Climate Change and the Built Environment Perspective of Climate Change – A Case study of Asaba.

Isiwele, A. J. and Akhimien, N. G.
Department of Architecture, Ambrose Alli University, Ekpoma, Nigeria.
E-mail: isijoe51@yahoo.com, lonewolfgann@yahoo.com

Abstract
The uncontrollable increase in human activities from population, ecology, the built environment and waste disposal system are all threats to the climate. It is no news that our world is continuously undergoing changes in all ramifications, this changes most of the time are detrimental to our climate. According to current findings, indoor and outdoor activities like heating, burning, cooking, cooling and other physical activities release intensive energy emissions that can disrupt the climate of a place. Our day to day activities has change the world we live in and therefore has altered the climate. This paper therefore aims at investigating the built environment as it relates to physical climate of the environment. Information were gathered from case studies, and useful literature materials such as books, magazines, journals and the internet was also very instrumental and was consulted in the course of the study in descriptive method of analysis based research. In addition questionnaires were distributed to professionals of the building industrial in Asaba to ascertain their level of awareness of climate change. The entire world is at risk, the continents are in a continues drift (continental drift), the seasons are no longer consistent, there is an uncontrolled rise of sea levels leading to flood and tsunami, the weather is harsh and the days are unpredictable, All of these points to climate change of the built environment. Experts of the built environment need to come up with new innovation for the survival of the environment and its inhabitance. It is no news that the world in the year 3000 will be allot different from the one we live in now, sustainable ideas and design strategies are profound ways to escape the plague that is before the earth. Findings from data collected and study indicates that 71% of people still use incandescent bulbs, 92% use petrol generators and another 28% use candles and other crude source for power generation. Built up environment without the integration of the ecosystem will amount to a failed act of procreation. The study recommends the design and building of a more ecologically balanced and sustainable environment that is friendly to the natural environment and could adapt to the change in climate.

Keywords: Climate change, Natural environment, Sustainability.

1. Introduction

A significant part of the man-made environment which avails a platform for human day to day activities is the man-made or built environment. The natural features of the environment metamorphose on a chain of renewal and recycling to maintain ecological balance in a bid of adding to population growth, globalization, industrialization, agricultural revolution and other aspect of human endeavour. The diversification of human and natural activities stands the complexity of an unforeseen gaseous reactions as in the mechanism of greenhouse effect.

The term '*greenhouse effect'* refers to the natural process whereby a required amount of the sun's energy is trapped within the atmosphere by greenhouse gases (GHG) to warm the earth and sustain life. Increase in human activities particularly the burning of fossil fuels in recent times keeps increasing the concentration of GHG with a resultant increase in the earth's temperature. The earth's average surface temperature is now within the range of 0.6-0.8°C and projected increase between 1990 and 2100 is put at 1.4 to 5.8°C (Ewings, 2008, Knight & Whitmarsh, 2009).Carbon dioxide (CO2), an important and most common greenhouse gas (Karpagam, 2003; Bhatia, 2006) is significantly increasing the earth's temperature to give rise to a state of global warming.

There are many forces responsible for shaping the earth climate. Operating and interacting at different scales in time and geographic space, these include (McMullen and Jabbour 2008): variations in radiation emitted from the sun (e.g., sun spot activity), the cyclical behaviour of the Earth's orbit and axis, changes in the gas composition of the atmosphere, volcanism, uplifting and wearing away of land surfaces, shifting distribution of landmasses and oceans caused by plate tectonics, and changes in the characteristics of the Earth's land surface. Evidence indicates that the Earth is currently going through an accelerated period of global warming. Increases in anthropogenic emissions of gases (e.g., carbon dioxide, methane) into the atmosphere, and an enhanced greenhouse effect, are considered to be the major driving force behind the accelerated global warming that has taken place over the last century. Since the introduction of the United Nations Framework Convention on Climate Change in 1994 few countries have been able to reduce gas emissions. Trends for the states and provinces associated with the Gulf of Maine indicate an increase in GHG emissions over the last decade (Environment Canada 2008; Regional Greenhouse Gas Initiative 2009). Global warming produces adverse weather consequences and unpredictable changes in the global climate, therefore, climate change has been responsible for of heat waves, inconsistent weather conditions, floods, droughts, rise of sea levels, melting glaciers, fluctuating agricultural yields and intensive solar radiations. At present, roughly 50 percent of the world‘s population live in cities, but this figure is expected to rise over the years. Most of the future growth of the urban population is anticipated in the developing world. Many low-income countries are already exposed to shortages of clean drinking water and poor sanitation, and often occupy high-risk areas such as floodplains and coastal zones, Haines, A., R. S. Kovats, D. Campbell-Lendrum & C. Corvalan (2006). As the concentration of urban populations is increasingly mixed up with growing risks of extreme events, millions of naira is lost and the cost is increasing by the day. The significant contribution made by the world‘s major cities to global climate change and the urgent need for energy efficient infrastructure and changed patterns of resource consumption is notable (Hunt, 2004). With such a range of issues to tackle, it is not surprising that there have been calls for wider participation and more effective interaction between complementary disciplines (Oke, 2006).

Buildings are designed to have at least a minimum resistance to the loads that act on the structure, and on building parts such as roofs and cladding. These loads are partially determined by climate effects. Changes in climate therefore may have consequences in the design of newly built structures, as well as the resistance in the existing building stock. Climatic actions on buildings – such as wind, temperature, rain and snow - have intensities that vary in time. Increasing the lifetime of a structure therefore increases the probability that, in a given time frame, the intensity of one of these actions will exceed the value assumed in the design. In order to work on a rational base, a conventional 'design life' for different types of structures must therefore be defined. The working life increases with the importance of the structure. In building codes, these definitions are given. The European standard for structural safety, EN 1990, uses 50 years for building structures and common structures and 100 years for monumental building structures, bridges and other civil engineering structures. Processed products and services. Climate change is a physical process that is dependent on humans. The availability and quality of natural resources (e.g., air, land, water, biota, and materials) any changes in the physical characteristics of the environment will be re4ected by cumulative, interacting social and economic impacts. Their intensity and frequency will not be the same due to variations in Site-specific characteristics (Sniffer 2009). Coastal areas and communities will be amongst the highest at risk because of their proximity to the sea. The direct risks and impacts of climate change will depend largely on the density of human populations and characteristics of settlements on the coastal strip (Lemmen DS, Warren FJ, Lacroix J, and Bush E (eds). 2008). Average population density along the coastline is relatively low, but high densities occur in coastal cities (e.g., Boston and Portland). The Gulf of Maine has a wide range of human settlements and development over its coastline and population density is expected to increase, particularly in areas close to the larger coastal cities over the next 30 years (Pesch and Wells 2004). The potential risks and impacts of climate change on human society have been identi5ed at global and regional levels for both Canada and the United States (Lemmen et al, 2008; Climate Change Science Program 2008; US Global Change Research Program 2009; Jacobsen 2009). These relate to human well-being, disruption of infrastructure and networks, access to goods and services, and adaptive capacity of communities to deal with the issue. Not all potential impacts can be classi5ed as negative as there are positive aspects that have been cited. It is difficult to measure many of the impacts, although some impacts can be evaluated in financial terms. For instance, the costs of storm and hurricane damage on coastal areas can be extremely high, as evidenced by estimates for Hurricane Katrina, the most costly natural disaster in US history, which generated damage in excess of US$100 billion (commercial structure damages of $21 billion, commercial equipment damages of $36 billion, residential structure and content damages of almost $75 billion, electric utility damages of $231 million, highway damages of $3 billion, sewer system damages of $1.2 billion and commercial revenue losses of $4.6 billion) (Burton and Hicks 2005). By comparison, in a less populated area the estimated costs of Hurricane Juan, which passed over Nova Scotia in 2003, amounted to CAD$200 million (Lemmen 2008).

3. Study Area

Delta state, Asaba, Nigeria with a population of about 3,218,332 million (NPC 2006) and with a growth rate about 1.5% with co-ordinates 6.20590N, 6.69590E, (Google earth, 2016). Asaba is a town, strategically located on a hill at the western edge of the Niger River, overlooking its sister city, Onitsha, an economic hub, across the Niger Bridge. It is the capital of Nigeria's Delta State. A fast developing urban area, Asaba has an estimated population of 150,032 (2006 census) and a cosmopolitan population of over half a million people. Asaba lies approximately 60 degrees north of the equator and about the same distance east of the meridian; about 160 kilometers (100 mi) north of where the River Niger flows into the Atlantic Ocean. The greater Asaba occupies an area of about 300 square kilometers. It maintains an average tropical temperature of 32 °C during the dry season and an average fertile rainfall of 2,700 millimeters (106 in) during the rainy season, Wikipedia (2016). These statistics are clear indications of the need to take proactive steps to monitor the current rate of GHG emission which will increase and further increase the world GHG emission. The study covered the South Local Government Area of Delta state. The Local government has a total population of 302,673 and households population of 667 according to local authorities. The choice of this settlement was informed by the physical features of the ecology zone, the residence include, low, medium and high density all living together in the area. This residential mix captures the energy supply, consumption, and use which of essence to this study. Over 110 questionnaires were randomly distributed to the residents, 77 copies were accurately completed for analysis.

2. Literature Review

Scott (2005) observed that many studies worldwide have analyzed the climate sensitivity of energy use in residential, commercial, and industrial buildings, and have used estimated relationships to explain energy consumption and to assist energy suppliers with short-term planning (Quayle and Diaz, 1979; Le Comte and Warren, 1981; Warren and LeDuc, 1981; Downton, 1988; Badri, 1992; Lehman, 1994; Lam, 1998; Yan 1998; Morris, 1999; Pardo, 2002). The number of studies in the United States analyzing the effects of climate change on energy demand, however, is much more limited. One of the very early studies was of the electricity sector and climate projected to 2010 - 2055, indicating that climate change could increase capacity requirements by an additional 14% - 23% relative to non-climate change scenarios, requiring investments of $200 billion – $300 billion ($1990) (Linder, 1990). Following on that study, in the early and mid-1990s, there was a handful of studies that attempted an "all fuels" approach and focused on whether net energy demand would go up or down in residential and commercial buildings as a result of climate change (Loveland and Brown 1990; Scott 2004; Rosenthal 1995; Belzer 1996), while a smaller number focused on other climate sensitive uses of energy such as agricultural crop drying and irrigation pumping (Darmstadter 1993; Scott 1993).
Previous authors have taken different approaches to estimating the impact of climate change on energy use in U.S. buildings. Most of these researchers used simple uniform increases in annual average temperature as the "climate" scenario, and did not focus on transient temperature increase scenarios from General Circulation Model (GCMs). Previous research has used building energy simulation models to analyze the impact of climate warming on the demand for energy in individual commercial buildings (Scott 1994) and on energy consumption in a variety of commercial and residential buildings in a variety of locations (Loveland and Brown 1990; Rosenthal, 1995). Additionally, there has been research that used econometrics and statistical analysis techniques (most notably, the Mendelsohn papers discussed below, but also Belzer 1996, Amato 2005, Ruth and Amato 2002, and Franco and Sanstad 2006). Another recent study "mapped" the climate changes in scenarios on top of existing weather files for 16 U.S. locations, and then used building energy simulations of prototypical commercial and residential buildings to analyze the impact of those climate changes on building energy use (Huang 2006).

Mendelsohn performed cross-sectional analyses to determine how energy use in the residential and commercial building stock relates to climate (Morrison and Mendelsohn 1999; Mendelsohn 2001), and he then used the relationships to estimate the impact of climate change in the year 2060 on all residential and commercial buildings. Mendelsohn (2003) used a two-step cross sectional model of the commercial and residential building stock, which uses U.S. data and accounts for the probability that a building is being cooled (which increases with the amount of warming), and its overall energy consumption as a function of climate (matched on a county level to the Energy Information Administration (EIA) buildings in the Residential Energy Consumption Survey (RECS) (US DOE 2005) and Commercial Building Energy Consumption Survey (CBECS)) (US DOE 2007). This was further elaborated by Mansur (2005) into a complete discrete continuous choice model of energy demand in residential and commercial buildings separately. In this analysis, when natural gas is available, the marginal impact of a 1°C increase in January temperatures in their model reduces residential electricity consumption by 3% and natural gas by 2%. Scott (2005), working with end uses rather than fuels, projected about a 16% to 60% reduction in the demand for residential space heating energy by 2080, given no change in the housing stock and winter temperature increases ranging from 2°C to 10°C, or roughly a 6% and 8% decrease in space heating per degree increase. Thus far, studies on building cooling and energy demand have been based on simplified analyses using constant increases in annual average temperature or changes in cooling degree days. These results may be inaccurate and insufficient in detail needed to quantify climate change impacts of different building energy technologies.

4. Discussions

Climate change has often been described as "one of the most pressing environmental challenge." Our lifestyles, our economies, our health and our social well-being are all affected by climate. Changes in climate have the potential to impact all regions of the world and virtually every economic sector. Although impacts will not be evenly distributed around the globe, all countries will need to deal, in one way or another, with climate change. There are a number of factors that drive climate variability. These include changes in the Earth's orbit, changes in solar output, sunspot cycles, volcanic eruptions, and fluctuations in greenhouse gases and aerosols. These factors operate over a range of time scales but, when considered together, effectively explain most of the climate variability over the past several thousand years. These natural drivers alone, however, are unable to account for the increase in temperature and accompanying suite of climatic changes observed over the 20th century. A more resilient built environment will be a key element in the creation of places and communities that are more resilient to the effects of climate change, and in the protection of the people living in and using them. A programme for increased resilience will need to look at the existing built environment, at new buildings and at opportunities for change within existing communities. Over the last century, global mean surface temperature has risen by about 0.6ºC. Although not unprecedented, this rate of warming is likely to have been the greatest of any century in the last thousand years. All regions of the world have not warmed by the same amount; certain areas have warmed much more than others, and some comparatively small areas have even experienced cooling. The timing of warming has also been variable. Most of the warming occurred over two distinct time periods of the 20th century there have been seasonal differences in the amount of warming observed and night-time minimum temperatures have increased by about twice as much as daytime maximum temperatures. This warming observed over the 20th century has been accompanied by a number of other changes in the climate system. For example, there has very likely been an increase in the frequency of days with extremely high temperatures, and a decrease in the number of days of extreme cold. Global sea level has risen, while sea-ice thickness and extent has decreased. The extent of snow and ice cover has very likely declined, and permafrost thickness has decreased in many northern areas. In the northern hemisphere, annual precipitation has very likely increased and heavy precipitation events have likely become more common. Why have these changes in climate been occurring? Much research has addressed this question, and the answer has become increasingly confident over time: "most of the warming observed over the last 50 years is attributable to human activities." That is to say that recent changes in climate can only be explained when the effects of increasing atmospheric concentrations of greenhouse gases are taken into account. Although the uncertainty associated with projecting future changes in precipitation is greater than for temperature, average annual precipitation is generally expected to increase and changes in precipitation patterns are likely. For instance, heavy precipitation events are expected to become more frequent, and there are likely to be larger year-to-year variations in precipitation. Seasonal differences will also be important, as most models suggest that there will be less precipitation during the summer months, but increased winter precipitation over most of Canada. Seasonal changes in precipitation patterns are expected to be more important than changes in annual totals in terms of impacting human activities and ecosystems.

The probability of extreme climate events will also change in the future. Such changes would occur whether there is a shift in mean values (e.g., such as is projected for annual temperature), a change in climatic variability, or both Increases in the frequency of extreme climate events are one of the greatest concerns associated with climate change. Such extreme events include heat waves, droughts, floods and storms.

It will need to consider both public and private action, as most of the built environment is privately owned. It will also have to consider both barriers to and opportunities for early action, e.g. where decisions need to be made now on new build and refurbishment. Although buildings can be modified later to help them withstand changing climatic conditions, their location, the way they are built and the way in which structural changes are carried out can make this easier or more difficult to accomplish. Currently, many existing buildings are maladapted. In other words, the way they have been built increases their potential vulnerability to the effects of climate change. Moreover, in some cases it is not considered cost-effective to modify existing buildings so that they can cope with a changing climate. Baum, S, Horton, S, Low Choy, D, Gleeson, B, 2009, in studying the climate change, health impacts and urban adaptability of Queensland's Gold Coast, makes a simple distinction between mitigation and adaptation, where 'climate friendly' development (mitigation) leads to low greenhouse gas emissions and 'climate safe development (adaptation) leads to low vulnerability to direct (temperature and water) and indirect (flooding, saline intrusion) effects of climate change. While mitigation efforts are clearly important in terms of slowing the rate of climate change, given the climate system has already changed, and will continue to do so irrespective of mitigation efforts, at least in the short to medium term, investment in climate change adaptation is a prudent course of action.

An adaptation approach acknowledges that there will be a need to adjust to unavoidable climate change to minimize building and infrastructure upkeep costs and maintain healthy ecosystems and livable urban areas. Importantly, strategies for adapting to unavoidable climate change impacts must not undermine mitigation efforts to stabilize greenhouse gas emissions to acceptable levels. Likewise, strategies for mitigation have the potential to be 'maladaptive' if they compromise adaptation. For instance, one possible side effect of improving the energy efficiency of dwellings is an increase in summer overheating of well-insulated, airtight dwellings, Hacker, J.N, Belcher, SE, Connell, RK (2005).

Buildings are designed to have at least a minimum resistance to the loads that act on the structure, and on building parts such as roofs and cladding. These loads are partially determined by climate effects. Changes in climate therefore may have consequences in the design of newly built structures, as well as the resistance in the existing building stock. Climatic actions on buildings – such as wind, temperature, rain and snow - have intensities that vary in time. Increasing the lifetime of a structure therefore increases the probability that, in a given time frame, the intensity of one of these actions will exceed the value assumed in the design. In order to work on a rational base, a conventional 'design life' for different types of structures must therefore be defined. The working life increases with the importance of the structure. In building codes, these definitions are given. The European standard for structural safety, EN 1990, uses 50 years for building structures and common structures and 100 years for monumental building structures, bridges and other civil engineering structures.

The physical processes that cause climate change are scientifically well documented: both human activities and natural variability are contributing to global and regional warming. According to the Intergovernmental Panel on Climate Change, whose documents are considered the most authoritative source for information on the "state of the science" on climate change, it is very likely that *most* of the observed warming over the past 50 years is the result of increased greenhouse gases generated by human activities. Numerous expert reports from the National Research Council have supported this conclusion as well. The release of greenhouse gases has increased significantly since the Industrial Revolution, mostly from the burning of fossil fuels for energy, agriculture, industrial processes, and transportation. Carbon dioxide, a major greenhouse gas, is increasing in the atmosphere faster than at any time measured in the past, having grown by about 35 percent since 1850. Two other greenhouse gases, methane and nitrous oxide, are present in the atmosphere at much lower concentrations than carbon dioxide but have increased rapidly. Methane has increased by 150 percent; in addition, it is 25 times more effective per molecule at trapping heat than carbon dioxide. Nitrous oxide, nearly 300 times more effective, has increased by more than 20 percent. Much remains to be learned about the factors that control the sensitivity of climate to increases in greenhouse gases, rates of change, and the regional outcomes of the global changes. Although scientific knowledge of climate is far from complete, the uncertainties concern the details: the scientific community is highly confident in the basic conclusions.

Many adaptive actions can be taken by individuals, households and businesses as they independently adjust to their circumstances due to experiences or perceptions about climate risk. This can include putting in place short-term adjustments to practices or infrastructure such as changing crop planting dates, or implementing flood protection measures for individual houses and businesses. These autonomous adaptation actions can offset some of the negative impacts of climate change, and often take place without the active intervention of policy. However, autonomous adaptation is unlikely to be optimal as there will be missed efficiency gains that would accrue from concerted actions and autonomous adaptation action in one sector may have unintended adverse impacts for other sectors, resulting in maladaptation. Maladaptation occurs when an adaptation action or investment increases, rather than reduces, overall vulnerability to climate change impacts. An example of maladaptation could be an increased focus on provision of air-conditioning in new buildings to manage increased temperatures rather than improved building techniques that will maintain comfortable temperatures. Many adaptation measures to date have been reactive in nature, taken directly to respond to extreme weather events that have occurred. Given the increased knowledge of climate change impacts, it is now necessary to develop adaptation planning so that we are better placed to deal with future events. Unlike autonomous adaptation, this planned approach to adaptation is the result of a deliberate policy decision, based on the awareness that conditions have changed or are expected to change, and that some form of action is required to reduce risk or avail of opportunities. By planning and anticipating climate impacts, it is possible to reduce the cost and maximize the effectiveness of adaptation actions. Adaptation of our built environment and the adoption of ecological designs could be a major remedy to the dangers posed by climate change.

5. Conclusion and Recommendation

It can be observed that the earth will continue to change its configuration to be stable, climate change is projected to result in changes in temperature, rainfall patterns and sea levels, as detailed in the UK Climate Projections analysis. The Climate Change Risk Assessment (CCRA) has completed an assessment of a variety of impacts for which this sector may need to prepare. Some of the key points from this assessment are summarized here. The results of climate change take account of changes in society (e.g. population growth, building population and developments in new technologies) Work on adapting to our changing climate most of the time is taking with levity – either as a process of specific adaptation or relevant work that is being carried out for other purposes not necessarily under the banner of “adaptation”. The challenge now is to ensure that these actions are complementary and that they all come together to ensure that our environment is as prepared as possible to manage the impacts of climate change and make the most of the opportunities that are likely to arise. Enough high quality data and information exists to begin and inform the adaptation planning process now. Sufficient information sharing and dissemination systems are being developed which can be used to inform many levels of decision-making. There should be a National Climate Change Adaptation Framework designed to provide a strategic policy to focus across all tiers of Government to ensure adaptation measures are taken across different sectors and levels of governance to reduce vulnerability to the impacts of climate change. Similar to the approach being taken by the EU in its *White Paper on Adaptation*, which will be further elaborated in the EU Adaptation Strategy to be published in spring 2013, it is proposed that this framework follows a two-phase approach to adaptation.

Phase 1 - this should focused on increasing our understanding the impacts and national vulnerabilities associated with climate change. A substantial amount of information already exists, which should be put into practice. Awareness of the dangers of climate change on the built environment should guide developmental programs which should be one of a major consideration.

Phase 2 - will focus on the development and implementation of sectorial and local adaptation action plans which will form the key pillars of the comprehensive national response to climate change adaptation. The plans will be informed by the outcome of Phase 1, including guidelines on the development of local adaptation plans, as well as a number of other resource tools, and will build on the progress made in terms of awareness and integration. Commencement of work in Phase 2 is not dependent on completion of work in phase one and so can begin immediately. It is therefore of great essence that policies are put in place and implemented considering sustainability and adaptation of the physical environment in the building of cities, towns and the built environment in general.

References

Amato A.D., M. Ruth, P. Kirshen and J. Horwitz. 2005. Regional Energy Demand Responses to Climate Change: Methodology and Application to the Commonwealth of Massachusetts. *Climatic Change* (2005) 71: 175–201

Badri, M. A. 1992. "Analysis of demand for electricity in the United States", Energy 17(7), 725–733.

Baum, S, Horton, S, Low Choy, D, Gleeson, B, 2009, 'Climate Change, Health Impacts and Urban Adaptability: Case study of Gold Coast City', *Urban Research Program Research Monograph 11*

Belzer, D.B., Scott, M.J. and Sands, R.D. 1996. *"Climate Change Impacts on U.S. Commercial Building Energy Consumption: An Analysis Using Sample Survey Data," Energy Sources 18*, 177–201.

Hacker, J.N, Belcher, SE, Connell, RK (2005). Beating the Heat: Keeping UK buildings cool in a warming climate, *UK Climate Impacts Programme briefing report.* Oxford: UKCIP,

Downton, M. W., T.R. Stewart, et al. 1988. *"Estimating Historical Heating and Cooling Needs: Per Capita Degree-Days," Journal of Applied Meteorology 27*(1), 84–90.

Ewings, S. (2008). *Global warming: What you can do*. Retrieved March 7, 2010 from http://www.global-greenhouse-warming.com/

Franco, G. and A.H. Sanstad. 2006. *Climate Change and Electricity Demand in California.* CEC-500-2005-201-SF. California Energy Commission, Sacramento California.

Haines, A., R. S. Kovats, D. Campbell-Lendrum & C. Corvalan (2006). Climate Change and Human Health: Impacts, Vulnerability, and Mitigation. *Lancet* 367 (9528): 2101–2109.

Huang, Y.J. 2006. The Impact of Climate Change on the Energy Use of the US Residential and Commercial Building Sectors. LBNL report, Lawrence Berkeley National Laboratory, Berkeley, CA.

Hunt, J. (2004). How can cities mitigate and adapt to climate change? *Building Research and information, 32*, pp.55-57

IPCC (Intergovernmental Panel on Climate Change), 2007. *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Metz, B., O.R. Davidson, P.R. Bosch, R. Dve, L.A. Myer (eds)], Cambridge, U.K. and New York, NY, U.S.A., Cambridge University Press, 2007.

Karpagam, M. (2003). *Environmental economics a textbook*. New Delhi: Sterling Publishers Private Limited.

Lam, J. C. 1998. "Climatic and Economic Influences on Residential Electricity Consumption", *Energy Conversion Manage*. 39(7), 623–629.

Le Comte, D. M. and H.E. Warren. 1981. "Modeling the Impact of Summer Temperatures on National Electricity Consumption", *J. Appl. Meteorol*. 20, 1415–1419.

Lehman, R. L. 1994. "Projecting Monthly Natural Gas Sales for Space Heating Using a Monthly Updated Model and Degree-Days from Monthly Outlooks", *J. Appl. Meteorol*. 33(1), 96–106.

Lemmen DS, Warren FJ, Lacroix J, and Bush E (eds). 2008: From Impacts to Adaptation: Canada in a Changing Climate 2007, Government of Canada, Ottawa, ON, 448 pp.

Loveland, J.E. and Brown, G.Z.: 1990, *Impacts of Climate Change on the Energy Performance of Buildings in the United States*, OTA/UW/UO, Contract J3-4825.0, Washington, DC, U.S. Congress, Office of Technology Assessment.

Mansur, E.T., R. Mendelsohn, and W. Morrison. 2005. *"A Discrete-Continuous Choice Model of Climate Change Impacts on Energy."* SSRN Yale SOM Working Paper No. ES-43 (abstract number 738544), Submitted to Journal of Environmental Economics and Management.

McMullen CP and Jabbour J (eds). 2009. Climate Change Science Compendium. UN Environmental Programme, Geneva. 72 pp.

Mendelsohn, Robert. 2003. ″The Impact of Climate Change on Energy Expenditures in California.″ Appendix XI in Wilson, T., and L. Williams, J. Smith, R. Mendelsohn, *Global Climate Change and California: Potential Implications for Ecosystems, Health, and the Economy*. Consultant report 500-03-058CF to the Public Interest Energy Research Program, California Energy Commission, August. http://www.energy.ca.gov/pier/final_project_reports/500-03-058cf.html

Morris, M. 1999. *The Impact of Temperature Trends on Short-Term Energy Demand*, EIA 2001.

Oke, T.R. (2006). Towards better scientific communication in urban climate. *Theoretical and Applied Climatology*, doi:10.1007/s0074-005-00153-0.

Pardo, A., V. Meneu et al. 2002. "Temperature and Seasonality Influences on the Spanish Electricity Load", *Energy Econ.* 24(1), 55–70.

Pesch GG and Wells PG 2004. Tides of Change across the Gulf. Prepared for the Gulf of Maine Summit: Comitting to Change. Gulf of Maine Council and the Global Programme of Action Coalition for the Guf of Maine. 81p. www.gulfofmaine.org.

Quayle, R. G. and Diaz, H. F.: 1979, "Heating Degree-Day Data Applied to Residential Heating Energy Consumption", *J. Appl. Meteorol*. 19, 241–246.

Rosenthal, D.H., Gruenspecht, H.K., and Moran, E.: 1995, *Effects of Global Warming on Energy Use for Space Heating and Cooling in the United States*, Washington, DC, U.S. Department of Energy.

Ruth, M., and Amato, A.D.: 2002, *Regional Energy Demand Responses to Climate Change: Methodology and Application to the Commonwealth of Massachusetts*, College Park, MD, Environmental Policy Program, School of Public Affairs, University of Maryland.

Scott, M. J., R.D. Sands, L.W. Vail, J.C. Chatters, D.A. Neitzel, and S.A. Shankle. 1993. *The Effects of Climate Change on Pacific Northwest Water-Related Resources: Summary of Preliminary Findings*. PNL-8987. Pacific Northwest Laboratory, Richland, Washington.

Scott, M.J., Hadley, D.L., and: Wrench, L.E. 1994, "Effects of Climate Change on Commercial Building Energy Demand", *Energy* 16(3), 339–354.

Sniffer 2009 Differential impacts of climate change in the UK. Scotland and Northern Ireland Forum for Environmental. Research. Literature Review, Project UKCC22. 85pp. http://www.sniffer.org.uk

Warren, H. E. and LeDuc, S. K. 1981. "Impact of Climate on Energy Sector in Economic Analysis", *J. Appl. Meteorol*. 20, 1431–1439.

Yan, Y. Y.1998, "Climate and Residential Electricity Consumption in Hong Kong", *Energy* 23(1); 17–20.