# Beyond climate change – a business view

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## Abstract

Economic growth and social progress are dependent upon access to clean and secure energy. No single energy issue can be tackled in isolation, but equally there is a need for focused and material action on specific issues if progress is to be achieved. This paper provides a personal view of the broad range of issues involved in providing clean and secure energy, and outlines focused action that can be taken within this broader context to address climate change.

## 1. Introduction

Global leaders and policy-makers are giving increasing attention to the challenges posed by energy and its impact on the environment. In particular climate change has become a headline issue. However, while such attention is welcome, if the momentum for action is to be sustained, it is important

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for policy-makers to devise solutions that address the whole range of concerns that surround the provision and consumption of energy. It would be tragic if the effort to combat climate change foundered because it failed to take account of other important issues.

These issues cover a wide range. To begin with, the poorest countries still suffer fuel poverty. They need increasing energy supplies to provide basic services and raise their life expectancy and living standards. Demand for energy is soaring in rapidly emerging economies such as China and India whose growth – unlike that of the OECD countries – is occurring at a time when the environmental impacts of energy are well understood. The advanced economies which have become used to high living standards made possible by access to low cost energy have concerns about the security of their energy.

There are also several negative impacts of energy besides climate change. Local environmental quality particularly where it impacts human health, for example air quality, is often of more pressing concern for communities than the longer-term threat of climate change.

Increasingly, policy needs to integrate energy and environmental security concerns, rather than simply addressing individual issues through a set of independent policy initiatives. We must also recognise that the concerns and priorities of different countries and regions will be different and 'one-size-fits-all' global solutions will not be optimal. An agenda distorted towards the main concern of one region or another is unlikely to succeed because the actions of those not participating will contradict, undermine and de-motivate the rest. If all key players are to join together in any effective program, then it must be one that tackles all of the disparate issues holistically.

Realism is the key. And if we are realistic, we will start from a point of view that acknowledges the positive role of energy as well as the negative impacts. Starting with any kind of premise that energy is intrinsically negative immediately distorts the picture and overlooks the massive benefits that energy has brought to the world. The well-being of the world's 6 billion people depends on secure access to affordable and clean energy. Energy is needed to fulfil basic needs for food, water, sanitation and shelter, as well as fuelling the heat, light and mobility that are needed for economic growth and social progress.

This paper advocates an integrated response to the various challenges posed by energy provision and consumption, including climate change, energy security, air pollution, and the needs of the developing world. The essay does not try to argue for a particular outcome. Rather it is a personal view of the main issues and drivers that will shape the future of energy, with a special focus upon climate change.

## 2. Context

The provision of clean and affordable energy is a global concern for everybody. Energy is needed to fulfil basic needs for food, water, sanitation and shelter, as well as fuelling the heat, light and mobility that are needed for economic growth and social progress. However, its provision does raise ethical issues, such as how the world's poorest and most vulnerable people can gain fair and equitable access to energy.

Rich economies benefit from fossil fuel consumption, but the impact of the associated carbon emissions affects some of the world's most vulnerable people in the least developed countries. Very reasonable arguments around fairness and equality can too quickly descend into arguments about economic inequality and differing definitions of social justice. These cannot be ignored, but neither can they be resolved in the case of energy alone without it being seen as part of the broader journey of human progress and development. This journey will spend some time focusing on fuel poverty and climate change, but it is a journey whose breadth encompasses many other factors, and which will continue long after our current concerns have become part of history.

In terms of climate change specifically, Steve Pacala and Rob Socolow from Princeton University have shown that the necessary technical solutions already exist, at least to deliver the required results over the next 50 years [1]. The question is whether we choose to take the necessary action to make climate change an integral part of the journey during that period.

The choices we make about climate change are informed and shaped by a past, present and future. The past provides us with a rich pool of personal experience and shared knowledge from which we create understanding about what is possible. The future provides hope, and is most effective when focused by a shared aspiration. Only the 'present' provides us with the space to take action. However, the action we take always needs to consider competing objectives such as poverty alleviation and health improvement, so action needs to be thoughtful, paced and purposeful. It should not consist of gestures based on shifting ethical fashion, or worse, on over-reaction to alarmist predictions of doom. We need to look for enduring, confident and timely action in which we are all:

- open about what needs to be done,
- avoid asserting priorities between equally valid ethical propositions,
- do not prescribe solutions, but let them emerge through experimentation,
- embrace a willingness to learn and adapt as understanding emerges.

Real progress has been made over many decades in providing energy and environmental security, to which the effort to address climate change is a recent addition. Further progress can be made, as long as we are not deflected by unhelpful competition between 'ideal' solutions and accusations of irresponsibility.

As society considers the consequences of its demand for energy, the place to start is by being open about the probable impacts from consumption. These impacts are uncertain. We have to work with predictions about an unknown future, based on our evolving scientific understanding. We need to be cautious about being too certain about the future, but we need to take action. Indeed we take action every time we choose to switch on a light or drive a car. The place to start is with our best understanding of the impacts, so society can allocate resources and make strategic choices, based on its best current understating of competing needs.

One stark way to look at the impacts and the competing needs is to examine the relationship of energy to major global issues that cause large numbers of deaths every day. The World Health Organisation (WHO) estimates that climate change caused 150,000 deaths in the year 2000, of which just under 80,000 were caused by malnutrition, around 50,000 by diarrhoea, and just under 20,000 by malaria [2,3].

The impacts of climate change are not unique, but rather climate change is an additional stress to existing major problems. While climate change prompts calls for less energy use, there are also 840 million people in the world who are malnourished, of who 24,000 die each day of starvation, despite there being so much food in the world that more than a billion people are overweight [4]. Starving people in very poor communities need energy to create sustainable livelihoods, cook food safely and refrigerate medicine. In addition millions are at risk from inhaling smoke caused by the burning of traditional biofuels indoors for cooking in developing countries. In many of these areas, solutions already exist, but are not fully implemented. We need to ensure that we are realistic in our objectives, and that we are solving the highest priority problems.

There is reason to believe that greater collective concern and action is emerging, and this can be accelerated by improved cooperation between business, governments and civil society.

Further acceleration can come from increased public awareness and through consumers becoming willing to purchase new solutions, either individually or through supporting collective political programs for action. Consumer support provides the key market incentive for the creation and growth of clean energy businesses.

So, given the momentum that has been created, what are the main factors that policy-makers need to address; first continued economic growth and development, second guaranteeing energy security, third continued improvements in human health, fourth mitigating and adapting to the impacts of climate change, and finally respecting the natural world within which we live. All are necessary objectives, but it would be foolish to ignore the legitimate process of political prioritisation.

## 3. Economic development and social progress

Population growth and economic development both create new demands for energy. Energy is a key enabler to human development for the poor, is needed to meet the increasing demand for modern goods and services, and is itself an important source of wealth creation for many societies. It would be foolish to suggest that this increasing demand for energy is going to diminish in the near future, although there will be many opportunities to provide and use energy more wisely.

### 3.1. Providing clean energy for development

Energy plays a fundamental role in economic growth, development and human progress. Any measures to curtail energy use in order to limit negative impacts have to be weighed against the positive impacts of its continued consumption. Energy is a prerequisite to social progress and economic development. It services basic human needs for water, food and shelter. It provides the heat, light, mobility and motive power that underpin social progress and are necessary for jobs, education and health care. Energy has undoubtedly had a positive role to play in the rise in global life expectancy from 46 to 63 years over the last 50 years. Conversely, lack of access to clean energy is one reason for unnecessary poverty for millions. The IEA estimates that 1.6 billion people in developing countries are without any electricity in their homes [5].

There is a clear relationship between per capita energy consumption and measures of development, such as the Human Development Index (HDI), a measure of life expectancy, education and standard of living. Countries who consume less than 2 tonnes of oil equivalent per capita per year of energy have a low HDI [5]. Large gains in HDI can be achieved for relatively modest increases in energy use up to this level, but above it, the industrialised OECD countries achieve only modest gains in HDI despite much higher energy consumption.

A similar pattern is seen in electricity consumption, with a rapid rise in HDI for developing countries up to an inflexion point of between 3 or 4 MWh per capita per year. Developed countries' consumption levels are all above this inflexion point, and they have much more modest increases in HDI despite their much greater electricity consumption, which reaches 20MWh per capita per year in Canada.

Urbanisation is also a key driver. Over the last century the world experienced unprecedented growth in urbanisation. In 1900 only 14% of the world's population lived urban areas, but by 1950 30% did so, and by 2000 the proportion was 47% or 2.8 billion people. It is expected that by 2030 this will have risen to 60%. Most of the increase will be in developing countries, and associated with the rise of 'mega-cities', those of more than 5 million people. There were 5 mega cities in 1950, all in the developed world. This rose to 41 in 2000, and is expected to rise to 59 by 2015, of which 48 will be in developing countries. Supplying the necessary energy to fuel these cities will be a key challenge for the future, as will their demand on a whole range of key resources, such as water, arable land, minerals and timber.

### 3.2. Energy and economic development

Affordability is a prime concern for economic development as energy supplies cannot be seen as secure if economic factors make them unaffordable to large groups of users. Investment in the global energy sector accounts for around 1% of global GDP, or 5% of all investment [6]. Oil consumption grew by 50% during the seventies, despite the large price increases of 1973/74 and 1979, and eventual peaked in 1979 [7]. The reduction in oil consumption that followed was largely because of switching from fuel oil to other fuels in the power and other sectors, while high energy prices reduced overall primary energy demand. Since 1985, and through a 5-fold range in oil price, from $10 to $50 per barrel, oil demand increases have averaged 1.5% per year. There is much debate about how responsive overall demand is to price changes. According to the IMF, at a macro-economic level, large changes in oil price have a demand elasticity of around - 0.5, while more modest changes are much more inelastic [9]. It seems likely that high oil prices will drive substitution, rather than sustained demand reductions, at least while there is sustained economic growth.

Much of this inertia in demand is caused by equipment choice, not fuel choice. Users' fuel choices are dictated by the equipment they possess, which acts to set technical limits on direct fuel switching. Price changes do not necessarily result in immediate reductions in demand for the primary energy. Instead they tend to have a delayed impact, affecting equipment choices that are made on timescales determined by capital stock turnover. However, demand can be suppressed by overall economic decline, as was demonstrated most clearly during the mid-nineties in Russia.

The price of energy is often not based on a conventional commercial return determined purely by open market pricing; but is a result of regulation, for example by public service commissions or through the imposition of producer or consumer taxation, or both. This tends to drive the price well above that which calculations based on costs and conventional profit margins would dictate. The commercial cost of production in the Middle East is estimated by the IMF to be just $2.6 per barrel for finding and development and $2.6 per barrel for production, providing a significant margin at higher oil prices for the resource owner [8].

Oil and gas companies also have an important role as generators of fiscal revenues for governments. For example, during 2004, on revenues of $285 billion, BP paid and/or collected $76 billion in taxes - $67 billion in consumption taxes, $6.4 billion in income tax and $2.2 billion in production taxes [9]. The future economics of energy needs to consider these flows, as they are an important source of revenues for governments, and they are placed under threat if material increases in the cost of the production or transformation of energy are needed to respond to concerns over energy or environmental security.

On the other hand, some forms of energy attract direct or indirect financial support from governments for a variety of socially beneficial reasons; such as clean and secure power from renewables, rural support programmes which encourage biofuels, assistance with public liability for the nuclear industry, and subsidies for the coal industry to protect employment.

## 4. Energy security

According to the IEA fossil fuels supplied 80% of the world's primary energy in 2003: coal providing 24%, oil 35% and gas 21% [10]. The fossil fuel industry is again in a state of flux, as is the energy industry more broadly. A sustained higher oil price creates new competitive options, both from non-conventional fossil fuels and other sources of primary energy. Nuclear power is again becoming a real option for some countries, and there is renewed commitment to energy efficiency, renewables and bio-fuels by many governments. While this flux reflects a broad range of concerns, energy security is increasingly a critical concern for many countries, along with the impact of environmental emissions arising from energy use.
Energy security in itself is a complex concept, made up of a number of individual but connected concerns, each with its own technical, economic and political dimensions. These are: availability, access, demand competition, physical security and reliability.

### 4.1. Availability

There is no immediate shortage of energy to meet the world's aspiration for economic growth and social progress. People have worried about the finite nature of oil reserves for many years, yet they continue to grow each year to offset production. There are at least 40 years of proven conventional oil reserves, at current consumption, and over 60 years of gas, with considerable unexplored upside potential, and at least 200 years of coal supply [11]. There are vast quantities of non-conventional oil and gas, such as heavy oil and gas hydrates.

The volume of reserves is very dependent upon price and the rate of technological innovation. It has been argued that since 1973 the oil price has been set by OPEC, or effectively by Saudi Arabia alone as the swing producer. However, the price also represents on a long term basis the marginal cost of non-OPEC production, and particularly production of technically more challenging oil by international companies – i.e. at the market cost of capital using the best available technology. At sustained oil prices of $20-40 per barrel vast qualities of non-conventional oil can provide as a substitute for conventional oil [12].

The wide geographical distribution of these resources would counterbalance the increasing reliance upon the Middle East for conventional oil. Some non-conventional sources have already demonstrated that they are economic even at modest oil prices, for example existing Venezuelan heavy oil production. Heavy oil, gas to liquids and potentially coal to liquids are becoming much more competitive, vastly increasing the effective resource of liquid fuels. As a result, oil, conventional or synthetic, will probably remain the fuel of choice for transport for many decades; while there will be continued competition between the remaining significant resources of gas, coal, nuclear and renewables energy in the power sector.

### 4.2. Access

For countries to enjoy energy security, the existing reserves need to be accessible, and much recent debate has centred on whether the location of the resources – particularly in the Middle East - could jeopardise the ability of consumer countries to reach them. Given the fears over disruption of supplies from the Middle East and other OPEC countries, it is important to note that OPEC's market share is only around 35% and most growth during the current decade is likely to occur from non-OPEC sources. The IEA predicts that OPEC's share will then rise, reaching 53% in 2030, just above the historic peak of 1973. It should also be noted that, rather than interrupting supplies, OPEC's record over the past decades has been one of helping to keep oil flowing, albeit often at relatively high prices, through crises such as the Iraq war and supply disruptions such as hurricanes and strikes. The world's second largest oil exporter, and the largest gas exporter, is Russia. It has prided itself on providing sustainable access to these resources, particularly gas, through several decades of internal political change. However this reputation has recently been called into question when gas supply to the Ukraine was interrupted in early 2006.

One means of easing pressure on access would be to find new forms of energy to replace conventional oil, particularly in transport, where there are few present-day alternatives. Over 96% of the world's transport requirements are met by oil, and the advantages of oil mean that there is no real alternative at present. Neither gaseous fuels, nor electric vehicles, are currently a viable alternative in most applications – although they do have successful niche markets. However, with the potential for sustained higher prices, there will be more diversity of supply, with bio-fuels and gas to liquid fuels or hydrogen becoming real options. There is also the potential use coal to liquids, particularly if their production can be optimised by being associated with power and/or chemical production.

### 4.3. Demand competition

Even if oil and gas are available and accessible, consumer countries are concerned that their supplies may be diverted by competition from other sources of demand.

Globally, energy demand has grown rapidly over the past half century due to increases in both population and per capita wealth. The world's population grew from 2.6 billion people in 1950 to 6 billion in 1998. Gross world productivity increased by 583% between 1950 and 1999, from $6 trillion per year to $41 trillion (real 1998), and average per capita GDP increased from $2,500 to $6,750. The recent high oil prices have been caused by high levels of Chinese demand (China alone accounted for 44% of oil demand growth in 2004) and continued economic growth in the OECD countries, as well as a lack of swing capacity in the Middle East. While additional capacity will be added, some countries are uncomfortable to simply rely upon the market to meet their particular demands in competition with others, and are again seeking special relationships between producers and consumers, for example the equity ownership being taken by Chinese companies.

## 4.4. Physical security

Physically securing access to energy has long been a prime concern of governments, not least because access to reliable energy is an essential component of a nation's defence capacity. The emergence of a global commercial market for many forms of fuel and energy technology has reduced the degree to which conflict can be motivated by securing physical access to energy. This has been re-inforced as countries have become more dependent upon trade, with increasing interdependence for access to raw materials and markets. This is a force for security in a wider sense as countries that are part of the same supply chain tend not to become adversaries.

However, there are still a number of 'choke points', where physical interruption of supply would have an impact. For example, each day 13 million barrels of oil pass through the Straits of Hormuz, 10 through Strait of Malacca, 3 through each of the Bab el Mandab and Suez Canal, and 2 through the Bosporus [13].

Responding to any supply disruption, whatever its cause is greatly facilitated by the operation of a global fungible market, where resources can be redirected in an economically efficient manner. The IEA was established following the supply disruptions in 73-74, when the global oil market was less well developed, to manage a process that ensures OECD countries would have access to emergency oil supplies during major disruptions. Currently, over 4 billion barrels are held by governments and businesses within this mechanism, which has only been used twice, firstly in 1991 following the first Gulf War, and recently as a result of hurricane Katrina.

Many people are concerned about the physical security of fissile materials associated with nuclear power. This concern has increased recently because of the potential of terrorists to attack energy infrastructure or the use of dirty bombs. Others argue that the danger can be limited by the use of the right processes and technology.

## 4.5. Reliability

The provision of energy on demand is essential at many levels within a modern economy: consumer, business, industry and critical services. Advanced economies have become used to easy access to transport fuels and resilient power networks that rarely fail. It is rare for there to be any failure in the provision of liquid transport fuels due to reliability issues, and the most important sources of failure in the power sector are extreme weather, equipment failure, under-investment, poor maintenance and physical attack – such as vandalism, terrorism or war. Beyond adequate investment and good maintenance, the key tools for managing the more uncertain events are redundancy and storage.

The failure of a power system can happen in the distribution, transmission, generation or fuel systems. The interconnected nature of large power grids provides an efficient way to deliver reliability, but it also carries the risk of cascading failure. A key challenge is ensuring that not only is power availability guaranteed, but that other key parameters are maintained within specification, for example voltage, frequency and reactive power. These parameters can change quickly, and the system needs to be able to manage them. The increased use of distributed generation can offer greater resilience, and greatly reduce transmission costs.

Intermittent renewable generation can introduce new dispatch constraints. One way to deal with this is to extend the idea of the 'spinning reserve' through some level of capacity mandate which is used to manage the need and ensure that supply and demand are constantly balanced, the additional cost of providing this service can be made more transparent by the regulator purchasing the reserve through a capacity payment. However, there may be other, complementary, mechanisms to ensure reliability, such as making more use of intelligent networks for distributed generation.

## 5. Environment

Environmental security is about the health of people and the biosphere, it is interdependent with economic growth and energy security in ways that we are only starting to fully understand.

### 5.1. Environmental health

Historically there have been two principal concerns about the impact of energy use upon human health. First, there have been positive benefits associated with access to energy as described previously. However, there are also negative impacts associated with energy provision and particularly consumption. The effects on public health of emissions from energy consumption, particularly via local air quality, is a major cause of concern.

It is estimated that one quarter of all ill health is to some degree associated with poor environmental conditions. Currently 1.7 million people die prematurely each year from unsafe water, sanitation and hygiene – associated with lack of energy as opposed to energy consumption. Meanwhile 800,000 die from poor outdoor air quality and 1.6 million die from the inhalation of smoke from solid fuels indoors [14].

However, poor air quality is not just a developing country issue. There is evidence that in the US 2% of all deaths are associated with poor air quality, and 5.5 million children are affected by asthma. A recent health impact assessment for Austria, France and Switzerland revealed that vehicle related pollution kills more people than car accidents [15]. Another recent European study has estimated the combined cost of health externalities from the consumption of coal and oil to be in the range Euro 0.02 to 0.07 per kWh, which is broadly similar to the cost of generation [16]. This cost is twice that associated with gas, while the cost of nuclear energy is half that of gas, and the cost of renewable energy half that of nuclear.

Increasingly the health burden from energy consumption will be associated with urbanisation in the developing world. 13 of the 15 most polluted cities in the world are in Asia. The US adopted its first significant air pollution regulations during the 1950s, when per capita income was around $13,000 per year. Japan adopted modern regulations during the early 1970s, when incomes were around $11,000 per year. However China and India started to regulate emissions during the 1990s, when average incomes were only $1,500 per year, and in some respects these regulations have surpassed those of the developed countries. For example recently China announced auto emission standards that are more stringent than at the US Federal level.

However, concern about such apparent modern concepts as urbanisation and sustainable mobility is not new. In fact oil and the internal combustion engine were part of a previous solution to similar concerns. Despite horses being only half as energy efficient as humans, their greater power made them essential. At the turn of the twentieth century the 200,000 horses in New York 'emitted' 7,000 tons of manure per day, creating an enormous health hazard and an expensive waste disposal problem. There was also a supply problem; a great deal of arable land was needed to grow food to fuel these horses.

The natural carbon cycle is not the only one being perturbed by human activity. The global nitrogen cycle is also affected [17]. Nitrous oxides (NOx) emissions are the product of combustion of fossil fuels with air, and play an important part in driving four key sources of damage: <2.5µm particulates, ozone, acidification and eutrophication. The nitrogen cycle is also heavily impacted by agriculture. The positive impacts of nitrogen based fertilisers to increase food production are widely recognised, but there are also systematic negative impacts which are global in scale, for example through increased respiratory and cardiac problems, as well as ecological damage.

Sulphur emissions from the combustion of coal and conventional petroleum fuels are important sources of both particulates and acidification, but the emissions are more controllable than NOx, either through removal of sulphur from the fuel in oil refineries, or through post combustion process like flue gas desulphurization (FGD) on coal fired power plants.

While in the past there has been a clear distinction between local air quality and the global impact of greenhouse gas emissions, the boundary is starting to blur. In South Asia air pollution is no longer focused upon emission 'hot spots', but is an increasing regional haze resulting from a combination of forest fires, fossil fuel consumption and the burning of conventional bio-fuels. The effects are wider than simply those direct impacts from conventional air pollutants because they give rise to regional changes in air quality and weather, such as a reduction in the level of sunlight reaching the earth's surface and changes in regional precipitation.

## 5.2. Ecological impact

The potential for ecological impacts occurs both from the provision and consumption of energy, although the balance between these, the nature of the potential damage and the geographical location of the impact vary depending on the particular supply chain from source to use. This makes comparisons between supply chains very difficult, not least because of different cultural expectations, even within a given supply chain. Of course these different cultural expectations are not limited to different values placed on ecological impacts, but also to broader ethical considerations. For example there are legitimate differences in perspective on the benefits and costs associated with nuclear power. How do you compare the climate benefits from greater use of nuclear power against increased threat of nuclear terrorism or risks associated with the management of radioactive waste?

Of course fossil fuels are only some of a number of key resources with limits to their exploitation. Others include water, arable land, minerals and timber. The limits on exploitation may not always simply be about resource availability. The limit to conventional fossil fuel consumption will probably be determined more by the effects on climate change than by the availability of fossil fuels.

Access to these key resources is also interdependent; both in a technical and political sense. For example, energy can be used to overcome fresh water limitations through desalination. Only 3% of the world's water is freshwater, and most of this is locked in ice caps or glaciers. Of the available freshwater it has been estimated that half has already been appropriated for human use. At times the competition for this water and its quality gives rise to tension, particularly among downstream users, for example between the countries that share the Danube, Nile, Jordan and Euphrates. At current consumption rates, 100% of freshwater will be appropriated by humans by 2050. Similar interdependences exist between energy and other key resources, such as the ecological, agricultural and health benefits of making modern fuels available to those who still rely upon 'sticks and dung' for cooking.

## 6. Climate change

The world is warming, and the societies that business serves are increasingly concerned about the impacts of rising average temperature, the increasing frequency and severity of extreme weather events, and the possibility of irreversible temperature induced effects. Human activity appears to be an important causal factor in recent warming, but many uncertainties remain. Societies need to respond to these concerns. Such a response needs to reflect the long term nature of the issue, but also recognise that the size of the challenge means urgent but informed measures are needed that will lead to the stabilization of atmospheric greenhouse gases. This section explores current policy and business response, and suggests that while no single technology or policy 'silver bullet' exists, a portfolio of solutions already exist. Progress is being made, and that there is a case for cautious optimism.

### 6.1. Climate impacts

Changes in regional weather due to climate change affect temperature, precipitation and the incidence of extreme weather events, and are estimated to currently cause around 150,000 premature deaths per year [2,3]. The principal health effects are malnutrition, water and food borne diseases, vector and rodent borne disease, allergies, temperature related illness, the physical impact of extreme weather events and air-quality related impacts. These impacts will combine with existing trends, for example increasing cardio-vascular disease associated with the aging population, but some of the additional burden can be avoided by behavioural changes. Other impacts such as diarrhoea will be reduced through improved living standards, where the recovery rate is nearly 100% once GDP per capita reaches $6,000 per year. There will also be geographical disparities. Death rates associated with climate change are highest in India and Sub-Saharan Africa, while North America and Europe may actually see a reduction in deaths – as winter extremes become less frequent.

Unlike many environmental issues, climate change is not just about the direct impact upon human and ecosystem health. Climate change modifies the future environment within which people live, such as the availability of fresh water or loss of land due to increases in sea levels. It also has direct economic impacts, increasing economic losses due to draught or storm damage. It will impose additional costs associated with adapting to living within river deltas, as 70% of the worlds population do. There is also the possibility of low probability but high impact events, such as the loss of Greenland and Antarctic ice sheets.

Many of the world's poorest people, in the least developed countries, are most exposed to the direct impacts of climate change. They have insufficient human and financial resources to adapt without help. Mechanisms like Kyoto's Clean Development Mechanism (CDM) offer very little help for these people; it is a sophisticated market based mechanism to mitigate emissions, well suited to the growth markets of China, India and Brazil, but less so to economies that rely on self sufficiency and barter, but who have a critical need to adapt.

### 6.2. Initial policy response

Over the last decade there has been much talk of 'internalising the environmental externality', and a emission Cap and Trade System (C&TS)

has emerged as an economically efficient tool for achieving this. A C&TS creates a new property right of emission allowances by establishing a regulated cap on the total emissions allowed. A carbon credit property right can also be created by having a legally enforceable definition of not emitting. These well defined property rights allow trading of both the emission allowances, and the use of credits to offset emissions where they exceed the allocated allowances. This trading in allowances and credits is economically efficient, allowing reductions to be made at the cheapest point, rather than forcing every emitter to make the same reduction irrespective of the cost of compliance. However, this is not the product of a conventional market – a tradable carbon product does not have the inherent ability to delight and engage consumers. It is a compliance market created by regulators.

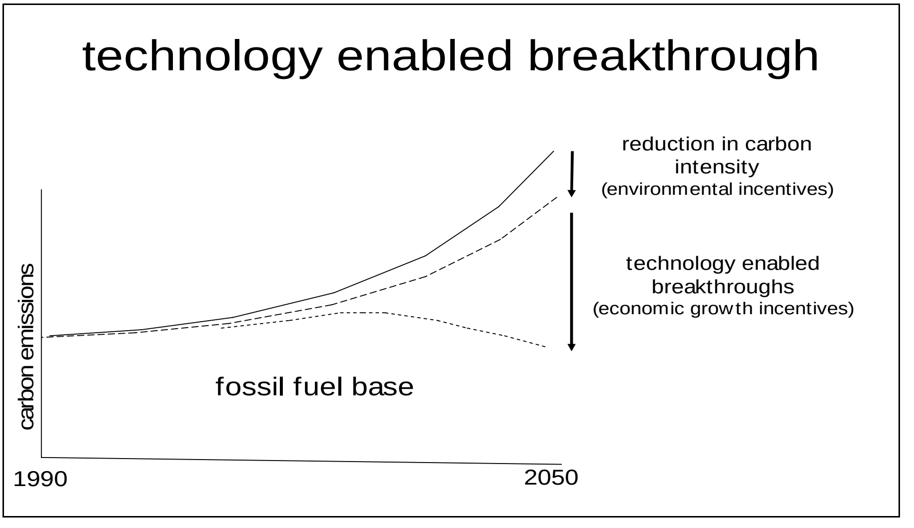
Of course there is a small market for environmentally aware companies and consumers who purchase carbon tradable products for their own satisfaction, particularly where their marginal cost is low. There is no evidence of a material market emerging for carbon tradable products outside those created by regulation. Most of us still 'talk thin, and buy fat', but this might change.

The key elements of a C&TS are establishing the overall cap, the allocation of allowances to specific emitters, and establishing the process for trading allowances and credits. The outcome is the necessary emission reduction, and a marginal price of abatement. An efficient and liquid market in trading the various allowances and credits is clearly helpful in delivering the lowest possible cost of abatement. However, in practise the policy focus needs to be holistic, where the choice of cap, allowances and process for trading allowances and credits is chosen to achieve a realistic abatement cost. A sensible test might be whether the abatement cost is sufficiently high to engage people in behaving differently, but not sufficiently onerous to cause overall competitive disadvantage to an economy.

Emission trading markets price the marginal cost of abatement, and because the property right is for a limited period, it should probably be the considered as the marginal cost of emission reductions within existing infrastructure. It is difficult to imagine an enduring and legally binding allocation, which would allow the market to internalise the full value of future allowances and credits, sufficient to justify the major capital investment needed to create a new low carbon economy. This probably implies that the cap and allocations are limited to driving efficiency into existing infrastructure, with some allowance for new low carbon entrants.

At times there is some confusion about the size of the emission trading market, with some people incorrectly taking the marginal cost within the C&TS and multiply it by total volumes to establish the overall carbon market size. This is erroneous as it misses two key facts. Firstly, in systems like the EU Emission Trading System (EU ETS) most allowances are allocated free. Secondly, many companies will find efficiency gains within their existing operations, where the net cost of emission reduction is NPV positive. It is only the minority of emission reductions that are priced within the trading scheme, and even then these are based on the assumption that a balance exists between people buying and selling. This balance might not necessarily exist, as there is a disparity between those with an absolute need to buy allowances to conduct their principal business, and those who can generate allowances to sell. Some businesses will choose to focus their limited resources upon adding value within their core business, rather than generating allowances for others, however profitable.

Carbon intensive societies can optimise their use of fossil fuels by imposing emission constraints, and C&TSs offer a route to achieve this. But it is impossible to deliver the necessary long-term reductions from within the existing infrastructure; new low carbon economies will need to be built. This requires transitionary incentives to induce the necessary technological change required to get onto a trajectory that will ultimately stabilise atmospheric concentrations at acceptable levels. With such transitionary incentives it should be possible to achieve the level of sustained cost reduction seen with other energy technologies, for example both deepwater oil production and photovoltaic technology have sustained a 5% per year cost reduction over many years, while wind and liquefied natural gas have seen a 3% annual reduction.




The key policy question is how to create competition between technologies which are at different stages of maturity, i.e. they each have their own learning curves, and at any specific moment have progressed down their own cost curve by differing amounts. A simple market based mechanism like a C&TS will clearly favour the current lowest cost technology, while using non-market based mechanisms to pick winners has not in the past proved an economically efficient way of allocating resources. Perhaps there is a need for a new hybrid policy that encourages new technologies to compete to achieve reductions at lowest long-term cost, despite their current differing state of maturity.

Ultimately as an increasing proportion of the economy is serviced by low carbon technology, the general price of carbon in the economy, as set by the marginal price of carbon reductions in the economy through a policy like C&TS, will become sufficient to make the new technology economic without the need for the transitionary incentives.

### 6.3. Business response

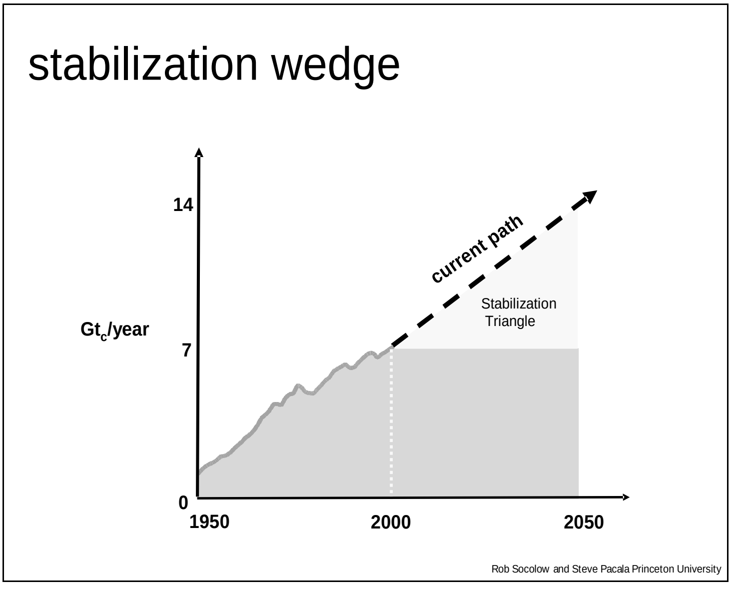
Business needs to be proactive in providing solutions to climate change. Like any other business activity, the first step is to be clear about what strategically needs to be achieved, and what the future business opportunities might be. While many uncertainties remain, based on the IPCC Third Assessment Report [18], there seems to be the emergence of a consensus that a sober approach would be to limit any increase in the average global temperature to around 2 degrees Celsius, above pre-industrial levels. Focused upon that goal, a growing number of experts have concluded that, at least for now, policy should aim to stabilize concentrations of carbon dioxide in the atmosphere in the range 500 to 550 parts per million (ppm), less than twice pre-industrial levels. However, the science remains inconclusive, and there is increasing evidence that a reduction of more than this might be needed, but the economic costs as we currently understand them may be prohibitively large. It is not the role of business to advocate long-term societal targets; that is the role of government. It is however, the role of business to anticipate emerging trends, respond by generating options, and deliver solutions.

While business needs to accept its role in improving the efficiency of the existing infrastructure, through instruments like C&TS, it's key role is to provide low carbon investment options, which will fundamentally change the carbon intensity of societies. In doing this it will create many new and exciting economic and business growth opportunities.

## 6.4. Low carbon business opportunities

Steve Pacala and Rob Socolow from Princeton University have shown that the necessary technical solutions already exist to limit climate change within the indicative target of 'no more than 2 degrees of global warming', or at least solutions exist to deliver the necessary actions for the next 50 years [1]. They developed a simple model, which helps to communicate the issue, and illuminate potential solutions. The diagram shows how emissions of carbon dioxide from fossil fuels have grown to their current level of around 7 billion tonnes of carbon per year. With conventional assumptions about population and economic growth, then it is expected that these emissions will double over the next 50 years, with emissions increasing to 14 billion tonnes of carbon per year.

The model makes the reasonable assumption that a long term stabilization aspiration could be achieved if emissions were broadly held flat over the next 50 years. Put simply, this means that the risks associated with climate change can be managed, despite a more than doubling of energy consumption, if we develop over the next 50 years a low carbon primary energy industry equal in size to the existing one. It does not mean the end of existing fossil fuel industry; the model assumes a similar level of emissions from fossil fuels in 2050 as we have today. Indeed there could be growth in certain types of fossil fuel consumption, where they are less carbon intensive, such as using gas rather than coal for power generation, or where the carbon emissions are captured and stored either geologically or biologically, a process that is sometimes known as sequestration.




To aid understanding of what needs to be achieved, take the 7 billion tonne wedge of emissions that need to be avoided over the next 50 years. Assume it is broken down into seven smaller 1 billion tonne wedges. Each is a solution that grows from zero today to avoiding the emissions of 1 billion tonnes of carbon per year in 2050.

Technology exists today for at least 16 possible solutions, each is broadly economic, and has been demonstrated somewhere in the world at scale. Each solution is capable of reducing emissions by 1 billion tonnes by 2050, and several are capable of delivering more than 1 billion tonne wedge. With such a large portfolio of options there is no need to pick winners, but there is a need for policy that encourages business to invest, innovate and deliver.

**possible 1Gtc/year wedges**

1. internal combustion engine efficiency
2. demand side reductions, e.g. reduce use of vehicles
3. buildings energy efficiency
4. industrial process efficiency
5. efficient baseload coal plant
6. gas for coal power
7. carbon capture & storage for power
8. carbon capture & storage for transport, e.g. synfuels from coal
9. Nuclear
10. Wind
11. pv solar
12. biomass for transport and power
13. hydrogen from gas
14. zero emission hydrogen
15. Forestation
16. Tillage

A 1 billion tonne wedge of reduced fossil fuel emissions would require the construction of 700 1GW nuclear power stations over the next 50 years, implying a construction rate similar to that achieved in the seventies and eighties. A 50 fold increase in the existing wind generation capacity would deliver a 1 billion tonne wedge, as would 700 fold increase in pv solar. A 700 fold increase might sound too great a challenge, but this requires only half the growth rate the solar industry has maintained over the last 25 years. Repowering the existing world fleet of coal fired power generation with gas would deliver one wedge, as would capturing and storing the emissions from half the existing coal fired power plants.

## 6.5. Integrated public policy

Increasingly governments will need to use a broad suite of policy measures to meet their climate objectives. Just as there is no single technical 'silver bullet', so there is no single policy instrument that by itself is adequate. However, policies that use the market to promote growth and responsible behaviours of consumers and business are most likely to be successful.

- Emissions **Cap and Trade Systems** drive efficiency into existing major infrastructure, reducing emissions per unit of output. C&TS are an economically efficient way of regulating emissions from current plant and equipment. While the current focus is upon large emitters, potentially it would be possible to create aggregation processes, which allowed the broader use of the system, potentially including the retail consumer.

C&TS offer an enduring market based mechanism to internalise the climate externality. They are likely to develop regionally, so emphasis needs to be placed on ensuring that exchange mechanisms exist between these regional systems. There is no need for a single carbon currency, no more than there is a need for a single global monetary currency. International trade in carbon can occur without a single unifying system, but there does need to be a strong benchmark currency, and for carbon this currently appears to be the one created by the EU ETS.

- **Technology Transitional Incentives** encourage the commercial development and deployment of near to market technologies like renewables and carbon capture and storage. Price signals from C&TS are not necessarily sufficient to promote all the potential low carbon investments, particularly in their early stages of deployment. Nor would it be wise to introduce across the whole of the economy a carbon price on all goods and services sufficient to incentivize the growth of these low carbon solutions. Governments should avoid imposing unreasonable costs upon their businesses and creating competitive disadvantage. The cost needs to be commensurate with the environmental benefit, both now and in the future. Significant cost reductions will be possible in the future from many technologies, history would suggest in the 2-5% per year range. Paced deployment is necessary, moving too quickly will lock in unnecessary costs, while delaying investment may mean the necessary reductions are not achieved.

- **Investment Criteria** would ensure that all new energy infrastructures are competitive against cost and emission benchmarks. The IEA estimate that $16 trillion dollars will be spent on new energy infrastructure over the next 30 years, almost half of which will be in developing countries. While investment in the OECD will increasingly become influenced by active climate policy, it is critical that the new investment in non-OECD countries is as economically and environmentally efficient as possible. A process analogous to the Equator Principles may be helpful, involving commercial banks, export credit agencies and business investors. With a voluntary agreement to only investments in projects that are top quartile in terms of cost performance and emission intensity, e.g. $/MWh and tCO2/MWh for new coal generating capacity

While these three generic policies focus upon the critical areas of market incentives for operational efficiency and investment by business, three additional enabling policies are critical, and should receive attention by governments. Their implementation will also create opportunities for business, creating new products and markets.

- **Public Awareness** to create acceptance of public policy and an increasing customer base for clean and secure energy.

- **Regulation** where there is clear market failure, for example energy efficiency in buildings, where the separation of development, ownership and occupancy can cause economic barriers to the effective use of market based signals.

- **Tax and Trade Consistency** to remove inconsistencies and barriers, for example the removal of import tariffs to allow the creation of an open global market for biofuels.

## 7. Conclusion

Energy provision and consumption underpins many aspects of human development, economic growth and social progress. It is a complex issue, which impacts everyone. Climate change adds another dimension, sometimes occurring as overwhelming in its complexity, uncertainty and importance.

Over the next decade we have the opportunity to lay the foundation for resolving the apparent contradiction between continued energy growth and the real constraint on carbon – which is increased atmospheric concentrations of $CO_2$, rather than availability of fossil fuel. A range of technology solutions already exists to address climate change concerns that are broadly economic today. The wider energy challenges are complex, and climate change must be addressed in a way that takes account of these issues. While there is considerable uncertainty and complexity, solutions do exist, all that is required is action.

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