Carbon neutrality: relevant tool or flawed concept?

A review of the process of achieving carbon neutrality and its validity as a tool to mitigate climate change

By Andrew M Spence

For Dr. Valerie M Lemay
and Dr. Peter L Marshall

April 12, 2010
FRST 497

Abstract

Climate change has become the defining issue of the twenty-first century. Institutions and organisations are starting to take proactive steps to reduce greenhouse gas emissions in response to growing local concern and inaction at higher levels of government (Willson & Brown 2008). A concept that is gaining significant publicity is that of ‘carbon neutrality’, a process of calculating emissions (or ‘carbon footprint’), reducing those emissions and offsetting residual emissions so that net carbon emissions equal zero. The evolving concept of carbon offset trading has given rise to a whole new industry and associated infrastructure. Proponents of carbon neutrality champion the concept as a valid tool in the alleviation of climate change. Equally there are fierce critics of the concept who believe it to be fatally flawed. By drawing on a thorough review of relevant literature in this report I seek to: present a clear understanding of the concepts of ‘carbon footprint’ and ‘carbon neutrality’ and their purpose in mitigating climate change; describe the recommended process and best practice for achieving carbon neutrality; and consider the arguments for and against carbon neutrality as a valid tool in mitigating climate change.

Key words

Carbon neutrality, carbon offsetting, climate change.

Contents

List of Figures

1. Introduction

Climate change has become the defining issue of the twenty-first century. Scientific consensus is articulated by the Intergovernmental Panel on Climate Change (IPCC) in their *Climate Change 2007: Synthesis Report* which states: "warming of the climate is unequivocal…" and "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations" (IPCC 2007). Institutions and organisations are starting to take proactive steps to reduce greenhouse gas (GHG) emissions in response to growing local concern and inaction at higher levels of government (Willson & Brown 2008). There is an increasing desire among individuals and organisations for more concerted action to reduce carbon emissions at a local and regional level.

A concept that is gaining significant publicity is that of 'carbon neutrality', a process of calculating emissions (or 'carbon footprint'), reducing those emissions and offsetting residual emissions so that net carbon emissions equal zero (DECC 2009b). The evolution of carbon offsets trading has resulted in a plethora of carbon consultancy, calculation and offsetting services being marketed on-line and the concepts of 'carbon neutrality' and 'carbon footprint' have become common terms. However, both terms lack commonly agreed definitions, leading to variations in the scope, calculation and offsetting of emissions. Carbon offsetting involves subjective considerations of measuring, accounting and verifying, as well as time problems involved in offsetting today's emissions with a promise of emissions reductions in the future. More fundamentally, there is some debate as to the validity of carbon offsetting as a tool for genuinely tackling the issue of climate change. Critics claim that carbon offsetting simply encourages people to feel absolved from the responsibility to change their behaviour and consumption patterns and to actively reduce emissions (Smith 2007).

My own interest in the concept of carbon neutrality was initiated during discussions I had recently with members of the Executive Board of the Association of British Columbia Forest Professionals (ABCFP), a local professional forestry association based in Vancouver. With some 5,600 members, the ABCFP's mandate is to protect the public interest in the practice of professional forestry in British Columbia (BC) and to advocate for and uphold the principles of forest stewardship (ABCFP 2010). Members of the Executive Board wish to calculate the association's carbon footprint, with a view to achieving carbon neutrality through a combination of emissions reduction actions and carbon offsetting. This aim is

related to the BC Provincial Government's *Greenhouse Gas Reduction Targets Act* passed in 2007, which legally requires all public-sector organizations to be carbon–neutral by 2010 (BC Government 2010). The ABCFP, being a high profile provincial professional association and whose members include government employees, has therefore set itself a similar target. My discussions with the association led me to consider a number of fundamental questions concerning the concepts of carbon neutrality and carbon footprint, in particular:

- What are the concepts of carbon footprint and carbon neutrality all about?
- What is their purpose in the context of mitigating climate change?
- What is the recommended process and best practice for achieving carbon neutrality?
- Is carbon neutrality actually a valid tool in mitigating climate change?

This paper sets out to answer the above questions by drawing on a thorough review of relevant literature. First of all, I introduce the issues of climate change as the context for understanding the concept of carbon neutrality and then define what carbon neutrality is fundamentally about. I describe the key procedures an organisation must follow in seeking to achieve carbon neutrality, expanding on the subject of carbon offsets and the associated carbon trading infrastructure. I briefly discuss the benefits and risks of forestry-related offset projects. Finally, I discuss the issues around carbon neutrality that are seen as contentious and consider the arguments for and against the concept of carbon neutrality as a tool for mitigating climate change.

2. The greenhouse gas habit

"Addiction is a terrible thing. It consumes and controls us, makes us deny important truths and blinds us to the consequences of our actions. Our society is in the grip of a dangerous greenhouse gas habit". These are the opening words of Ban Ki-moon, Secretary-General of the United Nations, in the Foreword to *Kick the Habit - a UN Guide to Climate Neutrality* (2008) (Kirby & Bogdanovic 2008). It is a suitably evocative description of the defining issue of our era: climate change. There is overwhelming scientific consensus that climate change is happening and is being driven by greenhouse gas emissions caused by human activities. This is articulated by the IPCC in their *Climate Change 2007: Synthesis Report* which states: "warming of the climate is unequivocal…" and "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations" (IPCC 2007).

Gases in the atmosphere such as carbon dioxide, methane and water vapour act like the walls of a greenhouse in trapping energy from the sun and keeping the surface of the planet warmer than it would otherwise be. As global climate models have shown, the strength of this effect depends upon the amount of greenhouse gases in the atmosphere. Global dependence on carbon-based energy has caused a significant increase in the amount of greenhouse gases in the atmosphere due to the burning of vast quantities of fossil fuels. Coal, gas and oil all release CO_2 and other greenhouse gases when they are burned. Around 1750, the start of the Industrial Revolution in Europe, there were 280 parts per million (ppm) of carbon dioxide (CO_2) in the atmosphere. Today the overall amount of GHG's in the atmosphere has exceeded 390 ppm of CO_2 equivalent, the highest at any point over the past 420,000 years (Kirby & Bogdanovic 2008). The IPCC predict in their 2007 report that CO_2 levels will more than double and global temperatures will rise by between 2.4^{O}C and 6.4^{O}C by 2100 in the absence of mitigation action (IPCC 2007). There is a strong scientific consensus that global average temperatures should not be allowed to rise by more than 2^{O}C over pre-industrial levels in order to minimise the risk of "dangerous" climate change and to keep the costs of adaptation to a warmer world bearable (Vandenbergh & Steinemann 2007). Climate models predict that there is a 50 per cent chance of meeting this 2^{O}C target increase if the total GHG concentration remains below 450 ppm (Kirby & Bogdanovic 2008). This equates to a global average emission of CO_2 equivalent of less than one metric tonne per person. The current global average is roughly four tonnes (Harre & Atkinson 2007). The scientific evidence provides a compelling argument for the need to urgently reduce greenhouse gas emissions. Returning to the words of Ban Ki-moon, there is a clear and dire need to "'kick' the carbon habit".

3. An increasing concern to (be seen to) be 'carbon neutral'

Institutions and organisations are starting to take proactive steps to reduce greenhouse gas (GHG) emissions in response to growing local concern and inaction at higher levels of government (Willson & Brown 2008). There is a growing sense of impatience at the lack of progress on the international stage and at a national level in tackling climate change. The 2009 Copenhagen Climate Change Conference has been widely interpreted as a failure in terms of reaching an international consensus on how best to tackle climate change with only limited agreement reached on legally binding emissions reductions (University of Chicago

2010). The perceived failure on an international level gives further impetus to the desire of people and organisations to take action at a regional and local level. A concept that is gaining a lot of publicity is that of 'carbon neutrality'. An increasing number of organisations and entities are publicising their plans to become carbon neutral, including for example:

1. The BC Provincial Government passed the *Greenhouse Gas Reduction Targets Act* in 2007, which legally requires all public-sector organizations to be carbon–neutral by 2010 (BC Government 2010);
2. The Prime Minister of New Zealand announced the government's aim for the country to be carbon neutral in 2006, accompanied by systematic plans for a carbon neutral public sector and a commitment for six government departments to become carbon neutral by 2012 (Ball et al. 2009);
3. In 2007, the President of Costa Rica announced that the country will become carbon neutral by 2021, Costa Rica's 200th birthday (Ball et al. 2009);
4. The Vancity Banking Group announced that they had achieved their goal to become a carbon neutral company as at 31 December 2007 through reduced emissions and the purchase of carbon offsets (Citizens Bank 2010);
5. In 2007, the Canadian forest industry announced a commitment to industry-wide carbon neutrality by 2015 without the purchase of carbon offset credits (Forest Products Association of Canada 2010).

4. What is carbon neutrality?

There are so many examples of organisations making plans to be, or claiming to already be, carbon neutral that the list given in the last section could be extended to fill a whole paper in itself. But what does it mean to be carbon neutral and what role can carbon neutrality play in mitigating climate change? A useful first step is to consider how 'carbon neutrality' should be defined. Reviews of both peer reviewed and other literature suggest that, whilst many definitions of the term have been put forward and with some overlap and broad consensus, ultimately there is no commonly agreed definition (Murray & Dey 2009). Carbon neutrality was voted Oxford American Dictionary's Word of the Year 2006, an indication of just how popular the concept has become (Energy Priorities 2006). According to the Oxford Dictionary: "being carbon neutral involves calculating your total climate-damaging carbon emissions, reducing them where possible, and then balancing your remaining emissions, often by purchasing a carbon offset: paying to plant new trees or investing in "green"

technologies such as solar and wind power" (Energy Priorities 2006). The United Nations (UN) Guide to Climate Neutrality uses the term to mean "living in a way which produces no net greenhouse gas emissions, achieved by reducing your own GHG emissions as much as possible and using carbon offsets to neutralise the remaining emissions" (Kirby & Bogdanovic 2008). The UK Department of Energy and Climate Change (DECC) defines carbon neutrality as "a transparent process of calculating emissions, reducing those emissions and offsetting residual emissions... (*so that*) net carbon emissions equal zero" (DECC 2009a. Italics added by author).

Fundamentally then, carbon neutrality is linked with the notion that an individual or an organisation are able to take responsibility for their own climate impact, or carbon footprint, by initially reducing their emissions and then by utilising an offsetting process for their remaining emissions. Offsetting is a process which aims to cancel the harmful effects of one greenhouse-gas-generating activity through another activity that reduces or prevents an equivalent amount of greenhouse gas emissions ((Murray & Dey 2009). For example, a reduction in greenhouse gas emissions generated by a project such as wind farm might be used to balance the emissions from another source such as a coal-fired power station. Carbon offsetting can be seen as a service, with the purchaser paying someone else to make greenhouse gas reductions on their behalf. This growing and evolving concept has led to a whole new industry and associated infrastructure. Carbon calculators are available to assess how much carbon needs to be offset; protocols have been developed to regulate emissions reductions and carbon sequestration projects; consultants offer validation and verification services; markets are developing to trade in carbon credits; carbon traders and consultancy businesses are growing; and carbon accounting mechanisms are being developed.

5. A process for achieving carbon neutrality

The achievement of carbon neutrality requires the completion of three separate but interrelated steps. These steps are summarised in Figure 1 and then discussed in more detail in the sections that follow.

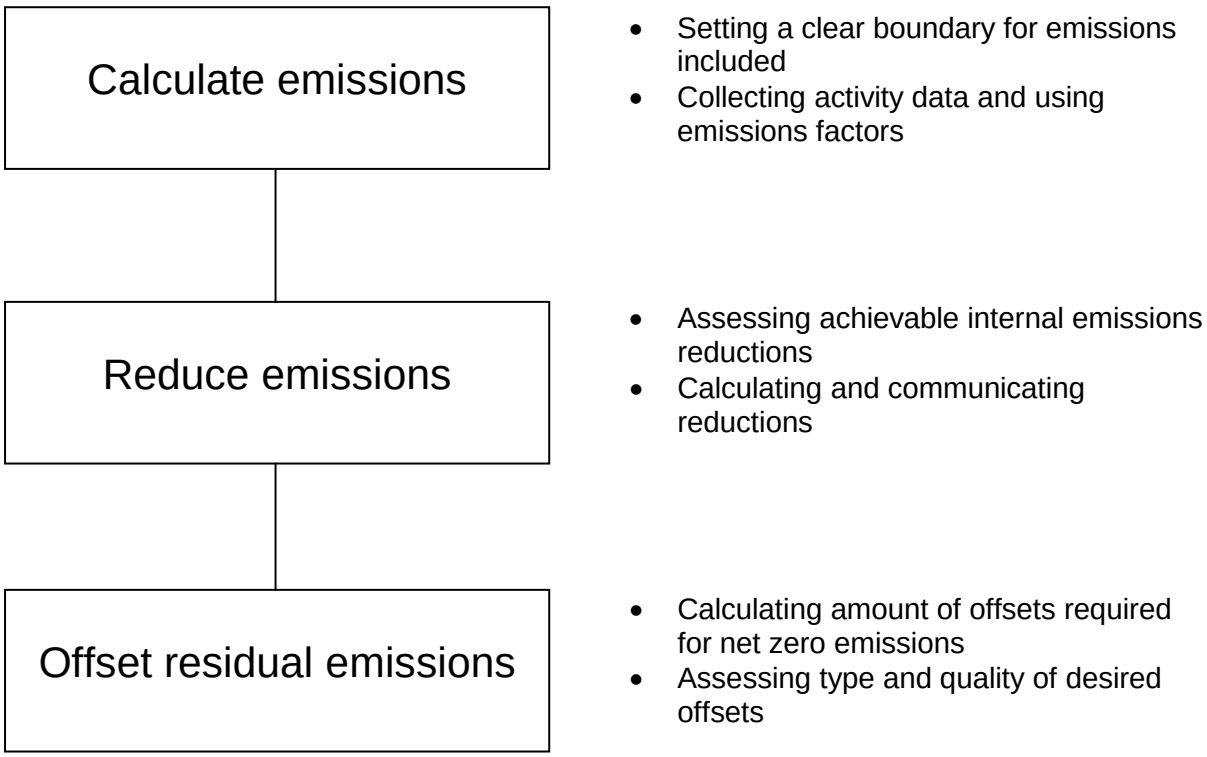

Figure 1. The three steps to achieving carbon neutrality (adapted from DECC, 2009b)

5.1 Calculating emissions

The first step in calculating emissions is to carry out an emissions inventory. The aim of the emissions inventory is to identify the major emissions sources in the organisation and to quantify them, usually in "CO_2 equivalent" (CO_2e) units. There are four primary steps involved in this process:

5.1.1 Establishing the emissions boundary or scope

A critical element is to set the scope of what should be included in an emissions calculation, since this subsequently determines the required level of carbon offsets. There are a number of factors to take into account when setting the scope and the decisions made can vary substantially the resulting analyses. Important questions to consider include:

1. Should all greenhouse gas emissions such as methane be included, or will the analysis be limited to carbon dioxide emissions?
2. Will the analysis concentrate on emissions under the direct control of the organisation or will a 'life-cycle' approach be taken, quantifying 'upstream' and 'downstream' emissions?
3. Should emissions from non fossil fuel sources, such as soils, be included?

Calculating carbon emissions of an organisation should be carried out in an accurate, consistent and transparent way to provide a sound basis for the subsequent reduction and offsetting processes. The World Business Council for Sustainable Development and the World Resource Institute jointly established the Greenhouse Gas Protocol (GHG Protocol) as an internationally accepted accounting method for measuring and reporting greenhouse gas emissions (David Suzuki Foundation 2008). The GHG Protocol provides the accounting framework for almost every GHG standard and program in the world as well as GHG inventories by individual companies. It is therefore recommended as an important resource for all types of organisation (David Suzuki Foundation 2008). The Department of Energy and Climate Change (DECC), a UK government department, similarly recommends that organisations follow the GHG Protocol in establishing the scope of their GHG emissions. The GHG Protocol groups emissions into three different scopes:

- Scope 1 (Direct emissions) – activities owned or controlled by the organisation that release emissions straight into the atmosphere, such as boilers, furnaces, vehicles and chemical production
- Scope 2 (Energy indirect) – emissions released into the atmosphere associated with the consumption of purchased electricity, heat, steam and cooling as a consequence of activities occurring at sources not owned or controlled. An example would be energy consumption related to rented office space.
- Scope 3 (Other indirect) – all other activities which release emissions into the atmosphere as a result of actions taken, that occur at sources not owned or controlled and not classed as scope 2 emissions. Examples include business travel by means not owned or controlled, waste disposal, and end uses of sold products

and services (for instance whether they can be recycled or whether they end up in a landfill) (DECC 2009b).

According to the UK Government's recommendation, organisations should include Scopes 1 and 2 in their emissions calculations as a minimum, plus significant Scope 3 emissions (DECC 2009b). The guidance suggests that 'significance' should be judged on consideration of scale, importance to the organisation, importance to stakeholders and potential for reduction (DECC 2009b). This last recommendation is an important one. Many of the protocol definitions from carbon registries have tools to help organisations analyse their carbon footprints; however they generally suggest including only Scopes 1 and 2 emissions. Given that Scopes 1 and 2 emissions average only 26% of total supply chain emissions (Matthews et al. 2008); this narrow definition is likely to lead to a significant underestimation of the true level of carbon emissions arising from the provision of products and services. Because consumers can influence the carbon footprints of goods and services through their purchase decisions and a corporation can likewise influence its suppliers, it is appropriate to take a broad estimation of carbon footprints that includes supply chain effects (Matthews et al. 2008). Organisations need a full understanding of their carbon footprint across the entire supply chain in order to pursue the most effective carbon mitigation strategies. For example, in reporting their emissions data to the Carbon Disclosure Project, companies such as Nissan, Unilever, Rio Tinto and Marks & Spencer found that Scope 3 indirect emissions accounted for over 95% of their reported totals (Martin 2008).

5.1.2 Collecting activity data

Once the boundary has been set, activity data need to be collected. Activity data are measurements of the activities that generate emissions and are usually collected in standard units such as kilowatt hours of electricity consumed, kilometres driven and litres of fuel used. Designing a suitable information management system will help to ensure full and accurate data collection. Since reductions are measured and reported each year, it is important to remain consistent in the approach taken to calculations and measurements.

5.1.3 Calculating emissions

Emission factors are used to convert activity data from an organisation into GHG emissions values, usually in kilograms or tonnes of carbon dioxide equivalent, CO_2e. The GHG Protocol encourages organisations to customise their own emissions factors, but also provides a number of calculation tools incorporating default emissions factors (The

Greenhouse Gas Protocol Initiative 2010). Automated calculation tools with built-in emissions factors are freely available on-line from a whole range of carbon consultants and offset retailers. For example, the National Energy Foundation (NEF) is a UK-based independent educational charity focused on helping individuals and organisations combat climate change through energy efficiency measures and renewable energy (NEF 2010). NEF provide a simple carbon calculator based on conversion factors recommended by the UK Government Department of Environment, Food and Rural Affairs. Conversion factors are provided for a range of energy and transport emissions sources. Two examples are: each kilowatt of electricity is multiplied by a factor of 0.54055 to give the equivalent carbon emissions in $kgCO_2$; each litre of petrol consumed is multiplied by a factor of 2.3035 (NEF 2010).

5.1.4 Quality control measures

The emissions calculations may be used in several different ways, including: corporate and public relations reporting; identifying areas for targeting emissions reductions; monitoring of reductions; and calculating required carbon offsets. Quality control procedures are important in ensuring accuracy of data and may include the use of external consultants and third party verification as well as internal checks.

5.2 Reducing emissions

Reducing emissions is the single most important part of an organisation's greenhouse gas management program since it is a vital component in helping to tackle climate change (David Suzuki Foundation 2008). Recommended steps in reducing emissions include: setting a reduction target; identifying reduction opportunities; choosing and implementing emission reduction measures; tracking reductions and cost savings; and, most important, seeking new reduction opportunities and repeating the process. Reduction targets may be expressed as absolute reductions or as an intensity-based reduction, for example per metre squared of office space or per unit of production. In terms of mitigating climate change however, only absolute targets will ensure that the overall amount of emissions entering the atmosphere is reduced.

There are many examples of reduction opportunities for an organisation, including: energy use; transportation; renewable energy sources; operational efficiency; material inputs (such as paper, packaging and refrigerants); upstream GHG reductions from suppliers and contractors (selecting low carbon suppliers for example); and downstream reductions

(designing products to be recycled for example). An important advantage for the organisation is that measures taken in these areas will potentially lead to cost savings as well as having positive impacts on reducing carbon emissions.

5.3 Carbon offsetting

A carbon offset is an emission reduction credit from another organisation's project that has resulted in a reduction in carbon emissions or an increase in carbon sequestered compared to a business-as-usual assessment. The buyer uses these offsets to mitigate their own greenhouse gas emissions. The seller benefits since their project becomes more economically viable. Carbon offsets are typically traded through trading platforms, brokers and online retailers (David Suzuki Foundation 2010).

5.3.1 Introducing the carbon markets

There are two recognised carbon markets: the compliance market (trading credits that are compliant with the mechanisms set out in the UN's Kyoto Protocol) and the voluntary, or non-compliance, market (trading credits that are non-Kyoto compliant) (Taiyab 2006).

Kyoto-compliant credits are issued through one of two mechanisms:

1. The Clean Development Mechanism (CDM) allows Annex I countries (the world's developed countries as listed by the Kyoto Protocol) to offset their emissions through emissions reduction projects based in non-Annex I countries (the developing countries). The intention is to enable developing countries to invest in renewable energy and energy efficiency technology and thereby avoid the fossil-fuel-intensive development experienced historically by the developed countries. The CDM process issues Certified Emissions Reductions (CER's) whereby 1 CER equates to 1 tonne of CO_2e saved.
2. The Joint Implementation (JI) mechanism enables Annex 1 countries to offset within other Annex I countries, for example 'economies in transition' such as Russia and the Ukraine. Units called Emission Reduction Units (ERU's) are issued with 1 ERU equating to 1 tonne of CO_2e saved.

The voluntary market runs in parallel with the CDM market and consists of companies, governments, Non Government Organisations (NGO's) and individuals that voluntarily purchase carbon credits for purposes other than to meet regulatory targets. Retailers invest in a portfolio of offset projects, slice them up into portions of emissions reductions and sell

them as carbon credits (Taiyab 2006). The carbon credits generated by projects that are not seeking CDM/JI registration are called Verified Emission Reductions (VERs). Since these projects are sold into the voluntary market, they do not need to follow the CDM process and are therefore often referred to as unregulated. A growing number of voluntary standards have emerged over the past few years to 'regulate' the voluntary market and provide greater credibility to the related projects. There are numerous retail offset vendors selling offsets from a wide range of projects. The voluntary carbon market accounted for CAD$460 million in transactions in 2008 (Hamilton et al. 2008) and is expected to generate CAD$1 billion of trading in 2010 (Falls et al. 2010).

5.3.2 Types of carbon offset projects

Buyers of carbon offsets will want to ensure that the underlying projects match their requirements and align with their own values in terms of carbon emission reductions. Buyers therefore need to exercise caution and make informed choices regarding the offsets they invest in, especially in the voluntary market. The first decision to make concerns the type of offset project that an organisation wishes to invest in. There are a number of different offset project types, each of which has a number of benefits and risks associated with it. Renewable energy projects, such as wind or solar, avoid greenhouse gas emissions associated with burning fossil fuels. Energy efficiency projects, such as low energy light bulbs, reduce greenhouse gas emissions by using less energy. Both of these types of energy-related projects are generally seen as providing high quality offsets since they result in measureable and irreversible climate benefits and support the transition to a sustainable energy economy. Tree planting projects and improved soil management techniques remove carbon from the atmosphere, sequestering it in living plant and soil biomass. One key risk with these projects is the potential for carbon to be re-released into the atmosphere following a disturbance such as fire. Forestry-related projects are discussed in more detail in a later section. Landfill gas recovery and livestock waste management projects capture and destroy methane. These projects are seen as the 'low-hanging fruit', reducing the climate impact of this potent greenhouse gas with relatively low risk and low investment involved.

5.3.3 Criteria for judging the quality of a carbon offset

The risks associated with different project types can be classified under the following headings, each representing an important criterion in judging the quality of a carbon offset:

5.3.3.1 Additionality

An offset project can only be classed as additional if it is not 'business as usual', i.e. the project would not have happened without the extra funding from the sale of offsets. This is crucial to the entire concept of offsetting – without additionality there is no net benefit to the climate. Evaluating additionality is a subjective exercise and a variety of tests have been proposed to help in making the assessment:

- Regulatory test – does the project go beyond legal requirements?
- Financial test – is the project economically viable without offset revenues?
- Barriers test – are there significant non-financial barriers a project needs to overcome?
- Common practice test – does the project go beyond common business practice?
- Timing test – was the project started after a given date?

(Clean Air-Cool Planet 2006)

Consider the following example: a project aims to avoid the release of methane from animal manure on a farm where the farmer currently lacks the information and the capital needed to install the required equipment. The project has an underlying economic viability for the farmer, due to the methane gas generated. However, the need to overcome both informational and financial barriers to get the project off the ground indicates that it meets the additionality criterion. In other cases, where anaerobic digesters make economic and environmental sense and are happening anyway, the criteria of additionality may not be met. It is therefore important to dig deep enough to be able to differentiate between 'additional' and 'business as usual' projects.

5.3.3.2 Avoiding leakage

A project must demonstrate that it has not caused an increase in carbon emissions elsewhere, i.e. upstream or downstream. For example, avoided deforestation in one area would be undermined from a climate change mitigation point of view if it led to logging in a new area.

5.3.3.3 Permanence

This refers to the longevity of a carbon pool and the stability of its stocks within its management and disturbance environment (Greig &, Bull 2009). Any risk of impermanence (such as a forestry project at risk of fire or disease) must be addressed by the project proponent or offset provider, for example through independent review and replacement of credits. Permanence is a particular issue with respect to forestry-related projects since forest

fires, logging and disease can quickly lead to large amounts of carbon being released back into the atmosphere.

5.3.3.4 Accurate quantification

For a project to offer genuine climate benefit, the associated emissions reductions must be quantified accurately. This involves a credible approach to estimating the baseline scenario, followed by the use of recognised quantification methodologies specific to the project type for estimating reductions. The longer the lifetime of a project, the greater the risk that the baseline becomes outdated and inaccurate, resulting in a need for re-calculation and determination.

5.3.3.5 Validation and verification

To ensure their credibility, offset projects should be validated and verified by accredited and recognised independent third parties. Validation refers to a process of checking that a project has been implemented according to the methodology and criteria of the applicable standard. Verification refers to a process of checking that emissions reductions and project benefits claimed have been properly measured in accordance with the project's validated design and monitoring plan.

5.3.3.6 Unique ownership: avoiding double counting

Steps must be in place to ensure that each offset is only sold once, for example by listing offsets on a public registry, tracking them and cancelling them once sold.

5.3.3.7 Sustainability issues

Projects should as a minimum have no negative environmental or social impacts, such as on wildlife and indigenous peoples, particularly in developing countries. There are huge emotions attached to land use, often based on pure fear, and the role of consultation is therefore very important in establishing sustainable projects.

5.3.3.8 Timing

In order to truly mitigate the risks inherent in timing differences between project development and actual emissions reductions taking place, carbon credits should be ex-post. This means that credits are only issued from a project after the emissions reduction has taken place.

5.3.4 Carbon offset standards

As well as undertaking their own research, buyers of carbon credits can gain some assurance regarding the quality of an offset project where it has met the requirements of a recognised offset standard. A number of offset standards have been developed to give assurance to purchasers that an offset has been checked by a qualified third-party auditor and has met the quality requirements of that standard. These standards are particularly important in the voluntary carbon market where there is a lack of government regulation. In 2008, there were approximately 17 standards for carbon offsets sold in the voluntary market, of which the most popular were The Gold Standard, the Voluntary Carbon Standard (VCS) and the Climate, Community and Biodiversity Standard (CCBS). The Clean Development Mechanism (CDM) was the most widely used standard in the compliance market (Taiyab 2006; David Suzuki 2009).

The Gold Standard was created by a group of NGO's led by the World Wildlife Fund to provide a consistent and stringent standard for sustainable development projects. Project types are restricted to renewable energy and end-use energy efficiency, with forestry excluded, and there are additional screens for baseline, additionality and sustainable development. The VCS was developed by industry stakeholders and is less rigorous than the Gold Standard covering basic quality criteria such as additionality. It covers most offset project types including forestry. The CCBS was developed for Land Use, Land Use Change and Forestry (LULUCF) projects including reforestation, conservation, agroforestry and bioenergy with the aim of promoting projects with biodiversity and community benefits. Independent auditors evaluate projects based on 15 required criteria and issue Silver or Gold status depending upon the quality of the project (Taiyab 2006). The CDM was developed for compliance with the Kyoto protocol with CDM carbon credits reviewed by United Nations-accredited auditors. CMD credits must be located in developing countries, but are sold in both the voluntary and compliance carbon markets (David Suzuki 2009).

Countries like Canada that have agreed to and are bound by targets under the Kyoto protocol must abide by the global carbon accounting rules created by the Kyoto protocol (David Suzuki Foundation 2009). These rules prevent voluntary offset projects located in Canada from being officially certified by either of the CDM or Gold standards in order to prevent a double-counting of emissions reductions. However, the VCS has recently been made available for use by offset projects developed in Canada. Under Kyoto, all emissions reductions that take place in Canada are accounted for by the federal government when it

measures Canada's total emissions for reporting progress against Canada's Kyoto target. Hence, reductions achieved by voluntary projects are counted as part of the federal government's own reduction efforts. Selling these same reductions through a carbon offset would be a form of double-counting and a violation of the unique ownership criterion. This issue could be alleviated by the creation of a national Canadian standard for carbon offsets and the use of a national registry so that reductions from the voluntary carbon sector can be excluded from the national accounting. Offset standards are being developed by the federal government for a federal offset system; however, there is currently no national Canadian standard or registry in place (David Suzuki Foundation 2009). Further progress on implementing quality Canadian offset standards is important so that vendors in Canada no longer have to rely on a patchwork of standards from around the world. A credible carbon offset standard that is applicable everywhere in Canada would have a number of benefits: Canadian offset vendors will be able to sell a standardised, high quality Canadian product; consumer confidence in carbon offset products will be improved; the carbon offset market will be more appealing to both project developers and vendors; and encouraging project development will ultimately reduce greenhouse gas emissions in Canada (David Suzuki Foundation 2009).

The BC provincial government has created the Pacific Carbon Trust (PCT), a Crown corporation that buys carbon offsets on behalf of (mainly) public sector clients seeking to meet their carbon neutrality obligations under the 2007 *Greenhouse Gas Reduction Targets Act* (Falls et al. 2010). PCT is targeting 1 million tonnes of carbon offset purchases in 2010 and has set a price of CAD$25 per tonne for the offsets sold to its clients (Falls et al. 2010). The aim is to stimulate emissions reductions in BC and drive a low-carbon economy. Local project developers will receive investment monies and public sector clients will have an incentive to reduce their emissions in order to avoid the CAD$25 per tonne cost. PCT aims to operate to the highest quality carbon standards and is currently developing its own offset protocol and regulations (Falls et al. 2010).

5.4 A short cut to carbon neutrality: on-line carbon calculators

Numerous carbon calculators are available on the Internet to provide a quick and easy way for an individual or organisation to 'fast track' through a process of calculating and offsetting their carbon emissions. The majority calculate carbon responsibility based on an input of car and other transport use, flights and household or office energy consumption. An assessment is provided of the payment needed to become 'carbon neutral'. This payment is then used to

buy offset credits, either from a government recognised carbon trading mechanism or through the voluntary market. There is however a significant lack of standardisation around calculators and the resulting offsets so that no two calculators are likely to provide the same level of carbon emissions, nor the same cost to offset them. The majority of calculators limit their scope to direct emissions and purchased energy and ignore upstream / indirect effects. Many also give little information on, or recognition of, the difficulties and assumptions inherent in carbon accounting methodology and calculation methods. The amount of detail provided concerning the nature and whereabouts of offset schemes and the organisations responsible for the offset projects on the ground also varies considerably. Even where a carbon offset retail website does provide information about the offset projects, this may well not match up with the actual on-the-ground story and judging the true value of a project in making genuine emissions reductions becomes extremely difficult (Murray & Dey 2009).

On-line calculators do offer a quick and easy means for an individual or organisation to make voluntary offset payments as part of a general aim to 'do their bit for climate change'. However, individuals or businesses who genuinely want to claim carbon neutrality should follow the more rigorous process outlined in Figure 1. This will enable them to gain a better understanding and more accurate assessment of their carbon footprint, better understand their opportunities for emissions reductions and how to achieve them, and adopt a more thorough process of ascertaining the most appropriate and effective offset projects for meeting their needs and values.

6. Assessing the quality of forest-related projects: benefits and risks

There is only one technology available to take CO_2 out of the atmosphere: photosynthesis. Trees represent a vital carbon pool, removing carbon from the atmosphere and sequestering it in living plant biomass. While all plants sequester carbon, trees and woody plants are most efficient as they produce resistant compounds such as lignin, giving wood excellent durability (Senanayake 2008). However, the role that trees play in removing carbon dioxide from the atmosphere is complex since trees both absorb and give off carbon dioxide. Carbon sequestration in tree biomass varies according to the growth stages of the trees (Böttcher & Breisgau 2007). Biomass stock increment is initially high in young forests and especially in fast-growing species, with more carbon absorbed through photosynthesis than emitted. Carbon accumulation then reaches a saturation point as the trees mature (Böttcher &

Breisgau 2007). An old mature forest emits increasing amounts of carbon through decaying leaves, branches and dead trees and can become a net source of carbon emissions rather than a sink (Senanayake 2008). Long rotation species have an advantage over short rotation species in terms of carbon sequestration because the active sequestering or growing phase is longer, the total biomass is larger, and wood durability is greater (Senanayake 2008; Deckmyn et al. 2004). A growing tree also contributes to the creation of soil organic matter, which represents another important carbon pool, storing 20-30% of organic matter reaching the soil from the above-ground environment (Senanayake 2008). The most productive forests in terms of sequestering carbon are those that have a long standing life as well as a high potential to develop deep organic soils (Senanayake 2008). However, in comparing strategies for carbon dioxide emission reductions, it is important to take all carbon fluxes into account. Short-rotation species such as hybrid poplar produce biomass for energy production, reducing the use of fossil fuels (Deckmyn et al. 2004). Longer-rotation species produce greater carbon storage in wood products and can also contribute to reduced fossil fuel use through the utilisation of logging waste for energy production (Deckmyn et al. 2004). To truly compare the different options of reforestation, all benefits and flows of greenhouse gases should be taken into account (Deckmyn et al. 2004).

The emerging carbon market has prompted considerable interest in forestry sectors across the world. Forestry-related carbon offset projects have a number of arguments in their favour. Firstly, 20-25 per cent of anthropogenic emissions released into the atmosphere originate from land use change and therefore land use and deforestation issues must be tackled as part of any climate change mitigation strategy (Taiyab 2006). Secondly, forestry projects have a number of potential co-benefits including the promotion of native biodiversity and habitats, reduced soil erosion, purification of water supplies and protection of the hydrological cycle. Thirdly, it has been argued that forestry projects provide the only means to access the carbon markets for very poor countries such as those in Africa (Taiyab 2006).

Forestry-related carbon offset projects can be grouped according to the three main strategies within forestry that exist in seeking to mitigate climate change: *conservation* (preventing emissions from existing forest carbon pools), *sequestration* (increasing forest carbon pool stocks) and *substitution* (using natural resource-sourced products in place of fossil fuel-based products, such as wood for steel).

There are a number of inherent risks that need to be considered and addressed in judging the suitability of forest-related offset projects for mitigating climate change:

1. Lack of permanence. Carbon must stay locked up in a tree for at least 100 years to help limit climate change impacts from other emissions (David Suzuki Foundation 2009). This is difficult to ensure given the risks of fire, disease and logging that can quickly release carbon back into the atmosphere. Climate change is already affecting the trees themselves, with warmer average temperatures contributing to drought-related stresses, forest fires and insect-related deaths and causing some forests to become net sources of emissions rather than sinks (David Suzuki Foundation 2009). However, climate change can also result in increased growth, as trees in the northern hemisphere take advantage of improved climatic and growing conditions. There are several methods proposed to mitigate against risks of impermanence including: legal guarantees requiring land to remain forested in perpetuity; creating buffer pools whereby some offsets are held back to replace ones that fail; substitution of offsets from other projects; temporary credits; and insurance schemes. However, because the standards, protocols and standard bodies are all very new these methods are as yet unproven (Taiyab 2006).
2. Measurement. The science of carbon capture and storage in living biomass by trees is not fully understood, creating uncertainties when it comes to measuring the amount of carbon captured over the life of a tree (Valatin 2010).
3. Timeframe. Since trees take many years to reach maturity and absorb limited amounts of carbon in their early years, it can be many decades after trees are planted for actual emissions reductions to be delivered. ‘Ex-post’ accounting – selling the reductions after they have occurred over the life of the project – is not economically viable; hence ex-ante accounting is usually adopted for tree planting projects. This means however that carbon reductions for the next 100 years are sold before they actually occur (David Suzuki Foundation 2009). Short rotation plantations of fast-growing species can give rapid incremental carbon storage over a rotation, producing a net sink in a comparatively short period of time (Deckmyn et al. 2004). However, over a longer time period, total carbon storage is relatively small compared to slower-growing species that produce greater biomass (Senanayake 2008; Deckmyn et al. 2004).
4. Additionality. Some projects may be non- additional due to natural regeneration and succession patterns. For example, a project involving the reforestation of a previously

logged area is non-additional if that area will regenerate naturally over time anyway (David Suzuki Foundation 2009; Valatin 2010).

5. Biodiversity and human impacts of large monoculture plantations. Carbon sequestration might be optimised through the planting of fast-growing, non-native species in monocultures, however the resultant forest is potentially unstable, contains little biodiversity and can lead to the displacement of local populations (Taiyab 2006).
6. Leakage. There is no net benefit to the climate if the protection or reforestation of one area of forest leads to the clearing of another area of the forest. Determining that there has been no leakage can be difficult with respect to forestry projects (David Suzuki Foundation 2009; Valatin 2010).

Hence, there are a number of complicated issues surrounding the use of forestry-related projects for carbon offsets. Because of these inherent risks, some offset providers only consider energy-based projects to be credible offsets. Other retailers are aiming to build an overall portfolio comprised of 20-25 per cent land use projects and 75-80 per cent energy-based projects to reflect the contribution of land use change and fossil fuel energy to climate change as a whole. A diversified portfolio also mitigates against some of these risks (Taiyab 2006).

7. Carbon neutrality: contentions and debate

The concept of carbon neutrality as a mechanism for mitigating climate change has its fair share of proponents and detractors in both the academic and grey literature. The following quotes emphasise the polarised views that are held:

> "Carbon offsets can result in real reductions in greenhouse gases" (David Suzuki Foundation 2009).
>
> "The sale of offset indulgences is a dead-end detour off the path of action required in the face of climate change" (Smith 2007).

There is a clear need for significant global emissions reductions to tackle the problems of climate change. Since developed economies around the world are heavily dependent on fossil fuels, strong leadership is required at provincial, national and international levels to set reductions targets, policies and regulations that will enable the transition to clean sources of energy (David Suzuki Foundation 2009). At the same time, the desire of poorer nations is to

continue on, and indeed accelerate, their path to industrial and economic development. Developing nations have little historical responsibility to reduce emissions and lack the finance and capacity to invest in low-carbon technologies. Therefore, solutions to the issues of climate change must incorporate significant emissions reductions in developed nations combined with a flow of investment into developing countries to support their transition to a low-carbon economy.

Given this backdrop, carbon offsets have been promoted as an important and useful component of a comprehensive climate change policy since they generate reductions in greenhouse gas emissions in addition to those mandated by regulation, whilst also stimulating the market for clean energy technologies within developing countries (David Suzuki Foundation 2009). The basic economic argument in favour of carbon offsets is that they enable emissions reduction projects to occur where costs are lower, thereby reducing the overall cost of bringing down the level of global emissions. Proponents argue that carbon offsets promote sustainability co-benefits via technology development and transfer to developing countries, thereby reducing the risk of poorer nations repeating the fossil-fuel-driven development witnessed in the western world (CORE 2010). Breaking the cycle of poverty in developing countries is essential and the stimulus from investments made in local carbon offset projects can help meet this aim (Falls et al. 2010).

The Clean Development Mechanism (CDM) created under the Kyoto Protocol was designed to be a mechanism that linked the carbon market with sustainable development objectives in developing countries. However, a number of underlying flaws are argued to be reducing its effectiveness. Firstly, there is a predominance of low-cost, high-volume projects favoured by the market, such as landfill to energy projects, which often provide little benefit to local economies. Secondly, bureaucratic processes and high transaction costs render many small projects economically unviable in this market. Thirdly, there is a concentration of projects in large markets such as India and Brazil and comparatively few in the least developed countries that need them most (Taiyab 2006).

Mirroring these findings, reviews of the voluntary carbon market have also indicated a number of limitations. Firstly, the boundaries of carbon emissions being counted have been narrowly defined resulting in businesses reporting and offsetting low levels of direct emissions (Martin 2008). Secondly, there is evidence that emissions reductions claims made by carbon offset retailers are not matched by on-the-ground results from the projects (Murray

& Dey 2009). Thirdly, there is a concern that money spent on carbon credits is ultimately ineffective in supporting climate change projects due to the proportion that is swallowed up by intermediaries such as verifiers and consultants. Validation and verification processes required by the recognised carbon standards are extensive and onerous and have perhaps been over-engineered for the scale of some offset projects, resulting in prohibitive overhead costs. One suggestion is that smaller projects could adopt a more conservative approach, accepting a lower estimate of emissions offsets in lieu of a less extensive and therefore cheaper auditing process (Falls et al. 2010). Fourthly, there is a concern about the timing of greenhouse gas reductions. Forestry-related projects such as tree planting have a slow response time in generating emissions savings; voluntary credits are often sold before emissions reductions are achieved (Lovell et al. 2009). Finally, and perhaps most fundamentally, the entire emissions reductions achieved through offsetting in both the compliance and voluntary markets are marginal when compared to the scale of global emissions (Martin 2008). On the other hand, given the backdrop of continued annual increases in global emissions, at least the voluntary markets *are* contributing emissions reductions (Falls et al. 2010).

Critics of the carbon neutrality concept believe that it is fundamentally flawed as an approach to mitigating climate change because it encourages a 'business as usual' attitude (Smith 2007). Technological solutions to climate change are not likely in themselves to be sufficient, or indeed arrive soon enough, to mitigate climate change impacts. Therefore, a cultural and societal transformation is needed that places primary emphasis on energy and climate conscious behaviour and discourages waste and excessive consumption. Carbon neutrality works against this transformation since it allows individuals and organisations to ease their conscience by simply paying a little extra for a carbon offset rather than encouraging a change in consumption patterns (Smith 2007). Equally, it is natural that carbon offset vendors are more interested in selling offsets than in helping their customers to reduce emissions (Martin 2008).

A similar argument is applied to the use of carbon offsets by industries such as airlines and oil companies that rely on a high-carbon economy for their profit margins. Carbon offset schemes present such industries with an opportunity to claim that their activities have been neutralised with respect to climate impact (sometimes referred to as "green-washing"). This reduces the impetus for some of the larger industrial emitters to make the systemic changes needed to mitigate climate change (Smith 2007; Martin 2008). There is a risk that the short-

term cost benefits offered by offset programs will lead to large industrial emitters delaying investment and innovation in new lower-emitting technology in favour of buying offsets. This would prolong the life of higher emissions infrastructures in developed nations, leading to higher long term costs of conversion to new technologies. It is therefore argued that deeper emissions cuts in the long run could potentially be achieved more effectively and at lower cost by using other mechanisms such as direct financial incentives or regulation (Lohmann 2008; CORE 2010).

Proponents of carbon neutrality and carbon offsets would counter that climate change is such a huge issue that a whole range of solutions is needed and that carbon offsets contributes to these solutions. They argue that offsets should not be seen as a replacement for direct emissions-reducing actions, but as a complementary measure. High quality offsets represent an innovative way to deal with unavoidable emissions thereby making it possible to take responsibility for an entire carbon footprint. Furthermore, there is an important educational benefit as people come to realise the impact of their lifestyle choices after calculating their emissions and better understand the importance of greenhouse gas measurement and management (David Suzuki Foundation 2009). Sir Nicholas Stern, Head of the UK Government Economic Service and Adviser to the Government on the economics of climate change and development, argues that a price must be put on carbon to reflect its negative impact on the climate and to stimulate a reduction in fossil fuel use (David Suzuki Foundation 2009). Carbon offsets represent an added expense to an organisation and are therefore seen by proponents as a step in this direction. Proponents also argue that carbon offsets represent a voluntary application of the “polluter pays” principle, whereby those who produced the pollution take responsibility for cleaning it up (David Suzuki Foundation 2009). This may be stretching a point since carbon offsets enable an emitter to simply pay an offset fee without taking any action to reduce directly-controlled emissions; there is no obligation under offsetting to ‘clean up’.

Critics of the carbon neutrality concept have expressed concern at the adverse impact that carbon offsets may have on the mobilisation of social and political will for addressing climate change. There is a belief that the huge structural and behavioural changes that will be required to alleviate climate change can only be achieved through collective social and political organisation (Smith 2007). Carbon trading companies are marketing an opportunity for individual consumers to offset their ‘unavoidable’ emissions and content themselves that they have ‘done their bit’. Having satisfied themselves that they have made a contribution

towards climate change mitigation, individuals are less likely to be stirred into action as part of a wider societal call for change, thereby undermining the social and political mobilisation that will be so essential (Smith 2007, Lohmann 2008).

On the other hand, there is an argument in favour of carbon neutrality due to its very impact on individual behaviour. Vandenbergh & Steinemann (2007) suggest that individual behaviour is a significant and often over-looked source of greenhouse gases, accounting for one third of all USA carbon emissions in 2000. If carbon neutrality can encourage a shift in consumers' behaviour towards reducing waste and conserving energy, this could equate to a significant emissions reduction. In the field of environmental regulation, policymakers have traditionally focused most regulatory prescriptions on large industrial sources and given comparatively little attention to individuals and households. For example, controlling emissions from residential electricity use tends to involve controls imposed on the utility companies with less emphasis on energy consumed in the home (Vandenbergh & Steinemann 2007). The carbon neutrality concept could act as a stimulus to shift regulatory focus towards individual behaviour, thereby encouraging changes in consumption patterns.

8. Conclusions

Climate change is such a large and complex issue that successful mitigation will require a whole range of solutions throughout all levels of society. Conceptually, carbon offsetting has a positive role to play by stimulating emissions reductions, facilitating technology transfer to developing nations and educating people in greenhouse gas management. Equally however, there are strong arguments that it may undermine the investment and innovation needed for systemic behavioural and structural change within industry and society as a whole. Given the early stage we are at in the evolution of carbon trading, it is difficult to make any definitive conclusions on this. A fundamental criticism levelled at the concept of carbon neutrality is the encouragement of a 'business as usual attitude', with people simply paying a little extra to offset their emissions rather than seeking to reduce them. On the other hand, a viable carbon trading market does have the potential to influence changes in behaviour through the educational impact of encouraging people to think and learn about their own carbon footprint and how to manage and reduce it. This is very important since individual actions to reduce emissions are essential in the fight against climate change. There is also evidence that consumers are increasingly acknowledging companies that take a lead role in

managing their carbon footprint. For example, a local Vancouver-based airline that imposed a 0.5% surcharge on flights to Victoria to fund carbon offsets gained a 10% increase in customers in the following year (Falls et al. 2010).

On the carbon offsets front, there is wide variability in the quality of offsets being marketed, especially in terms of their effectiveness in producing emissions reductions. There needs to be a greater transparency and ability to prove that the emissions marketed by carbon credit retailers are actually happening on the ground (Martin 2008). This is especially true in the voluntary market where the number and variability of standards is an issue. The emergence of a single consolidated global carbon standard for the voluntary market is unlikely given the wide range of project types and products (Falls et al. 2010). However, the development of more stringent and higher quality standards, such as the VCS, is a positive development, raising the credibility of projects to the benefit of both project owners and offset purchasers.

At the institutional level, there are calls for organisations to move beyond the concept of carbon neutrality in order to more effectively tackle climate change. Martin (2008) adopts the term “carbon positive” and prescribes a four-step strategy for organisations that incorporates: counting and reducing all carbon, engaging all employees, influencing all stakeholders, and updating the organisation’s business model to fully reflect a carbon constrained world. There is evidence that organisations are increasingly looking to carbonise their business model. For example, Walmart now require their suppliers to review and report on their carbon footprints (Falls et al. 2010). Any organisation making claims about achieving carbon neutrality must make a genuinely comprehensive effort to manage their greenhouse gas emissions. This involves a broad assessment of all emission sources, including any Scope 3 indirect emissions that are deemed to be significant.

With the continuing evolution of major new carbon markets and offset trading, the concept of carbon neutrality is likely to play an increasing role in climate change mitigation. Carbon offsetting is no ‘silver bullet’ and an effective climate change solution will depend heavily on government regulations that set firm, science-based targets for greenhouse gas reductions and impose an adequate price on emitting carbon (Chafe & French 2008). However, the carbon neutrality concept has the potential to promote improved carbon management and to facilitate genuine emissions reductions. Ultimately this can only benefit the fight against climate change.

References

Association of BC Forest Professionals (ABCFP) (2010). *ABCFP overview* (online). Available from: http://www.abcfp.ca/about_us/abcfp_overview/about_abcfp.asp (Accessed 13 March 2010).

BC Government, Victoria (2010). *Carbon-neutral government* (online). Available from: http://www.gov.bc.ca/yourbc/carbon_neutral/cn_planet.html?src=/planet/cn_planet.html (Accessed 21 January 2010).

Ball, A., Mason, I., Grubnic, S. & Hughes, P. (2009). The Carbon Neutral Public Sector. *Public Management Review* 11(5):575-600.

Böttcher, H. & Breisgau, F. (2007). Forest Management for Climate Change Mitigation. Albert-Ludwigs-Universität, Freiburg im Breisgau.

Carbon Offset Research and Education (CORE) (2010). Stockholm Environment Institute. *Introduction to offset policies* (online). Available from: http://www.co2offsetresearch.org/policy/index.html (Accessed 6 March 2010).

Chafe, Z. & French, H. (2008). Improving carbon markets, Chapter 7 in *2008 State of the World: innovations for a sustainable economy.* Washington, DC: Worldwatch Institute. pp. 91-106.

Citizens Bank (2010). *Citizens Bank is carbon neutral* (online). Available from: https://www.citizensbank.ca/Personal/AboutUs/CorporateSocialResponsibility/CarbonNeutralCommitment/ (Accessed 21 January 2010).

Clean Air-Cool Planet (2006). *A consumers' guide to retail carbon offset providers*. Trexler Climate & Energy Services Inc. Portland, Oregon.

David Suzuki Foundation (2008). *Doing Business in a New Climate: A Guide to Measuring, Reducing and Offsetting Greenhouse Gas Emissions* (online). Available from: http://www.davidsuzuki.org/Publications/Doing_Business_in_a_New_Climate.aspx (Accessed 14 March 2010).

David Suzuki Foundation (2009). *Purchasing carbon offsets: a guide for Canadian consumers, businesses and organisations* (online). Available from: http://www.davidsuzuki.org/Publications/offset_vendors.asp (Accessed 3 March 2010).

David Suzuki Foundation (2010). *What is a carbon offset?* (online). Available from: http://www.davidsuzuki.org/Climate_Change/What_You_Can_Do/carbon_offsets.asp (Accessed 3 March 2010).

Department of Energy and Climate Change (DECC) (2009a). *Consultation on the term carbon neutral* (online). Available from:

http://www.decc.gov.uk/en/content/cms/consultations/open/carbon_neutrality/carbon_neutrality.aspx (Accessed 21 January 2010).

Department of Energy and Climate Change (DECC) (2009b). *Guidance on carbon neutrality* (online). Available from: http://www.decc.gov.uk/en/content/cms/consultations/open/carbon_neutrality/carbon_neutrality.aspx (Accessed 21 January 2010).

Deckmyn, G., Muys, B., Quijano, J.G. & Ceulemans, R. (2004). Carbon sequestration following afforestation of agricultural soils: comparing oak/beech forest to short-rotation poplar coppice combining a process and a carbon accounting model. *Global Change Biology* 10(9):1482-1491

Energy Priorities (2006). *Carbon Neutral Is Oxford Dictionary 2006 Word of the Year* (online). Available from: http://energypriorities.com/entries/2006/11/carbon_neutral_oxford_word.php (Accessed 20 January 2010).

Falls, R., MacDonald, D.S., Ouyed, M. & Tansey, J. (2010). "Voluntary Carbon Markets: Opportunities and Risks", *Globe 2010*, Vancouver, BC.

Forest Products Association of Canada (2010). *Carbon neutral pledge* (online). Available from: http://www.fpac.ca/index.php/en/carbon-neutral-pledge/ (Accessed 21 January 2010).

Greig &, M. & Bull, G. (2009). Carbon Management in British Columbia's Forests: Opportunities and Challenges*. FORREX Series 24*.

Hamilton, K., Sjardin, M., Marcello, T. & Xu, G. (2008). Forging a frontier: State of the voluntary carbon markets 2008. New York, NY: Ecosystem Marketplace & New Carbon Finance.

Harre & N. & Atkinson, Q.D. (2007). *Carbon Neutral by 2020: how New Zealanders can tackle climate change.* Nelson, New Zealand: Craig Potton.

Intergovernmental Panel on Climate Change (IPCC) (2007). *Synthesis Report*. IPCC, Geneva, Switzerland. pp. 56.

Kirby, A. & Bogdanovic, J. (2008). *Kick the Habit: A UN Guide to Climate Neutrality.* Malta: Progress Press Ltd.

Lohmann, L. (2008). Carbon trading, climate justice and the production of ignorance: ten examples. *Development* 51(3):359-365.

Lovell, H., Bulkeley, H. & Liverman, D. (2009). Carbon offsetting: sustaining consumption? *Environment and Planning A* 41(10):2357-2379.

Martin, P. (2008). *Beyond carbon neutral*. CarbonSense. Teignmouth, UK.

Matthews, H.S., Hendrickson, C.T. & Weber, C.L. (2008). The importance of carbon footprint estimation boundaries. *Environmental Science & Technology* 42(16):5839-5842.

Murray & J. & Dey, C. (2009). The carbon neutral free for all. *International Journal of Greenhouse Gas Control* 3(2):237-248.

National Energy Foundation (NEF) (2010). *Simple carbon calculator* (online). Available from: http://www.nef.org.uk/greencompany/co2calculator.htm (Accessed 07 April 2010).

Senanayake, R. (1998). *On the setting of value for Carbon sequestering* (online). Available from: http://www.elements.nb.ca/Theme/climate/jean/ran_seq.htm (Accessed 8 April 2010)

Smith, K. (2007). *The Carbon neutral myth: Offset indulgences for your climate sins.* Carbon Trade Watch. Amsterdam, Netherlands: Trans-national Institute.

Taiyab, N. (2006). *Exploring the market for voluntary carbon offsets.* International Institute for Environment and Development. London, UK.

The Greenhouse Gas Protocol Initiative (2010). *FAQ* (online). Available from: http://www.ghgprotocol.org/calculation-tools/faq (Accessed 07 April 2010).

University of Chicago (2010). *U.N. Copenhagen climate change conference: report-back from Harris school student Kyle Gracey* (online). Available from: http://sustainability.uchicago.edu/news/jan2010/copenhagenreportback.shtml (Accessed 07 April 2010).

Valatin, G. (2010). Forestry carbon: valuation, discounting and risk management. Forest Research discussion paper. Roslin, Scotland.

Vandenbergh & M.P. & Steinemann, A.C. (2007). The Carbon-Neutral Individual. *New York University Law Review* Dec 2007 82(1673).

Willson, R.W. & Brown, K.D. (2008). Carbon Neutrality at the Local Level: Achievable Goal or Fantasy? *Journal of the American Planning Association* 74(4):497-504.