18TH ANNUAL PACIFIC-RIM REAL ESTATE SOCIETY CONFERENCE
ADELAIDE, AUSTRALIA, 15-18 JANUARY 2012

A REVIEW ON 10 COUNTRIES' SUSTAINABLE HOUSING POLICIES TO COMBAT CLIMATE CHANGE.

RITA YI MAN LI[1]

Hong Kong Shue Yan University

ABSTRACT

The recent extremely cold weather in United Kingdom and United States, flooding in Australia, Pakistan and India remind us the problem of global warming. Politicians, green groups, building professionals and general public are finding the ways out. What have our housing policy makers done to combat inevitable climate change and reduce the greenhouse gases emission by energy reduction? This paper reviews 1) the factors which lead to global climate change, 2) general overview on 10 countries' recent housing policies which are designed to combat climate change, 3) cost and benefit analysis of the abovementioned housing policies.

Keywords: global warming, climate change, sustainable development, housing policies

INTRODUCTION

Until 1950, natural factors, including solar radiation variations and dust produced by volcanoes, were the dominant causes of temperature change. Human-induced changes have become the leading cause of climate change thereafter. Previous research shows that there was an increase in global mean temperature of approximately 0.5 degrees Celsius from 1950 to 2000 (Li, 2009). Global climate change affects agriculture, ecosystem, energy demand, coastal zone inundation, human health and water supplies etc. For example, differences in water temperature and salinity produce the Gulf Stream and other currents which bring warm surface water to the North Atlantic. The climate in northern Europe becomes significantly colder. The heavy unexpected heavy snowfall this year may be one of the vivid evidence of global climate. Freights of European countries were cancelled early this year. Table 1 illustrates the details of the possible impact due to global climate change. In view of the serious impact associated with climate change, scientists identify some of the possible solutions to eliminate or reduce the threat of greenhouse warming (Table 2). The 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change and some other similar reports suggest that there is a need for greenhouse gas emission reductions in developed countries of approximately 80 to 90% by 2050 avoid an

[1] Email: ritarec1@yahoo.com.hk

unacceptable risk of global warming of up to 3°C (Chapman, 2008). To prevent the global greenhouse gas accumulated, low carbon policy implementation has gained much weight in policy making nowadays (While, 2008). The private household consumption, resource use and the corresponding environmental impacts are identified as key aspects in sustainable development (Holden and Norland, 2005). While the goal of carbon emission reduction has always been considered as the core part of sustainable development, making genuine progress on a low carbon economy poses regulatory challenges for governments (While, 2008). Much of the current approach has been relied on a mixture of voluntary measures, fairly weak direct regulation and market-based incentives (While, 2008). Today, Policies and programs which aims at enhancing energy efficiency often change over time to meet the needs of our society (Philippa et al., 2009), residential sector is one of them.

Table 1 Possible Climatic Consequences of Higher Global Temperatures (McKibbin and Wilcoxen, 2002).

Climatic consequence	**Details**
Atlantic circulation	Differences in water temperature and salinity produce the Gulf Stream and other currents that bring warm surface water to the North Atlantic. Without these currents, the climate in northern Europe would be significantly colder. Current climate models show that this circulation is likely to weaken over the next 100 years, but not enough to cause a negative net temperature change in Europe: the increase due to global warming exceeds the reduction due to changes in currents.
Decomposition of methane hydrates	Deep ocean sediments contain an enormous reservoir of methane in the form of frozen deposits called hydrates. If ocean temperatures warmed enough to allow these deposits to thaw, there would be a dramatic increase in atmospheric greenhouse gas concentrations. However, recent studies indicate that the temperature changes expected from global warming over at least the next 100 years will be too small to trigger such an event.
Extreme weather events	Increase in frequency of heat waves; higher risk of summer droughts in continental areas at mid altitudes; more intense level of precipitation.
Patterns of precipitation	Increase in average global evaporation and precipitation. There is however, a substantial regional variability.
Tropical storm intensity	Higher wind speed and more intense precipitation in cyclones, hurricanes as well as typhoons.

Table 2 Possible ways to eliminate the threat of greenhouse warming (Nordhaus, 1991).

Method to solve global warming	Details
Reduce emissions and concentrations of greenhouse gases.	1. Reduce energy consumption 2. Reduce GHG emissions per unit of energy consumption 3. Shift to low-carbon dioxide fuels 4. Find substitutes for CFCs 5. Remove greenhouse gases from atmosphere 6. Plant more trees
Offset climatic effects.	1. Climatic engineering; shoot particles into the stratosphere 2. Fertilize the ocean with trace iron
Adapt to warmer climate.	1. Central governmental policies 2. Build dikes to prevent ocean's invasion 3. Land use regulations 4. Research on crops which can tolerant drought 5. Market adaptations 6. People migrate to new temperate zones 7. Corn belt migrates to Siberia and Canada

CLIMATE CHANGE AND PROPERTY PRICE

The basic economic axiom assumes that men are selfish, individuals choose to live in a place where they can maximise their net benefits. Living in climatically different places implies a consumption of different types of goods. Because of this reason, housing price differentials exist in these regions (Li, 2009). The study on the impact of climate on housing price was firstly introduced in early 1980s. It was found that an increase in rainfall decreases housing prices. Home buyers who live in heavy rainfall regions are willing to pay less, however, they are willing to pay a higher price for one-degree-Celsius rise in temperature. Previous study estimated increases in price of 298.28 pounds per dwelling for a one-degree-Celsius increase in annual mean temperature. Thus, global warming might benefit British home sellers (Li, 2009).

GLOBAL HOUSING POLICIES COMBAT CLIMATE CHANGE

Housing, an essential aspect of quality of life, plays a significant role in sustainable development. Many of the major international statements on sustainable development nowadays include housing or settlement strategies. Sustainable housing is linked to a number of considerations. It includes location selection, design, construction,

management, maintenance and use of housing. Since the use of housing entails consumption of water and energy as well as waste production, all these can be reduced by good design of housing and facilities inside (Winston and Eastaway, 2008). Over the past few years, the ever increasing requirements in environmental laws and soaring energy prices increase the need for efficient and sustainable housing construction to reduce energy consumption, as well as upgrading the existing housing to energy efficient and environmentally friendly design. Current residential construction in regulations countries such as Australia, New Zealand and the USA usually incorporate the criteria to ensure both design and construction materials have to attain certain level of energy efficiency and sustainability while existing housing stock built prior certain period of time is unaffected (Eves and Kippes, 2010).

In 2009, the Australia government has opted for voluntary schemes to improve the energy efficiency and sustainability of older housing blocks, such as the solar hot water schemes and the home insulation scheme (Eves and Kippes, 2010). Besides, the Green Building Council has developed Green Star environmental rating system. It evaluates the environmental design and construction of buildings. Nowadays, approximately one-tenth of Australia's CBD commercial office buildings are Green Star certified (French et al., 2007).

New Zealand has imposed thermal insulation requirement in new houses since 1 April 1978 (French et al., 2007). Warm Homes Energy Check was introduced and implemented among the new housing stocks in 2002 (Eves and Kippes, 2010). Nowadays, household heating system efficiency gains serve three major intersecting objectives: reduce CO2 emissions, reduction improved health, and energy security. Some of the benefits are recorded in the New Zealand Energy Efficiency and Conservation Strategy: insulating our homes keeps us healthier and warmer (Philippa et al., 2009). The other two climate zones cover the remaining area of the North Island. These thermal insulation requirements apply only to new houses. Older houses are not required to upgrade to the current standard, but in some cases roof and floor insulation has been voluntarily installed. Houses are typically stand-alone with one or two levels (French et al., 2007).

Denmark has regarded as the forefront of environmental and energy development for many years and the Danish architectural professionals play an active role in this process. While the European Union Energy Performance of Buildings Directive (EPBD) provides a common energy savings framework in the building sector, the Denmark BPBD was implemented by introducing a new chapter on Energy.

Consumption in the Building Regulations in 2006 provides much broader low-energy requirements:

•It aims at keeping the room temperature at 26 Degree Celcius or below, standard cooling equipment are considered.

• Energy consumption in mechanical cooling, domestic hot water, space heating and building services is covered.

• A building's own renewable energy production in both photovoltaics and solar thermal is taken into account (Marsh and Lauring, 2011).

In Denmark, the energy frames in building codes for residential buildings have been divided into two levels of energy consumption as shown in the following Table (Knudstrup et al., 2009).

Table 3 Residential building energy regulations in Denmark (Knudstrup et al., 2009).

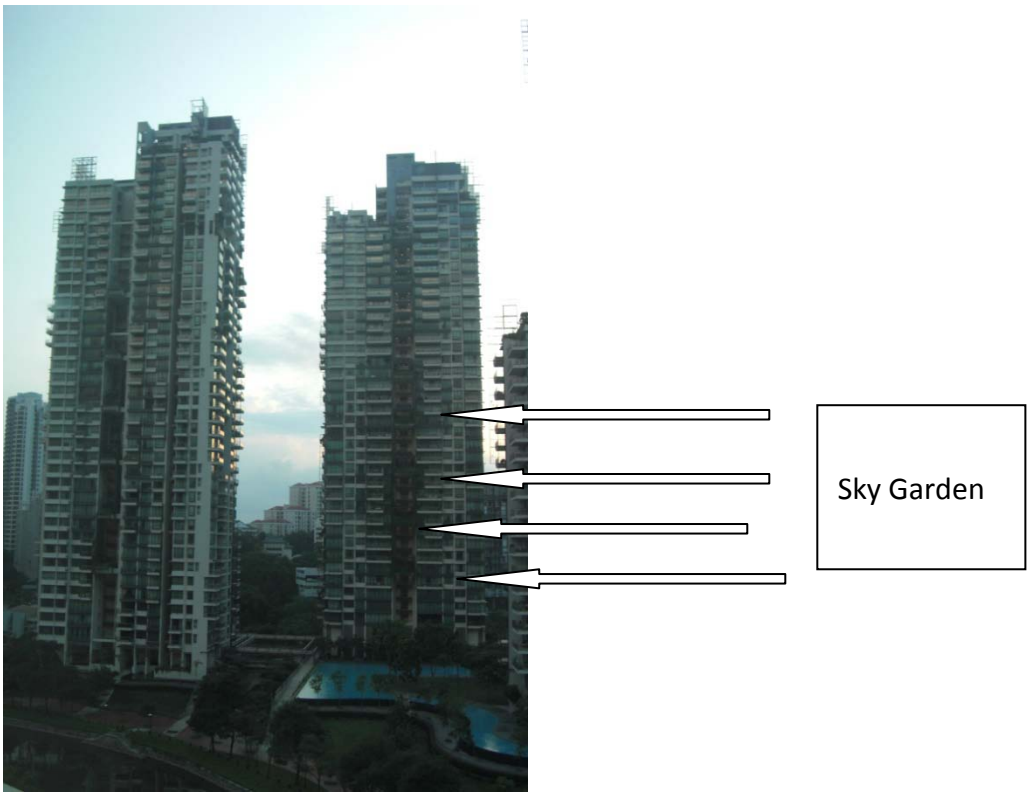
Energy frame	**Conditions**
70kWh/m2 +2200 kWh//heated floor area Low-energy class 1: 35 kWh/m2 + 1600/heated floor area Low-energy class 2: 50 kWh/m2 + 1600/heated floor area	Energy consumption for basic ventilation (0.5/hour) space heating, cooling and hot water

In United States, during this 20 year period, there has been a growing concern on energy efficiency in residential units design and construction materials selection, efficient heating and cooling system planning. In the mid 1980s, the USA introduced the rating systems for construction and energy use in property, Home Energy Rating Schemes (HERS) and Demand Side Management programs (Eves and Kippes, 2010). The number of states which offered HERS increased substantially from 17 in 1993 to 47 by 2000. The USA adopted a national home energy rating system to assess energy efficiency for new homes, and the requirements were extended to retro fit older homes by using it as a basis for "energy efficient mortgages" in 1999 (Eves and Kippes, 2010). In fact, energy saving in residential and commercial buildings is important. They accounted for 72% of the US total consumption of electricity and 36% of total natural gas consumption in 2008, such consumption is even greater than the consumption in industry or transportation sectors. The U.S. Green Building Council develops Leadership in Energy and Environmental Design (LEED) to provides a concise framework for implementing and identifying measurable and practical green construction, operations, building design and maintenance solutions. Since 2003, Atlanta mandatorily required all the new city financed construction projects had to be

LEED™Silver-certified. It also implemented the City of Atlanta Tree Ordinance to ensure that there will not be any net loss of trees inside the city (Li, 2011). In Alaska, the Newly constructed residential units and major home renovations shall be certified to at least 10% reduction below the baseline energy consumption according to the Performance Rating Method of Appendix G of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Standard 90.1-2007. Such requirement is applicable to all projects which had not yet entered into the "schematic design phase" as of the effective date of the Program.

In Singapore, more than 900,000 HDB flats shape Singapore's housing supply. More than 80% of the Singaporeans live in Housing and Development Board (HDB) flats, and more than 90% of them buy the flats where they are living in. Therefore, sustainable public housing is important in Singapore. The Singapore Government introduced a minimum energy performance standard for air-conditioners and household fridges in 2011. The Singapore government also aims at achieving a recycle rate of 65% by 2020 and 70% by 2030 by introducing new measures, for example, providing incentives to building more recycle facilities increase recycling and (Li, 2011). A Green Mark GFA Incentive Scheme has been established to encourage new buildings to attain Green Mark GoldPlus and Platinum ratings. The Green Mark Certified Rating aims at achieving a minimum level of energy efficiency in 80% of Singapore's existing building stock by 2030. It has also established a $100 million Green Mark Incentive Scheme to encourage energy efficiency retrofitting in existing buildings. The Scheme requires existing government buildings that exceed 10,000 square metres of air-conditioned floor area to receive Green Mark GoldPlus ratings by year 2020. New public sector buildings with 5,000 square metres of air-conditioned floor area are required to attain the Green Mark Platinum rating (Li, 2011). Vertical greening was introduced both to the residential blocks with an aim to soften the physical edge of the concrete buildings. As the concrete traps heat, Singaporean start planting on the roof tops to prevent the concrete from storing the heat. The plants also cool the area when the water they transpire evaporates. Some rooftops are designed as roof gardens as an additional space for the residents (Meng and Yin, 2004).

Figure 1 Sky Garden in Singapore's residential building (author's photo).



In United Kingdom, the Standard Assessment Procedure (SAP) insist on the calculation of a Standard Assessment Procedure (SAP) rating for all new dwellings and those converted through material change of use (Eves and Kippes, 2010). The British wish to reduce UK's carbon dioxide from 60% to 80% by 2050 (Chapman, 2008). There is also draft planning *policy* statement on climate change; a raft of related *policy* initiatives across government departments and ministerial enthusiasm for a personal carbon-trading scheme. Much of the discussion has been focused on the actions required to reduce our carbon footprint: shifting the energy supply away from carbon based fuels; investing in renewable energy technologies (While, 2008). In the UK, the SAP energy rating system is a mandatory scheme which covers both new and existing (when the extensions is larger than than $10m^2$) homes. Based on the energy balance of the residential property, the SAP calculation a range of factors that contribute to energy efficiency is taking into account:

1. the heating systems' efficiency and control;
2. materials used for the dwelling construction;
3. thermal insulation of the building fabric;
4. solar heat gains through openings of the housings;
5. ventilation characteristics of the ventilation equipment and dwelling;

6. the fuel used to provide ventilation and lighting and water heating and renewable energy technologies to the space (Eves and Kippes, 2010).

The Commission on Resources and Environmental Act (CORE Act) was adopted by British Columbia in Canada since 1992. It empowered the development of an overall provincial and regional sustainable development strategy, such as sustainable land use plans, increased Aboriginal involvement and public participation, improved dispute resolution processes and government coordination (Day et al., 2003). The national Home Energy Rating Schemes -- the EnerGuide was introduced in 1998 (Eves and Kippes, 2010). In Northwest part of Canada, the Northwest Territories Housing Corporation (NWTHC) supports the efficient use of utilities to mitigate environmental impacts to reduce greenhouse gas emissions and to reduce operating costs. NWTHC's Contributing Assistance for Repairs and Enhancements homeownership program also provide the opportunity to improve the energy efficiency of their homes through repairs and upgrades (Northwest Territorries Housing Corporation, 2010). In Nunavut, Energy audits have been carried out on the Greenland House in three distinct communities in Nunavut (Cape Dorset, Taloyoak, Rankin Inlet). It includes a structural evaluation, blower door test and thermal imaging. Besides, Preliminary Upgrading and Retrofit Recommendations proposed an upgrading energy retrofit to achieve an EGH rating of 80. Prepare Upgrading/Retrofit Blueprint Drawings, Scopes of Work, Specifications and Material Lists aim at bringing the existing houses up to EGH 80 and EGH 85 (Semple, 2010).

In Hong Kong, public housing building blocks are orientated to suit the microclimate of the site, for example, they can easily access to prevailing wind and sunlight. Energy usage can be reduced. Computer simulation and modeling techniques are valuable tools for the environmental performance of building design evaluation. Detail study such as solar heat gain provides necessary information for building design improvement. After obtaining the relevant information, introduction of shading device or adjusting size of windows etc can significantly reduce energy use. Other includes natural daylight and visual comfort helps to ensure human comfort in the interior residential units (Ng, 2002).

Figure 1 Verbena Heights in Hong Kong (author's photo).

In Dubai, escalators must be fitted with controls to reduce speed or to stop when no traffic is detected in new buildings. The average lighting power density for the interior connected load must be no more than the watts per square meter of gross floor area. The maximum watts per square meter

1. Covered parking lots and drives: 1.6w/m^2
2. Main entries: 98w/linear meter of door width
3. Outdoor stairways: 10.8 w/m^2
4. Other doors: 66w/linear meter of door width
5. Open sales areas: 5.4w/m^2
6. Walkway less than 3m wide: 3.3w/linear meter
7. Walkway 3m wide or greater: 2.2 w/m^2

(Dubai Electricity and Water Authority, 2010).

In Libya, qualifies sustainable construction as a special consideration in sustainable development targeting the specific group of construction industry. This group has to develop, plan design, build, alter or maintain the built environment. It includes all the building materials manufacturers and suppliers (Adebayo, 2002)

ANALYSIS ON GLOBAL HOUSING POLICIES

The abovementioned sustainable housing policies show that countries use different methods to improve their environment. Comparison of different policies can help policy makers to draft and implement new policies in the near future. Table 4 summarizes the types of sustainable policies used in different countries, namely, energy audit, sustainable building design, green building subsidies.

Table 4 Sustainable housing policies in different parts of the World.

Types of sustainable policies	Country	Examples
Energy audit	U.S.	The U.S. Green Building Council develops Leadership in Energy and Environmental Design (LEED) to provide a concise framework for implementing and identifying green construction, operations and building design.
	U.K.	There is Standard Assessment Procedure rating for dwellings.
	Canada	In Nunavut, Energy audits carried out on the Greenland House in three distinct communities in Nunavut
Energy Rating	U.S.	The rating systems for construction and energy use in property, Home Energy Rating Schemes (HERS) and Demand Side Management programs. The US adopted a national home energy rating system to assess energy efficiency for new homes as a basis for “energy efficient mortgages”.
	Australia	Green Building Council has developed Green Star environmental rating system. It evaluates the environmental design and construction of buildings
	Singapore	A Green Mark GFA Incentive Scheme has been established to encourage new buildings to attain Green Mark GoldPlus and Platinum ratings.
	U.K.	The Standard Assessment Procedure (SAP) insist on the calculation of rating for all new dwellings and those converted through material change of use.
	Canada	The national Home Energy Rating Schemes -- the EnerGuide was introduced in 1998. In Nunavut, Preliminary Upgrading and Retrofit Recommendations proposed an upgrading energy retrofit to achieve an EGH rating of 80.

Types of sustainable policies	Country	Examples
Sustainable building design	Hong Kong	Computer simulation and modeling techniques are valuable tools for the environmental performance of building design evaluation
	Singapore	Vertical greening was introduced both to the residential blocks
Electrical appliance	Dubai	Escalators must be fitted with controls to reduce speed or to stop when no traffic is detected in new buildings.
Subsidies for green improvements	Canada	The Northwest Territories Housing Corporation supports the efficient use of utilities to mitigate environmental impacts to reduce greenhouse gas emissions and to reduce operating costs. Its contributing assistance for Repairs and Enhancements homeownership program provide the opportunity to improve the energy efficiency of their homes through repairs and upgrades.
Framework / regulations of energy saving	Denmark	The Denmark Energy Performance of Buildings Directive provides a common energy savings framework in the building sector, BPBD was implemented by introducing a new chapter on Energy. Consumption in the Building Regulations
Framework / regulations of energy saving	New Zealand	There was thermal insulation requirement since 1978
Qualification given to sustainable group	Libya	There is a special consideration in sustainable development. It targets specific group of construction industry which develop, plan design, build, alter or maintain the built environment. It includes all the building materials manufacturers and suppliers

CONCLUSION

Many years ago, natural environment such as eruptions is the major cause of an increase in temperature. Nowadays, human activities become the major cause in global warming. They lead to the melting of ice in North and South Pole which may cover the low land area if the problem continues. Sustainable housing policies are

some of the many good examples where we can help to mitigate the problem. Although different countries design and implement different sustainable housing policies to suit their countries' needs. Many of them share similar policies common characteristics: 1) the usage of rating (US, UK, Singapore, Australia, Canada); 2) the usage of energy audit system; 3) reduce energy consumption (UK, US, HK), 2) increase green area (HK, Singapore), 4) usage of green source of energy but is mostly restricted on solar heating only. Review of different countries' green policies is getting more important as they can help our policies makers to design better policies and learn from the other countries' experience in designing and implementation. As our world is getting flatter with the presence of world wide web and other communication and information technologies, it is expected that there will be more similar policies implement in different countries. (Note: for further reading on different countries' policies, please refer to Rita Yi Man Li (2011) *Building Our Sustainable Cities*, Illinois, Common Ground Publishing)

REFERENCES

ADEBAYO, A. A. 2002. *Sustainable Construction In Africa* [Online]. Available: http://cibworld.xs4all.nl/dl/publications/A21SCDC/Adden1.pdf.

CHAPMAN, R. 2008. Transitioning to Low Carbon Urban Form and Transport in New Zealand. *Political Science,* 60**,** 89-98.

DAY, J. C., GUNTON, T. I. & FRAME, T. M. 2003. Toward Environmental Sustainability in British Columbia: the Role of Collaborative Planning. *Environments,* 31**,** 21-38.

DUBAI ELECTRICITY AND WATER AUTHORITY. 2010. *Green Building Regulation* [Online]. Available: http://www.dewa.gov.ae/images/gb/greenbuilding2010e.pdf [Accessed 21 February 2011.

EVES, C. & KIPPES, S. 2010. Public Awareness of "Green" and "Energy Efficient" Residential Property An Empirical Survey Based on Data from New Zealand. *Property Management,* 28**,** 193-208.

FRENCH, L. J., CAMILLERI, M. J., ISAACS, N. P. & POLLARD, A. R. 2007. Temperatures and Heating Energy in New Zealand Houses from a Nationally Representative Study—HEEP. *Energy and Buildings* 39**,** 770-782.

HOLDEN, E. & NORLAND, I. T. 2005. Three Challenges for the Compact City as a Sustainable Urban Form: Household Consumption of Energy and Transport in Eight Residential Areas in the Greater Oslo Region *Urban Studies,* 42**,** 2145-2166.

KNUDSTRUP, M. A., HANSEN, H. T. R. & BRUNSGAARD, C. 2009. Approaches to the

Design of Sustainable Housing with Low CO2 Emission in Denmark. *Renewable Energy,* 34**,** 2007-2015.

LI, R. Y. M. 2009. The Impact of Climate Change on Residential Transactions in Hong Kong *The Built & Human Environment Review,* 2**,** 11-22.

LI, R. Y. M. 2011. *Building Our Sustainable Cities,* Illinois, Common Ground Publishing.

MARSH, R. & LAURING, M. 2011. Architecture and Energy: Questioning Regulative and Architectural Paradigms for Danish Low-energy Housing. *Architectural Research Quarterly,* 15**,** 165-175

MCKIBBIN, W. J. & WILCOXEN, P. J. 2002. The Role of Economics in Climate Change Policy. *The Journal of Economic Perspectives,* 16**,** 107-129.

MENG, N. C. & YIN, J. K. K. 2004. *Improving the Hardware, Retaining the Heartware– The Singapore Way to Sustainable Housing* [Online]. Available: http://www.housingauthority.gov.hk/hdw/ihc/pdf/ihc04hd.pdf [Accessed 18 September 2011.

NG, J. C. Y. 2002. *Sustainable Design in Public Housing* [Online]. Available: http://www.housingauthority.gov.hk/haconf2002/download/papers/pjng.pdf [Accessed 20 February 2011.

NORDHAUS, W. D. 1991. To Slow or Not to Slow: The Economics of The Greenhouse Effect. *The Economic Journal,* 101**,** 920-937.

NORTHWEST TERRITORRIES HOUSING CORPORATION. 2010. *Northwest Territorries Housing Corporation* [Online]. [Accessed 21 February 2011.

PHILIPPA, H. C., VIGGERS, H., CHAPMAN, R., O'DEA, D., FREE, S. & O'SULLIVAN, K. 2009. Warm homes: Drivers of the Demand for Heating in the Residential Sector in New Zealand. *Energy Policy* 37**,** 3387-3399.

SEMPLE, B. 2010. The Challenges for Sustainable Housing and Communities in the Canadian Far North.

WHILE, A. 2008. Climate Change and Planning: Carbon Control and Spatial Regulation. *The Town Planning Review,* 79**,** vii-xiii.

WINSTON, N. & EASTAWAY, M. P. 2008. Sustainable Housing in the Urban Context: International Sustainable Development Indicator Sets and Housing. *Social Indicator Research,* 87**,** 211-221.