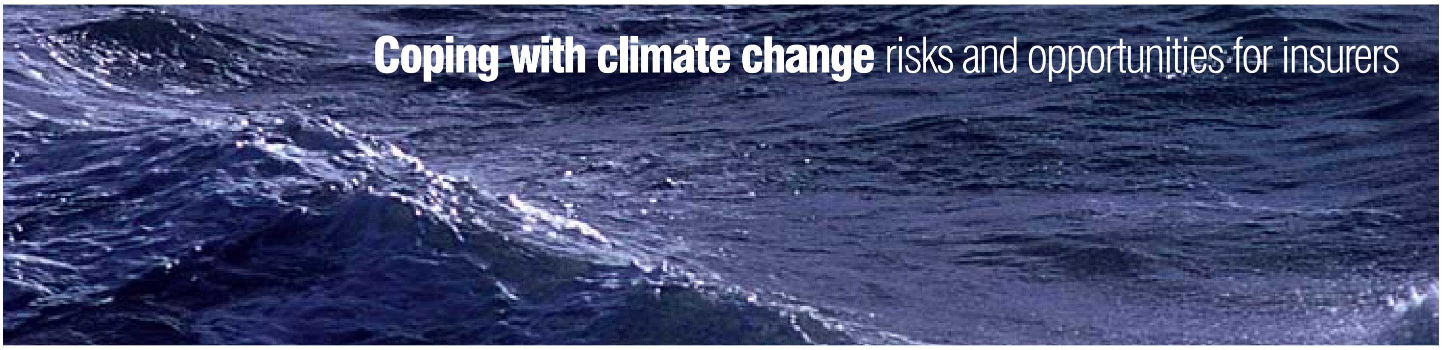


Chapter 12
Energy

12.1 Introduction and background

The energy insurance market is truly international as energy risks represent some of the largest and most complex risks in the insurance market. Historically the insurance market has focused on oil and gas. It comprises both upstream onshore and offshore production and extraction operations along with downstream storage, refining, distribution, and power generation facilities, including increasingly new renewable energy technologies such as wind farms, solar, and hydro risks. All of these risks are exposed to elemental losses but offshore installations are particularly vulnerable to storm damage. The risk transfer programmes that are put together for these risks require the participation of direct insurers, reinsurers, self insurance or captive arrangements, and industry funded mutual companies. Other financial instruments such as Catastrophe Bonds and Hedge Funds are also utilised to provide the necessary protection capital for these risks.

The largest energy market in the UK is Lloyd's of London where approximately £1019 million of business is underwritten, representing 6% of business transacted at Lloyd's. The rest of the UK energy market is made up of insurers writing specialist energy lines many of which will be London-based UK branches of overseas subsidiaries as well as large multinational insurers writing onshore downstream risks in their general property and casualty book of business.

The CII climate change review took place during a period of great contrasts for the energy market. The review commenced in the aftermath of two of the worst hurricane seasons on record. Of the 10 most costly hurricanes in the United States of America (U.S.A.), 3 occurred in 2005 Katrina, Rita and Wilma and 4 occurred in 2004 Charley, Frances, Ivan and Jeanne (Insurance Information Centre 2006). In total some 116 oil platforms were destroyed and 56 more severely damaged by the 2004–2005 hurricanes (Mills, E. and Lecomte, E. 2006). The total energy losses for the year 2005 were estimated to be US$19billion of which some US$15billion was due to elemental losses in North America (Willis, 2006, 1). During the actual period of the review the two years of 2006 and 2007 proved to be two of the most benign years on record enabling reinsurers and insurers to make near record profits. Such vagaries in fortune made the insurance cycle revolve almost full circle in a relatively short period of time but in so doing left a legacy for the future.

Although the energy market covers far more than just North American oil rigs, windstorm cover for Gulf of Mexico exposures is the "elephant in the corner" that cannot be ignored. Business from Gulf of Mexico offshore risks accounts for approximately 25% of annual global energy premiums (Ulbrich, W. (2006) and as such constitutes a major part of any upstream energy underwriter's book of business (Willis, 2006, 1). Thus it is an important area of strategic consideration for most energy insurers.

The first part of this chapter will take a chronological look at the impacts of these extremes of fortune in the U.S.A. on both the upstream and downstream markets as well as considering other aspects of the energy market. The second part of the chapter will look at the future of energy production as this is increasingly linked with the global response to impending climate change and the spectre of "Peak Oil". This section will focus particularly on developments in existing fuel technologies and the growth in Renewable Energy Technology (RET). The third part of the chapter will assess the implications of these changes for the energy insurance market. The final part of the chapter presents the conclusions and recommendations.

12.2 Recent insurance history of the energy insurance market

"It was the best of times; it was the worst of times..."[1]

Energy insurance is often described as one of the most volatile of insurance classes and the period 2004 to 2007 clearly demonstrates the capricious character of this line of business. The nature of energy production and distribution makes its insurance arrangements highly susceptible to large scale losses as risks are often situated in some of the most hostile environments on the planet; environments which are greatly exposed to elemental forces.

The worst of times

The disastrous nature of the 2004 and 2005 hurricane seasons had a major effect on the energy upstream market simply by virtue of the amount of upstream business based in the Gulf of Mexico and the southern states of the U.S.A. In the UK, Lloyd's reported energy losses of approximately £1,307 million for 2005, the "first real test" of the restructuring programme put in place by Lloyd's during 2002 and 2003 (Lloyd's, 2006, 1). As well as the large claims generated by Katrina and Rita there were other large energy losses that year at the Suncor Refinery in Canada and in India where an Oil and natural gas corporation (ONGC) platform was severely damaged by fire, a loss aggravated by the severe weather conditions that were

[1] Charles Dickens. A Tale of Two Cities

present in the region at the time. However, it was Hurricane Katrina that had the most devastating impact on Lloyd's results as it struck in an area where Lloyd's was "a clear market leader in this class of business" (Lloyd's, 2006, 1).

The upstream market response to these disastrous losses was inevitable with restrictions in covers and terms being coupled with reductions in capacity (Lloyd and Partners, 2005 July) and dramatic increases in rates – up 400% in some instances (JLT, 2006, ed. 10). As a more longer term consequence there were distinct moves to segregate the underwriting of "elemental" cover for upstream risks operating in the Gulf of Mexico from all other types of energy risk (Cooper, M. 2006, Willis, 2006, 1, JLT 2006, ed. 11). Aggregate sub-limits were applied for Gulf of Mexico named windstorms which effectively give the market the ability to withstand 2 or 3 devastating hurricanes in one season (JLT, 2006, ed. 12). Understandably there were moves towards increasing the minimum percentage deductibles to be applied to all windstorm losses (JLT, 2006, ed. 11). This hardening of the market served to attract new capital into the market place which replaced lost capacity and so enabled most insurance programmes to be completed.

The operation of the "market cycle" in insurance is often criticised and certainly it frustrates all parties at times, yet it serves a useful purpose in helping to attract capital into the market place and so ensuring that cover is available for the future. For example, despite two seasons of heavy losses, the influx of new capital and the restructuring of protection arrangements gave rise to the expectation in Lloyd's that the market would be able to write seven percent more business in 2006 (JLT, 2006, ed. 10). The cycle helped to replenish capital from fresh sources and so served the market well during this period and as such worked better than the model favoured by the mutual companies.

In the mutual market, the retrospective payment of losses hit members at a time when they had already suffered heavy losses. Overall the concept of mutuality was put under threat following the 2004/5 hurricanes as members with non-Gulf of Mexico exposures balked at the idea of having to pay more to cover those with exposures in these areas as well as coming to realise that the retrospective addressing of losses only added to risk uncertainty (Willis, 2006, 2). Although OIL was to survive the crisis, albeit with a fall in membership to 57 companies (Willis, 2008), sEnergy was not so resilient and went into run off in 2006 (JLT, 2006, ed. 12). The respite that was to follow in 2006 and 2007 gave the mutual companies time to restructure their model and their approach to the reinsurance and insurance markets. This has put them on a stronger footing, albeit providing reduced protection to their members than the levels enjoyed before 2004 (Willis, 2008). As such they are still an important part of the risk protection arrangements available to the market.

Some commentators saw underwriters being as much victims of bad practice as bad weather and there was a sense that the upstream market needed to move away from pricing on a "trader mentality" basis towards greater risk differentiation (Willis, 2006, 1). Certainly it was recognised that greater underwriting discipline needed to be restored and maintained in this market place (Lloyd's 2007, Lloyd and Partners Oct 2007). It was the case that modern platforms had withstood the storms better than their older counterparts (Ulbrich, 2006) and one of the key lessons to be learnt was the need to concentrate on selective underwriting taking greater account of the engineering of risks (Willis, 2008).

Upstream business interruption losses in many instances outstripped the property damage costs and as a consequence the underwriting of business interruption also tightened up as the market moved away from blanket coverage towards more risk specific cover with sub-limits applied (Willis, 2006, 1). The increase in oil prices added to business interruption costs and as a consequence many insurers moved towards an agreed value form of cover by fixing the price for oil at the start of the contract (Cooper, M. 2006, and JLT 2006, ed.10). Ironically increased oil prices which stem from market reactions to reduced oil production actually boosts revenue for the larger oil producers so immediate production losses on some rigs are offset by revenue gains on other production sites. This offsetting of losses particularly through the use of a hedging programme means that it can be economic for some insureds to carry more of the loss of production risk for themselves (JLT 2006, ed. 12). Larger energy companies in particular are looking to self insurance as the primary method of managing their physical asset risks (Willis, 2006, 2, Lloyd and Partners 2007, Jan).

Although not as exposed to North American windstorm losses, the downstream market still suffered in 2005 with power generation utility losses as well as elemental ones. However, the market was generally more measured in its response; underwriting discipline has tended to be stricter and so the market did not suffer to the same extent as the upstream one. Overall this market has not been as reliant on business from the Gulf of Mexico and as a consequence has been more selective about the risks it insured in this part of the world. Although not as exposed to windstorm as the offshore market the increase in windstorm intensity, not just in the Gulf of Mexico but elsewhere, has led to an increase in the amount of deductibles for windstorm. Reinsurance protection was tighter in 2006 with pressure applied to reduce exposures particularly to windstorm risks but overall the capacity in the market place remained unchanged from previous years as new capital providers came in to replace capacity. However, protection for windstorm losses was restricted and cover was often capped (Willis, 2006, 1).

Just as with the upstream markets the downstream market focused closely on its Business Interruption covers, particularly the knock-on effects of upstream losses feeding into contingent Business Interruption losses for downstream risks. There is very little leeway in the world oil production system for any loss in production capacity without an effect on oil prices. The increase in the price of oil which flowed in part from the 2005 hurricanes became a problem for downstream energy producers, such as electricity generators, increasing their costs and threatening their supplies. The same is true for natural gas, which is increasingly the fuel of choice for electricity, due to its low greenhouse gas profile, and the fact that oil is needed for transportation. Oil and gas users particularly power generators are keen to secure their supply and so enter into long term supply deals to maintain supply; these deals guarantee them a certain price in return for the purchaser buying a guaranteed quantity. These sorts of deals can cause a business interruption problem in the event of a material damage loss putting a power generator out of action as they are contracted to continue buying oil or gas at a fixed price even if they are not going to use it. Thus underwriters were looking closely at their wordings and the requirements of their clients in order to calculate potential Business Interruption exposures.

The resilience of the global insurance and reinsurance market was put to the severest of tests following these two hurricane seasons and it undoubtedly stood up well to the challenge. At the start of 2006 rating agencies were requiring all reinsurers to hold more capital and there was a more widespread acknowledgement of the need to build in greater resilience for catastrophic losses. Lloyd's were proactive in increasing the protection requirements they placed on the Lloyd's market. Although not necessarily popular at the time, with hindsight it was a sound decision and probably helped the market to absorb such huge losses. As a result of the 2005 hurricane season Lloyd's syndicates were asked to submit $10billion Realistic Disaster Scenario (RDS) models for offshore energy losses in the Gulf of Mexico in 2006. The RDS models submitted ranged from conservative estimates of 65% to as little as 10% but the imposition of this level of discipline enables syndicates to meet better performance standards of underwriting (Cooper, 2006). Lloyd's subsequently increased its RDS requirement for offshore energy risks to $11billion (Lloyd and Partners, April 2007) and included in these scenarios exposure to North American Windstorm losses. This sort of discipline is necessary to ensure that the market remains robust and better able to survive catastrophic events.

The best of times

As 2006 dawned there were questions whether windstorm cover in the Gulf of Mexico could continue to be underwritten in the "traditional" way. Many clients not exposed to these windstorm risks were unwilling to subsidise those who were so exposed and the underwriting of this risk element became more segregated (Willis, 2006, 2, Lloyd and Partners, Oct 2006). In the immediate aftermath of the hurricanes the market responded very cautiously to windstorm cover particularly for offshore energy accounts in the USA and there were moves to restructure programmes into separate silos split by territory or peril to prevent entire portfolios being hit by a single loss. There was the possibility of elemental cover being arranged in separate "towers" with further subdivisions for windstorm exposures (JLT 2006, ed. 10, Willis, 2006, 2). OIL were actively looking at creating a separate windstorm pool although this needed ratification at their 2007 AGM (Willis, 2006, 2) and there was a separate reinsurance windstorm market developing in mid-2006 (JLT, 2006, ed. 11).

In many respects this was potentially a rather unsophisticated underwriting approach, since in principle, risks should be aggregated to improve variability. However, it indicates how nervous the market was about further, sustained losses from this cause.

As 2006 progressed the increased rates being charged attracted more capital into the market and more diverse arrangements became available to provide the necessary protection. These options included establishing more Captives or Protected Cell Companies for insureds to carry their own windstorm risks (JLT 2006, ed. 12) as many larger insureds began to retain more of the risk for themselves (Willis, 2006, 2, Willis 2008). There was a dramatic increase in instruments such as Catastrophe Bonds where the market grew from about $2billion worth of bonds in 2005 (JLT 2006, ed. 12) which itself represented an increase of 74% over 2004 (Perin, 2006) up to nearly $7billion worth of Catastrophe bonds by the end of 2006. Many of these bonds covered European windstorms and U.S.A. earthquakes and windstorms. (Lloyd and Partners, Jan 2007). Although bonds do ensure a "full collateralisation of risk without any insurer solvency concerns" (JLT 2006, ed. 12), this aspect of the market was becoming a "meaningful percentage of the capacity of the reinsurance market place" (Lloyd and Partners, Jan 2007). The financial futures market also entered into the fray, with products being launched to allow investors to speculate on the amount of damage caused by hurricanes in the USA either on a single storm basis or on the whole hurricane season (JLT 2006, ed. 13). Some of the new developments in these securitisation deals did not directly affect the energy market, but they provided protection in other areas and so released reinsurance capacity to write more energy business (JLT 2006, ed. 13). For a while reinsurers developed "sidecars"; that is separately capitalised companies that sat alongside existing reinsurance companies to write a proportion of their business, to take part of their risks (Willis, 2006, 2, JLT 2006, ed. 13) but many of these arrangements were allowed to lapse in 2007 partially as the reinsurance market began to soften (Willis, 2008) but also because of the impact of the Florida Insurance Bill 2007 which generated catastrophe reinsurance protection of US$28bn (Lloyd and Partners, April 2007).

At the start of 2006 hurricane predictions were not hopeful but as the year wore on the market became more optimistic as the hurricane season progressed quietly. As 2007 began confidence was returning to the market and despite further gloomy predictions there were already pressures building to reduce rates and to increase covers. As it was 2007 recorded the highest number of natural catastrophes since 1974 (Lloyd and Partners, April 2008) but very few of these events impacted upon the energy account.

The climate related losses that did hit the energy account included a major flood at the Coffeyville refinery in Kansas, U.S.A. estimated at US$200m which coincided with a temporary shut down at a large BP refinery. This stretched the U.S.A. refining capacity to the limit and causing a spike in the price of oil (Lloyd and Partners, Oct 2007, Willis 2007). Other losses included a US$45m loss to a Floating Production Storage and Offloading (FPSO) vessel in Hong Kong (JLT, 2006, ed. 13) and a further loss of US$15m to a rig in China (Willis, 2006, 2). There were also heavy weather losses to plant in Texas (US$16m), New Mexico (US$11m), Bolivia (US$28m) and Holland (US$17m) and Dominican Republic (US$7m) (Willis, 2006, 2, Willis 2008).

Overall though these were not sufficient to dampen the growing sense of optimism in the market and as 2007 progressed the energy market cycle began to soften as more capacity entered the market in the form of new ventures and insurers found themselves under increasing pressure to reduce rates and to increase covers (Lloyd and Partners Oct 2006, Jan 2007, July 2007, Oct 2007). Initial resistance by the reinsurance market to weaken ratings helped insurers to maintain their rates but gradually as competition increased both within the London Market and from the emerging regional markets there was a greater willingness to reduce rates, to make concessions and to increase coverage (Lloyd and Partners various, Lloyds 2007, Willis 2008). However, premium levels were maintained mainly as a result of increased asset and B.I. figures feeding through to much higher values at risk. These increases were fed by the rising price of oil, the cost of construction materials such as steel and the rising cost of contractors. Although these increases help to maintain premium volumes they do so at the cost of much greater exposures for risk carriers (Willis 2008).

The energy casualty market is not immune to climatic losses either as there were huge clean up costs after Katrina due to the escape of liquids from facilities damaged by winds, floods and storm surge. The flood and subsequent spillage of oil at the Coffeyville refinery also caused a massive clean up operation as large areas were contaminated. Legislators are becoming increasingly concerned about potential environmental impairment as illustrated by the E.U. Environmental Liability Directive (2004/35/EC) and the Natural Resource Damages legislation in the U.S.A. which have made environmental liability insurance a key requirement for many energy operations (Willis 2008). Thus climatic losses will have an impact on casualty type risks as spillage risks become more frequent, because more installations are likely to be damaged. The issue of whether fossil fuel companies and their insurers should be concerned about liability for change in general is discussed more fully in Chapter 10 of this report.

The "echoing footsteps"[2]

One of the key lessons for underwriters stemming from the momentous events that have happened in the last four years is the need to concentrate on the construction and engineering of assets. This is going to be even more important in the future as the dramatic rise in the price of oil has increased the impetus to look for oil in more remote and inhospitable areas. These developments will include traditional oil platforms but in much deeper waters, e.g. off the coast of Brazil, as well as new technologies exploiting resources such as tar sands or oil recovery techniques, all of which will involve increasingly new and untested techniques. This is going to test the knowledge and skills of underwriters and so insurers should focus on the training and recruitment of personnel to ensure they have the right skill sets to make the necessary assessments required (Willis 2008).

The hurricanes of 2004 and 2005 effectively "pruned" much of the "dead wood" in the Gulf of Mexico leaving better, stronger energy assets behind (Lloyd and Partners July 2007). However, this "pruning" has still to take place in other parts of the world and the concerns expressed by the UK Health and Safety Executive over the condition of North Sea platforms

[2] Charles Dickens. A Tale of Two Cities.

probably holds true for similarly aged risks in other parts of the world. Thus as the replacement costs of assets continue to rise, increasing exposure values, underwriters will need to adopt a more discerning approach based upon the construction features of each risk if they are not to get caught out by a natural catastrophe in other parts of the world (Willis 2008).

The business interruption consequences of these developments are perhaps even greater. Construction capacity is stretched to the limit and the availability of skilled contractors to both build and carry out specialist survey work such as underwater exploration is limited. The day costs for hiring semi-submersibles as well as the costs of specialist contractors have sky-rocketed. Thus any interruption to business activity is going to incur greater delays as well as increased recovery costs (Willis 2008, Lloyd's 2007).

The four hurricane seasons covered by this review period have shown how difficult it is for insurers to predict their likely losses. In contrast to the devastation caused by the 2004 and 2005 hurricane seasons the 2006 hurricane season proved to be the quietest one since 2002 (Essen, 2006) due to the El Nino phenomenon and the presence of dust in the prevailing winds coming from West Africa (JLT, 2006, ed. 13). However, the 2006 season was one of the longest seasons on record with the first named tropical storm forming on the 11th June, more than a month ahead of the average start date of the 10th July (Lloyd and Partners, Jan 2007). The 2007 hurricane season contained two Category 5 hurricanes, the first time this has happened since 1900, and it was the first time ever that two such hurricanes made landfall. However, unlike the hurricanes of 2004 and 2005, these hurricanes veered away from the U.S.A. and the major energy production sites in the Gulf of Mexico. These hurricanes took their less destructive path courtesy of the "Bermuda High" steering current which is presently helping to steer hurricanes away from the "oil patch". Ironically it was this very same current which steered the hurricanes of 2004 and 2005 towards this heavy concentration of energy assets (Lloyd and Partners, October 2007).

The question is whether the increased hurricane activity generally experienced in the Atlantic is symptomatic of a long-term change or part of the normal variation of hurricane activity. It is generally recognised that sea temperatures are rising and warmer waters certainly feed the strength of hurricanes (Lloyd's, 2006, 2) but the increase in hurricane activity only appears to be happening in the Atlantic Ocean (Lloyd and Partners, July 2007). Thus the question is whether this increase in hurricane activity is due to multi-decadal Atlantic Ocean circulation variations or whether it is due to changes in ocean salinity caused by more fundamental climate change (Guy Carpenter 2006, Lloyd and Partners, July 2007). There appears to be no consensus of opinion on this issue and as such there is a dilemma for insurers that if they are too cautious and overprice windstorm cover clients will use other instruments to provide the financial protection they require which ultimately will feed into a fall in prices as demand drops off (Willis, 2006, 2). The science of climate change is discussed in more detail in Chapter 3 of this report.

This has highlighted once again the need to have models that are better able to predict climate related losses and to accurately assess risk exposures (Dlugolecki and Lafeld, 2005). Increasingly current losses are not mirroring past experience and thus losses are becoming less predictable and more of a "surprise" (Mills, 2005, 2). There are arguments for adopting better methods of analysis of exposures not based on extrapolation from previous years but based on holistic views of all lines of business and allied perils (Rauch, 2006). Although there is a greater need for better and more accurate models this is very difficult to achieve in the current period of unprecedented climate change (Dlugolecki et al, 2005). Perhaps one approach is to use short to medium term models rather than long-term trends or averages, to take into account medium term activity patterns (JLT, 2006, ed. 12). However, even looking ahead over a 12 month period is extremely difficult as evidenced by the predictions for the 2006 hurricane season. In the early stages of 2006 the initial view of the year's hurricane season was very pessimistic (Cooper, 2006) but by September 2006 experts such as the team at Colorado State University were downgrading their forecasts for the Atlantic storm season (Dey, 2006). Ultimately if the rating agencies remain sceptical about insurers' use of models and calculation of exposures they will reduce credit ratings which would reduce underwriting capacities (Willis, 2006, 1). This area of modelling is discussed more fully in Chapter 4 of this report but it is the case that generally the insurance market has seen increased collaboration between insurers, reinsurers, centres of climate expertise and computer modellers. These collaborations have produced some good modelling systems, e.g. the Norwich Union flood risk map for the UK, and it is surely the case that insurers and reinsurers increasingly need to pool resources to develop better and more accurate systems to help predict and underwrite future climate-associated risks (Dlugolecki et al, 2005).

Climate change also raises a number of insurance issues for power generation and distribution. Whilst the overall exposures and potential aggregations may not be as great as for the Gulf of Mexico, there is still the potential for losses both on the material damage and the business interruption front. The floods in central Europe in August 2005 created havoc in many countries, damaging power lines and cables with major material damage and business interruption losses. A freak cold spell in January 2006 in Eastern Europe caused widespread power shortages and claimed many lives. The incredibly hot weather of July 2006 brought the UK perilously close to running out of energy as the demand for air-conditioning in large cities such as London nearly over-stressed the system at a time when power demand would normally be much lower. This increased demand reduced the amount of time that generators could devote to essential maintenance work which ultimately could lead to more breakdowns later on. Research has shown that weather disruption can account for some 59% of bulk power outages (Mills, 2005, 1).

Conventional power generating plant is not generally vulnerable to weather impacts; however, the distribution systems for power are highly susceptible to weather-related losses particularly lightning, storm or flooding. Many underwriters see floods as having the potential for causing the next major aggregated loss (JLT, 2006, ed. 13). The severe flooding in the UK in 2007 in Gloucestershire and Worcestershire nearly destroyed a major electricity sub-station and a huge operation was mounted to maintain this equipment and to ensure it stayed on line. Modern societies are heavily dependent on electricity and the potential costs of any short to medium term disruption in supply are high both in economic and humanitarian terms. There is a correlation between rises in temperature and increases in air-ground lightning (Mills, 2005, 2). Power cables can be brought down during storms and underground cables are exposed to land slip caused by flooding. Catastrophic changes in temperature would have implications for any power infrastructure built on or in permafrost (Mills, 2005, 2). Changes in rainfall patterns also expose hydro-electricity risks to drought or flooding. Tidal barriers have a limited experience history, thus failure and damage rates are not fully understood. Rising sea levels could engulf existing barriers under certain storm conditions generating huge property and business interruption losses. Wind turbines are becoming bigger and more powerful and by their very nature are sited in exposed, windy places making them vulnerable to storm losses. Solar panels are vulnerable to wind or sand storm damage as well as to hail storms.

The power generation market is seeing increased consolidation towards “super utilities”, particularly in Europe, providing generation and distribution, and extending their operations by the acquisition of electricity, gas and/or water utilities. Insurers are going to need to be able to transact insurance on a global scale to be able to service these customers. Many of them will have their own captive insurance arrangements which will deal with the wholesale market. Thus insurers will need to be able to offer suitable arrangements for captives.

In the longer term the major change facing power generators is the way they will produce their energy in the future as two key factors converge. Firstly, oil and gas are becoming more costly as demand soars in developing countries and power generators will need to look for other sources; secondly the power generation market is going to come under increasing governmental and consumer pressure to reduce its “greenhouse gases” from substances such as coal as the need to address the impacts of climate change become more pressing. 12.3 of this chapter will look at this issue in more detail.

12.3 Future trends in energy production

“The times they are a-changing”[3]

Fossil fuels

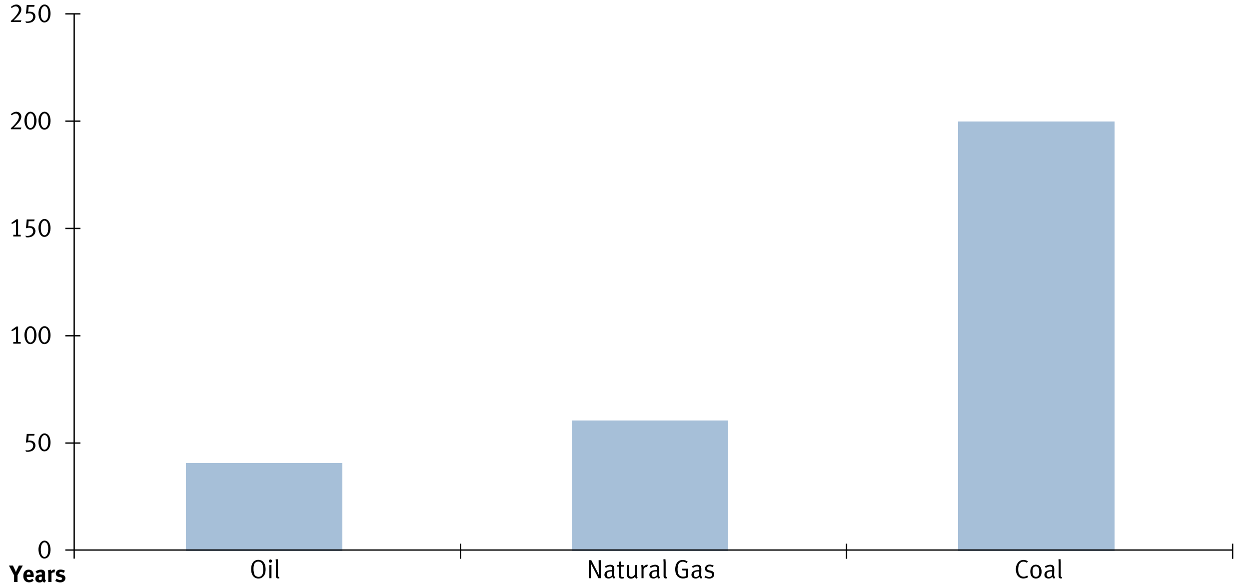
Climate change and energy production are two of the great issues facing the world in the 21st century and the two are undeniably linked. Access to a plentiful supply of energy is a prerequisite for any modern economy and as economic expansion spreads across the globe the pressure on “traditional” energy supplies increases. Overall the International Energy Agency (IEA) predicts a rise in global energy demand of 50-60% by 2030 (Black, 2006). Over 80% of the world’s energy is supplied by the three main fossil fuels, coal, gas and oil and about 60% of the world’s electricity is produced using these fuels (BBC, 2006, 1). However, the burning of fossil fuels for energy accounts for some 22 billion tonnes of carbon dioxide (CO_2) being pumped into the atmosphere each year (Carey, 2003), or 65% of all greenhouse gas emissions (Stern, 2006). We cannot continue to produce energy in this way as it is neither economically nor environmentally sustainable as resources dwindle and as the impacts of climate change worsen. All of this will have implications for the risks that will present themselves to the energy insurance market in the near future.

Economically the world’s demand for oil is only just matched by the oil supply. Increasingly infrastructures and refining facilities are operating at maximum capacity to meet demands (Willis, 2008). In 2006, demand stood at 83 million barrels per day whilst oil production was around 84.2 million barrels a day. Pressure on oil supply and thus oil prices is increased by

[3] Bob Dylan. The Times they are a-changing

the growing economies of India and China who want to ensure oil supply for their continued economic expansion (Cooper, 2006). The demand for oil is likely to double in China over the next 20 years which can only serve to increase the price of oil (Kirby, 2004). We still rely on oil for 90% of our transport but the projection is that our current reserves of oil will run out by the middle of the century or at best by the end of the century and the position for gas is not much better either (Kirby, 2004). Figure 1 sets out the estimates of available resources of the three main fossil fuel types.

Figure 1: Supplies of fossil fuel



Source: Clerici, 2004

The need to find a solution to the long-term sustainability of fuel supplies is a critical one for all countries as without it the "economic, social and political costs will be unprecedented" according to a report prepared in 2005 for the U.S. Department of Energy (Hirsch, Bezdek and Wendling, 2005). 2006 saw a deterioration in the political environment in many countries as governments took action to assert greater control over valuable energy assets including actions taken in Bolivia, Venezuela, Ecuador, Kuwait, Mauritania, Chad and Russia (JLT, 2006, ed. 13). Increasingly oil reserves are controlled by nationally controlled companies requiring the independent companies to explore harsher environments and to reply on new untested technologies. (Willis 2008). Actions in Russia are also raising the prospect of "supply-rich" countries using access to their energy supplies as a means to exert political pressure over their dependent "supply-poor" countries. When such "supply-poor" countries include some major economies in Western Europe the political stakes become potentially very high indeed.

The reduction in readily available supplies of oil and gas raises the spectre of "Peak Oil" a theory developed by American geophysicist Marlon King Hubbert in 1956. Peak Oil refers to the point at which aggregate global oil economic reserves reach an apex and whilst there is great debate over when this point could be reached there are reports that some experts believe it could be as early as the next 20 years (Hirsch et al 2005). Certainly major oil producers are looking at various new "hydrocarbon energy sources" such as tar sand and shale (van der Veer, 2006). Unfortunately the energy needed to refine these resources is considerable, as is the volume of water, thus insurers and investors need to be aware of the many environmental and cost problems associated with this method of production. The current price of oil and gas coupled with dwindling supplies have increased the attractiveness of once uneconomic sources of supply and have also driven technological developments to make the most of these finite resources. Research is taking place to enable oil extraction from sources at greater depths under the sea than currently thought possible (BBC News 2006). Other potential developments include liquefied natural gas (LNG) which can be easier to transport as well as being more useable in transportation, and coal gasification. From a climate point of view these improved methods of extraction are still producing carbon-intensive supplies of energy, but energy producers are beginning to recognise the need to "integrate CO_2 solutions" to minimise the impact on emissions (van der Veer, 2006).

The most abundant fossil fuel is coal and as problems increase with the supply and pricing of both oil and gas many energy generators are reverting to coal-fired electricity generation (Cooper, 2006). Unfortunately coal is the dirtiest of all the CO_2 emitting fuels and any return to wide scale use of coal needs to be coupled to clean energy technology if it is not to add to the growing problem of carbon emissions. "Clean Coal technology" includes improving the efficiency of coal-fire generation which can reduce emissions by up to 40%[4] as well as "Carbon Capture and storage" (CCS) methods which could capture up to 90% of CO_2 emissions (Farley, 2006). Burning coal gives rise to a number of pollutants including sulphur dioxide (acid rain), nitrogen oxide (ground-level ozone) as well as the greenhouse gas carbon dioxide. Processes have been developed to remove sulphur dioxide and nitrogen oxide but CO_2 emissions remain a problem requiring greater technological attention. CCS involves capturing the CO_2 gasses and storing them deep underground potentially in disused coal or oil fields (BBC, 2006, 2). Sequestration underground of CO_2 is relatively new technology although even in the 1970s oil producers were pumping CO_2 into oil wells to make the oil more fluid and so easier to extract (Carey, 2003). Many projects are currently underway to investigate CCS and to evaluate the longer term efficacy of storage regimes in both terrestrial and ocean locations (National Energy Technology Laboratory 2006). At present terrestrial sequestration is in a more advanced form of development and potential time scales for wider spread use of some of these techniques could be as early as 2012 (National Energy Technology Laboratory 2006).

Capturing CO_2, transporting it to the storage site, possibly by pipeline, and then injecting it into the selected underground or submarine reservoir are not especially challenging. Problems at that stage should be readily identified and rectified (Trabbuchi. and Patton, 2008). Insurers would need to include the cost of replacing emissions permits in their assessment of liability.

However, the CO_2 has to be stored inertly for hundreds of years, during which time unforeseen defects may arise, and leakages might occur, but by then commercial entities may have ceased to operate. Therefore liability for the long-term geological storage of carbon dioxide is a major obstacle to large-scale deployment of the technology (International Energy Agency, 2007). It needs clear guidelines on the responsibility for short- and long-term liability. It also raises such issues as whether carbon dioxide should be considered as a commodity rather than a waste product, and what regulatory framework should apply to under-sea storage. Until it is resolved, insurers and financiers will be reluctant to participate in projects.

This is really a political matter; there is no 'right answer'. Solutions may well differ from one country to another, with international protocols to cover international transport and storage. Risk transfer for the most contentious process, long-term geological storage of carbon dioxide, may be handled in a layered or portfolio approach. Setting a limit to corporate CCS liability is one solution that could preserve insurability. This could be combined with setting a 'caretaker sunset' for each site, after which storage is passed over to a government facility. A range of risk transfer tools could be used, including insurance, letters of credit, sureties, bonds, and 'self-insurance' by project developers or operators in consortia (World Resources Institute, 2007).

One of the problems to overcome is the initial capture of the CO_2. Current methods involve bubbling the gases produced when burning coal through a solvent which is then heated to release and capture the CO_2 but this method is energy-intensive, which increases the costs, so further research is needed (Carey, 2003). One approach to the problem would be to remove CO_2 from fossil fuel before it is burnt, e.g. by gasification which has the added attraction of producing other gases such as hydrogen which could be used to make electricity or fuel cars (Carey, 2003). The fossil fuel, usually coal, is combined with oxygen and steam to produce a "syngas" which can be cleaned and then burned to produce steam to power a steam turbine. This can be done at an Integrated Gasification Combined Cycle (IGCC) plant although the technology is very costly and still largely unproven (BBC 2006, 2). No plant exists in the UK but plans are in the offing to build a new clean coal power station in Teesside and potential backers for this project include companies like Centrica who run the UK's largest fleet of gas fired power stations (Centrica, 2006). An alternative approach is to carry out the process underground in the coal seam itself, known as Underground Coal Gasification (UCG). This technique traces its roots back to the 1930s but it is currently proving difficult and costly to put into practice although countries such as China and Australia are looking very closely at this technology (Coal Authority, 2006).

Natural gas has become the "fuel of choice" for modern power plants as it is quite versatile, e.g. for matching sudden shifts in demand. Gas can be used at centralised generating plants and in more localised small scale energy generation plants (Natural Gas, 2006). Natural gas is often associated with oil deposits and is extracted in similar fashion by the drilling of wells in the locations where it is found; as such the production of natural gas is faced with the same climate related risks as oil production. One of the advantages of natural gas is that it does not give off the same amount of harmful by-products as other fossil fuels, for instance it produces only half as much CO_2 as coal for the same amount of electricity generated (Natural Gas, 2006), but even so it is still a source of greenhouse gases and as such needs to be coupled to clean technology.

[4] For example, Intergrated Gasification Combined Cycle, or IGCC

Like two juggernauts converging on an intersection there is an impending disaster ahead. Firstly the growth of worldwide energy demand means finding new ways of producing energy. Secondly current reliance on fossil fuels is causing massive changes to the climate that can only result in more widespread economic hardship, perhaps reducing the global economy by as much as 20% according to the Stern Report. Although we face the prospect of "Peak Oil" sometime during the next 50 years the current reserves of oil and other hydrocarbons are sufficient to increase levels of greenhouse-gas concentrations in the atmosphere to "dangerous" proportions (Stern 2006). Governments have become increasingly more concerned about the effects of climate change and its prominence at events such as the 2008 G8 summit demonstrate that this issue is high up the political agenda. Emissions targets now exist in many countries although the arguments persist over whether these are tough enough or even policed robustly enough. However, power generating companies are investing in new technologies, e.g. more efficient turbines and other capital plant, as well as looking at "greener" options such as biomass conversion, geothermal, wind, wave, tidal and sun. It is likely that emissions considerations will soon be "an important factor in investment decisions regarding generation assets, i.e. technology and fuel" (Dlugolecki et al 2005). Thus we are in a period when there is a growing realisation that we need to be able to produce more and cleaner energy from sustainable sources other than fossil fuels not just to meet our energy needs but also to avert climate catastrophe (Stern 2006).

One solution to the converging energy and environment crises lies in the development of the CCS technologies, discussed above, combined with an increase in the amount of power generated by Renewable Energy Technology (RET). All of these changes in production are affecting the risks that are presenting themselves to the energy insurance market. Clean coal technology is going to require careful underwriting particularly if sequestration of gas underground proves both practically and economically feasible. Even existing technology such as Combined Cycle Gas Turbines which produce power more efficiently causes some concern due to a number of recent design failures (Willis, 2006, 2). The renewable energy market, according to the World Energy Council, could be worth 1.4 trillion euros by 2020. Already there are insurers actively underwriting RET but it is certainly an area where the energy market can further develop its risk management expertise and product range (Dlugolecki et al 2005). The next sections deal with this issue.

Technology and the politics of climate change

The ultimate reason for encouraging all types of renewable energy sources to produce power is to reduce the carbon emissions produced by conventional means. The 2001 report by the CII introduced statistics on the production of electricity from renewable sources that were current at the time. In this part of the report, we aim to update these statistics and to delve into the types of renewable energy technology (RET) now available, including discussions on the advantages and disadvantages of these sources and the impact on the environment

Progress since 2001

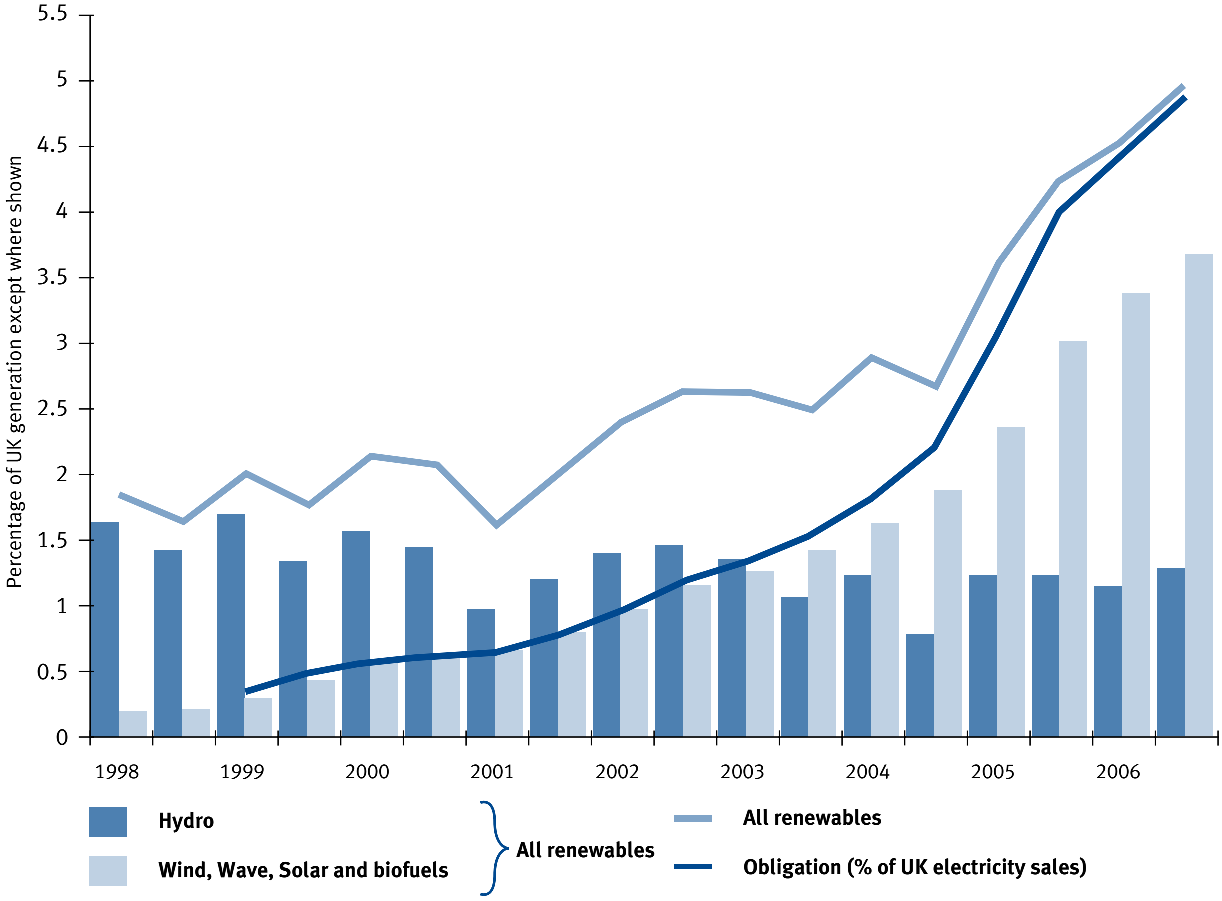
Has the UK progressed with the aim to reduce emissions by moving away from carbon based sources and towards the use of renewable energy? According to the statistics, the answer to this is, not as much as expected or required in order to make any real impact on reducing carbon emissions.

In the late 1990's UK electricity is supplied from one-third natural gas, one third coal, 25% nuclear fuel and 3% renewable sources (CII, 2001). In 2003, it was reported that 74% of electricity was generated from conventional thermal sources (53% gas, 44% coal, 2% oil, 1% other), 23% nuclear fuel and 3% renewable sources (1% hydro, 2% others). This shows that up until 2003, there appears to be no progress in the UK towards increasing renewable energy sources for power production.

Compared with other EU countries, the UK cannot be considered as a leader in the field of renewable energy. Germany, for example, is one of the world's largest operators of renewables capacity, with some 11.8% of its electricity being supplied from renewable sources (2006 data), which is up from 6% in 2003. Spain and Portugal are both investing heavily in renewable energy (particularly wind power in Spain) and are not far behind Germany in meeting their renewable targets.

However, since 2003, the UK is starting to catch up. According to the DTI, the percentage of electricity generated from all renewables as a percentage of all electricity generated in the UK was 3.6% in 2004 and 4.2% in 2005 (see Figure 2). The 2005 figure represents a 19.4% increase over 2004 in total electricity generation from renewables, with the main contributors coming from offshore wind farms (up 102%), small scale hydro schemes (up 65%), co-firing of biomass with fossil fuels (up 148%) and onshore wind farms (up 44%). In 2007, renewables accounted for 5% of electricity generated in the UK and this was up from 4.5% in 2006. These statistics show a slow move in the right direction for the UK electricity production from renewable sources, however, the target of 10% from such sources by 2010 seems to be a long way off.

Figure 2: Growth in electricity generation from renewables since 1990



Source: restats.org.uk website

The Kyoto Protocol

The Kyoto Protocol was put in place with a view to obtaining commitments by developed countries to reduce their carbon emissions. The countries that have signed up to the Protocol have agreed to reduce their collective emissions of six key greenhouse gases by around 5% in aggregate (see Chapter 2 for more detail).

EU Countries have collectively agreed to reduce emissions by 8%. The target must be achieved by the period 2008-2012, calculated as an average over the 5-year period. The UK must reduce its carbon dioxide emissions by 12.5% below the 1990 level during the 2008-2012 commitment period to achieve its share.

So, how is the UK progressing so far? In fact, the UK has been only one of four Western European countries to achieve a drop in carbon dioxide emissions since 1990, despite an increase of 11.2% in total energy consumption. UK emissions of the 'basket' of six greenhouse gases covered by the Kyoto Protocol fell by 15.3 per cent between the base year and 2005, down from 775.2 to 656.2 million tonnes carbon dioxide equivalent (Defra, 2007). This is due to an early switch from coal to gas-fired electricity generation, and progress recently has been minimal.

Emissions permits

A key element of government policy is setting limits on greenhouse gases in energy-intensive sectors. For the energy sector in the EU, this particularly affects energy utilities, since it makes fossil fuels more expensive. (The problem is not so marked for coal, oil and gas extraction, since most of the emissions are released at the point of end-use, not at the extraction and refining processes.) Apart from altering the economics of the different technologies and fuels, the emissions regulations have a significance for the valuation of assets and liabilities of energy-intensive companies. Therefore they affect the sums insured, and the adjustment of claims values. In particular, cessation of operations due to a loss will reduce emissions, and so that will reduce the amount of a claim. However, there is an "absence of specific accounting standards on emissions trading" (CDP, 2008), so this is not as simple as it might seem, since different approaches are possible.

Renewable energy sources

Introduction

When we talk about 'renewable energy' generally the first thing people think of is wind farms. Wind turbines are highly visible and have been installed throughout the UK (there is even one on the M25!). However, as time and technology progress, renewable energy has evolved, and has improved in efficiency, making renewable energy sources a much more viable (and cost effective) alternative to traditional fuel sources, such as coal, gas and oil.

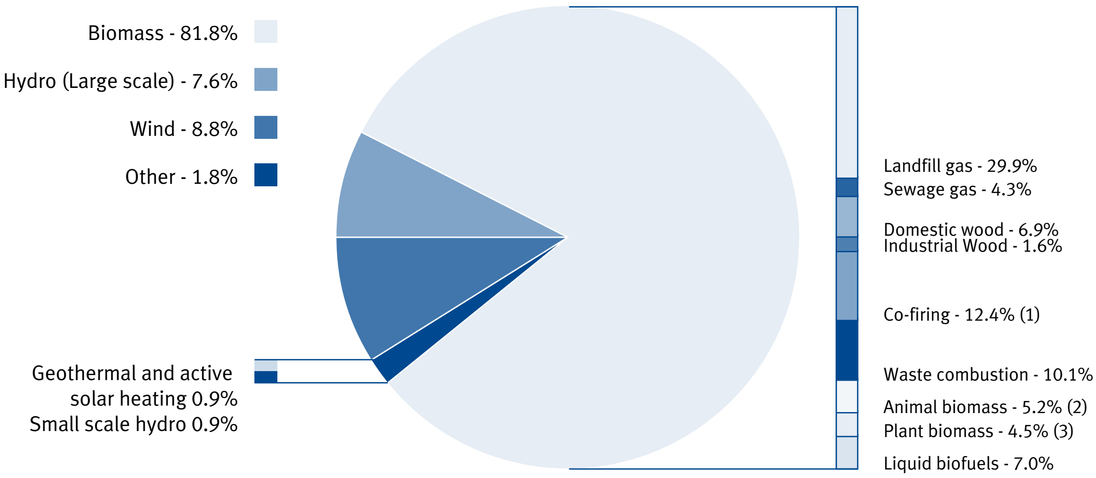
Near-commercial renewable energy now falls under several main types, which are:

- wind
- solar – photovoltaic cells & active solar thermal
- water – hydro, tidal, wave
- biofuels and biomass
- energy from waste
- biogas – landfill & anaerobic digestion
- geothermal – including heatpumps

In the past, hydro-electric power was the greatest contributor to the UK's electricity supply from renewable sources. The fraction of power supplied from large-scale hydro-electric sources has reduced (see Figure 2). Most of the reduction in hydro power production has been made up with electricity generation from wind farms over the last few years; however, newer technology is starting to feature more prominently.

Renewable energy utilisation in the UK in 2007 was dominated by biomass (nearly 82%) with wind energy coming in at 8.8%. The trend for the future seems to be continuing in the same vein, unless more offshore wind sites are authorised for construction. See Figure 3 below for UK renewable energy utilisation in 2007.

Figure 3: renewable energy utilisation, 2007



Total renewables used = 5.17 million tonnes of oil equivalent

Excludes all passive use of solar energy and all non-biodegradable wastes. In this chart renewables are measured in primary input terms

(1) Biomass co-fired with fossil fuels in power stations; imported 7.3% of total renewables, home produced 5.1%

(2) 'Animal biomass' includes farm waste, poultry litter, and meat and bone combustion

(3) 'Plant biomass' includes straw and energy crops

Source: restats.org.uk website

The move towards renewable energy sources has implications for the insurance industry in the way it views and underwrites energy risks, particularly the implications of climate change on those risks. These will be considered in 12.4 of this chapter.

Figure: 4 Wind farm site – Cefn Croes in Wales

The technology

Wind

Wind turbines are highly flexible in design, which is useful bearing in mind that the resource that they utilise to produce power – the wind – is variable. Turbines are constructed out of many separate components, and specifically, tower height and blade length are adjusted to suit their operational environment. Turbines, also, have been tested and can operate in many different and diverse environments, from hot deserts to cold ice covered areas, out in the sea and on top of mountains. They can operate on a large scale, small scale or stand-alone. This flexibility of the system is one of wind energy's biggest advantages over other types of renewable energy. The other major advantage will be mentioned later.

The main expansion of wind farms in the UK and Europe will come from construction of offshore projects. There are already several operating in the UK – off Kent and Norfolk and in the Irish Sea.

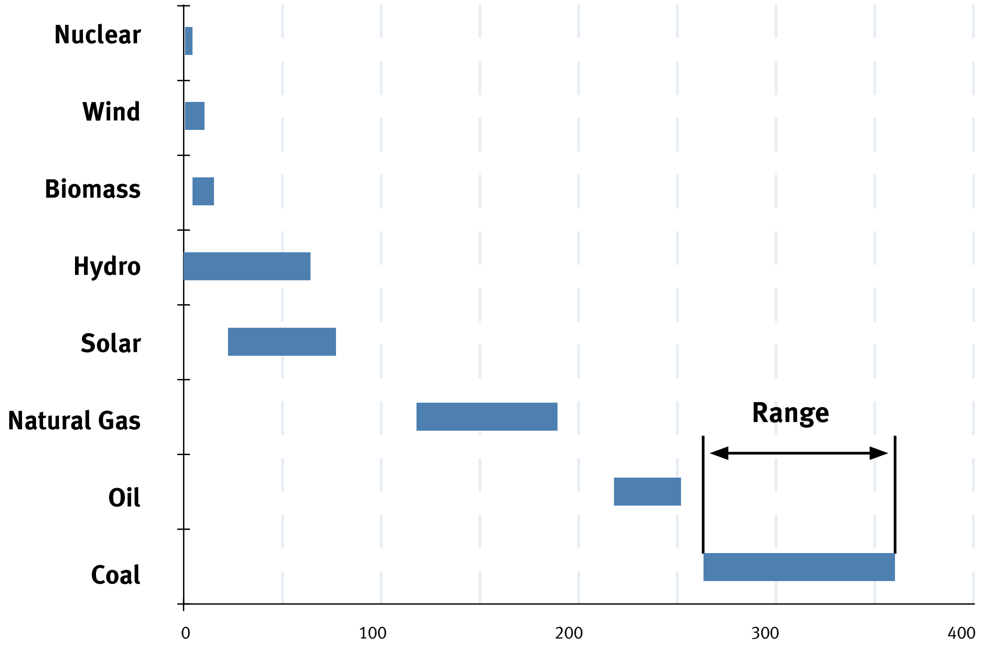
In the past, there have been many objections to wind farms – 'they spoil the view', 'they are a danger to wildlife, particularly birds', they are noisy'. A lot of research has been undertaken on wind farms and their impact on the environment, and many of the objections have been silenced. In respect of the noise issue, whilst some of the first turbines were in fact noisy, technology has improved, therefore making the units much quieter. In fact, a busy main road in front of your house will produce a much higher decibel level of noise than a turbine in your back garden! Many naturalists have been concerned about wildlife being disturbed by turbines. During construction, there can be some disruption (in France, they actually stop construction during breeding time on sites where birds nest), but once running, turbines do not cause any problems. A study was made on the Blyth harbour-wall turbines, which are located in a busy bird area. It was discovered that only 1 in 10,000 birds actually flew into the turbines, which equated to about 1-2 bird kills per turbine per year. When you compare this with bird kills by vehicles in the UK (estimated to be over 10 million), this is very insignificant. The RSPB made their own studies at wind farms in Wales, and drew the same conclusion. As far as wind farms spoiling the view, it depends on what you compare it with. If you compare a wind farm site with, say a coal power station or an open cast mine, the wind farm wins hands down. Indeed, there is evidence that wind farms have increased tourist numbers in certain areas – the UK's first commercial wind farm in Cornwall attracted 350,000 visitors in the first 8 years. The turbine at Swaffham in Norfolk can be climbed by visitors. In Denmark, boat trips are run frequently to show off the offshore wind farm near Copenhagen.

There are real disadvantages that need to be faced. The windiest sites are remote from habitation, so that means that the power needs lengthy transmission lines. The more serious one is that wind power is intermittent, so it cannot be relied upon, though the wind strength can at least be predicted well in advance. This entails back-up of some other source, or storage. In itself this is not a "show-stopper", since all power plant needs back-up in case of failure or unexpected demand or operational problems.

The disadvantages of wind farms are far outweighed by the advantages, one of which is mentioned above. One other, and perhaps the most important factor as to why more wind farms should be developed, is that the greenhouse emissions to produce wind farms (including preparation, construction and transport) is the second lowest of all types of energy productions (after Nuclear) – see Figure 5. So, not only is wind power clean (it does not produce CO_2 when generating power), it also does not contribute as much CO_2 to the atmosphere in production as any other renewable energy type. Quite an achievement!

Figure 5: Relative emissions of power generation technologies

Greenhouse gas emissions by fuel type*
(grams of carbon equivalent per kilowatt-hour)



Source: National Geographic August 2005

* Includes fuel mining, preparation and transport plant construction: power production

What of the future? Turbine units are being manufactured to produce more power output per unit – 3 to3.5 mW for onshore wind turbines and 6 mW units for offshore. There is even talk of testing 10 mW units for offshore. Turbines are becoming more efficient and produce power more cheaply than other sources, including nuclear. Technology is being developed to store wind power (which solves the problem of what happens when the wind does not blow), such as storing the power as hydrogen, which can be used in fuel cells.

On the smaller scale, turbines have been developed for domestic use. David Cameron, the Conservative Party leader, has received planning permission to install a roof top turbine to his house. Will this be the vision for the future – domestic wind turbines, coupled with solar panels? There have been several designs for small turbines for domestic use. One has been developed in a 'Y' shaped design containing 5 separate turbines within the framework. The designers say that it could produce 10% of London's total electricity demand. Another development is the vertical axis turbine, which has 3 blades twisted at 120 degrees, which gives constant rotation due to one blade always facing the wind. It should be noted though, that advice from industry engineers suggests that domestic wind turbines are a less satisfactory solution that other micro renewables. Many measurements used to promote them seem to have been assessed on high exposed ground, rather than urban conditions, so output will be much lower in practice. On the other hand, if a proper structural engineer is not consulted a freak gust could take the side of your house!

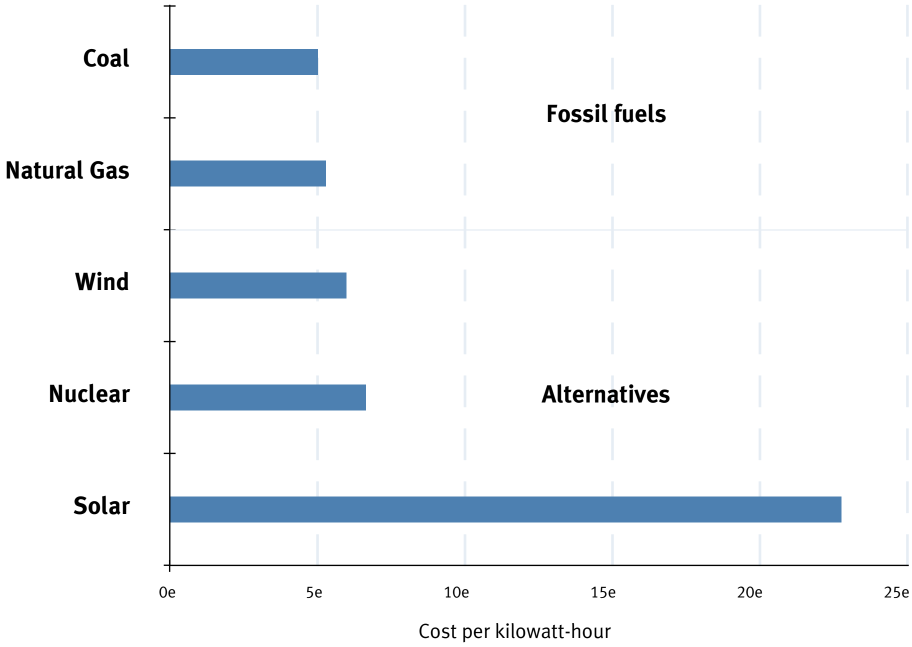
Solar

Energy from the sun can be converted directly into electricity using photovoltaic cells, or into heat using active solar heating systems. The main benefit of solar power generation is that the electricity or heat is delivered at the point of use. With large centralised power plants, the electricity has to travel long distances, which is highly inefficient. In fact, although two-thirds of energy that is contained in fossil fuels is wasted (in the form of heat) before the electricity has left the power station, more is lost through distribution. The further away the user of the electricity is, the more electricity is lost. With solar power, the electricity is produced locally to the end user, so the system is much more efficient[5].

The main disadvantage of solar generated electricity is still that it is relatively costly to install, compared with other types of renewable energy, particularly wind (see Figure 6)

[5] This applies to cooler countries like UK. in hot countries, centralised solar power is possible - see later

Figure 6: Relative costs of RET



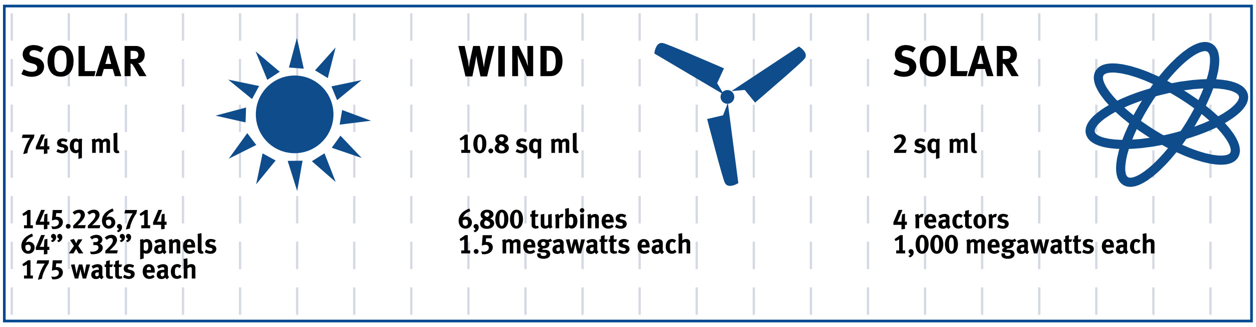
Source: National Geographic 2005

The Cost of a Kilowatt-hour

Solar power will remain expensive for some time, as shown in a comparison of energy prices calculated for new plants coming on line in 2013. But the cost of solar should fall as technology imporves.

Also, you would need many more solar panels than, say, wind turbines, to power the same amount of houses so a larger area is required (see Figure 7).

Figure 7: Area required to provide different climate-friendly power



Source: National Geographic August 2005

If New Yorkers picked a single climate – friendly technology to generate 60% of their electricity, the share taken by coal and natural gas at present, it would require the designated land areas shown for each of solar, wind or nuclear. The figures for wind and solar reflect the fact that they are intermittent, so they need back-up.

New ideas for use of the sun for generating electricity include solar furnaces and solar towers. Solar furnaces use a large number of mirrors to concentrate the sun’s power into a small space, which produces very high temperatures (up to 33,000 degrees Celsius). There is one in France for a scientific research site, and a power station in California utilises a similar system to heat oil, which generates steam to drive turbines. Solar towers need a large greenhouse, with a tall tower situated in the middle. Hot air in the greenhouse rises quickly up the tower and drives the turbines on the way up. It needs a lot of sunshine and land, so it is best suited to countries like Australia or Dubai.

Water (including marine energy)

Figure: 8
Offshore marine turbines

The UK has virtually tapped all its large-scale inland hydro capacity. However, it is still an important source of electricity generation in many countries, particularly in remote areas where other power sources are not viable. Hydro power can be exploited at large and small scale, with the growth in hydro power generation being on the small scale schemes. The reason for this is that large-scale hydro projects are subject to many environmental and social constraints. In particular, the construction of large hydro-projects is an energy-intensive operation and the rotting vegetation under the water gives off ghg emissions. Conversely, small-scale schemes (which can consist of a small dam and storage reservoir or "in-flow" located on a stream) have minimal impact on the environment, and are more flexible and cost efficient.

Tidal and wave power are gaining popularity as alternatives to traditional hydro power generation, particularly as technology has improved, making such schemes more viable. Tidal schemes involve either a barrage with turbines built across an estuary or bay, or arrays of 'in flow' tidal turbines which utilise tidal flow between headlands or islands. An example of the first type has been in operation since the mid-1960's in the form of a barrage across the Rance Estuary in Northern Brittany in France. There have been discussions over many years about placing a large barrage across the Severn estuary, and it is estimated that such a scheme could produce 6% of the energy needs of England and Wales. However, there is much opposition, specifically from environmentalists. An advantage of such schemes is that it is a reliable source of power, occurring in the same place and regularly. The obvious disadvantage, excluding environmental issues, is the fact that tides occur only once every 10 hours (twice a day), so power can only be generated at these times, for a limited period.

One fascinating development is the construction of underwater offshore facilities that use turbines similar to those used in wind farms above the water, but these use tidal flows and general water movement to turn the blades. The main advantage of this system is that the environmental impact is much reduced compared to the problems experienced by barrages, as the system allows water (and its sediment load) to be free-flowing up and down the area where the turbines are located (i.e. across the mouth of an estuary).

Wave schemes are more varied and have the potential to be located in more sites than tidal schemes. Wave power could be used to generate energy from large numbers of smaller units, which would be more beneficial from the point of view of risk management, financing, and flexibility of supply. The most advanced technology is the system where air is forced in and out of a constricted chamber as waves flow in and out. The air flows are directed to a turbine which drives the generator. The advantage is that it can be incorporated into other coastal features, such as breakwaters and coastal protection barriers, reducing the environmental impact.

Other methods of harnessing wave power are the use of the pressure differential in water as a wave moves over a particular point, and the use of buoyancy of objects in the water.

Biomass/Biofuel

Biomass comes from agricultural wastes (straw, crop residues), crops specifically grown for the purpose (willow, oil seed rape, miscanthus) and waste from other sources (cattle, pig and poultry slurry). The biomass is burnt in the same way as traditional fossil fuels – burning heats water to make steam, which turns the turbines and then the generators, which produces the electricity. The main advantage of using biomass is that it is self-sustaining and the system has a relatively low cost to install.

A biomass plant is often built in conjunction with CHP[6] systems, which provide a reliable, local source of heat and electricity for industrial or commercial purposes. This

[6] CHP is combined heating and power - see BOX 2

is highly efficient, as the electricity does not need to travel far (see section on solar), so less electricity is wasted during transport to the end user. An additional advantage of this type of system is that any surplus electricity generated can be sold to the grid, enhancing the income for the operator.

Biomass fuels are also used with other technologies, such as gasification systems (dry biomass) or anaerobic digester systems (wet biomass). Liquid fuel produced from biomass is called biofuel, and is already in widespread use in Brazil. Many governments are mandating that it should be used as an ingredient of motor transport fuel. There are growing concerns about the environmental sustainability of these processes. For example, the priority will be to use fertile land for food crops, rather than for biomass/biofuel. This limits the potential for biomass/biofuel projects (see Chapter 13 for a fuller discussion). However, one positive argument made about the emission of CO_2 from burning biomass is the fact that it is a 'carbon neutral cycle'. Plants growing now (for biomass production/food) utilise CO_2 in order to grow, which reduces atmospheric CO_2. When these plants/food waste are converted to biomass and burned, the CO_2 is then released back to the atmosphere. What comes out goes back in, in a neutral system. Fossil fuels, however, were formed many millions of years ago, and we are digging them up to burn, thereby releasing carbon dioxide into the atmosphere which was not there in our lifetime, therefore increasing the CO_2 levels in the atmosphere and so global warming occurs. An interesting variation on biomass-produced power would be to combine it with CCS: effectively that would constitute negative carbon, since it would extract CO_2 from the atmosphere via the fuel source, and then bury it rather than releasing it.

Energy from waste

Humans produce an enormous amount of waste each year, most of which is piled up in landfill sites. Two main problems with landfill are the general environmental issues surrounding landfill sites (smell, pollution of soil, etc) and the lack of suitable new sites.

Technologies are being developed to utilise these mountains of waste in a suitably environmental way. There are several ways in which waste is used to produce power. The main way is to burn the waste after the recovery of recyclable products (e.g. aluminium and plastics). Before burning, the waste is treated (usually with high pressure steam), which makes the waste biologically inactive and thus removes potential harmful emissions. Again, often the system is coupled with CHP systems, to provide local efficient electricity supply.

Other technologies include gasification and pyrolysis, but both these systems demand uniform waste of a high standard, which can prove expensive to produce. Gasification involves the waste being heated in an oxygen deficient environment, causing partial oxidisation of the waste, to produce a low-energy gas (containing hydrogen, carbon dioxide and methane), which is used to turn the turbines to generate electricity. Two advantages of this system is that emissions are much reduced, and the system is on a smaller scale than waste incinerators, so costs less and impacts on the environment less. Pyrolysis is similar to the gasification process, but the products from heating the waste (in total absence of oxygen) are gas, olefin liquid and char. The gas and olefin can be used in combustion engines and the char is used as a fuel.

The main benefit of using waste for energy is obvious – it provides a relatively safe and cost effective solution to dispose of the waste problem. One disadvantage is the fact that emissions of carbon dioxide still occur, albeit at a much lower value than burning fossil fuels. There is something positive to say about this disadvantage: methane gas is about 23 times more damaging than CO_2 for global warming, and we are producing significant amounts of methane in our landfills. If the landfill is utilised as fuel for power plants, less methane is produced, and even though CO_2 is produced during burning, the overall effect reduces greenhouse gas emissions.

Biogas

We have already discussed above the effect of landfill on the production of methane (and carbon dioxide). Biogas systems utilise the methane and carbon dioxide produced by landfill, or produced in anaerobic digesters from sewerage sludge, to generate electricity.

Biogas from landfills is collected by drilling into the waste and extracting the gas as it forms. The gases are then piped to a turbine or engine to produce the power. The advantages of this system are that it can produce gas for up to 30 years after the landfill site has stopped being used and it provides some safety of the site for the duration. The main disadvantage is that it does not reduce the need for landfill sites, and the issues that they themselves raise from an environmental point of view.

Anaerobic digesters work on the same principle that occurs naturally in landfill sites, but it is developed to speed up the process of decomposition of waste. It is mostly used to process wet waste, such a sewerage or animal slurries, the advantages of which are obvious!

Geothermal

Geothermal energy emanates flows from the Earth's hot core. It can be exploited where zones of high heat flow are relatively close to the surface. It is a proven resource, and has been used for electricity generation and the production of heat for industry, space heating, aquaculture and other purposes for over 70 years. Geothermal plants offer several advantages: simple engineering; moderate scale (1-50MW); and capability to provide base load.

There are several techniques for exploiting it, depending on whether the source is deep or shallow, and wet (hot aquifers) or dry (hot rocks). The main technical challenges fall under three headings: exploration, i.e. how to identify likely zones deep below the surface; drilling, which is similar in nature to oil and gas drilling, but still very costly, typically accounting for half of the capital costs; and reservoir technology, i.e. techniques to extract the heat more extensively and efficiently. A deep geothermal borehole can cost £2 to £4 million to sink, with no guarantee of success, and the payback is much less than for an oil or gas strike. On a smaller scale, naturally available heat can be exploited by means of heat pumps – see Box 1.

BOX 1
Heat pumps

A heat pump is a device which moves heat energy from one place to another, from a lower to a higher temperature. The source is usually renewable energy from an ambient heat source or waste energy. For example, a fluid is pumped around a circuit of pipe which passes through a water source (river, lake or ground water) or under ground, and in the process it extracts heat from that source and carries it to where it is needed.

Heat pumps are efficient as well as climate-friendly. For example, with a 3:1 performance ratio, for every three units of heat delivered, two units can be from the renewable heat source and one from the electrical power supply. A heat pump, operating on a 'green electricity' supply would deliver three units of renewable energy for every one unit purchased as 'green electricity'.

The running costs of a heat pump can be less than those of a traditional gas boiler heating system and definitely less than some other forms of heating (LPG, oil, electricity). The initial capital cost is usually higher than other conventional heating systems. The 'whole-life' cost, combining the capital and running costs, can be favourable for heat pumps compared to fossil fuelled systems – and, especially, compared with other forms of electric heating.

In addition to providing domestic heating, heat pump systems are used in commercial premises (offices, hotels, supermarkets) – often providing heating and cooling – and also in some industrial processes and applications.

Technological improvements in the reliability of heat pump components have addressed the operating problems of the early heat pump designs. The ground loop pipes, or collectors, use materials and jointing developed in the oil, water and gas industries. Ground collectors are now believed to have a reliable operating life of 40+ years.

Insurance for heat pumps can be provided under standard engineering insurance policies for larger installations, while domestic ones can be covered under customised scheme arrangements, as for domestic heating systems.

A classic, if atypical case, is Geopower Basel. In late 2006, the company started a geothermal borehole near a geological fault located at the city of Basel in Switzerland. Within weeks there had been three minor earthquakes, and currently drilling is still suspended. Clearly the public liability if an earthquake occurred would be huge. The last event in the year 1356 destroyed every major structure in a radius of 30 km, and killed many hundreds.

Government policy on renewables

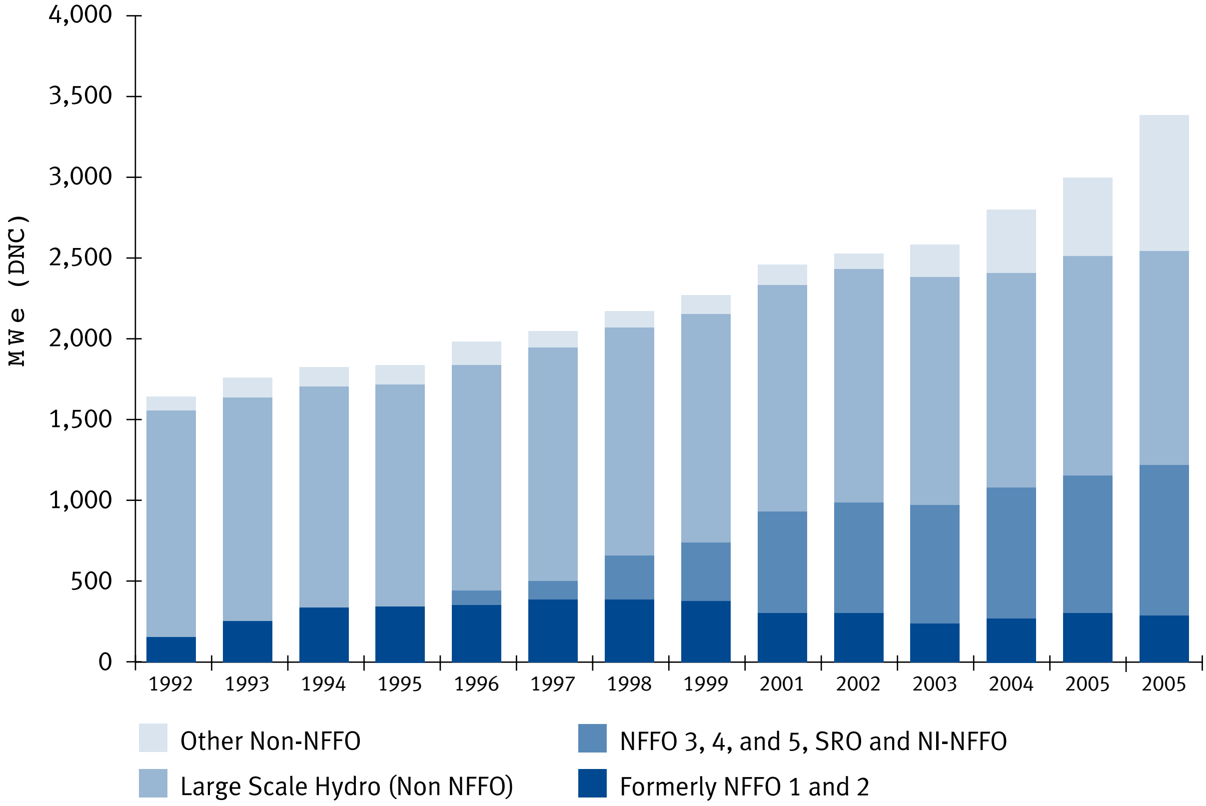
Research by the Carbon Trust shows that with the retirement of coal and nuclear generating capacity in the UK, there will be a gap of around 14GW between supply and demand for power by 2015, which is equal to approximately one fifth of Britain's capacity requirement. However, there are currently problems and barriers to advancement of renewable energy technologies in the planning process and grid connection.

The UK's Renewables Obligations (RO) show that under the current framework, renewables will meet only 10% of the UK's electricity requirement by 2020, which falls short of demand by some way. The RO is the Government's main policy tool to promote renewable energy and requires all electricity suppliers in England and Wales to buy a proportion of their energy from renewable energy sources. Many state that the current framework is not good enough at present, and that the RO needs expanding to encompass other renewable energy sources and not just concentrate on a few.

Recently, there have been calls to reform or replace the RO, to deal with the problems mentioned above, particularly for offshore renewables. A better framework will decrease costs and increase development, which is desperately required if the supply of electricity is to meet demand in 2015.

Figure 9: Trends in UK renewables capacity

Renewable generating capacity from NFFO and former NFFO conracts (including equivalents in Scotland and Northern Ireland) and capacity outside of NFFO



Source: Chart has been taken from the 'Digest of United Kingdom Energy Statistics'

For all generators of "clean energy" a major part of their revenue comes from emissions trading and thus any material damage losses which put the plant out of action will potentially result in a complex Business Interruption loss. Under the EU Emissions Trading Scheme producers of "dirty" emissions can meet their emissions targets by buying surplus allowances not used by producers of "clean" emissions. Thus renewable energy producers are looking for specific products to protect this revenue.

Other technologies to save carbon in the energy sector

Apart from changes to the use of fossil fuels, and the introduction of renewable sources, there are other strategies for reducing carbon: changes in the distribution of energy; decentralisation; hydrogen power; and nuclear power. The first two are promising, but the hydrogen economy is a more distant prospect; and this review does not favour expansion of nuclear.

Distribution

Two problems with a centralised grid system for electricity are that a huge proportion of energy is lost in between leaving the power station and reaching the point of end-use, and that it is difficult to balance supply and demand finely. Considerable efforts are being made to address these two problems with advanced technology such as superconducting cables (i.e. maintained at very low temperatures to reduce losses of power in transit) and rapid response controls that will swiftly react to changes in demand or supply. 'Smart grids' and 'smart meters' might be used to improve system management by providing advanced information on grid behaviour, incorporating devices to route current flows on the grid, and introducing real time pricing to regulate demand for non-essential appliances. This would considerably increase the capital values of the distribution systems for insurance purposes.

Decentralisation

Another strategy is to decentralise, so that power production is closer to end-use. This has other advantages, such

BOX 2
Combined heat and power (CHP)

CHP is the simultaneous generation of usable heat and power (usually electricity) in a single process. It is a highly efficient way to use both fossil and renewable fuels and can therefore make a significant contribution to the UK's sustainable energy goals, with environmental, economic, social and energy security benefits.

CHP systems can be employed over a wide range of sizes, applications, fuels and technologies. In its simplest form, it burns fuel to create electricty that can be used on- or off-site. The heat produced during power generation is recovered, usually in a heat recovery boiler and can be used to raise steam for industrial processes and to provide hot water for space heating.

Because CHP systems make extensive use of the heat produced during electricity generation, they can achieve overall efficiencies in excess of 70%. The efficiency of conventional coal-fired and gas-fired power stations, which discard this heat, is typically around 38% and 48% respectively, at the power station. Efficiency at the point of use is lower still because of the losses that occur during transmission and distribution.

CHP achieves this because it is decentralised. It is a really a philosophy of energy use, not a single technology. It can be used to provide energy to anything from a single home to a large industrial plant, or even a whole city. CHP units are sited close to where their energy output is to be used; the main design criterion is that, there must be a need for both the heat and electricity.

In the home, a microCHP unit resembling a gas-fired boiler will provide both heat for space and water heating, as does a boiler, but also electricity to power domestic lights and appliances. MicroCHP units are a very new technology only recently appearing in the UK market, but the potential for them is as large as the number of homes in the country.

For commercial buildings and small industrial spaces, a factory-assembled, 'packaged' CHP system is appropriate. Here, an electricity generator, heat exchanger, controls and either an engine or a turbine is packaged together into a CHP unit that can be connected to the heating and electricity systems of the building. Some building types, particularly those that need a lot of energy, or operate around the clock, are particularly suitable for CHP, for example leisure centres, hotels and hospitals. CHP systems can supply cooling for air conditioning as well as heating, in a 'trigeneration' system.

Insurance for CHP can be provided under standard engineering insurance policies for larger installations, while domestic ones can be covered under customised scheme arrangements, as for domestic heating systems.

as reducing the risk of major systems collapse, and also various security threats. Previously, the economies of scale were too large, but with more sophisticated technology, and the need to improve energy efficiency, the equation has changed.

Decentralised or distributed energy systems are already commercial in urban markets that have very large peaks in demand (causing problems in supply for users with an imperative for total reliability), and in rural markets with high grid connection costs but abundant renewable energy resources. With the envisaged expansion of renewables, a decentralised grid is essential to enable the generation plant to link up with the users. CHP installations are a further technique in this decentralisation approach (see Box 2).

One advantage for insurers of a trend to decentralisation would be a reduction in the risk of a large aggregation of business interruption losses due to a failure of power.

Hydrogen

The hydrogen economy is a proposed method of delivering energy for almost any purpose including transportation and space heating. It entails burning hydrogen, and the only byproduct would be water vapour. The hydrogen could in principle be created in a variety of processes, including the electrolysis of water, i.e. splitting it into its component chemicals of hydrogen and oxygen by electricity.

One possibility is that the hydrogen could be made using intermittent energy sources, like windpower, then transported and stored for use when required. This would avoid ghg emissions, and also reduce dependency on fossil fuels, e.g. oil for transportation.

However, conversion to hydrogen would require a complete new infrastructure, and there are many technical problems in handing it safely. It is not likely to become a major element of the energy mix in the next two decades at least, although it is already in use experimentally in fuel cells (see Box 3).

BOX 3
Fuel cells

Hydrogen fuel cells make electricity by combining hydrogen ions with oxygen atoms. Basically, the hydrogen ions pass through an electrolyte (which conducts electricity) and reacts with the oxygen atoms. The result is an electric current at both electrodes, with the current being proportional to the size of the electrodes. A number of buses now utilise fuel cell technology to operate in main city centres across the UK (particularly in London), in an effort to reduce pollution in built up areas.

Fuel cell technology is still very expensive, so the devices are not cost-effective in mass use, but considerable effort is being devoted to improve their performance, and to find new, cheaper versions.

Nuclear Power

It is worth mentioning nuclear power here, as nuclear fission produces over 15% of the world's electricity at present (BBC 2006, 1). Whilst nuclear power is not a renewable energy source (although radioactive minerals are fairly abundant), it is a 'climate-friendly' source of energy. Nuclear power stations produce less CO_2 emissions to construct and run than any other source of energy, including renewables (see Figure 6) and can produce electricity on an industrial scale with no CO_2 emissions (BBC 2006, 3). Should we not, therefore, encourage the construction of more nuclear power stations bearing in mind that the fuel is available (and should be for some time) and the CO_2 emissions are practically non-existent?

The problem is that there are many barriers to nuclear energy as a power source and from a risk management viewpoint the concept seems questionable. The largest barrier is public opinion on safety of nuclear installations (operation of the station and storage of the waste), and the concern that the fuel could be stolen and utilised by terrorist groups or rogue states. Disposing of the waste and discontinued sites has proven to be very expensive. Nuclear power also uses a lot of water for cooling purposes and if water supply becomes uncertain due to climate change there is a potential for a chronic failure in power supply. There have been a number of high profile 'accidents' at nuclear power plants (such as Chernobyl) that have turned the public against nuclear. Until nuclear can be proven to be safe to operate, and cheap to decommission, and security and cooling problems are resolved, nuclear power will not be popular.

12.4 Implications for the energy insurance market

"...fresh woods and pastures new."[7]

The changes needed to address the twin problems of fossil fuel supplies and climate change caused by fossil fuel emissions are going to impact upon the risks presenting themselves to the energy insurance market. This is a challenge to the market but the industry has responded to such challenges in the past and insurance has often proved to be "uniquely positioned" to "advance forward-thinking solutions" (Mills et al 2006). The energy insurance market has a role to play in helping the development of renewable energy technology by providing protection to new developments. For the time being though it is likely that the world will retain its addiction to oil and continue to find ways to extract oil from increasingly more hostile environments in an attempt to delay the inevitable point at which oil reserves run out (BBC 2006). This will mean that underwriters will be asked to take on increasingly more technologically advanced operations that are potentially more exposed to elemental risks or which pose different risks such as CO_2 capture and storage.

Renewable Energy Technology (RET)

The RET sector is one that is expanding and is projected to grow from $40 billion in 2005 to over $150 billion in 2015 (Mills et al, 2006), which presents a great opportunity as well as potentially a great technical challenge. RET takes many forms and from an insurer's point of view there are a number of obstacles to overcome in underwriting them. Firstly there is the insurance of any new technology with the potential for picking up inherent design, materials and workmanship problems. This is exacerbated by the locations of many renewable energy sites particularly the offshore sites where the potential for installation losses is great. Secondly there is a lack of data to support risk assessments and claims projections which make rating an even less exact science (Marsh, 2006, 2). Thirdly there is not the number of homogeneous exposures that insurers need to benefit from the law of large numbers. Finally there are concerns about making an adequate underwriting profit on small scale projects and commercially marginal technologies (Mills et al 2006).

The sorts of product solutions needed to supplement the more traditional material damage and business interruption risks include:

- Weather derivative products, as many RET projects rely on the weather as the source of "raw material". The indices that need to be developed could include temperature, rainfall, wind speed, days of sunshine. This is a growing market and the notional value of the weather market stood at US$4,578 million in 2003/4 (Dlugolecki et al 2005). One example would be a wind power derivatives, in which payments are made to the producer if revenues fall below a pre-determined level, and, conversely, payments made to the derivative provider if performance exceeds expectations (Mills et al 2006). At the moment this is an area that the capital markets providers are beginning to explore so the insurance market needs to develop products quickly if it is to fully exploit this opportunity before demand is satisfied.
- Insurers are developing carbon financing products and these need to be more widely developed to cover the growing

[7] John Milton. Lycidas

"green trade"; the carbon trading market in the European Union alone was expected to hit $30 billion by the end of 2006 (Mills et al 2006).

- Risk assessment and risk management services including climate risk management services can be sold as products to the RET industry (and the energy industry) so that even where insurance cover is not available, expertise and guidance to lessen risks is still provided (UNEP, 2004).

Critically though, the industry needs to come up with a more joined up approach in the way that RET business is underwritten as this is one of the main areas of concern for the developing RET market (UNEP, 2004). At the moment a lot of RET business is written in the property and casualty markets where many of the covers needed by such projects are either not available or fall through gaps between the different lines of business (UNEP, 2004). This is surely an area where the international energy insurance market with its expertise in onshore and offshore risks needs to take a lead. Indeed that was the inspiration for Ascot Renewco to be established in 2007 and others are now also trying to adopt a similarly holistic approach, so this is an area where the market is already moving forward. Spreading risks and having a diversified portfolio is the traditional way for insurers to avoid a large accumulation of losses from one source and so it is the right time for the energy insurance sector to be insuring a greater variety of energy projects.

As well as "conventional risks" (Mills et al 2006) each type of RET project presents its own problem. Table 1 page 23 sets out a simplified summary of the main barriers associated with these type of projects. It also sets out risk management considerations for these barriers. Table 1 highlights two problems faced by insurers: some high risk exposures such as offshore wind, and secondly risks associated with the emerging nature of these technologies (Mills et al 2006). However, many of these issues apply equally to oil and gas production. If solutions can be found there with multi-million values at risk, surely they can be found for RET projects. The key issues are to develop risk management expertise in this field through closer liaison with the RET industry and to develop the necessary insurance products to support this technology (Dlugolecki et al 2005).

Table 1: The main barriers to RET Projects

RET Type	Key Risk Issues	Risk Management Considerations
Geothermal	• Drilling expense and associated risk (e.g. blow out) • Exploration risk (e.g. unexpected temperature and flow rate) • Critical components failures such as pumps breakdown • Long lead times (e.g. planning consents)	Limited experience of operators and certain aspects of technology in different locations Limited resource measurement data Planning approvals can be difficult on location "Stimulation Technology" is still unproven but can reduce exploration risk
Large PV	• Component breakdowns (e.g. short circuits) • Weather damage • Theft/vandalism	Performance guarantee available (e.g. up to 25 years) Standard components with easy substitution Maintenance can be neglected (especially in developing countries)
Solar thermal	• Prototypical/technology risks as project sizes increase and combine with other RET (e.g. solar towers)	Good operating history and loss record (since 1984) Maintenance can be neglected (especially in developing countries
Small Hydropower	• Flooding • Seasonal/annual resource variability • Prolonged breakdowns due to offsite monitoring (long response times) and lack of spare parts	Long term proven technology with low operational risks and maintenance expenses
Wind power	• Long lead times and upfront costs (e.g. planning consents and construction costs) • Critical component failures (e.g. gear train/box, bearings, blades.) • Wind resource variability • Offshore cable laying	Manufacturing warranties from component suppliers Good wind resource data Loss control (e.g. fire fighting can be difficult offshore due to height/location) Development of best practice procedures
Biomass Power	• Fuel supply availability/variability • Resource price variability • Environmental liabilities associated with fuel handling and storage	Long-term contracts can solve the resource problems Fuel handling costs Emission controls
Biogas Power	• Resource risk (e.g. reduction of gas quantity and quality due to changes in organic feedstock) • Planning associated with odour problems	Strict safety procedures are needed as are loss controls such as fire fighting equipment and services High rate of wear and tear
Tidal/wave power	• Survivability in harsh marine environments (e.g. mooring systems) • Various designs and concepts but with no clear winner at present • Prototypical/technology risks • Small scale and long lead times	Mostly prototypical and technology demonstration projects Good resource management data

Source: Marsh 2006, 2

In providing the necessary protection for energy producers, underwriters need to come up with strategies to address the different risk profiles presented by the various methods of production. In analysing the risks associated with various types of energy production including the more traditional methods using coal, gas and nuclear. Munich Re produced an evaluation table for such risks. Whilst being a little simplistic for underwriting purposes as it masks the considerable variation between the type and frequency of losses affecting the different technologies, it does serve to illustrate risk profiles (see Table 2).

Table 2: Risks in the event of loss or damage

	Damage to the plant from internal and external causes		Risk to the environment in the event of loss or damage			Exposure to terrorist attacks	
Power Plant Type	Frequency	Amount of single loss	Frequency	Intensity	Geographical extent	Exposure	Consequence for the Environment
Onshore wind Farm	3	1	1	1	1	1	1
Offshore wind farm	3	2	1	1	1	1	1
Convent. Hydro-electric power plant	1	2	1	2	1	2	1
Wave power plant	2	2	1	1	1	1	1
Tidal power plant	2	2	1	1	1	1	1
Photovoltaic	1	1	1	1	1	1	1
Large-scale solar power plant	2	2	1	1	1	1	1
Solar chimney power plant	1	2	1	1	1	1	1
Biomass	2	1	1	1	1	1	1
Biogas	2	1	1	1	1	1	1
Geothermal power plant	2	1	1	1	1	1	1
Fuel cells	2	1	1	1	1	1	1
Coal power plant	1	2	1	1	1	1	1
Gas power plant	2	2	1	1	1	1	1
Nuclear power plant	1	4	1	4	4	4	4

Source: Munich Re, 2004

Legend 1 = Low Risk 2 = High Risk 3 = Very High Risk 4 = Extreme Risk

Underwriting renewables

General considerations

What are the implications for the insurance industry of the shift towards power produced by renewable energy sources rather than the traditional sources? The following are the main considerations:

- Less concentration of large, high risk potential in one place (such as a power station).
- Increase in medium-scale risks. For example, a number of insured windfarms may be affected (in respect of BI) if a main export transformer cannot operate due to an accident such as fire or explosion. Similar considerations apply to offshore cabling, etc – care should be taken on aggregate exposures with regards to customers/suppliers extensions.
- Increase in aggregation of risk over large areas (e.g. a number of wind farms that could be affected by a large storm or hurricane – such as the 1987 hurricane across the South of England).

- Many of these technologies are being sited in increasingly hostile environments – prone to the elements by necessity, and long-term exposure to these will have as yet unknown effects. This may pose difficulties in monitoring aggregates – e.g. for 'quake aggregates on solar panels in California. PML assessment even for a single wind or solar farm can be problematic. Any offshore/marine installations will be significantly riskier and more specialist particularly during construction, and, with regard to cables and grid connections, will be inaccessible for long periods of bad weather.
- Requirement for wider experience and expertise in technology (and the need to keep updated with emerging technologies) to facilitate underwriting – an ever changing market!
- Shift towards breakdown risks (requiring technical and engineering based expertise) and away from natural perils. There are significant design issues – not least as existing technology is scaled up to such an extent that new models are largely again prototypical in nature. Series losses are a major concern as hundreds, or thousands of units may be installed before a problem is identified.
- Reinsurance is bought differently. Large power or nuclear stations require specific excess of loss layers on mainly the fire/explosion risk. Widespread renewable energy risks, with lower individual values, but catastrophe hazard require excess of loss bought on a portfolio basis to protect against windstorm, flood, hurricane/cyclone & earthquake perils.
- More insurance companies have capacity to deal with lower value individual risks, which encourages competition. Large power/nuclear stations are handled by a few, large specialist insurers.
- Each renewable energy source has different insurance considerations and is affected more, or less, by different perils (see elsewhere for detail).
- Throughout the RE industry there are major concerns with supply chain constraints regarding specialist equipment and personnel to instal and maintain equipment. This affects BI losses, due to the length of time before an item or site is operational again.
- Staff safety issues are particularly acute with any marine risks (Note the HSE requirement for inspection of turbine safety equipment following death in the UK from failure of safety equipment).
- Some technologies can have a pollution exposure themselves – waste from biomass and biofuels and feedstocks for waste to energy plants.

The current appetite across the insurance market for renewable energy risks is strong particularly for onshore risks where traditional material damage and business interruption covers can be offered. Cover is increasingly available for wind energy projects, geothermal energy projects, solar PV, and small hydro risks. However, there is far less appetite for wave, tidal and ocean current risks as well as offshore wind generating risks because of the increased marine and elemental risks, e.g. losses associated with offshore cable laying (Marsh, 2006, 1, Marsh 2006, 2). This is surely an area where the energy insurance market can transfer expertise and experience to offer more suitable products that cover offshore based risks. Covers for Biomass and Biogas plants are being developed but there are still concerns about the processes used in this production technique (Marsh, 2006, 2).

Individual renewable energy types

Wind energy is currently the most popular renewable energy in the UK at present (and across Europe), which means that there could be major insurance and reinsurance implications. Insurance is generally bought on the full perils basis, including breakdown cover and resultant business interruption. A single wind farm, whilst vulnerable to a high amount of damage in a severe local storm, generally is not much of a concern to the insurer.

However, with many wind farms being built in relatively close proximity, the risk of aggregation of loss in the event of a major storm is increased. Reinsurance is often sought for the catastrophe perils, such as windstorm and hurricane/cyclone, on an excess of loss basis over a portfolio.

Other insurance considerations are the risk of fire in a nacelle, explosion or fire in the transformer. Although the physical damage is restricted, the business interruption risk could be substantial, especially if one transformer is used for more than one wind farm. Lightning strike, whilst very specific, can occur repeatedly (especially as onshore farms are frequently sited on high ground), which causes attritional losses over a period of time. Lightning is occurring more often, due to climate change, so it is an important factor. Tornado damage is a insurance consideration, particularly if providing insurance in other countries (such as the Mid-West USA). The UK has always had a high number of tornadoes each year, although not reported on due to their generally low intensity. However, it seems that the strength of tornadoes is increasing in the UK, although this could be distorted due to the press coverage.

Solar The insurance considerations include the impact of adverse storm conditions, such as hailstorm and sandstorm, plus also wildfire and earthquake. Solar installations, by nature of their operation, mean that they are most effective in hot, dry environments. In Spain, there have been problems with wildfire due to dry conditions. Solar installations are vulnerable to fire, so this is a major insurance consideration. If dry conditions are more prevalent due to global warming, then wildfire will become more problematic. Earthquake is a consideration in certain areas, such as California (which has invested heavily in solar technology) – it can cause widespread damage and aggregation of risk. Loss from hailstorm has reduced due to technological advances that have made solar/PV panels more robust. However, solar panels are often at ground level and more exposed to theft. In view of high replacement costs, they can incur high losses.

Water-based energy. Here the insurance is based mainly on the location of the scheme. During construction of a hydro scheme, the method of construction is the main consideration, particularly as there is much ancillary construction required that will not be part of the main risk once the scheme is operational (such as diversion of the river and coffer dams). Once in operation, generally it is the natural perils that will drive the provision of insurance. Large hydro schemes are usually located in remote, mountainous areas, where the elements are extreme (snow storms, freezing/thawing). Earthquake is also a major consideration (such as in New Zealand).

Wave and tidal schemes are usually insured in the Marine insurance market (but not exclusively) due to the fact that these schemes are, by their very nature, in or on water. Such schemes are obviously vulnerable to water related perils, such as inundation by abnormally high tides, hurricane or cyclone, tidal surge and tsunami (particularly during installation). There are limited windows when work is possible until the next tide, current, etc which prevents further work and the surge may be so strong that it is almost impossible to use divers. Aggregation of risk is a consideration when schemes are close together. However, there are not currently many schemes in operation in the UK, so the risk is more specific. Further afield, if wave and tidal schemes become popular worldwide, a critical risk will be earthquake followed by tsunami. The Boxing Day tsunami in 2004 shows the far reaching effects of such an event, and the insurance implications.

Insurance. There have been some recent press articles highlighting the problems of insuring hydrogen fuelled vehicles. Some motor insurers have stated that hydrogen fuelled cars must not be kept in enclosed spaces (such as a garage) due to the explosive nature of the hydrogen gas. Therefore, explosion and fire is a major consideration for insurance. However, this is very specific to this type of renewable energy.

Biomass and biofuel Insurance of these schemes is mainly based on the technology itself, and is engineering based. Failure due to breakdown is a major consideration, as is explosion and fire. The production of ethanol is very similar to a distillery, while bio-diesel is essentially a refining process, so hazardous, but not necessarily new risks in concept. Biomass production, as with waste to energy, requires a considerable amount of quality control on input. Also many biomass units are small facilities installed at a factory – operator training and cleaning and maintenance controls become critical (otherwise the frequency of loss increases).

Waste to energy plants. The insurance considerations are similar to those for biomass/biofuel risks.

Biogas plants involving fermentation processes, technology and operational risks are a concern for underwriters, as are the health risks associated with noxious gases. The fermentation process is sensitive to the introduction of contaminants or changes in the composition of the material to be fermented. Without strict safety procedures and operational experience for the technology and operators involved in controlling the fermentation process there are difficulties in obtaining wide coverage.

Geothermal. The main insurable risks relate to the quality of resource (exploration risk), the pumps, and the reservoir technology. In one notable case Munich Re took the exploration risk at a premium of 25% of the sum insured. The overall value of the project was EUR20 million and the premium for resource risk cover was EUR4 million. The drilling risk is in fact less than for oil and gas, since 'blow-outs' are less likely. The drilling policy would cover: costs of materials and services to bring the well(s) under control, extra expenses reasonably incurred to restore or redrill an insured well, and clean up of seepage and pollution.

Other energy insurance considerations

Nuclear. From an insurance standpoint, nuclear public liability insurance is virtually uninsurable. Dedicated pools with capacity from the private insurance market supply some very limited capacity (Faure and Fiore, 2008). Operators of nuclear power plants are liable for any damage caused by them to third parties, regardless of fault, as defined by both international conventions and national legislation. In 2004, contracting parties to the OECD Paris and Brussels Conventions signed Amending Protocols, setting liability limits at 1,500 million euros. Non-OECD countries have similar arrangements through the IAEA's Vienna Convention. In the US, the national Price-Anderson Act was passed so that damages are covered by insurance backed by the US Government for damages limited to USD 200 million, and a reactor operator pool which provides up to USD 9.43 billion per accident (IPCC, WG 3, 2007).

Carbon capture and storage (CCS).

Lability for the long-term geological storage of carbon dioxide is a major obstacle to large-scale deployment of the technology (International Energy Agency, 2007). It needs clear guidelines on the responsibility for short- and long-term liability. It also raises such issues as whether carbon dioxide should be considered as a commodity rather than a waste product, and what regulatory framework should apply to under-sea storage. Until it is resolved, insurers and financiers will be reluctant to participate in projects.

This is really a political matter; there is no 'right answer'. Solutions may well differ from one country to another, with international protocols to cover international transport and storage. Risk transfer for the most contentious process, long-term geological storage of carbon dioxide, may be handled in a layered or portfolio approach. Setting a limit to corporate CCS liability is one solution that could preserve insurability. This could be combined with setting a 'caretaker sunset' for each site, after which storage is passed over to a government facility. A range of risk transfer tools could be used, including insurance, letters of credit, sureties, bonds, and 'self-insurance' by project developers or operators in consortia (World Resources Institute, 2007).

Liability for climate change

This issue comes up periodically in discussion of fossil fuels. See Chapter 10 for a full discussion, but in brief this seems most unlikely to materialise for private sector companies and their insurers.

Emissions permits

As noted earlier, the energy sector is a "prime suspect" for emissions regulations. This could affect the valuation of assets and liabilities for the purposes of sums insured and also for claims adjustment. Currently there is not an accepted accounting standard for valuing emissions permits, so this is a matter for negotiation.

12.5 Conclusions and Recommendations

"The Knitting Done"[8]

A Strategy for the Future

All sectors of the insurance industry need to control their exposures to natural catastrophes as well as develop better techniques for underwriting and predicting climate-associated risks (Dlugolecki et al 2005). The energy sector is greatly exposed to elemental losses and this exposure is likely to increase as growth in worldwide energy demand encourages producers to explore more hostile environments to meet these needs.

In the face of overwhelming evidence from scientists the argument over climate change has moved on from whether it is real or not to one of acceptance and increasing concern over frequency, severity and volatility in loss patterns. Increasingly there is a shift in government thinking towards even more direct intervention on environmental and climate change. The sectors most sensitive to this gathering political momentum include the oil and gas industries, coal, and power utilities (Dlugolecki et al 2005). An increase in nuclear fission generation has its own problems, and cannot provide immediate answers thus clean fuel technology and RET are the only near-term options and it is likely that governments will increasingly move to encourage these forms of energy development. As the RET market will be a direct beneficiary of any climate-positive political changes it is expected that investment in cleaner energy is likely to rise from a current level of US$20 billion to US$100 billion by 2015 (Dlugolecki et al 2005).

The technology behind RET power generation is improving all the time and investment in this field is growing, for example major American investors announced intentions to invest 400 million euros in RET projects (Dlugolecki et al 2005). The question is whether the energy insurance market is ready to underpin this investment by providing the insurance products necessary to help the technology through its formative stages. There is a growing RET insurance market but it is still on the periphery of the energy insurance market. To really make an impact it needs to become part of the main-stream energy market and to do this will require increased technical expertise and better capitalisation.

[8] Charles Dickens. A Tale of Two Cities

There is an expanding RET insurance market with more products becoming available as the technology becomes more widespread and proves its reliability and robustness. This still appears to be a fringe market within the energy insurance sector. However, major players like the Royal and SunAlliance are moving into this market (Insurance Times 2007). For RET to really take off and therefore for the RET insurance market to take off, certain things have to come into place:

- Governments have to tighten up on their commitments, with “unambiguous policies” that set a price on carbon through taxation, trading regimes or regulation (Stern, 2006). Clear financial incentives or penalties will encourage movement to renewable and sustainable energy forms, otherwise businesses will not readily move unless there is a switch in consumer demand.
- RET has to continue to demonstrate robustness and prove that it can deliver reliable, cost effective energy.
- With the right government backing and proven technology financial institutions including insurance companies are more likely to invest in RET (Mills et al 2006). It is possible that the number of projects would increase by 300% if insurance protection were more readily available (Dlugolecki et al 2005). One area though where insurers will have concerns at this stage in the development of these newer technologies is any form of efficacy guarantee but conventional peril capacity should not be in short supply.
- Insurers and other risk carriers need to have the products to back up this investment and provide institutions with the confidence that their investments are being protected (UNEP, 2004).

In addition, more public money needs to be spent on essential research and development work for RET and clean fuel technology as the private sector alone either cannot or will not put up sufficient funds. Successes in this area include Japanese public investment in photovoltaics which has helped to bring about a 95% decrease in production costs and American public investment in Advanced Turbine Systems which have resulted in production of some of the most efficient and cleanest gas turbines in the world (Watson and Scott, 2001).

Some of these are a chicken and egg situation as financial backers for an RET project want a good insurance product to be in place to protect the project against “events”. However, insurers also want more projects to be in place so that they can benefit from the statistical data that additional risks generate as well as enjoying protection from the increased numbers of homogeneous exposures. From the insurance industry’s point of view there is a fine balance to be drawn between suffering big losses on relatively untried technology and adopting an over-cautious approach and missing out on a growing business opportunity. In such times of fine judgement, success will often go to those with the best knowledge and for that reason there is a need for insurers to work closely with other stakeholders in the RET field to help develop greater understanding and trust, better products, different underwriting methodologies and risk management strategies (UNEP, 2004).

In the long run insurers will continue to offer insurance for windstorm risks in the Gulf of Mexico but increasingly they may channel their resources and expertise into the developing areas of the energy market to take advantage of risk factors that can justify high rates. The clean fuel technology and RET markets with their prototypical and elemental exposures are just such a market place but without the high aggregate potential present with Gulf of Mexico risks. Thus clean fuel technology and RET risks could present a potentially more profitable area of business with the added benefit of helping to protect technology that mitigates the very climate change problems that are damaging the global insurance industry.

Recommendations

1. Insurers[9] need to increase the diversification of their energy portfolios with less concentration in high risk areas such as the Gulf of Mexico. The growing renewable energy market offers a source of new business that should be explored by traditional energy insurers as well as a possible new avenue of business for other insurers. Energy producers will be expanding their businesses to include a renewable energy capability and so energy underwriters should develop products to meet these needs.

2. Insurers need to develop robust strategies to ensure stability in the face of volatile climatic conditions – more realistic disaster scenarios, with greater retentions and pricing these accordingly. Insurers should also consider catastrophe bonds as a way of protecting their portfolios against climate risks.

3. Past experience is no guide to future losses and current models can be inaccurate even with current climatic conditions. Insurers need to collaborate with scientific experts to develop better models to predict future trends more accurately. One such example is the Lighthill Risks Network, which provides its insurance members with access to leading edge research, and there are others.

[9] In this section, reinsurers are included within insurers for brevity.

4. In the absence of more accurate models underwriters need to assess risk exposures far more cautiously and rate risks on their individual merits. Reinsurers in particular, are going to want to satisfy themselves about the underwriting prudence of ceding offices, and so insurers are going to need to look at rating risks on their exposure and risk factors and putting forward greater risk improvement measures designed to minimise climatic risks. Underwriters need to make sure that routine maintenance of plant is carried out despite periods of increased production as a consequence of prevailing weather conditions.
5. In putting forward property and BI covers underwriters need to be more careful about their extension wordings and need to fully consider the risks that these extensions could involve. Downstream insurers could well pick up the consequence of upstream losses over which they have no control.
6. Exposure values are set to increase both in terms of property damage losses and business interruption losses, because of the increasing complexity of plant. Underwriters must undertake regular reviews of sums insured and limits to ensure that cover is adequate and to make sure that they are obtaining the correct premium for the risk they are running. BI exposures will reflect the erratic oil prices.
7. Underwriters must continue to maintain discipline and focus on the physical hazards of each risk, particularly the construction and location of the exposure. As the energy industry explores more hostile terrain, construction technology is going to be pushed to the limit and underwriters need to be very aware of the engineering capability being deployed. Insurers will need to ensure that their underwriters have the right levels of technical knowledge and skills to assess these risks correctly.
8. Any significant impact on oil production will lead to increased oil prices and thus producers who suffer damage and lost production from some rigs will have their losses partially offset by increased revenues from their other sites. Thus upstream insurers should consider whether hedging arrangements can be built into programmes to cover such circumstances and so mitigate business interruption losses.
9. In view of the current lack of clarity over the valuation of emissions permits, insurers should ensure that the method adopted by the insured is acceptable when going on risk.
10. Some risks may prove uninsurable and so insurers and brokers need to be thinking about various risk management and claims services that they can sell to clients to maintain revenue schemes. These may involve helping to set up various types of self insured mechanisms supported by insurance services such as risk surveys, claims handling arrangements, and loss information services.
11. Insurers need to keep abreast of liability trends particularly continuing moves towards making energy producers liable for wider aspects of climatic or environmental change. Ensuring that liability wordings are restricted to an identifiable, single event happening, similar to pollution cover, should limit exposure. At the same time there is a developing market for environmental liability covers which could offer opportunities to underwriters.

Renewables

12. Energy production is changing as producers respond to the need to produce cleaner energy as well as reacting to the availability of oil and natural gas. The general upward trend in the price of gas and oil will make it economically viable to extract these commodities from more extreme environments and so underwriters will need to consider the risk profiles of these new activities. In addition coal-fired generation will enjoy a revival as stocks of this resource remain high. However, such production will be coupled to cleaner-coal technology which will require insurance cover. Underwriters will need to understand all these technologies and the technical issues that they present so that they can charge the appropriate premium rates for the risks that will be presented. Underwriters will also have to determine how they are going to approach new risks such as CO_2 storage either underground or underwater.

13. The market for renewable energy is expanding as traditional fuel sources dwindle and global governmental pressure grows to set more stringent emissions targets. Underwriters will need to develop products to protect these new risks and develop risk management expertise to help clients with these risks. The insurance market will need to provide protection such as breakdown cover and possibly design risks for emerging technologies, as well as specific products to cover the different risk factors inherent with renewable energy risks, wind farms, solar panels, hydro risks, tidal production, biofuels, etc. as well as providing cover on aspects such as carbon-trading credits that form a significant part of the business interruption risk for renewable energy producers.
14. Many renewable energy projects will be based in local communities on a smaller scale to traditional energy production. This opens up the energy market to non-specialist insurers to offer cover for the small to medium sized risks, e.g. CHP and heat pumps. Those companies will need to offer suitable products. Underwriters will need to look at their reinsurance arrangements as these types of risk will have different aggregation profiles to the larger, traditional risks and so different reinsurance programmes will be required.
15. Household insurers will need to consider their response to requests to cover domestic energy production such as roof top wind turbines or solar panels. There is scope to offer either specific products or extensions to existing products that insurers can use as a new source of income.
16. Most renewable energy technology relies on the ready availability of a natural power source, e.g. wind or sunshine. These sources cannot be guaranteed and so there is a market that insurers should be exploring to provide weather derivative products to cover clients against resource deficits.
17. Brokers will need to continue to expand their knowledge of these new areas and develop their expertise in order to offer suitable advice to clients.
18. Claims professionals will also need to consider the implications of renewable energy in terms of managing and minimising losses arising from damage to renewable energy operations.

Energy policy

19. The insurance market's trade associations, e.g. the ABI and BIBA, should lobby the Government to be proactive in responding to climate change. More stringent targets are needed for greenhouse gasses to avoid problems of uninsurability in major insurance markets. Such policies will also stimulate moves towards cleaner energy production and consumption. A growth in renewable energy production would encourage more insurers to move into offering products for this sector.

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Biography

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Ian has worked in the insurance industry since 1979 starting life in the private motor department before moving onto work in the commercial department in various underwriting roles. He currently works as Knowledge Development Manager for AXA Corporate Solutions UK, a specialised part of the worldwide AXA Group focusing on the insurance of large, multi-national commercial risks.

He is also a member of the International Underwriting Association Training and Education Committee as well as being a past president of the Insurance Institute of Ipswich, Suffolk and North Essex.

Ian's interest in the effects of climate change are more than just professional as he and his family only live two miles away from the North Sea on a particularly flat part of the Suffolk coast line.

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Christina has been working in the Engineering and Construction market in an underwriting capacity for over 20 years, more than 15 of which have been in London. For the last nine and a half years she has worked at HSB Engineering Insurance Limited in various underwriting roles. Currently, she is a Senior Underwriter in the Risk Managed and International Department, specialising in underwriting renewable energy risks of all types. Christina also underwrites a portfolio of engineering, construction and erection covers, with risks spread over the UK, Europe and Australasia.

Having gained by ACII qualification back in 1997, and later receiving Chartered status, Christina found that she had some spare time, so she embarked on an Open University degree in Geology. She has managed to obtain a Diploma in Earth Science, but now that her spare time is much scarcer, the last two subjects she requires for the BSc Hons have had to be put on the back burner! Christina is nearly 40 years only, married with no children, and lives in the wonderful Hampshire countryside.