 4a, and 4b overleaf show the historical energy use per capita trend of the countries adopted in this analysis. The trends will be used to find the whether energy use per capita is increase or decreasing, and at which rate this is occurring. This will provide the basis for the comparative study.

Figure 5 - Energy use per capita (lower energy use countries)

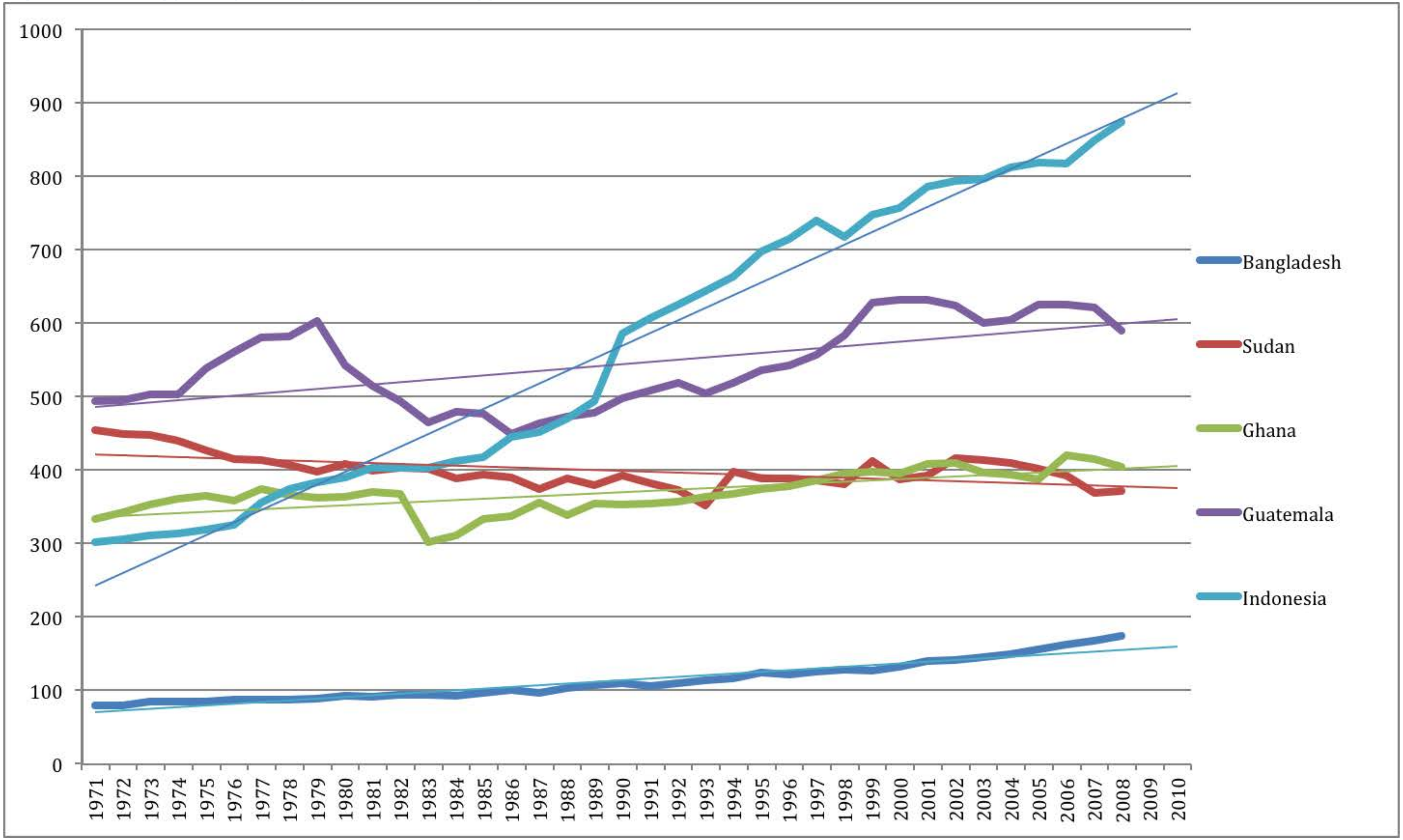
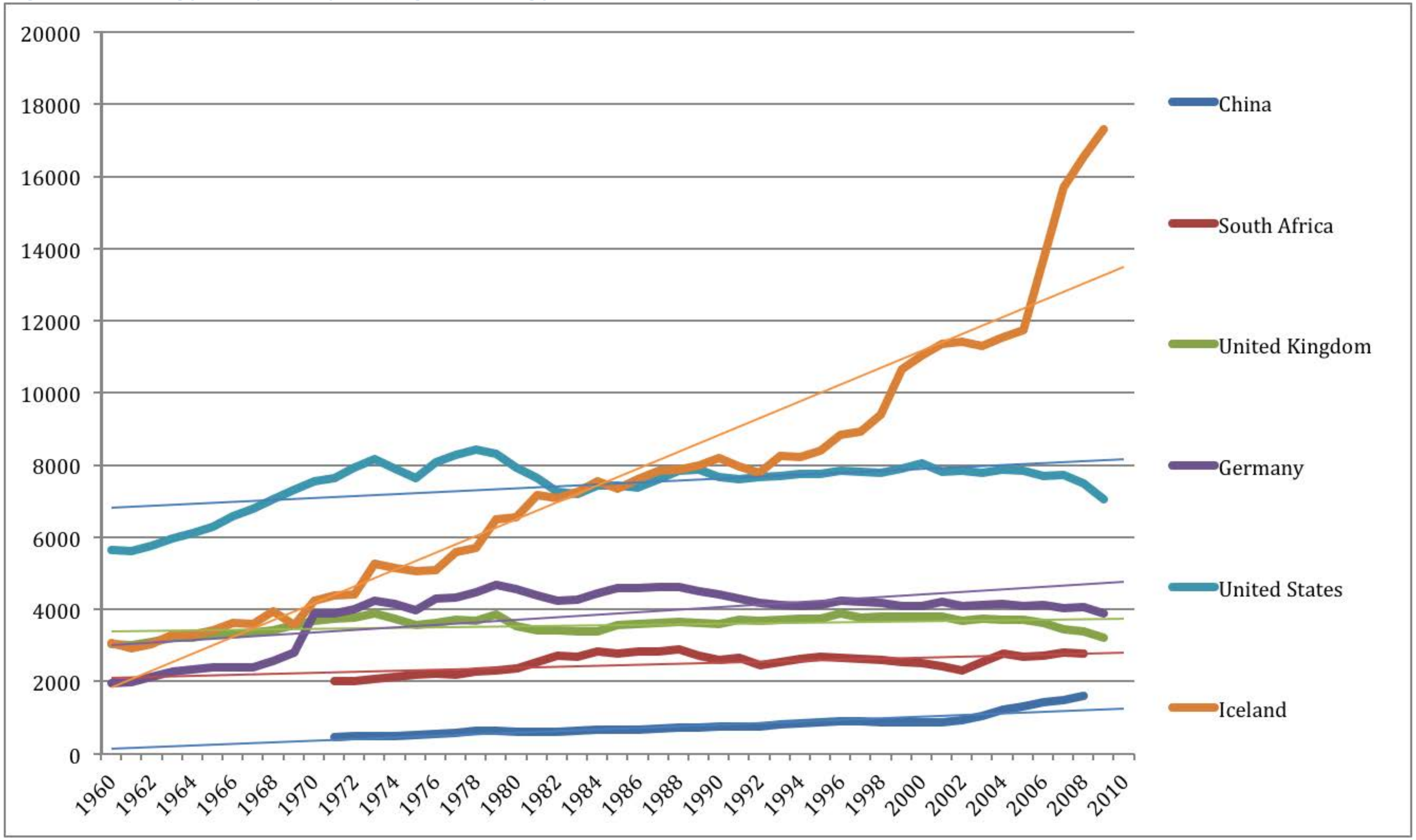


Figure 6 - Energy use per capita (higher energy use countries)



Energy use per capita trends

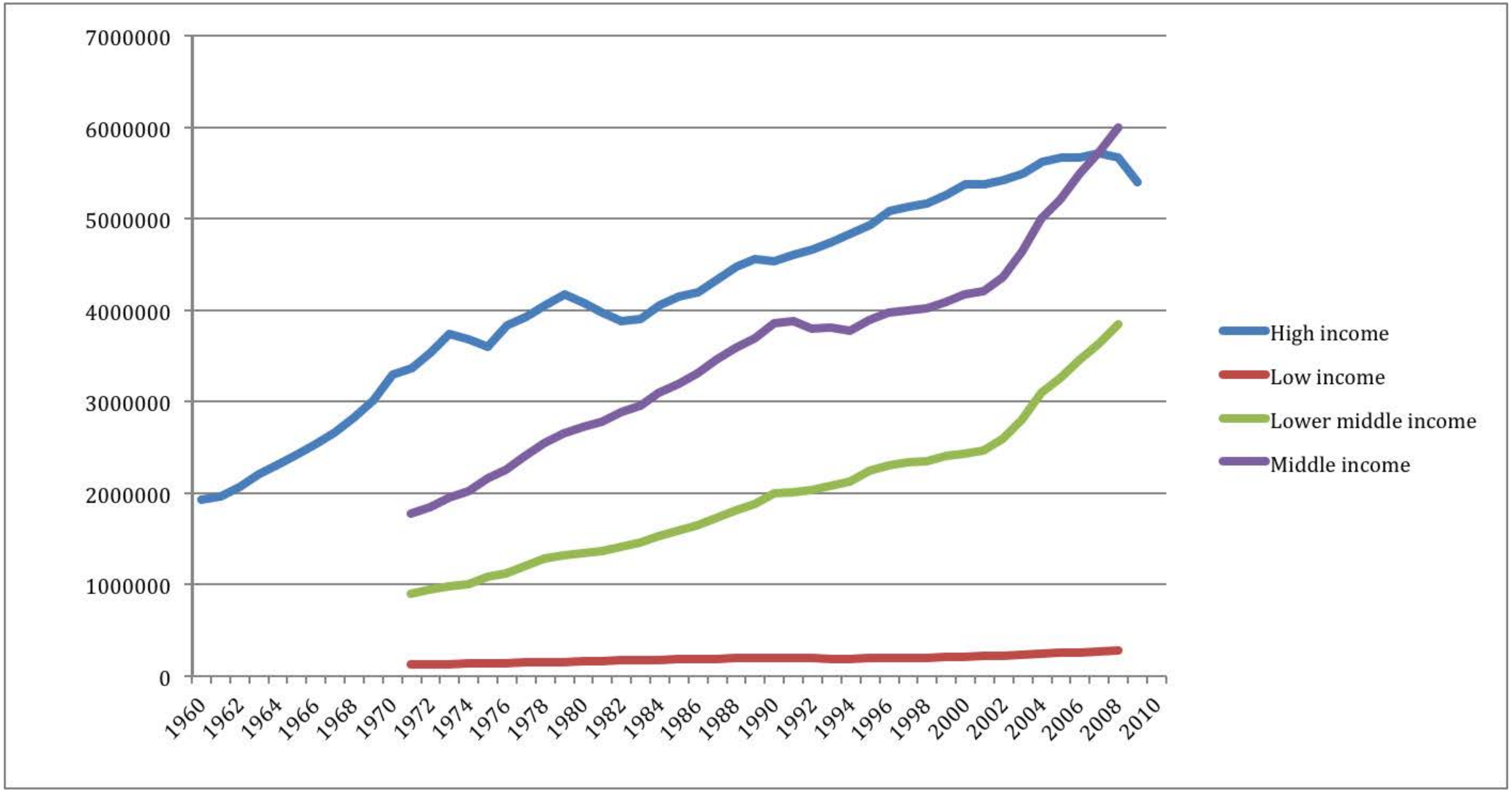
From the trend lines plotted in figures 4a and 4b, we can see that energy use per capita is increasing over time in 11 of the 12 countries in the analysis, including Bangladesh, Ghana, Guatemala, Iraq, China, South Africa, United Kingdom, Germany, United States and Iceland. The country where it is found to be decreasing is Sudan.

As expected from literature, it appears, apart from Sudan, the increase in energy use per capita is happening at a higher rate in developing countries. The graph shows that most of these are developing rather rapidly in terms of energy use. In contrast all the developed countries, apart from Iceland, are displaying signs of levelling off in terms of energy use per capita, with the United Kingdom, Germany, and United States all showing signs of a decrease since around 2006. This seems in line with suggestions in literature that the economic depression may have had a significant impact on the way we use energy.

Whilst energy use can be seen to be increasing, the rate at which this increase is occurring is of interest. Iceland, Indonesia and Bangladesh display the highest rates of energy use increase (since 1971), These figures are 278%, 190%, and 118% respectively. However despite the rapid increase, the fact that the developing countries are averaging 732kg of oil equivalent per capita, and the developed countries in this study average 6859kg of oil equivalent per capita currently, the population of each region becomes crucial to observing the whole picture. If population was constant between all regions a 9.4% average increase for example in the energy use per capita in across developing countries would equal the same quantity increase as a 1% average increase in a across developed countries.

Figure 4c overleaf shows the overall picture in terms of total energy used per income level globally. It shows that whilst developing countries usage per capita may be growing, in terms of the overall picture they only use a fraction of the total global energy. However what can be ascertained is a definite increased rate in low income countries from around 1999, a major increase in middle and lower middle since around 2000 and a decrease in energy use from high income regions since 2006. This shows the potential for a dramatic increase in worldwide energy use, even with the reductions coming from high income regions.

Figure 7- Total Energy Use by Income level



4.1 Comparative analysis

12 countries energy use per capita and five indicators of development were analysed on SPSS using Pearson's correlation coefficient. The analysis aims to discover the strength of the relationship between the amount of energy used per capita and the level of development within a country. The indicators of development chosen are;

1. Population
   - Rural Population
   - Urban Population
2. Infrastructure
   - Rural access to safe drinking water
   - Urban access to safe drinking water
   - Access to Sanitation
3. Education
   - Literacy rate
   - Female out of school (primary education)
   - Male out of school (primary education)
4. Mortality rate (under 5s)
5. Gross Domestic Product (GDP)

Predicted Relationships

The following section shows the expected outcomes of the analysis based on the findings in literature.

Energy use per capita and Population

The author expects to see a high correlation between energy use per capita and urban population, however a moderate, or even negative correlation between energy use per capita and rural population. These predictions have been formulated on the assumption that urbanisation leads to higher energy use, and rural population is growing however in many developing countries with traditional sources such as wood fuel being heavily relied on and low income levels, energy patterns will not change dramatically in rural areas without the introduction of modern energy sources.

Energy use per capita and Infrastructure

The author expects to see a moderate correlation between safe water access in both rural and urban areas, and access to sanitation facilities. The reason for the moderate correlation is that the author believes that this would be a secondary relationship. The author does not believe there would be a strong relationship between just energy and facilities, however the linking factors could be increased income leading to more facilities, increased awareness of the benefits from higher education levels, and such factors. Therefore whilst the author believes that as energy use per capita rises, infrastructure will rise, but maybe not as a direct result of each other, as a result of other benefits from energy use increases.

Energy use per capita and Education

Thinking of the energy ladder, and as energy use increases, one of the first improvements comes in the form of lighting, either by electricity or other fuel using lamps, the author would expect education to be affected. The introduction of lighting allows to extended study hours into the evening where before it may not have been possible. Energy in the form of electricity also allows for aids to education such as computers, televisions, and radios to be adopted, further increasing knowledge. Therefore the author would expect to see strong positive correlations between energy use per capita and Literacy rates.

Child Mortality (under 5s)

Where energy use increases allow for improved efficiency appliances, access to modern energy and access to electricity the author would expect child mortality and energy use per capita to be strongly negatively related, due to the fact that more efficient appliances, and access to modern energy helps to decrease household pollution levels from traditional sources such as woodfuel open fires, and access to electricity allows for clinics to be better equipped to which facilities such as refrigerators for immunisations and such. In addition to this increased energy in the form of fuel could allow for quicker transport to facilities when required.

Energy use per capita and Gross Domestic Product (GDP)

Literature appears to be somewhat divided over the relationship between GDP and energy use. The author expects to see a moderate correlation between Energy use and GDP, as possibly a secondary advantage, due to increased education and health affects of increased energy use.

This section of the report will now go on to highlight the findings from the data analysis in SPSS, and explore the strength of the relationships between energy and the above indicators, in relation to both initial predictions and suggestions from literature. The table overleaf explains the abbreviations used in this following analysis, and the source of the specific data used.

ABBREVIATIONS:

The standard abbreviations used in this section are;

PC Pearson's correlation coefficient

SIG Significance (one-tailed test)

N Number of pairs analysed for correlation coefficient

DATA SOURCE:

Energy use (kg of oil equivalent per capita)

[http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE]

Population (Rural, Urban, Total)

[http://data.worldbank.org/indicator/SP.RUR.TOTL]

[http://data.worldbank.org/indicator/SP.URB.TOTL]

Infrastructure (Rural water, Urban water, Sanitation)

[http://data.worldbank.org/indicator/SH.H20.SAFE.RU.ZS]

[http://data.worldbank.org/indicator/SH.H20.SAFE.UR.ZS]

[http://data.worldbank.org/indicator/SH.STA.ACSN]

Education (Literacy rate, Females out of school, Males out of school)

[http://data.worldbank.org/indicator/SE.ADT.LITR.ZS]

[http://data.worldbank.org/indicator/SE.PRM.UNER.FE]

[http://data.worldbank.org/indicator/SE.PRM.UNER.MA]

Mortality (under 5)

[http://data.worldbank.org/indicator/SH.DYN.MORT]

Gross Domestic Product (GDP)

[http://data.worldbank.org/indicator/NY.GDP.PCAP.CD]

Happiness Indicators

[www1.eur.nl/fsw/happiness]

Correlation Standard Descriptions

Statistically significant correlations will generally be considered in the following way;

0.7 or higher	=	Very Strong relationship
0.4 to 0.69	=	Strong relationship
0.3 to 0.39	=	Moderate relationship
0 2 to 0.29	=	Weak relationship
0 01 to 0.19	=	No or negligible relationship

(where a negative correlation is found, the word 'negative' will precede the description)

4.1.1 Energy and Population

Energy use per capita and population is being compared as a part of this study to discover if suggestions from the literature review relating to increased energy use caused by urbanisation can be upheld. The table below shows the output from SPSS of the correlations between Rural population (RPOP), Urban Population (UPOP), Total population (TPOP) and energy use per capita

	RPOP SDU			UPOP SDU			TPOP SDU		
	PC	LC% K'	Rpop K'	PC	Sig	N	PC	Sig	N
Bangladesh	0.956	0	38	0.974	0	38	0.965	0	38
Sudan	-0.664	0	38	-0.434	0.003	38	-0.54	0	38
Ghana	0.673	0	38	0.779	0	38	0.747	0	38
Guatemala	0.604	0	38	0.655	0	38	0.634	0	38
Indonesia	0.45	0.002	38	0.978	0	38	0.982	0	38
Iraq	0.747	0	38	0.889	0	38	0.855	0	38
China	0.106	0.263	38	0.924	0	38	0.862	0	38
South Africa	0.663	0	38	0.514	0	38	0.562	0	38
United Kingdom	-0.42	0.001	50	0.48	0	50	0.484	0	50
Germany	0.444	0.001	50	0.679	0	50	0.658	0	50
United States	0.53	0	50	0.512	0	50	0.534	0	50
Iceland	-0.778	0	50	0.961	0	50	0.97	0	50

All of the correlations in the energy use per capita and population analysis were found to be statistically significant, apart from Rural population in China. This therefore demonstrates that population has a bearing on energy use per capita, as the majority were correlated above 0.5. What interests the author about the population and energy comparisons is the difference (if one exists) between rural population and energy per capita, and urban population and energy per capita. As the general consensus exists that urbanisation effects and increases energy use. Therefore this will be discussed in more detail. The table overleaf summarises the meanings of the numbers produced by SPSS

Country	Rural Population	Urban Population	Total Population
Bangladesh	There is a **very strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a total population rise, which are **very strongly related**
Sudan	There is a **strong negative correlation**, which indicates an energy per capita decrease and a rural population rise, which are **strongly related**	There is a **strong negative correlation**, which indicates an energy per capita decrease and a rural population rise, which are **strongly related**	There is a **strong negative correlation**, which indicates an energy per capita decrease and a rural population rise, which are **strongly related**
Ghana	There is a **strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a total population rise, which are **very strongly related**
Guatemala	There is a **strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a total population rise, which are **strongly related**
Indonesia	There is a **strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a total population rise, which are **very strongly related**
Iraq	There is a **very strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a total population rise, which are **very strongly related**
China	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed	There is a **very strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a total population rise, which are **very strongly related**
South Africa	There is a **strong correlation**, which indicates an energy per	There is a **strong correlation**, which indicates an energy per	There is a **strong correlation**, which indicates an energy per

	capita rise and a rural population rise, which are **strongly related**	capita rise and a urban population rise, which are **strongly related**	capita rise and a total population rise, which are **strongly related**
United Kingdom	There is a **strong negative correlation**, which indicates an energy per capita rise and a rural population decrease, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a total population rise, which are **strongly related**
Continues overleaf Germany	There is a **strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a total population rise, which are **strongly related**
United States	There is a **strong correlation**, which indicates an energy per capita rise and a rural population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **strongly related**	There is a **strong correlation**, which indicates an energy per capita rise and a total population rise, which are **strongly related**
Iceland	There is a **very strong negative correlation**, which indicates an energy per capita rise and a rural population decrease, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a urban population rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a total population rise, which are **very strongly related**

All the correlations, apart from rural population in China, were found to be either strong or very strong. These findings therefore strongly suggest that variations in population are influential in energy use per capita variations. Overall 15 correlations were found to be very strong (over 0.7), and 19 were found to be strong (between 0.4 and 0.69), with just one being found to have no or negligible correlation (under 0.19).

Looking at rural population, three of the correlations were found to be very strong, and eight were found to be strong, with just one showing a negligible relationship. However, not all these correlations show a positive relationship. The majority (8 out of 12) show that as energy use per capita increased as rural population increased between 1971 and 2008, with five of these being developing countries. The findings from Sudan differ to those in other developing countries, the analysis shows that Sudan has a strong negative correlation with rural population, therefore as the energy use per capita is decreasing , rural population is increasing. This differs from the majority of findings. In addition to this, two of the developed countries displayed negative correlations. The United Kingdom being one, displayed a strong negative correlation, therefore as energy use per capita is increasing, rural population is decreasing, and likewise with a very strong negative correlation found in Iceland. Therefore no general consensus was found between rural population and energy use per capita, however the majority of results displayed strong positive correlations at an average Pearson correlation coefficient of 0.63.

Moving onto Urban population, six of the correlations between energy use per capita and urban population were found to be very strong (over 0.8), and five of these relationships were found in developing countries. The remaining five countries displayed strong correlations (between 0.4-0.79). In all cases an increase in urban population was displayed, and in the vast majority this related to increased energy use per capita, apart from Sudan. In Sudan much like the rural population findings, a negative strong correlation was found which showed a decrease in energy use per capita and an increase in urban population. As you can see, the analysis shows in the vast majority of cases a strong relationship between urban population rise and energy use per capita rise, which amounts to an average Pearson correlation coefficient of 0.76, which is stronger than the relationship between rural population and energy use. Overall the total population findings show a combination of both rural and urban population with six very strong correlations, and six strong correlations.

The initial predicted outcomes differed from the results, as the expectation was that rural population would have a weaker relationship with energy use per capita such as a moderate correlation. However the predictions did show that the relationship between the urban population and energy use per capita would be stronger than the rural population relationship, and whilst the difference was not as large as expected, it was present. The high relationship between urban population and energy use per capita findings seem consistent with the those of Parikh (1995) who said that Urbanisation has the potential to influence patterns of resource use, and can increase both indirect and direct energy consumption. Jones (1991) explained that traditional agricultural practise is adapting to support urbanisation, and this could also help to explain the strong relationship between increasing energy use per capita and urban population growth.

On average the population link to energy use per capita was found to be stronger in both rural and urban locations in developing countries than it was found to be in developed countries.

4.1.2 Energy and Infrastructure

Energy use per capita and infrastructure are being compared as a part of this study as the literature review suggests that energy is an important factor in the provision of basic human needs. The table below shows the output from SPSS of the correlations between Rural safe water access (RW%), Urban safe water access (UW%), sanitation facility (SAN%) and energy use per capita .

	RW% SDU			UW% SDU			SAN% SDU		
	PC	Sig	N	PC	Sig	N	PC	Sig	N
Bangladesh	0.934	0.01	5	-0.934	0.01	5	0.985	0.001	5
Sudan	0.339	0.288	5	0.359	0.277	5	-0.003	0.498	5
Ghana	0.919	0.014	5	0.955	0.006	5	0.845	0.036	5
Guatemala	0.814	0.047	5	0.803	0.051	5	0.795	0.054	5
Indonesia	0.993	0	5	-0.979	0.002	5	0.99	0.001	5
Iraq	0.238	0.35	5	-0.24	0.348	5	-0.211	0.395	4
China	0.917	0.014	5	0.676	0.105	5	0.904	0.018	5
South Africa	0.531	0.179	5	0.69	0.099	5	0.549	0.169	5
United Kingdom	.a	.	5	.a	.	5	.a	.	5
Germany	.a	.	0	.a	.	0	.a	.	0
United States	.a	.	0	.a	.	0	.a	.	0
Iceland	.a	.	0	.a	.	0	.a	.	0

(.a – denotes missing data)

The numbers from the analysis are highly varied, and in many cases, not statistically significant. Much of the data required was not available in developed countries, however in most cases this can be assumed to be 100% access to the services in question. The table overleaf summarises the results of the analysis. The discussion will continue after the table.

Country	Rural safe water access	Urban safe water access	Access to Sanitation facilities
Bangladesh	There is a **very strong correlation**, which indicates an energy per capita rise and a rural water access rise, which are **very strongly related**	There is a **very strong negative correlation**, which indicates an energy per capita rise and an urban water access decrease, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a sanitation access rise, which are **very strongly related**
Sudan	There is a **moderate correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **moderate correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed
Ghana	There is a **very strong correlation**, which indicates an energy per capita rise and a rural water access rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and an urban water access rise, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a sanitation access rise, which are **very strongly related**
Guatemala	There is a **very strong correlation**, which indicates an energy per capita rise and a rural water access rise, which are **very strongly related**	There is a **very strong correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **very strong correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**
Indonesia	There is a **very strong correlation**, which indicates an energy per capita rise and a rural water access rise, which are **very strongly related**	There is a **very strong negative correlation**, which indicates an energy per capita rise and an urban water access decrease, which are **very strongly related**	There is a **very strong correlation**, which indicates an energy per capita rise and a sanitation access rise, which are **very strongly related**
Iraq	There is a **weak correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **weak negative correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **weak negative correlation However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**
China	There is a **very strong correlation**, which indicates an energy per capita rise and a rural	There is a **strong correlation**. **However the significance of the correlation was found**	There is a **very strong correlation**, which indicates an energy per capita rise and a

	water access rise, which are **very strongly related**	**to be over 0.05, therefore the null hypothesis could not be rejected.**	sanitation access rise, which are **very strongly related**
South Africa	There is a **strong correlation. However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **strong correlation. However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **strong correlation. However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**
United Kingdom	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*
Germany	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*
United States	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*
Iceland	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*

As you can see from the table, a majority of the correlations are found to be statistically insignificant, 11 out of 36, which means we cannot reject the null hypothesis, and therefore we cannot be sure that any correlation is down to more than just chance. In addition to the vast quantity of insignificant correlations, a total of 12 comparisons could not be made, due to lack of data. However as mentioned previously the expected access in developed countries is expected for the large part to be 100%. So looking at the correlations that have been found to be significant 12 were found overall and all of these were found to be very strong (0.7 or over).

As there were no significant correlations relating to the five developed countries, the discussed analysis will be relating to developing countries only. Access to these basic services is assumed to be 100% in the majority of cases in developed countries.

The correlations relating to rural safe water access and energy use per capita, show very strong positive correlations across 5 countries including, Bangladesh, Ghana, Guatemala, Indonesia and China. The Pearson correlation coefficients were very strong ranging from 0.814 to 0.993, and they displayed an access to safe rural water increase which relates to energy use per capita increase. In contrast two of the three correlations relating to safe urban water access show a negative correlation, therefore displaying that an energy use per capita increase relates to an urban safe water access decrease, in both Bangladesh and Indonesia.

However Ghana shows a very strong positive correlation between an urban safe water increase and energy use per capita increase. So the results found in urban safe water access are variable and no consensus was found.

Four very strong correlations were found between access to sanitation facilities and energy use per capita. All of the found correlations were positive therefore showing an access to sanitation facility increase which is related to an energy per capita increase.

Whilst the correlations that were found were strong, many of the correlations within the analysis were not statistically significant. Therefore it would appear that there are many other factors which influence access to basic facilities across many of the developing countries in the analysis. Therefore whilst Bangladesh, Ghana, and Indonesia display strong correlations across all categories, the findings from other countries didn't not also reflect this, therefore a general consensus could not be found. Further research to investigate why energy use per capita affects infrastructure in these countries would be useful to gain insight, however not possible within the scope of this project.

The initial predictions stated that moderate relationships were expected, as benefits to infrastructure were seen as a secondary benefit and not a primary function of energy access. Of the correlations that were found these were much stronger than originally anticipated with all being found to be very strong. However many of the correlations were found to be insignificant, or very close to the figure of insignificance which is 0.05. So whilst strong correlations were found, there was no real general consensus to validate that energy played a vital role in this, and that other country specific factors weren't the primary driving forces for these improvements. Specifically looking at Bangladesh and Indonesia, negative correlations were found, which were not anticipated in the initial predictions. These highlighted that as energy use per capita increased the access to urban safe water decreased. Kebede (2010) suggested that unless adequate energy services were provided people may be driven into migrating in search of a better living condition, thus encouraging rapid urbanisation. So whilst the correlations coefficients alone cannot prove this to be the case, it would seem a reasonable explanation that many people went to urban areas in search of a better life, and ended up forming urban slums where water access may not have been able to cope with the additional population. Which ultimately suggests that energy could be a crucial factor, however this cannot be proved within the scope of this project, further research would be required.

4.1.4 Energy and Education

Energy use per capita and education are being compared as a part of this study as a general consensus in literature exists which believes increased energy use can have education benefits, and access to modern energy can allow higher female enrolment in education, therefore this relationship is of interest. The table below shows the output from SPSS of the correlations between literacy rate (LR), Females out of primary education (FNS) males out of primary education (MNS) and energy use per capita.

	LR			FNS			MNS		
	PC	Sig	N	PC	Sig	N	PC	Sig	N
Bangladesh	0.999	0.017	3	-0.852	0	16	-0.292	0.136	16
Sudan	.[a]	.	1	.[a]	.	1	.[a]	.	1
Ghana	.[a]	.	1	-0.204	0.286	10	-0.126	0.364	10
Guatemala	1	.	2	-0.769	0	19	-0.823	0	19
Indonesia	0.986	0.001	5	-0.893	0.001	9	-0.818	0.004	9
Iraq	.[a]	.	1	-0.452	0.012	25	0.18	0.195	25
China	0.992	0.039	3	-0.301	0.256	7	0.778	0.02	7
South Africa	0.985	0.055	3	0.191	0.405	4	0.086	0.457	4
United Kingdom	.[a]	.	0	-0.446	0.005	32	-0.504	0.002	32
Germany	.[a]	.	0	0.112	0.387	9	0.124	0.375	9
United States	.[a]	.	0	0.304	0.103	19	0.212	0.191	19
Iceland	.[a]	.	0	0.472	0.061	12	0.146	0.326	12

(.a – denotes missing data)

The numbers from the analysis are highly varied, and in some cases, not statistically significant. Literature rate information was not available for many countries, however it was used where available. The table overleaf summarises the results of the analysis. The discussion will continue after the table.

Country	Literacy Rate	Female out of primary education (Female Non-School)	Male out of primary education (Male Non-School)
Bangladesh	There is a **very strong correlation**, which indicates an energy per capita rise and a literacy rate rise, which are **very strongly related**	There is a **very strong negative correlation**, which indicates an energy per capita rise and a FNS decrease, which are **very strongly related**	There is a **weak negative correlation. However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**
Sudan	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*	*There was insufficient data available to carry out this analysis*
Ghana	*There was insufficient data available to carry out this analysis*	There is a **weak negative correlation. However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed
Guatemala	*There was insufficient data available to carry out this analysis*	There is a **very strong negative correlation**, which indicates an energy per capita rise and a FNS decrease, which are **very strongly related**	There is a **very strong negative correlation**, which indicates an energy per capita rise and a MNS decrease, which are **very strongly related**
Indonesia	There is a **very strong correlation**, which indicates an energy per capita rise and a literacy rate rise, which are **very strongly related**	There is a **very strong negative correlation**, which indicates an energy per capita rise and a FNS decrease, which are **very strongly related**	There is a **very strong negative correlation**, which indicates an energy per capita rise and a MNS decrease, which are **very strongly related**
Iraq	*There was insufficient data available to carry out this analysis*	There is a **strong negative correlation**, which indicates an energy per capita rise and a FNS decrease, which are **strongly related**	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed
China	There is a **very strong correlation**, which indicates an energy per capita rise and a literacy rate rise, which are **very strongly related**	There is a **moderate negative correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not**	There is a **very strong correlation**, which indicates an energy per capita rise and a MNS rise, which are **very strongly related**

		be rejected.	
South Africa	There is a **very strong correlation**, which indicates an energy per capita rise and a literacy rate rise, which are **very strongly related**	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed
United Kingdom	*There was insufficient data available to carry out this analysis*	There is a **strong negative correlation**, which indicates an energy per capita rise and a FNS decrease, which are **strongly related**	There is a **weak correlation** which indicates an energy per capita rise and a MNS rise, which are **weakly related**
Germany	*There was insufficient data available to carry out this analysis*	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed
United States	*There was insufficient data available to carry out this analysis*	There is a **moderate correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	There is a **weak correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**
Iceland	*There was insufficient data available to carry out this analysis*	There is a **strong correlation**. **However the significance of the correlation was found to be over 0.05, therefore the null hypothesis could not be rejected.**	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed

Over half of the data for the analysis was found to be either statistically insignificant, or was not available, however 12 correlations were found. Overall across all three categories nine correlations were found to be very strong (over 0.7), and three were found to be strong (between 0.4 and 0.69).

Looking specifically at adult literacy rate, in many countries this information was not available, however where it was available three of the four correlations were found to be statistically significant and displayed a very strong positive correlation. Therefore in Bangladesh, Indonesia and China a rise in adult literacy rate is related to a rise in energy use per capita. However with the data not available in the majority of cases and where it was available the maximum number of data pairs compared being 5, we cannot be sure of the reliability of these findings as a general theme.

More data was available for the analysis of females and males out of primary education, 22 out of the 24 correlations could be analysed, with only data from Sudan unavailable. However whilst 22 correlations could be made, 13 of these were found to be statistically insignificant. Of the nine correlations that were significant, six were found to be very strong (over 0.8), and three were found to be strong (between 0.4 and 0.79). Looking specifically at females out of primary education all of the correlations were found to be negative, therefore showing a decrease in the numbers of girls out of primary education and energy use per capita increase which are related. With regards to males out of primary education, the findings were very similar to the female findings. Interestingly the three very strong relationships between males out of school and energy use per capita were found in the same countries as the female equivalent findings, which demonstrate at least in these cases that a gender bias is not dramatically present.

Initial predictions stated that the expectation was for high positive correlations between energy use per capita and literacy rate. Whilst this information was not available in many cases, the countries were correlations were carried out found the relationship between energy use per capita and literacy rates as very strong. These findings appear consistent with the suggestion that whilst energy is not a basic human need it is necessary for delivery and provision of basic needs including education (Kemmler, 2007). Many of the educational advantages to do with energy related to the provision of electricity. Kanagawa (2008) believed a huge impact on education could be brought about by energy access improvements and in particular electricity access. Electricity allows for illumination, TV, radio and information technology to be used for education purposes. The data used in this study did not distinguish between traditional energy, or more modern forms such as electricity access, therefore whilst we can say that education appears to have increased as a result of increased energy use per capita, we cannot be sure what form of energy produced these results.

4.1.5 Energy and Mortality

Energy use per capita and education are being compared as a part of this study various health concerns are raised in the literature review which related to energy use. The table below shows the output from SPSS of the correlations between mortality rate (under 5) and energy use per capita.

	Mortality SDU		
	PC	Sig	N
Bangladesh	-0.964	0	10
Sudan	0.725	0.009	10
Ghana	-0.813	0.002	10
Guatemala	-0.648	0.021	10
Indonesia	-0.984	0	10
Iraq	-0.962	0	10
China	-0.865	0.001	10
South Africa	-0.855	0.001	10
United Kingdom	-0.506	0	46
Germany	-0.73	0	22
United States	-0.675	0	50
Iceland	-0.867	0	14

The numbers in the energy per capita and mortality analysis are somewhat similar across all countries. All the correlations were found to be statistically significant. The table below summarises the results of the analysis. The discussion will continue after the table.

Country	Child Mortality (under 5s)
Bangladesh	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
Sudan	There is a **very strong correlation**, which indicates an energy per capita decrease and a child mortality decrease, which are **very strongly related**
Ghana	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
Guatemala	There is a **strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **strongly related**
Indonesia	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
Iraq	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
China	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
South Africa	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
United Kingdom	There is a **strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **strongly related**
Germany	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**
United States	There is a **strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **strongly related**
Iceland	There is a **very strong negative correlation**, which indicates an energy per capita rise and a child mortality decrease, which are **very strongly related**

All the correlations were found to be either very strong or strong, meaning that there is a strong relationship between the two variables in all of the countries considered in this analysis. Breaking down the correlations of the 12, nine were found to be very strongly correlated, and three were found as strong correlations. There is a distinct pattern of mortality decrease, and in the majority of cases this is related to an energy per capita increase. However in Sudan, the mortality rate decrease is coupled with a decrease in energy use per capita. This would suggest that mortality rate decrease is not reliant on an increase in energy use per capita, however causality cannot be determined from this analysis, and the vast majority relate an increase in energy use per capita with a decrease in child mortality.

The initial predictions stated that a strong negative correlation would be found, due to increased access to appliances and facilities brought about by increased energy use per capita. The findings strongly upheld these initial predictions, and the majority of correlations showed that an increase in energy use per capita is strongly related with decreased mortality rates. One of the main concerns with using traditional energy sources is the inefficient burning which leads to indoor smoke exposure which is harmful to health (Arthur et al, 2011). Just under two million deaths worldwide occur as a direct results of solid fuel use (UNDP, 2009) It could be that increased energy use per capita is related to the use of more modern efficient fuels which would therefore decrease this dangerous exposure. Increased energy use could also be associated with electrification which would allow for clinics and hospitals to be better equipped to deal with health concerns, therefore improving mortality rates. Another energy increase could be related to transportation which would allow easier access to clinics and hospitals which would also improve mortality rates. These suggestions are not proved by the correlations however they appear reasonable from these findings and suggestions from literature. Further investigation would be required to prove these theories, which is not included in the scope of this project.

4.1.6 Energy and Gross Domestic Product (GDP)

Energy use per capita and GDP are being compared as a part of this study as the literature review findings were varied surrounding the links between economic growth and energy use. The table below shows the output from SPSS of the correlations between Gross Domestic Product and energy use per capita

	Gross Domestic Product		
	PC	Sig	N
Bangladesh	0.958	0	38
Sudan	-.503	0.001	38
Ghana	0.460	0.002	38
Guatemala	0.662	0.000	38
Indonesia	0.845	0	38
Iraq	0.097	0.305	30
China	0.959	0.000	38
South Africa	0.739	0.000	38
United Kingdom	0.292	0.020	50
Germany	-0.305	0.028	40
United States	0.419	0.001	50
Iceland	0.935	0.000	50

The numbers in the energy per capita and GDP analysis are varied across all countries. Most of the correlations were found to be statistically significant, apart from the analysis in Mozambique, and Iraq. The table below summarises the results of the analysis. The discussion will continue after the table.

Country	Gross Domestic Product (GDP)
Bangladesh	There is a **very strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **very strongly related**
Sudan	There is a **strong negative correlation**, which indicates an energy per capita decrease and a GDP rise, which are **strongly related**
Ghana	There is a **strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **strongly related**
Guatemala	There is a **strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **strongly related**
Indonesia	There is a **very strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **very strongly related**
Iraq	**No correlation or a Negligible correlation** was found, therefore no relationship can be formed
China	There is a **very strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **very strongly related**

South Africa	There is a **very strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **very strongly related**
United Kingdom	There is a **weak correlation** which indicates an energy per capita rise and a GDP rise, which are **weakly related**
Germany	There is a **moderate negative correlation**, which indicates an energy per capita rise and a GDP decrease, which are **moderately related**
United States	There is a **strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **strongly related**
Iceland	There is a **very strong correlation**, which indicates an energy per capita rise and a GDP rise, which are **very strongly related**

Across all countries, other than Germany and Iraq, a GDP rise was found with a Pearson correlation coefficient ranging from 0.292 at the lowest to 0.959 at the highest. Breaking these relationships down of the eleven correlations found, five very strong correlations were found along with, four strong, with two further split equally between moderate and weak.

As mentioned previously whilst most countries showed a GDP rise, whilst Iraq highlighted no or a negligible relationship, Germany differed and showed a negative relationship, showing a GDP decrease associated with an energy use per capita rise. Also interestingly, whilst Sudan showed a GDP rise, along with the majority, this rise was associated strongly with an energy use per capita decrease.

The initial predictions stated that a moderate correlation was expected to be found between GDP and energy use per capita. The majority of relationships were found to be strong, especially in developing countries. These findings are in line with those of Siddiqi (1995) who identified a good correlation between GDP and energy use across various countries, and would therefore support the view of Lee (2005) who states that in developing countries energy is important for economic development, and energy conservation measures introduced here may harm economic growth. However the findings from Sudan which related a decreased energy use per capita and increasing GDP, slightly contradict the other findings, which may suggest that a consensus between the direction of energy consumption and economic growth could not be established (Ozturk, 2009) in these findings along with other bodies of research.

Summary of Findings:

Energy use per Capita (EUPC) and Population

Findings show that the relationship between EUPC and population is strong, with the vast majority showing increased population relating to increased EUPC. The relationship between Urban population and EUPC was found to be stronger than rural population. Developing countries also showed stronger relationships between population and energy than developed countries on the whole.

Energy use per Capita and Infrastructure

The results of this analysis varied drastically between correlations that were not statistically significant, and very strong relationships. Rural water access was found to relate strongest in the most amount of countries with EUPC with five developing countries showing high correlations, with sanitation access coming 2nd with four developing countries, and Urban water access with just three. Interestingly access to urban safe water was the only infrastructure indicator found to relate negatively with EUPC.

Energy use per Capita and Education

In the three developing countries where data was available a very strong relationship was found between increasing EUPC and increased Literacy rate. However the results from both females and males out of primary education was some what varied ranging from correlations that were not statistically significant, and very strong relationships, and no general consensus was found.

Energy use per Capita and Child Mortality

All the results show either a very strong or strong relationship between EUPC and mortality. In all cases a decrease in child mortality is shown, and this is shown to be related to an increase in EUPC in all cases but one, which is Sudan, where a decreased EUPC is noted.

Energy use per Capita and Gross Domestic Product

A majority of the relationships between EUPC and GDP were found to be either strong or very strong. In most cases a relationship was found between increased EUPC and GDP. However results from two countries differed. A negative relationship was found in Germany showing an EUPC increase relating to a GDP decrease, and a negative correlation with a different meaning was found in Sudan, a decrease in EUPC was found to related to an increase in GDP.

4.2 Threshold analysis

The threshold analysis aims to discover the quantity of energy per capita provided/used which leads to access to services such as sanitation and clean drinking water, adequate health services, and education. It will take into account the strength of the relationships between energy and the indicators as found by the Pearson Correlation Coefficient analysis carried out previously in this report.

The reason for this analysis is that global data shows the ability of many developing countries in achieving the Millennium Development Goals (MDG) is unlikely, and whilst there is no specific MDG on energy, the aspirations embodied in these goals cannot become a reality without huge increases in both the quantity and quality, of energy services (UNDP, 2009). Therefore to explore this the analysis includes all developing countries that currently have less than 1000kg of oil equivalent energy use per capita, and six indicators, including the five from the previous analysis, and additionally a happiness rating for all countries. The thresholds for each indicator are explained in the relevant sections, and are all based on the target values from the Millennium Development Goals.

4.2.1 Energy Ranking

The table overleaf shows the countries in the analysis and the chosen indicators. The countries are ranked by their energy use per capita from the smallest to the largest. In the energy column, red indicates less that 250kg of oil equivalent per capita, orange indicates 250-500kg, yellow indicates 500-750kg, and green indicates 750-1000kg of oil equivalent energy use per capita. In all other indicator columns, red denotes below target, green denotes meeting or above set targets for each indicator.

Generally speaking, as you can see from the table overleaf, many of the countries with lower energy use per capita, lack access to facilities, and have high mortality rates, however moving up the energy use scale, more targets begin to be met. This table is only intended to provide an overview and a general idea of the situation, each individual indicator will be explained in more depth in the next section of this report.

country	Energy Use	RW	UW	TW	SAN	MORT	Ratio of G to B	Happi ness
Eritrea	138.2214332	57	74	61	14	58.2	97.285	13
Bangladesh	174.6498603	78	85	80	53	55.2	105.708	33
Senegal	234.1296882	52	92	69	51	95.4	96.597	15
Haiti	280.7702643	55	71	62	17	89.3	94.219	26
Myanmar	316.1429694	69	75	71	81	72.6	88.051	23
Yemen, Rep.	326.3010754	57	72	62	52	69.5	Missing	39
Nepal	340.1305527	87	93	88	31	51.4	99.437	1
Congo, Dem. Rep.	346.2677434	28	80	46	23	198.6	83.424	M
Benin	346.9141267	69	84	75	12	120.7	86.628	2
Tajikistan	364.6825236	61	94	70	94	64.2	95.764	12
Sudan	371.7737976	52	64	57	34	108.9	100.207	27
Cameroon	372.0587153	51	92	74	47	154.7	85.852	11
Congo, Rep.	378.4073256	34	95	71	30	126.8	93.57	28
Ethiopia	392.7970652	26	98	38	12	108.5	82.369	37
Togo	396.8349202	41	87	60	12	100.2	98.597	24
Ghana	405.080278	74	90	82	13	72	97.89	M
Mozambique	416.1280584	29	77	47	17	146.8	90.518	41
Sri Lanka	443.2878259	88	98	90	91	15.3	102.348	3
Tanzania	446.2158544	45	80	54	24	111.4	96.078	38
Kenya	464.8743702	52	83	59	31	85.9	97.365	35
Morocco	473.871479	60	98	81	69	39.2	97.892	5
Pakistan	498.6951922	87	95	90	45	89.1	Missing	40
Cote d'Ivoire	499.1427934	68	93	80	23	120.9	99.187	42
Kyrgyz Republic	541.882188	85	99	90	93	38	missing	10
India	544.7299147	84	96	88	31	68.2	99.783	19
Zambia	582.7949578	46	87	61	49	145.1	80.402	21
Bolivia	587.3667864	67	96	86	25	54.2	99.323	36
Guatemala	589.7942793	90	98	94	81	40.7	99.027	6
Angola	608.856453	38	60	50	57	165.6	81.077	30
Nicaragua	621.1043129	68	98	85	52	27	Missing	32
Honduras	631.798512	77	95	86	71	30.6	Missing	17
Vietnam	689.1829457	92	99	94	75	24.2	97.683	20
Georgia	693.7525815	96	100	98	95	29.7	89.059	16
Paraguay	698.9582156	66	99	86	70	23.3	82.603	31
Nigeria	735.0991541	42	75	58	32	142.9	97.808	25
Zimbabwe	762.7451089	72	99	82	44	93.4	97.914	M
Ecuador	767.426349	88	97	94	92	25.1	79.386	14
El Salvador	795.9034286	76	94	87	87	17.9	Missing	7
Korea, Dem. Rep.	850.5902891	100	100	100	Missing	33.1	97.886	18
Moldova	866.9639665	85	96	90	79	17.4	99.431	8
Egypt, Arab Rep.	867.3181991	98	100	99	94	23	Missing	29
Indonesia	873.9093815	71	89	80	52	40.5	Missing	34
Tunisia	888.6694165	84	99	94	85	21.3	87.673	9
Syrian Arab Republic	957.2286346	84	94	89	96	16.7	88.346	4
Armenia	973.9731116	93	98	96	90	22.9	101.667	22

4.2.2 Rural Safe Water Access

country	Energy Use	RW
Ethiopia	392.7970652	26
Congo, Dem. Rep.	346.2677434	28
Mozambique	416.1280584	29
Congo, Rep.	378.4073256	34
Angola	608.856453	38
Togo	396.8349202	41
Nigeria	735.0991541	42
Tanzania	446.2158544	45
Zambia	582.7949578	46
Cameroon	372.0587153	51
Senegal	234.1296882	52
Sudan	371.7737976	52
Kenya	464.8743702	52
Haiti	280.7702643	55
Eritrea	138.2214332	57
Yemen, Rep.	326.3010754	57
Morocco	473.871479	60
Tajikistan	364.6825236	61
Paraguay	698.9582156	66
Bolivia	587.3667864	67
Cote d'Ivoire	499.1427934	68
Nicaragua	621.1043129	68
Myanmar	316.1429694	69
Benin	346.9141267	69
Indonesia	873.9093815	71
Zimbabwe	762.7451089	72
Ghana	405.080278	74
El Salvador	795.9034286	76
Honduras	631.798512	77
Bangladesh	174.6498603	78
India	544.7299147	84
Tunisia	888.6694165	84
Syrian Arab	957.2286346	84
Kyrgyz Republic	541.882188	85
Moldova	866.9639665	85
Nepal	340.1305527	87
Pakistan	498.6951922	87
Sri Lanka	443.2878259	88
Ecuador	767.426349	88
Guatemala	589.7942793	90
Vietnam	689.1829457	92
Armenia	973.9731116	93
Georgia	693.7525815	96
Egypt, Arab Rep.	867.3181991	98
Korea, Dem. Rep.	850.5902891	100

This section of the threshold analysis is looking the amount of countries, which are deemed to have an acceptable access to safe water in rural areas. The safe water access targets set in the Millennium Development Goals, are aiming for 89% of the developing world population having access to safe drinking water (UN, 2011). This is therefore the threshold to be used in this section

The table to the left shows the developing countries and their corresponding energy use per capita and access to safe rural water percentages. These are ranked by the percentage of population access to rural water.

As you can see from the table, the majority of countries do not meet this target thus far. Guatemala was the lowest energy use per capita country which managed to meet the target with 589kg of oil equivalent per capita.
The average energy use per capita of these which fall below the 89% rural safe water access target is 510kg of oil equivalent. The average energy per capita of those countries which meet the safe water access target is 777kg of oil equivalent.

4.2.3 Urban Safe Water Access

Country	Energy Use	UW
Angola	608.856453	60
Sudan	371.7737976	64
Haiti	280.7702643	71
Yemen, Rep.	326.3010754	72
Eritrea	138.2214332	74
Nigeria	735.0991541	75
Myanmar	316.1429694	75
Mozambique	416.1280584	77
Congo, Dem. Rep.	346.2677434	80
Tanzania	446.2158544	80
Kenya	464.8743702	83
Benin	346.9141267	84
Bangladesh	174.6498603	85
Togo	396.8349202	87
Zambia	582.7949578	87
Indonesia	873.9093815	89
Ghana	405.080278	90
Cameroon	372.0587153	92
Senegal	234.1296882	92
Cote d'Ivoire	499.1427934	93
Nepal	340.1305527	93
Tajikistan	364.6825236	94
El Salvador	795.9034286	94
Syrian Arab	957.2286346	94
Congo, Rep.	378.4073256	95
Honduras	631.798512	95
Pakistan	498.6951922	95
Bolivia	587.3667864	96
India	544.7299147	96
Moldova	866.9639665	96
Ecuador	767.426349	97
Ethiopia	392.7970652	98
Morocco	473.871479	98
Nicaragua	621.1043129	98
Sri Lanka	443.2878259	98
Guatemala	589.7942793	98
Armenia	973.9731116	98
Paraguay	698.9582156	99
Zimbabwe	762.7451089	99
Tunisia	888.6694165	99
Kyrgyz Republic	541.882188	99
Vietnam	689.1829457	99
Georgia	693.7525815	100
Egypt, Arab Rep.	867.3181991	100
Korea, Dem. Rep.	850.5902891	100

This section of the threshold analysis is looking the amount of countries that are deemed to have an acceptable access to safe water in urban areas. The safe water access targets set in the Millennium Development Goals, are aiming for 89% of the developing world population having access to safe drinking water (UN, 2011). This is therefore the threshold to be used in this section The table to the left shows the developing countries and their corresponding energy use per capita and access to safe urban water percentages. These are ranked by the percentage of population access to rural water.

As you can see from the table over half of the countries in the threshold analysis meet the 89% target for access to urban safe water. There is a wide range of energy use per capita which meet the 89% target, ranging from 234kg at the lowest to 973kh at the highest. This is a shows a range of 739kg, which is a large range. However looking at the average figures, the average energy use per capita of those which fall below target is 396kg, and the average of those which meet the target is 620.2kg of oil equivalent.

4.2.4 Total Population access to safe water

country	Energy Use	TW
Ethiopia	392.7970652	38
Congo, Dem.	346.2677434	46
Mozambique	416.1280584	47
Angola	608.856453	50
Tanzania	446.2158544	54
Sudan	371.7737976	57
Nigeria	735.0991541	58
Kenya	464.8743702	59
Togo	396.8349202	60
Eritrea	138.2214332	61
Zambia	582.7949578	61
Haiti	280.7702643	62
Yemen, Rep.	326.3010754	62
Senegal	234.1296882	69
Tajikistan	364.6825236	70
Myanmar	316.1429694	71
Congo, Rep.	378.4073256	71
Cameroon	372.0587153	74
Benin	346.9141267	75
Bangladesh	174.6498603	80
Cote d'Ivoire	499.1427934	80
Indonesia	873.9093815	80
Morocco	473.871479	81
Ghana	405.080278	82
Zimbabwe	762.7451089	82
Nicaragua	621.1043129	85
Bolivia	587.3667864	86
Honduras	631.798512	86
Paraguay	698.9582156	86
El Salvador	795.9034286	87
Nepal	340.1305527	88
India	544.7299147	88
Syrian Arab	957.2286346	89
Sri Lanka	443.2878259	90
Pakistan	498.6951922	90
Kyrgyz Republic	541.882188	90
Moldova	866.9639665	90
Guatemala	589.7942793	94
Vietnam	689.1829457	94
Ecuador	767.426349	94
Tunisia	888.6694165	94
Armenia	973.9731116	96
Georgia	693.7525815	98
Egypt, Arab Rep.	867.3181991	99
Korea, Dem. Rep.	850.5902891	100

This section of the threshold analysis is looking the amount of countries that are seen to have an acceptable percentage of the total population with access to safe water. The safe water access targets set in the Millennium Development Goals, are aiming for 89% of the developing world population having access to safe drinking water (UN, 2011). This is therefore the threshold to be used as a guide in this section.

The table to the left shows the developing countries and their corresponding energy use per capita and the percentage of the total population with access to safe water. These are ranked by the percentage of population access to safe water.

From the table you can see that over half of the countries in this analysis fail to meet the target. There is a general pattern showing that the countries that have a higher energy use per capita generally have a higher percentage of the population with access to safe water. There are however a few exceptions, but this is the general theme.

On average the countries which meet or exceed the 89% access target use 740kg of oil equivalent per capita. This is almost 300kg more than the 466kg of oil equivalent average of the countries that fail to meet the target. This total access analysis shows the overall picture better than the individual rural and urban access analysis. Whilst many countries have been able to achieve the target for urban access they are still failing to meet the target based on the total population, which is important to consider. Just six countries in the analysis meet the 89% target in rural locations, despite 30 countries meeting the target at an urban level.

Whilst the Pearson correlation coefficients from the previous section were somewhat variable, strong relationships were found between access to services and energy use per capita in some countries, which would suggest that other factors may play a part also. However from the table above a pattern can be seen, and generally the countries with more energy use per capita have greater access to safe drinking water. No country in the analysis achieved the target with less than 443 kg of oil equivalent energy use per capita, some countries with higher energy use than this still failed to meet the target.

4.2.5 Access to sanitation

country	Energy Use	SAN
Benin	346.9141267	12
Togo	396.8349202	12
Ethiopia	392.7970652	12
Ghana	405.080278	13
Eritrea	138.2214332	14
Haiti	280.7702643	17
Mozambique	416.1280584	17
Congo, Dem. Rep.	346.2677434	23
Cote d'Ivoire	499.1427934	23
Tanzania	446.2158544	24
Bolivia	587.3667864	25
Congo, Rep.	378.4073256	30
Kenya	464.8743702	31
Nepal	340.1305527	31
India	544.7299147	31
Nigeria	735.0991541	32
Sudan	371.7737976	34
Zimbabwe	762.7451089	44
Pakistan	498.6951922	45
Cameroon	372.0587153	47
Zambia	582.7949578	49
Senegal	234.1296882	51
Yemen, Rep.	326.3010754	52
Indonesia	873.9093815	52
Nicaragua	621.1043129	52
Bangladesh	174.6498603	53
Angola	608.856453	57
Morocco	473.871479	69
Paraguay	698.9582156	70
Honduras	631.798512	71
Vietnam	689.1829457	75
Moldova	866.9639665	79
Myanmar	316.1429694	81
Guatemala	589.7942793	81
Tunisia	888.6694165	85
El Salvador	795.9034286	87
Armenia	973.9731116	90
Sri Lanka	443.2878259	91
Ecuador	767.426349	92
Kyrgyz Republic	541.882188	93
Tajikistan	364.6825236	94
Egypt, Arab Rep.	867.3181991	94
Georgia	693.7525815	95
Syrian Arab	957.2286346	96

This section of the threshold analysis is looking the amount of countries that have an acceptable access to sanitation facilities. The sanitation target set in the Millennium Development Goals, are aiming for 71% of the developing world population having access to sanitation facilities (UN, 2011). This is therefore the threshold to be used in this section

The table below shows the developing countries and their corresponding energy use per capita and access to sanitation percentages. These are ranked by the percentage of population with access to sanitation facilities.

Over half of the countries in this analysis fail to meet the target, and the general theme (with a few exceptions) is that the higher energy users per capita have a higher percentage of the population with access to sanitation facilities. The majority of countries which achieve the target are in the 750-1000kg of oil equivalent bracket, however the achievement of the target is met by a range of energy use from 316 to 973kg of oil equivalent. The average energy use per capita of those countries which meet the target is 692kg and the average of those who don’t are 459kg of oil equivalent.

Looking at infrastructure as a while, 11 countries met with both the water and sanitation targets, and these countries had energy use per capita ranging from the lowest at 443kg to the highest with 973kg of oil equivalent. The average energy use per capita of the 11 countries that meet both targets is 752kg of oil equivalent.

4.2.5 Under-5 Mortality per 1000

country	Energy Use	MORT
Sri Lanka	443.2878259	15.3
Syrian Arab	957.2286346	16.7
Moldova	866.9639665	17.4
El Salvador	795.9034286	17.9
Tunisia	888.6694165	21.3
Armenia	973.9731116	22.9
Egypt, Arab Rep.	867.3181991	23
Paraguay	698.9582156	23.3
Vietnam	689.1829457	24.2
Ecuador	767.426349	25.1
Nicaragua	621.1043129	27
Georgia	693.7525815	29.7
Honduras	631.798512	30.6
Korea, Dem. Rep.	850.5902891	33.1
Kyrgyz Republic	541.882188	38
Morocco	473.871479	39.2
Indonesia	873.9093815	40.5
Guatemala	589.7942793	40.7
Nepal	340.1305527	51.4
Bolivia	587.3667864	54.2
Bangladesh	174.6498603	55.2
Eritrea	138.2214332	58.2
Tajikistan	364.6825236	64.2
India	544.7299147	68.2
Yemen, Rep.	326.3010754	69.5
Ghana	405.080278	72
Myanmar	316.1429694	72.6
Kenya	464.8743702	85.9
Pakistan	498.6951922	89.1
Haiti	280.7702643	89.3
Zimbabwe	762.7451089	93.4
Senegal	234.1296882	95.4
Togo	396.8349202	100.2
Ethiopia	392.7970652	108.5
Sudan	371.7737976	108.9
Tanzania	446.2158544	111.4
Benin	346.9141267	120.7
Cote d'Ivoire	499.1427934	120.9
Congo, Rep.	378.4073256	126.8
Nigeria	735.0991541	142.9
Zambia	582.7949578	145.1
Mozambique	416.1280584	146.8
Cameroon	372.0587153	154.7
Angola	608.856453	165.6
Congo, Dem. Rep.	346.2677434	198.6

This section of the threshold analysis is looking the amount of developing countries that meet the targets for lowering child mortality rates. The child mortality rate set in the Millennium Development Goals, are aiming for no more than 33 deaths per 1000 children under 5 in developing countries (UN, 2011). This is therefore the threshold to be used in this section The table to the left shows the developing countries and their corresponding energy use per capita and the corresponding child mortality rate per 1000. These are ranked by the mortality rate.

You can see from the table that a general theme exists whereby the countries meeting the mortality rate target, are using over 600kg of oil equivalent per capita, and the ones failing the target are using below 500kg of oil equivalent. There are however exceptions to this, such as the lowest mortality rate is in Sri-lanka with an energy use per capita of less than 500. The average energy use per capita of the countries who do not meet the mortality target is 458kg, and the average of those who do meet the target is 761kg of oil equivalent.

In the comparative analysis a high correlation was found between mortality and energy use per capita in the majority of cases. The findings in this table seem to be consistent with the higher energy using countries generally having lower mortality rates.

4.2.6 Ratio of Girls to Boys in Primary Education

country	Energy Use	Ratio of Girls to Boys in Primary Education
Ecuador	767.426349	79.386
Zambia	582.7949578	80.402
Angola	608.856453	81.077
Ethiopia	392.7970652	82.369
Paraguay	698.9582156	82.603
Congo, Dem. Rep.	346.2677434	83.424
Cameroon	372.0587153	85.852
Benin	346.9141267	86.628
Tunisia	888.6694165	87.673
Myanmar	316.1429694	88.051
Syrian Arab Republic	957.2286346	88.346
Georgia	693.7525815	89.059
Mozambique	416.1280584	90.518
Congo, Rep.	378.4073256	93.57
Haiti	280.7702643	94.219
Tajikistan	364.6825236	95.764
Tanzania	446.2158544	96.078
Senegal	234.1296882	96.597
Eritrea	138.2214332	97.285
Kenya	464.8743702	97.365
Vietnam	689.1829457	97.683
Nigeria	735.0991541	97.808
Korea, Dem. Rep.	850.5902891	97.886
Ghana	405.080278	97.89
Morocco	473.871479	97.892
Zimbabwe	762.7451089	97.914
Togo	396.8349202	98.597
Guatemala	589.7942793	99.027
Cote d'Ivoire	499.1427934	99.187
Bolivia	587.3667864	99.323
Moldova	866.9639665	99.431
Nepal	340.1305527	99.437
India	544.7299147	99.783
Sudan	371.7737976	100.207
Armenia	973.9731116	101.667
Sri Lanka	443.2878259	102.348
Bangladesh	174.6498603	105.708

This section of the threshold analysis is looking the amount of countries that achieve an acceptable female to male ratio in primary education. The ratio set in the Millenium Development Goals, are aiming for a female to male ratio of 100/100, therefore aiming for an equal split in primary education (UN, 2011). This is therefore the guideline to be used in this section

The table to the left shows the developing countries and their corresponding energy use per capita and the corresponding female ratio per 100 male in primary education. These are ranked by the female to male ratio.

From the table we can see that the vast majority of countries do not meet the equal quota for males and females in primary education. Only one country, Sudan, meets the female to male ratio, with three further countries exceeding it, showing more females than males in primary education. From the vast range and limited numbers of those countries meeting or exceeding the target no real number can be formulated as a guide for policy in this instance.

The findings of the comparative analysis strongly suggests in developing countries a gender bias in primary education attendance is not related to energy use per capita, as in the countries where strong relationships were found between decreased non-attendance and energy, they were found in both female and male data sets. The findings in this table therefore uphold the theory that energy use is not directly associated with gender bias in education.

4.2.8 Happiness Rating

country	Energy Use	Happiness
Nepal	340.1305527	1
Benin	346.9141267	2
Sri Lanka	443.2878259	3
Syrian Arab Republic	957.2286346	4
Morocco	473.871479	5
Guatemala	589.7942793	6
El Salvador	795.9034286	7
Moldova	866.9639665	8
Tunisia	888.6694165	9
Kyrgyz Republic	541.882188	10
Cameroon	372.0587153	11
Tajikistan	364.6825236	12
Eritrea	138.2214332	13
Ecuador	767.426349	14
Senegal	234.1296882	15
Georgia	693.7525815	16
Honduras	631.798512	17
Korea, Dem. Rep.	850.5902891	18
India	544.7299147	19
Vietnam	689.1829457	20
Zambia	582.7949578	21
Armenia	973.9731116	22
Myanmar	316.1429694	23
Togo	396.8349202	24
Nigeria	735.0991541	25
Haiti	280.7702643	26
Sudan	371.7737976	27
Congo, Rep.	378.4073256	28
Egypt, Arab Rep.	867.3181991	29
Angola	608.856453	30
Paraguay	698.9582156	31
Nicaragua	621.1043129	32
Bangladesh	174.6498603	33
Indonesia	873.9093815	34
Kenya	464.8743702	35
Bolivia	587.3667864	36
Ethiopia	392.7970652	37
Tanzania	446.2158544	38
Yemen, Rep.	326.3010754	39
Pakistan	498.6951922	40
Mozambique	416.1280584	41
Cote d'Ivoire	499.1427934	42

This section of the threshold analysis is looking the amount of the comparative happiness of the developing countries in this analysis. This has been carried out as findings from literature suggest that energy has effects on education which can improve social-economic aspects leading to better quality of life, and also that increased energy use in the form of electricity can allow for entertainment such as a television to be introduced into the household.

This table shows that energy use per capita is highly varied when compared to happiness. There is no general theme such as the more energy you use the happier you are. These results show that happiness is not achieved by access to energy alone, otherwise there would be a recognisable pattern in the table above. As a result no reflective threshold can be established for happiness.

This is somewhat surprising given the various benefits that have been discussed in literature relating to increased energy access, such as extended hours in the evening where reading, study or if electrified, watching television can take place, or increases in healthcare, sanitation, and water services. It would seem rational that these benefits would increase happiness.

4.3 Threshold analysis findings

The table below outlines the main findings of the threshold analysis, and identifies the threshold of energy provision for a particular target to be satisfied were possible.

Indicator	Average energy use per capita below indicator target	Average energy use per capita above indicator target	No country failed indicator target above
Rural safe water access	510kg	777	N/A
Urban safe water access	396kg	620	762
Total population safe water access	466kg	740	888
Sanitation access	459kg	692	888
Mortality rate (under 5)	458kg	761	888
Primary school sex ratio	N/A	N/A	N/A

From this table you can see that the average energy use per capita of all the countries which fail the target for any given indicator is lower than the average energy use of those which meet the target. These findings would also suggest that energy use per capita has a role in development.

The aim of this analysis was to find a threshold, which mean the quantity of energy per capita used whereby all countries using equal or above that number meet the target for the given indicator. This analysis has found four thresholds in the below 1000kg of oil equivalent category which uphold. The threshold for total population with safe water access, sanitation, and low mortality rate was found to be 888kg of oil equivalent. The threshold for acceptable percentage of the urban population with access to safe drinking was found to be slightly lower at 762kg of oil equivalent.

Whilst these were the absolute thresholds above which targets were satisfied, various countries in the study with lower energy use per capita also met the targets, therefore the average energy use per capita of those countries meeting the target is of interest. A general theme exists, of around 600-800kg of oil equivalent energy use per capita (and sometimes lower) countries have the ability to also meet the targets in place. The overview table at the start of this section shows that above around 600kg of oil equivalent a majority of the targets are met by various countries, however the minority still fail to meet the target. This would therefore suggest that providing around 600kg of oil equivalent energy per capita in countries along with the good initiatives in place, are in a in good position for development advances.

There is also a general theme surrounding the average energy use of those countries that fail to meet the indicator targets. This is generally in the region of 400-500kg of oil equivalent energy use per capita. From the overview table at the beginning of this section you can see that generally below 600kg of oil equivalent energy use per capita a vast majority of the indicator targets are not met.

Based on the discussed averages and patterns, as a guideline for provision. It would be suggested that above 600kg of oil equivalent energy use per capita is an acceptable quantity to allow for basic human needs. But below this figure it appears difficult for countries to achieve these basic human needs.

5.0 Recommendations

Whilst a general consensus could not be found in this study, various relationships were found which give an indication that energy has a strong influence in development in some areas. Based on the report findings the following three recommendations for energy provision have been formulated. It is envisioned that local councils and policy makers, with government and international support; can carry out these recommendations;

1. **Specific Energy Access Targets**

It is said that whilst energy is seen as a fundamental component for development, many developing countries lack targets associated with energy provision. Energy targets in the short, medium and long term should be set. These targets should relate to provision quantity and quality, efficiency, and end-use. Therefore based on literature findings and the threshold analysis in this study, it has been found that an average of 600kg of oil equivalent energy per capita is the amount required for the majority of basic human needs can be satisfied. Therefore in the early stages of development this should be the key provision target if not already met. It is not suggested that simply providing this amount of energy will be a catalyst for change, however it was shown in the analysis that the majority of countries with access to 600kg of oil equivalent per capita were able to provide the majority of basic human needs and therefore suggests that this will help create an enabling environment for development.

2. **Strategic Service Provision**

In this study strong relationships were found between urbanisation and energy use per capita increases. Therefore a method to decrease the increasing energy use rates in developing countries could be to increase energy access at rural levels to prevent increased movement to urban areas. This would allow for energy to increase quality of life and help obtain basic human needs such as lighting and education. Urbanisation is said to increase energy use per capita in various direct and indirect ways, and this study upheld these concerns so to prevent unnecessary movement to urban areas by creating opportunity through energy provision in rural locations could help decrease the long term energy demand. Population trends can have an impact on energy use patterns. Therefore whilst energy cannot be used to control natural growth rate, it can be used to help control movement. For example if services are provided in one town only, people may go in search of a better quality of life, and emigrate/immigrate to this area. Therefore energy provision could be used in rural locations to discourage rapid urbanisation, or services could be improved in several townships to disperse a large city population. The reasoning behind this strategic service provision would be that energy is indicated or at least believed to provide opportunity and a better quality of life.

Therefore based on the findings of this study, the specific advice to policy makers in developing countries during urban planning, or to access movement to existing urban areas would be to;

- Carry out situational analysis of existing urban areas, or planned developments, looking for nearby rural settlements and communities.
- Embark on a survey of existing energy services to these rural communities, taking into account quantity, quality, and cost. It would also prove useful to talk to local people to find out what services they would actively seek, to discover if energy quantity or quality is an important factor for opportunity, to discover if movement to urban areas is likely.
- Carry out feasibility study (where likely movement is found) into increasing quantity and/or quality of energy provision in surrounding rural locations to discourage rapid urbanisation, and increased movement from rural to urban locations.
- Where increased energy services in surrounding rural areas is not feasible, additional planning for energy efficiency, energy conservation measures and clean sources of energy should be strictly enforced to limit the effects of rapid urbanisation on global climate change.

3. Energy Source Analysis

There are various concerns relating to current and increased energy use, especially where oil, coal, and gas are the primary sources used. A growing perception by society surrounding the risks of climate change due to greenhouse gases, particularly the emissions of carbon dioxide, has spurred an interest in carbon free and carbon neutral technologies (da. Silva, 2010). Renewable energy is becoming increasingly recognised, and this is energy derived from resources that are regenerative, and will not deplete over time (Kumar et al, 2010). In many areas of developing countries where energy provision is low, renewable energy sources are abundant. Many of the concerns relating to energy use increases are down to global warming and resource limitations. Supplies of fossil fuels are depleting, so there is the requirement to find alternative sources.

Therefore if developing countries can utilise their resources to good effect, then they may be able to grow economically on a different path from the fossil fuelled way developed countries grew. Whilst it is unlikely to reverse the damage to the climate by fossil fuels, increased use of clean energy would help to slow down the accumulation of carbon dioxide in the atmosphere. Renewable energy leads to lower emissions of several pollutants, and there are known environmental benefits in terms of avoiding carbon dioxide emissions (del Rio, 2008).

Renewable energy sources and technologies are also seen as having potential solutions to long standing energy problems in developing countries (Kumar et al, 2010). The gap between energy demand and the supply has been increasingly growing over the last 40 years and it looks to grow further in the future (Kebede, 2010). Renewable energy sources such as wind, solar, geothermal, ocean, biomass, and fuel cell technology can all be used to overcome fossil fuel and energy shortages (Kumar et al, 2010). However practically speaking this may be an expensive option, therefore worldwide co-operation both financially and technologically is really required to make this a successful solution.

Therefore based on this information and the findings on this study, the advice for policy makers in developing countries are;

1. Carry out extensive survey of local conditions, including current energy sources used, in both terms of quantity, quality, and cost.

2. Carry out a sustainability survey of existing resources in terms of supply levels, environmental damage, and other implications, such as health, time spent collecting etc.

3. Investigate renewable sources available to both local rural and urban locations. The potential renewable sources of energy that may be available are; (adapted from Pereira et.al, 2011);
    - Biomass; This represents approximately 14% of the world's energy consumption, and it is estimated that it could be 15-50% of the world's primary energy use by the year 2050. Biomass resources for energy use cover a wide range of materials, such as firewood collected in farmlands, and forestry crops grown specifically for energy production purposes.
    - Hydropower; Obtaining power from water is through the process of converting the potential energy of the kinetic energy of moving water into mechanical energy.

Currently, globally, we only use 17% of the vast 15,000 MW hydro potential available in the world.

- Wind energy; Wind is one of the most widely distributed renewable energy sources and the total world wind capacity as measured in 2006 was high with 72,000 MW total potential recorded.
- Solar energy; 'Solar energy is the most abundant permanent energy resource on earth', it is available for use in both direct and indirect forms. The world's total annual primary energy consumption is 450 EJ, and the total annual solar radiation falling on the earth is more than 7500 the consumption value. The annual solar radiation reaching the earth's surface is approximately 3,400,000 EJ, and it is greater than the estimated total of all non renewable energy resources, including fossil fuels and nuclear.
- Geothermal energy; This is energy generated from heat stored in the earth, or the collecting of adsorbed heat derived from underground. Large amounts of thermal energy are generated and stored in the Earth's core, mantle and crust. Geothermal energy contributes currently around 10,000MW globally.

4. Where potential renewable resources are found, investigate the likely outputs of these sources and the cost of associated infrastructure for collection and use, along with the quantity of the population which could be served, for use in potential tariff structures.

5. Map potential renewable sources and outputs, along with population to be served, in an easily understandable way. Such as a colour coded local map.

6. Look to phase out unsustainable or harmful sources of energy, and revert to more efficient or renewable sources of energy highlighted by the mapped resources, where possible, through short, medium and long terms strategies.

These three recommendations are essentially setting an access target, planning to limit environmental damage, and utilising local resources effectively. Whilst the relationship between energy and development remains complex, these recommendations aim to provide a basic outline for policy makers to consider the current local situation and improving energy services for the population, whilst limiting environmental damage and helping combat the global energy crisis by utilising the clean energy resources available.

6.0 Conclusion

The main aims objectives of this conclsion are to;

- Identify how the research has met the specific objectives
- To make recommendations for policy makers in developing countries regarding energy and development
- To discuss limitations of this research
- To make a final conclusion

6.1 How did the research meet the specific objectives

The specific objectives of this research were;

- To investigate the magnitude of energy poverty globally
- To discover the relationship between energy and various indicators of development
- To look for trends in existing data analysis
- To establish thresholds of energy provision for development.

These specific objectives were explored throughout the course of this research. The magnitude of energy poverty globally is a wide issue, which has been discussed in in a vast amount of literature, therefore this was explored in the literature review. Current energy poverty statistics and future predictions were explored. However as discussed in the relevant section, doubts surround the accuracy of the future predictions, when so many factors involved are based heavily on assumptions. Therefore this objective was met.

Whilst the author carried out various data analysis between energy and various indicators of development, a general consensus was difficult to find. Some indicators showed stronger correlations than others, which gave an indication of development areas where energy access has a stronger influence. So whilst this objective was explored and an indication of the relationship was found, it would be misleading to say a strong general consensus surrounding energy use and indicators of development relationships was discovered.

The third objective relates to trends in existing data. These were explored, and some trends were found between various countries in the comparative analysis. However the stronger trends were found in the threshold analysis, showing that many countries with higher energy use per capita have more access facilities catering to basic human needs. Therefore this objective was explored and met to some extent in this research.

Finally as touched upon in the last paragraph, the final objective relates to the establishment of thresholds of energy provision for development. Trends in the existing data allowed for thresholds to be established, therefore this objective was met by the research.

This summary shows how the author explored and met the majority of the objectives of the research. However it prove beneficial to expand this research in the future to more in depth at the relationship between energy and indicators of development, taking into account the various external factors which may have affected the results.

6.2 Recommendations

As explained in the previous section, based on the findings of this report, three main recommendations have been devised for policy makers in developing countries, these include;

1. Specific Energy Access targets
    - All countries should set specific energy targets relating to quantity and quality. This report recommends a short term minimum access target of 600kg of oil equivalent per capita, as the majority of basic human needs were met by countries with 600kg of oil equivalent per capita or more.

2. Strategic Energy Service Provision
    - Rapid urbanisation should be discouraged from an energy use and environmental damage stance. Therefore providing basic levels of energy to rural communities may help increase opportunity and discourage rapid movement to urban areas.

3. Energy Source Analysis
    - It is important to understand the current energy situation and look for improvements. Therefore undergo an extensive energy survey of current access, source, quantity, quality, cost, sustainability etc, then look at potential renewable and more efficient sources which could be utilised. Where feasible, traditional sources should be phased out and replaced in a series of short, medium and long term strategies.

6.3 Limitations of this Research

There are various limitations of the research. Firstly the data analysis in this research relied on secondary data, which was not collected by the author. Therefore there is no real way to validate the findings to check for accuracy. However the data used was from the World Bank Data collection system which has specific validation methods and therefore a certain degree of accuracy therefore is expected, but cannot be guaranteed. Relating specifically to the data, the energy use per capita amounts were the average of all users in the country, therefore they do not take into account the inequities between the poorer and richer population, distinguishing between the two, would have proved better for the purposes of the study, however the data was not available or able to be collected within the constraints of this project.

Other limitation relates to the analysis method. The analysis of the data compared two variables from various countries, one being energy and the other an indicator of development to discover any correlation between the two. This analysis however simply took into account the two variables to establish correlation, and it could not provide any information surrounding casuality. There may have been other factors in certain countries which affected this relationship differently to other countries in the analysis which were not taken into account in this study, which may have affected the results. However the comparative analysis was only used to give an indication of the strength of the relationships between energy and particular indicators, therefore the accuracy levels achieved were acceptable for the purpose.

Whilst limitations exist within the scope of the project, the author overcome these as much as possible by comparing any findings in this research with findings and ideas from literature to check for conformity.

6.4 Final Conclusion

Whilst it appears that energy is related to various aspects of development, as relationships were found between energy and various indicators, the strengths, directions and significance of the findings differed on many occasions. This would indicate that there are factors, which differ from country to country which could have a significant influence in the findings of this study. Without fully exploring all possible factors relating to development the magnitude of the role energy plays cannot be precisely determined. However whilst the exact influence cannot be determined, a strong relationship between energy and development indicators would suggest that energy in fact does play a role in whatever context. Therefore the indication from this study is that energy does play a part in various aspects of development, however unanimous consensus was not achieved across all countries, showing that the magnitude of its influence varies.

The strongest relationships were found between urban population and energy use per capita, and mortality rates and energy use per capita. However even in these cases where an almost perfect consensus was found across all developing countries, Sudan appeared to contradict these findings. Sudan was the only country in the study to record a decreasing energy use per capita. Therefore to find the same results in Sudan as the other countries in the study, it meant that the same affects were being found with decreasing energy use. Looking deeper at this however it uncovered, that whilst the energy use per capita was decreasing, the population had increased at such a rate that the country wide energy use had more than doubled despite this. Showing that it may not be the energy use per capita that influences the relationship between energy and development, but it may be the countrywide energy use that has the greatest influence overall. These findings just further prove the complexity surrounding energy and development links.

The threshold analysis showed that for a majority of indicators, the targets were met by the higher energy using countries. This study highlighted general trends that suggested for development purposes, providing 600kg of oil equivalent energy per capita puts a community or country in a strong position to be able to satisfy basic human needs. However whilst the calculations show that this increase may be beneficial in terms of development, this increase also has the ability to cause detrimental environmental effects. Whilst it appears hard to gain a general consensus of the effects of energy on development, the effects of energy use on the environment has been well documented. Increased energy use in developing countries is already a concern based on global projections. It is also predicted that developing countries will bear the brunt of the detrimental effects caused by increased energy use.

Due to various relationships being established between energy use and development, the author would encourage increases in energy access in developing countries. However, this could cause adverse effects in the long term. Energy is currently, and will continue to be a global issue. Therefore the global population must provide assistance in ensuring that this development does not take place in the fossil fuelled way developed countries grew, but instead to look to renewable clean sources to bridge the energy gap.

Bibliography

Arthur, R., Baidoo, M., Antwi, E., 2011. Biogas as a potential renewable energy. Renewable Energy Journal **36,** 1510-1516.

AGEC, 2010. Energy for a sustainable future. Summary report and recommendations. New York.

Blaxter, L., Hughes C., Tight, M., 2006. How to research, 3rd edition. Berkshire, England. Mcgraw-Hill Education.

Brew-Hammond, A., 2010. Energy access in Africa: Challenges ahead. Energy Policy Journal **38,** 2291-2301.

Bryman, A., 2001. Social Research Methods. New York. Oxford University Press.

Del Rio, P., Burguillo, M., 2008. Assessing the impacts of renewable energy deployment on local sustainability: towards a theoretical framework. Renewable and Sustainable Energy Reviews Journal **12,** 1325-1349.

De Vita, G., Endresen K., Hunt, L.C., 2006. An empirical analysis of energy demand in Namibia. Energy Policy Journal **34,** 3446-3463.

Ebohon, O., 1996. Energy, economic growth and causality in developing countries. Energy Policy Journal **24 (5),** 447-453.

Farhar, B., 1998. Gender and renewable energy: Policy, analysis and market implications. Renewable Energy Journal **15**, 230-239.

Field, A., 2009. Discovering statistics using SPSS. 3rd edition. Sage Publications, London.

Gay, L.R., 1996. Educational research; competencies for analysis and application. Upper Saddle River, NJ: Merril.

Haines, A., et al. 2006. Climate change and human health: Impacts, vulnerability and public health. Public Health Journal **120,** 585-596.

Hitz, S., Smith, J., 2004. Estimating global impacts from climate change. Global Environmental Change Journal **14,** 201-218.

IEA, 2002. World Energy Outlook 2002. International Energy Agency Report.

IEA, 2009. World Energy Outlook 2009. International Energy Agency Report.

Jin-ke, L., Feng-Hua, W., Hua-Ling, S., 2009. Differences in coal consumption and economic growth between developed and developing countries. Procedia Earth and Planetary Science **1,** 1744-1750.

Jones, D., 1991. How urbanisation affects energy use in developing countries. Energy Policy Journal, 621-630.

Kanagawa, M., Nakata, T., 2008. Assessment of access to electricity and the socio-economic impact in rural areas of developing countries. Energy Policy Journal **36,** 2016-2029.

Kanagawa, M., Nakata, T., 2006. Analysis of the energy access improvements and its socio economic impacts in rural areas of developing countries. Ecological Economics Journal **62,** 319-329.

Kaygusuz, K., 2011. Energy services and energy poverty for sustainable rural development. Renewable and Sustainable Energy Reviews Journal **15,** 936-947.

Kebede, E., Kagochi, J., Jolly, C., 2010. Energy consumption and economic development in Sub-Sahara Africa. Energy Economics Journal **32,** 532-537.

Kemmler, A., Spreng, D., 2007. Energy indicators for tracking sustainability in developing countries. Energy Policy Journal **35,** 2466-2480.

Kerr, A., Hall, H., Kozub, S., 2002. Doing statistics with SPSS. Sage Publications, London.

Kumar, A., et.al, 2010. Renewable energy in India: current status and future potentials. Renewable and Sustainable Energy Reviews Journal **14,** 2434-2442.

Pereira, M. et.al, 2010. Rural electrification and energy poverty: empirical evidences from Brazil. Renewable and Sustainable Energy Reviews Journal **14,** 1229-1240

Lee, C-C., 2005. Energy consumption and GDP in Developing Countries: A cointegrated panel analysis. Energy Economics Journal **27,** 415-427.

Lloyd, B., Subbarao, S., 2009. Development challenges under the clean development mechanism (CDM)- Can renewable energy initiatives be put in place before peak oil?. Energy Policy Journal **37,** 237-245.

Madlener, R., Sinyak, Y., 2011. Impacts of urbanisation on urban structures and energy demand: what can we learn for urban energy planning and urbanisation management?. Sustainable Cities and Society Journal **1,** 45-53.

Martinez-Zarzoso, T., Marriott, A., 2009. The impact of urbanisation on CO2 emissions; Evidence from Developing Countries. Ecological Economics Journal **70,** 1344-1353.

Mirza, M., 2003. Climate change and extreme weather, Climate Policy Journal **3,** 233-248.

Murota, Y., 1996. Global warming and developing countries. The possibility of a soluation by accelerating development. Energy Policy Journal **24 (12),** 1061-1077.

Nayar, C., Thomas, F., 1991. Design consideration for appropriate wind energy systems in developing countries. Renewable energy **1 (5/6),** 713-722.

Ozturk, I., 2009. A literature survey on energy-growth nexus. Energy Policy Journal **38,** 340-349.

Parikh, J., Shukla, V., 1995. Urbanisation, energy use and greenhouse effects in economic development. Results from a cross national study of Developing Countries. Global Environmental Change Journal **5** (2), 87-103.

Rong, F., 2010. Understanding developing country stances on post 2012 climate change negotiations comparative analysis of Brazil, China, India, Mexico and South Africa. Energy Planning Policy Journal **38,** 4582-4591.

Sagar, A., 2005. Alleviating energy poverty for the world's poor. Energy Policy Journal **33**, 1367-1372.

Sari, R., Soytas, U., 2007. The growth of income and energy consumption in six developing countries. Energy Policy Journal **35,** 889-898.

Shafiee, S., Topal, E., 2009. When will fossil fuel reserves be diminished? Energy Policy Journal **37,** 181-189.

Siddiqi, T., 1995. Energy inequities within developing coutries. An important concern in the global environmental change debate. Global Environmental Change Journal **5 (5),** 447-454.

Silva, D., Nakata, T., 2009. Multi-objective assessment of rural electrification in remote areas with poverty considerations. Energy Policy Journal **37**, 3096-3108.

Sinyak, Y., 1994. Global climate and energy systems. The Science of the Total Environment Journal **143,** 31-51.

The World Bank, 2008. The World Development Report 2008. Washington, DC.

Tol, R., et.al. 2004. Distributional aspects of climate change impacts. Global Environmental Change Journal **14,** 259-272.

UN, 2011. The Millennium Development Goals Report. New York.

UNDP, 2009. The energy access situation in Developing Countries. A review focusing on the least developed countries and Sub-Saharan Africa. UNDP New York.

UNDP, 2010. UNDP and energy access for the poor. UNDP New York.

Urban, F., 2007. Modelling energy systems for developing countries. Energy Policy Journal **35,** 3473-3482.

Vera, I., Langlois, L., 2007. Energy indicators for sustainable development. Energy Journal **32,** 875-882.

Wamukonya, N., Davis, M., 2001. Socio-economic impacts of rural electrification in Namibia: Comparisions between grid, solar and unelectrified households. Energy for Sustainable Development Journal **V (3).**

Wang, X., Feng, Z., 2003. Energy Consumption with sustainable development in developing country: a case in Jiangsu, China. Energy Policy Journal **31,** 1679-1684.

Williams, R., 1993. Options for the control of CO2 emissions in developing countries. Energy Conservation Management Journal **34 (9-11),** 719-727.

Wolde-Rufael, Y., 2005. Energy demand and economic growth: The African experience. Journal of Policy Modeling **27,** 891-903.

Wuebbles, D., Jain, A., 2001. Concerns about climate change and the role of fossil fuel use. Fuel Processing Technology Journal **71,** 99-119.

Yaron, G., Forbes, I., Jansson, S., 1994. Solar energy for rural communities. The case of Namibia. Intermediate Technology Publications, SRP Exeter.

Zidansek, A., et.al. 2009. Climate changes, biofuels and the sustainable future. Internation Journal of Hydrogen Energy **34,** 6980-6983.