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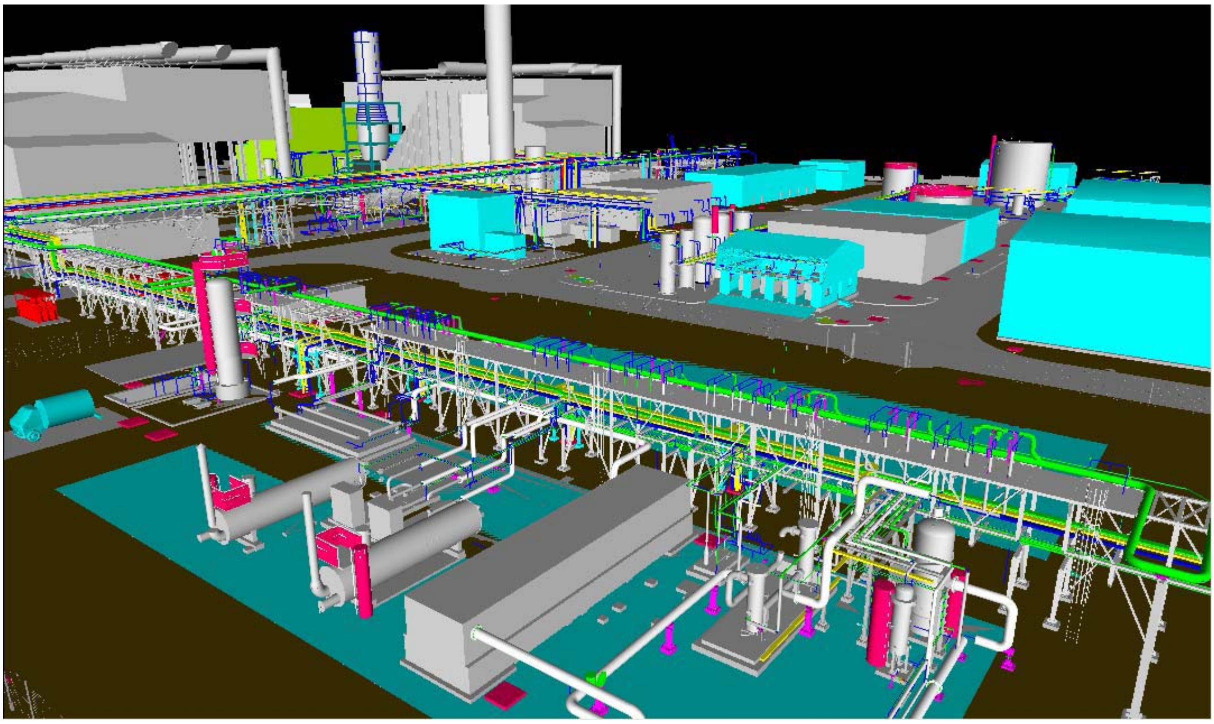
Fast developing technology underwriting and claims issues



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Executive Summary

Underwriters have been successfully insuring risks involving developing technology for many years. High frequencies of loss in some fast developing technologies have made them wary and conscious of the need for particular care. Successful underwriting requires a high level of understanding of the technology to be insured and special measures are needed for fast developing technologies where up to date information is particularly important. Getting access to specialist expertise is not always easy.

Mid-term re-underwriting and the exercising of review and break clauses tend to be relatively infrequently used on general engineering risks but they may need to become the norm as technological changes become more frequent.

Increasing market pressures for innovative products are clearly going to continue to increase the pace of development. Although insurance may not be a primary consideration for innovators it may have to act as a brake where insufficient attention has been paid to managing the possible adverse consequences of new developments. Insurers and their retained experts can provide a valuable source of risk management expertise and will need to develop and implement new risk management tools to meet future challenges.

Insurance trade organisations and international associations have an important role to play in helping to disseminate information on new and fast developing technologies to help underwriters from many companies to ensure that they have access to up to date information. Some technology developers already provide special briefings for insurers and their example may need to be more widely adopted.

Underwriters are likely to be less able than with conventional engineering risks to rely on loss experience for rating fast developing technology risks and will have to adapt and develop tools for quantifying uncertainties.

Existing policy clauses covering such issues as series losses and output improvements are available to meet some of the needs of fast developing technology risks although some adaptation of these clauses appears inevitable.

Some claims issues particular to fast developing technologies have been examined in this paper. Underwriters may need to pay more attention to anticipating claims issues that are likely to arise to ensure that steps are taken before losses occur to minimise the chances of disputes. There is a role for brokers to ensure that coverage provisions are appropriate for fast developing technologies where values can change significantly within a short time period. It is also important for buyers of insurance to understand what they have purchased and what they can expect after a loss has occurred which may be different in the case of a fast developing technology from what they are used to.

The pool of experts and loss adjusters with experience in some technologies is limited which can create short term problems with claims handling.

In the future, insurers may need to become involved earlier in the process of developing innovation and explore the boundaries of insurability. To do this will require a more fundamental understanding of the technologies being developed and the risks they will create.

1 Introduction

By pooling risks, engineering insurers have, over a long period, facilitated the development and diffusion of new technologies in many fields including power generation, shipping, railways, and construction. Mandatory insurance has helped to mitigate some of the negative consequences of technological innovation by forcing companies to take account of risks and liabilities in their businesses.

Throughout the history of insurance, technology has been changing. Except for projects, the duration of most insurance policies is however three years or less. This has meant that Underwriters have, with some confidence, been able to assume that the form of the technology relevant to a particular policy will be constant throughout the duration of the policy.

In the past, technological change has come either in major well-publicised events or through a gradual process. In both cases the impact of changes on the insurance world has largely been straightforward to determine and account for.

The pace of technological change has however been steadily increasing and we are now faced with the prospect of significant technological changes taking place within the period of an insurance policy, creating a much less certain environment in which insurance coverage has to operate. Technology may be changing too rapidly to allow us to plan precisely for the future. With the faster pace of change come increased risks for developers, producers, sellers and users as well as for insurers. At the same time, the pace of change also creates opportunities. Insurance underpins the development and deployment of technologies by helping to manage technological risks and provide a secure financial framework for innovation. It can regulate the rate and direction of radical technologies which have potential impacts on the environment, users and third parties. It can also promote innovative solutions for managing risks created by new technologies.

The purpose of this paper is to analyse how technology has changed, examine the problems it creates and look at ways these problems might be addressed by insurers. There seems every likelihood that the speed of change will continue to increase. To demonstrate the pace of change we have examined the development process for 4 technologies familiar to engineering insurers namely, Steam turbines; Gas Turbines; Wind turbines and Solar panels.

Underwriters are likely to need new tools if they are to continue to provide traditional insurance coverage. Up to now, insurance has provided only limited coverage for the consequences of technological change, for example in the field of product liability. Insurers may however find that other insurance products are exposed to the risks associated with technological change in a way that was not anticipated or allowed for. For business buyers of insurance the border between insurable risk and commercial risk is likely to become even more blurred than it is already.

It may be necessary for policy wordings to be modified to deal with the changing situation and this paper examines some of the associated issues as well as looking at ways in which the risks associated with technology change might be managed.

2 ”Fast Developing Technology”

The pace of change

Up until the 18th century, there were large gaps between advances in technology which made technological change hard to perceive. Since the mid-nineteenth century technological change has become ever more obvious. This is often put down to a combination of factors. Standards of living have been increasing making money available to spend producing increasing sales which have encouraged the market to create new products to sell. At the same time new scientific ideas and discoveries have been made. Thirdly man’s proficiency with machinery has grown enormously. To tackle the need to fuse science, technology and the needs of the consumer, companies and governments set up research laboratories where scientists could develop new inventions. This changed the process of technological development from one of random findings of isolated inventors to one where science and technology were solidly bound together. The result was an outpouring of inventions and discoveries at an accelerating pace. Developments occurred in transportation with railroads, steamships, cars and airplanes. New energy sources were exploited using oil and electricity that were able to transfer energy over long distances. Developments in building materials including steel and concrete have allowed higher buildings and longer bridges. In the fields of medicine, chemicals, communications, agriculture and others huge strides forwards have also taken place.

Technological change is generally thought to follow an exponential trajectory. In the early stages of an exponential trajectory the path looks flat and we may feel that the current rate of change will continue into the future whilst in fact the rate of change is increasing all the time. Some even believe that change is following a double-exponential trajectory with the rate of exponential change increasing exponentially (Kurzweil 2001).

Industries with high rates of development

In the 1950s the term high technology or “high tech” was first used and has since been applied to industry sectors including aerospace technology, artificial intelligence, biotechnology, energy, instrumentation, nanotechnology, nuclear physics, optoelectronics, robotics, and telecommunications. The OECD ranks industries according to their research intensity (the percentage of sales value spent on research and development) which produces a ranking as follows:

Industry name	**Total R&D-intensity (1999, in %)**
High-Technology	
Pharmaceuticals	10.46
Aircraft & spacecraft	10.29
Medical, precision & optimal instruments	9.69
Radio, television & communication equipment	7.48
Office, accounting & computing machinery	7.21
Medium-High-Technology	
Electrical machinery & apparatus	3.60
Motor vehicles, trailers & semi-trailers	3.51
Railroad & transport equipment	3.11
Chemical & chemical products	2.85
Machinery & equipment	2.20

Some sectors of industry seem less prone to the use of fast developing technology but this can be deceptive. For example the penetration of fast developing technology into construction does not appear very pronounced but it is still there. The control systems of construction equipment are becoming increasingly sophisticated and automated. In the energy industry new materials are constantly being developed and introduced. New and stronger materials have allowed new forms of machines to be created. New computerised control systems have rendered obsolete past generations of control systems. This has the advantage of improving the performance of machines but also has the consequence of making it hard, expensive or occasionally impossible to repair them. Nanotechnology holds the potential to further and dramatically reduce the size of microprocessors whilst at the same time increasing their processing capacity.

The drivers of change

There are many ways of analysing the pace of technological change; the best known being Moore's law. This law was devised by an American professor in 1970. It describes a long-term trend in the history of computing hardware in which the number of transistors that can be placed inexpensively on an integrated circuit has doubled approximately every two years. However, rather than being a naturally-occurring "law" that cannot be controlled, Moore's Law is effectively a business practice in which the advancement of transistor counts occurs at a fixed rate. [see Fig I]

The capabilities of many digital electronic devices are strongly linked to Moore's law: processing speed, memory capacity, sensors and even the number and size of pixels in digital cameras. All of these are improving at (roughly) exponential rates as well. This has dramatically increased the usefulness of digital electronics in nearly every segment of the world economy. Moore's law describes a driving force of technological and social change in the late 20th and early 21st centuries. The trend has continued for more than half a century.

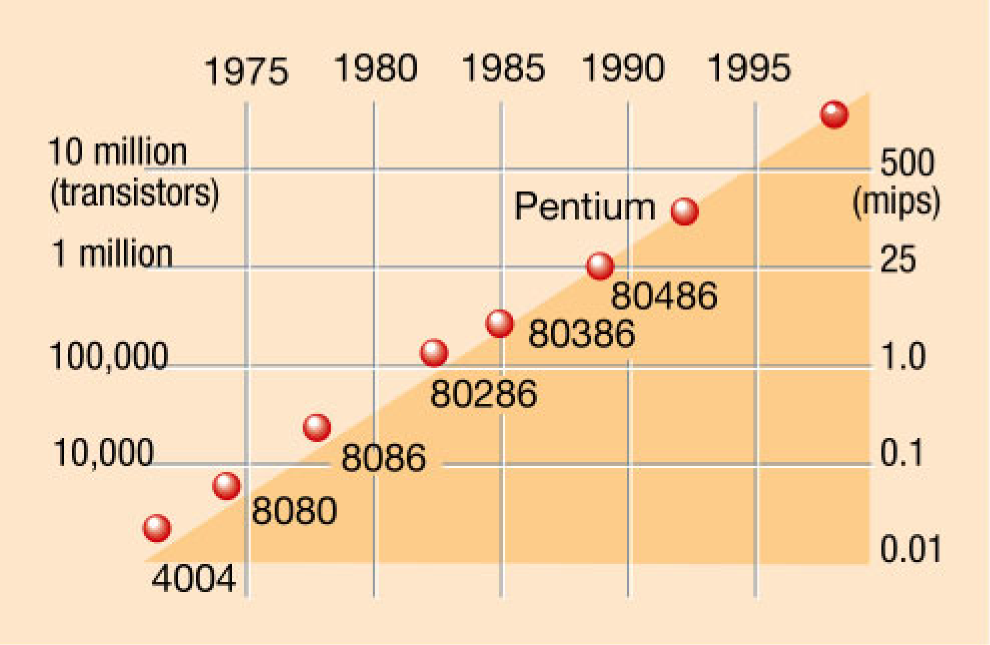


Fig.1. Moore's law. The growing power of Silicon chips measured in instructions per second

This accelerating speed of change leads to innovations for electronic circuits and the electrical appliances they are steering. As a result, the repair of appliances of the former generation is cumbersome, expensive or often impossible.

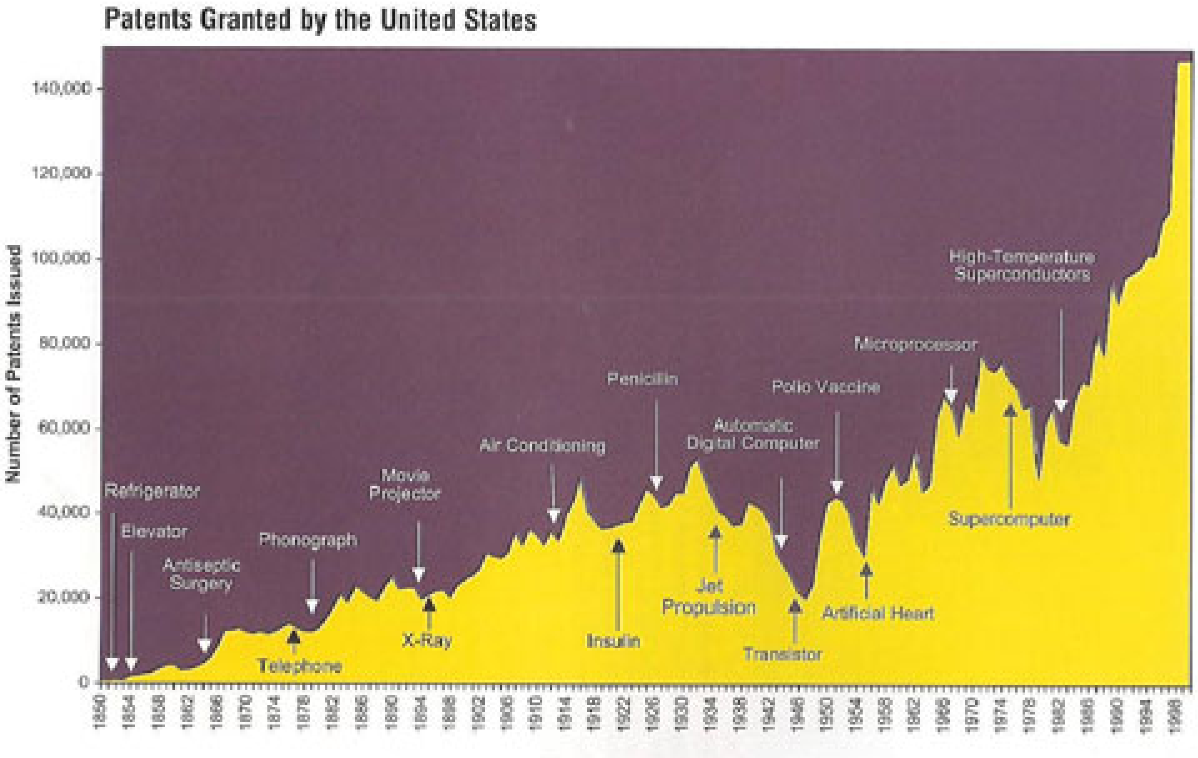
The speed of technological change is also affected by globalisation which changes investment patterns and their time dependency. Survival in the new global business market calls for improved productivity and increased ability to cope with competition. Companies in various industries have to upgrade their products and use technology skilfully in order to meet increased global challenges.

The rate of change in technology is the contemporary trend of networking, which in the long run implies that fewer options for solving a technical problem prevail since there are less organisations developing solutions independently. Networking can exclude some technical solutions and thus make them obsolete. Beyond networking is the merging of producing firms, which can also lead to the same results as the number of independent producers of a technology reduces. The costs of entry to some technological fields are so high that few organisations can afford them thereby restricting competition

Finally one trend also enhancing the speed of technology change is the endeavour to produce products intended for a shorter life-span. Manufacturers and their marketing and selling organisations strive to sell new products with slightly enhanced capabilities. Some of the enhancements may not be essential but they may create a competitive advantage. Such trends tend to shorten the time to obsolescence and make items hard to replace when they are damaged.

Patents

Fast developing technology is often subject to patents which give the supplier a monopoly and can result in high costs for repairs and restrictions to competition. The number of patents granted in the US during the two last centuries has been growing at an increasing rate as shown in Fig 2.



SOURCES: U.S. Patent and Trademark Office, *U.S. Patent Activity*, 1790–1998 (Washington: Government Printing Office, 1999); and Louisiana State University, *Important Historical Inventions and Inventors*, www.lib.lsu,edu/sci/chem/patent/srs136.html.

Fig.2. Number of US patents granted as a function of time.

Increasing risks

Scientific innovations leading to new materials, faster data acquisition and processing, the effects of globalisation distributing new technology, the trends for firms and corporate groups to co-operate using networking and resulting mergers, enhances the speed of change in technology and makes the world more challenging for insurers. Fast developing technologies certainly bring benefits to society but they also introduce new risks.

In the past technological innovations have often been driven by strategic or military necessities with much of the research undertaken in an environment where insurers were not exposed in the early stages. Such technologies therefore will probably have reached a more mature state before being released into commercial markets where insurance was required. Increasingly however, technological innovations are driven by market demands and their first use is commercial resulting in exposure of insurers to the earlier stages of development.

Designs can be improved using computer aided design techniques and virtual simulations and safety margins can be reduced because of more refined designs. This benefit has to be weighed against the dangers of designers losing contact with their designs because they are harder to understand.

Some technologies appear not to be developing fast owing to the mechanical nature of the operations they perform (for example excavation or drilling). This outward appearance can be deceptive however since the control systems for such activities have often been subject to a fast pace of development. When considering the pace of development of an activity it is important to look at the components that are used to see whether these have been changing even if the remainder has not. Changing even a part of a process can have unforeseen adverse consequences even in areas where there is a great deal of past experience.

Remote monitoring of critical machines means that maintenance and repair can be concentrated on critical components. Examples of this can be found in the way that gas turbines and wind turbine parks are remotely monitored. Monitoring wind parks is not possible other than remotely but gas turbines can be monitored locally if unit operators are sufficiently trained to interpret the output of monitoring equipment such as vibration sensors. Remote monitoring has the advantage of allowing almost instant automatic alerts of problems to owners. It can however generate such large volumes of data that problems of data management may defeat the benefits. With remote monitoring there can be a loss of contact between operator and machine because operators may rely solely on the analysis of the company selling the analysis service. The user and owner can become completely dependent on another company and thus more vulnerable to misinterpretations made by that company’s staff.

3 Industries of interest to engineering insurers

The competitive nature of a free market economy compels manufacturers of technology to offer new products at frequent intervals and thus to shorten their product cycles. By applying cutting edge technologies to differentiate their products from those of their competitors, producers have to become more and more sophisticated. What is more, since the transfer time between research and development departments and the market launch is getting shorter, defects or design errors are sometimes accepted in order not to lose the competitive advantage of launching a new product ahead of competitors.

The faster technologies reach the market, the faster the market develops. New products may, for a time, be the only ones of their type available to meet market demand irrespective of whether they are the best technical solution rather than second best. Many purchasers will buy what is available rather than waiting for a more fully developed product to emerge.

Another major driver for rapid development is the reaction of manufacturers to changed boundary conditions such as those created by changes in legislation, changes in customer demand such as that for green energy or changes to tackle world problems such as CO_2 emission reduction.

Irrespective of the drivers, the common ground of rapidly developing technologies is the frequent application of high-end or cutting edge innovations. Typical fields using such technologies are:

- Microelectronic and telecommunication
- Nano technology
- Optoelectronics
- Medical technology
- Bio technology
- Aerospace industry
- Power industry

The power industry, which is a main focus of the climate change discussion, is also of great interest to engineering insurers. It provides insurers with one of the highest exposures. It is also the technology that generates the highest premium income of any of those listed above.

Every technology develops in a different way and at different paces at different stages of its development. For the purposes of this paper four technologies well known to engineering insurers have been analysed:

- Steam turbines
- Gas turbines
- Wind turbines
- Solar panels

They have all developed at a fast pace at some point in their history but in some cases that pace has slowed considerably as the benefits of new discoveries become fully or almost fully exploited. Wind turbines appear to be in the midst of a period of fast development and solar panels appear about to enter such a period.

Development of some power industry technologies

Steam turbines

The modern steam turbine was invented in 1884 and the first model was connected to a dynamo that generated 7.5 kW of electricity. This used a large number of stages in series, allowing extraction of the thermal energy in the steam in small steps. The reaction-stage principle was also developed according to which a nearly equal pressure drop and energy release takes place in both the stationary and moving blade passages. During the 1880s small reaction turbines that turned at about 40,000 revolutions per minute were developed to drive cream separators. Their high speed, however, made them unsuitable for other commercial applications. Before 1900 turbines with capacities from about 15 to several hundred horsepower were built including multistage impulse turbines. By 1900 the largest steam turbine-generator unit produced 1,200 kW, and 10 years later the capacity of such machines had increased to more than 30,000 kW. This far exceeded the output of even the largest steam engines, making steam turbines the principal prime movers in central power stations after the first decade of the 20th century. Following the successful installation of a series of 50,000 kW turbines in transatlantic passenger liners launched in 1906, steam turbines also gained pre-eminence in large-scale marine applications, first with vessels burning fossil fuels and eventually with those using nuclear power. Steam generator pressures increased from about 1,000 kPa gauge in 1895 to 1,380 kPa gauge by 1919 and then to 9,300 kPa gauge by 1940. Steam temperatures climbed from about 180° C (saturated steam) to 315° C (superheated steam) and eventually to 510° C over the same time, while heat rates decreased from about 38,000 to below 10,000 kJs per kWh.

By 1940, single turbine units with a power capacity of 100,000 kW were common. Ever-larger turbines (with higher efficiencies) have been constructed during the last half of the 20th century, largely because of the steadily rising cost of fossil fuels. This required a substantial increase in steam generator pressures and temperatures. Some units, operating with supercritical steam at pressures as high as 34,500 kPa gauge and at temperatures of up to 650° C, were built before 1970. Reheat turbines that operate at lower pressures (between 17,100 to 24,100 kPa gauge) and temperatures (540–565° C) are now commonly installed to assure high reliability. Steam turbines in nuclear power plants typically operate at about 7,580 kPa gauge and at temperatures of up to 295° C to accommodate the limitations of reactors. Turbines that exceed one-million-kW output require exceptionally large, highly alloyed steel blades at the low pressure end.

Although the use of large steam turbines is tied to electric power production and marine propulsion, smaller units may be used for cogeneration when steam is required for other purposes, such as for chemical processing, powering other machines (*e.g.,* compressors of large central air-conditioning systems serving many buildings), or driving large pumps and fans in power stations or refineries. However, the need for a complete steam plant, including steam generators, pumps, and accessories, does not make the steam turbine an attractive power device for small installations.

The total output from turbo-generators constructed for land purposes alone, has exceeded 22 million kW. Today’s steam turbines can reach output levels of 1,600,000 kW and more, a scaling factor of 32 since they were invented. However, today’s pace of steam turbine development is related more to achieving higher levels of reliability, availability and safety than to higher outputs. It would be wrong therefore to link technological development only to the achievement of larger sized units with greater capacity. It is also impossible to say when a new development will suddenly trigger a further period of further fast development.

The graph below shows the development of steam turbines produced by Hitachi for industrial applications over the years.

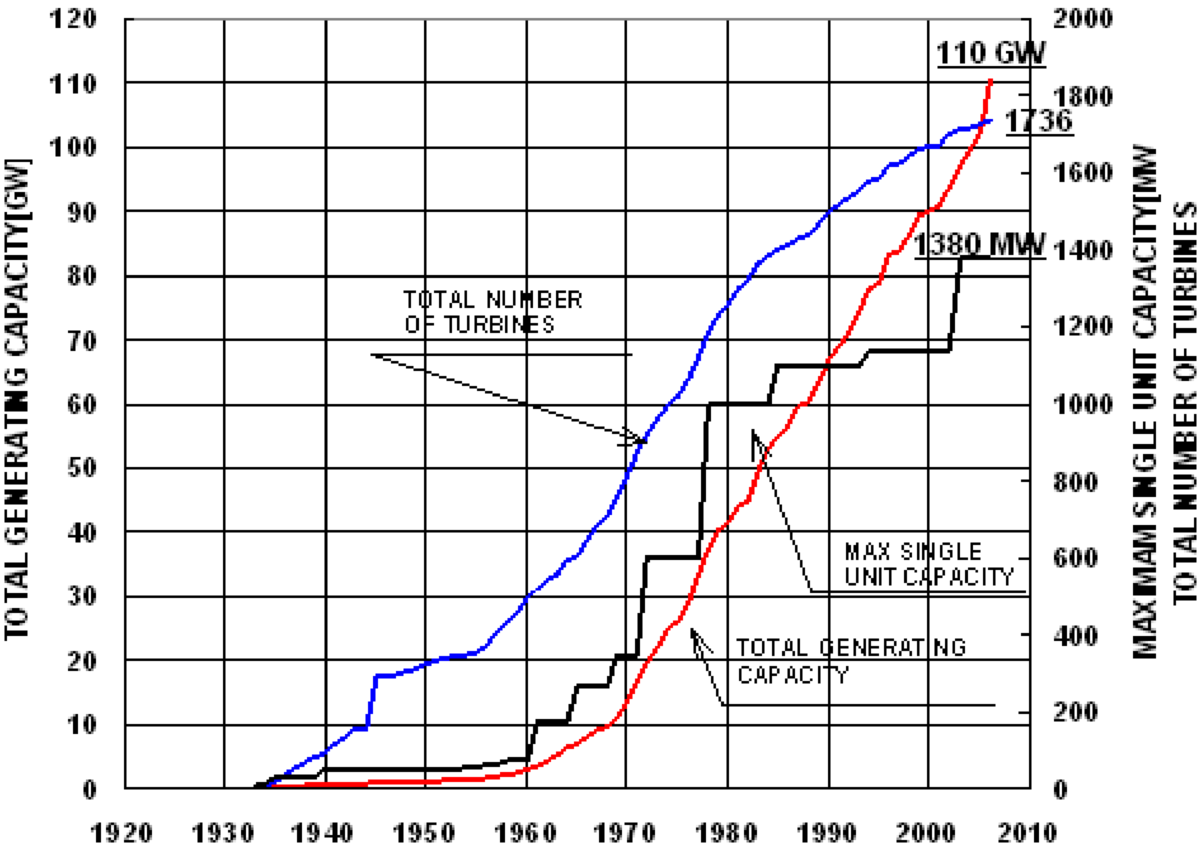


Fig 3 Graph showing total generating capacity and maximum single unit capacity for steam turbines

Gas turbines

In 1903 the first successful gas turbine was built using both rotary compressors and turbines - the first gas turbine with excess power. In 1914 the first application was made for a gas turbine engine. The first industrial gas turbines were built in 1939 to provide power for jet propulsion in aircraft. At the same time work began on axial-flow compressors, which were complex and costly, but suitable for detailed blade-design analysis and could reach high pressures and flow rates and, eventually, higher efficiencies than their centrifugal counterparts. A fully operational jet aircraft engine that featured a single centrifugal compressor and a radial-inflow turbine was successfully tested in 1939. Before the end of World War II gas-turbine jet engines built by Britain, Germany, and the United States were flown in combat aircraft. Within the next few decades both propeller-driven gas-turbine engines (turboprops) and pure jet engines developed rapidly, with the latter assuming an ever larger role as airplane speeds increased.

The first industrial gas turbine had an output of 4 MW with a turbine inlet temperature of approximately 550°C. In 1942, a 1,650 kW (2,200 horsepower) gas turbine was used on a locomotive. Within 10 years there were 43 manufacturers producing gas turbines of a variety of designs placed in a variety of services as main engines for trains, tanks or in the power industry.

Over more than 100 years, the development of gas turbines has received a significant innovative boost from material sciences and applied sciences including fluid dynamic and thermodynamics. The greatest steps in output increase have come with the development of

IT based modelling of thermodynamics and fluid dynamics in the late 1970's. Today the increase in power output is only in a single-digit range of MW per technology leap.

Current research and advancements in gas turbine technology is creating more efficient gas turbines and small micro-turbines. Suppliers for turbine parts are limited because gas turbines are extremely delicate machines that require extremely strict quality standards on parts. Due to very high temperatures and fast moving parts, this manufacturing is a niche technology that has been mastered by a few organisations, and therefore a kind of monopoly exists in the market. As a result, lead times for Free On Board supply sometimes reach 3 years, and down time for plants can exceed 6 months if ex-factory stock is not available.

Gas Turbine components are mostly patented and therefore can only be manufactured and sold by the patent owners or Original Equipment Manufacturer (OEM) joint developer or an assignee.

OEMs place a great deal of emphasis on the data generated during operation of their equipment. Each run hour represents cumulative experience on the particular model and is an indicator of its success. OEMs have preferences as to who should install and run their machines, a practice which has an impact on costs but increases reliability of operations.

Generally OEMs insist that replacement parts be approved by them (i.e. each component needs to complete reliability and durability runs) and each manufacturer needs to adhere to the preferred quality standards/procedures of the OEM to make supplied parts acceptable to the OEM.

Wind turbines for power generation

The first known electricity generating windmill was a battery charging machine installed in 1887. By the 1930s, windmills for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. A forerunner of modern horizontal-axis wind generators was in service in Russia in 1931. This was a 100kW generator on a 30 m tower, connected to the local distribution system. The first mass production of wind power plants took place in the early 1950s. They were designed to supply electricity to farmsteads lying far from the public grid. In coastal areas these turbines drove 10 kW generators. Even today, some of these turbines remain in operation after more than 50 years of service.

After the 1960s, cheaper fossil fuels made wind energy technology economically uninteresting, and it was only in the 1970s that it returned to the spotlight due to rising fuel prices.

In the 1980's the Danish concept of a three blade wind turbine was established and copied by other manufacturers. In contrast to other designs a simple tower construction with a horizontal rotation axis and a fixed rotation speed was established. This was the base for the today's modern wind turbines. In the 1980's, wind turbines with total capacity of around 1500 MW were installed in California alone. In the initial phases, turbines of the 50 kW capacity were used. Progressive scaling-up has led to wind farms with turbines in the megawatt range.

Progressively increasing turbine size using designs of widely differing types and costs has led to the development of machines in the 500kW and megawatt classes that are remarkable for their high availability and good return-on-investment potential.

The development of the three-phase synchronous generator and the industrial fabrication of fibre glass blades gave another boost at the beginning of the 1990's. This not only improved efficiency but decreased investment costs.

Increased demand for CO_2 neutral power and government support for payments for electricity fed back into the grid gave another boost to this technology.

Today's wind turbines are reaching outputs of 7MW with a tower height of 198m and a rotor diameter of 126m. The next big technological leap in the wind turbine industry is to tackle the challenges posed by off-shore applications.

One new development has been the trend towards gearless wind turbines. Several attempts have been made to introduce high-speed, horizontal-axis turbines with direct-drive generators. Up until now these attempts have met with limited success.

Vertical-axis rotors have up until now mostly been built with gearing and generators at base level but have not been very successful in establishing themselves widely in the wind power market so far. Other variants include permanently magnetised machines with the combination of a low-speed generator and a turbine-side gearbox (for example Multi-brid turbine).

Nevertheless, similar to gas turbines, the application of advanced materials such as fibre glass, highly developed gear boxes built with computerised force modelling and the need for CO_2 free power gave the base for increased wind turbine development in the late 1980's.

A report published by World Wind Energy Association (WWEA) (2009), gives the world wide capacity of power generation from wind turbines at 159,213 MW by the end of 2009 out of which 38,312 MW were added in 2009. The trend is that wind turbine capacity doubles every three years.

Estimates provided by WWEA state that total global wind capacity is expected to pass 200,000 MW by the year 2010 and 1,900,000 MW by 2020. This power generation sector can be considered as one of the fastest growing in the field along with a fast pace of technological development.

Fig 4 Development of rotor diameter and rated output (year on year)

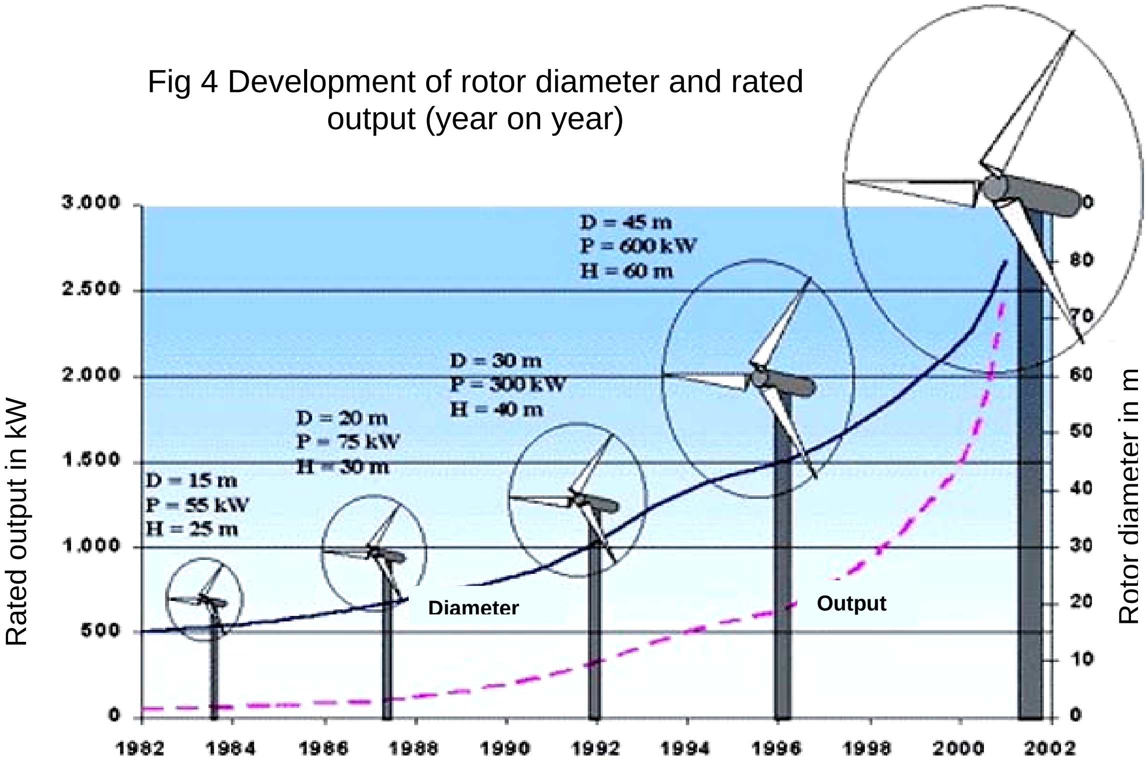


Fig 5 Total Installed Capacity (MW) and Prediction 1997 – 2010 – World Wind Energy

Solar panels

Solar Energy includes both Photovoltaic (PV) Panels and Concentrating Solar Panels (CSP), two different types of technology for producing power.

Photovoltaic panels use the photoelectric effect on materials (predominantly Silicon), to produce direct current electricity. Concentrating Solar Power is an indirect way of producing power from the sun's energy by focussing it to boil water or synthetic oils and produce steam which is then converted to electric power.

In 1883 the first Photovoltaic cell was built. The semiconductor selenium was coated with an extremely thin layer of gold to form the junctions. The device was only approximately 1% efficient. In 1954 the first Silicon based cell was developed with an efficiency of about 4-6%. The first industrial application was integrated into a satellite in the late 1950's. The high demands of space application solar panels were the driving force for the pivotal development of today's high-efficiency solar cells. Today's thin-film solar cells have efficiencies of up to 15% and mono-crystalline Silicon panel efficiencies of 18%.

Due to the growing demand for renewable energy sources, the manufacture of solar cells and photovoltaic arrays has advanced dramatically in recent years. According to 2010 SRI World Group, Photovoltaic production worldwide has been doubling every two years, increasing by an average of 48% each year since 2002, making it the world's fastest-growing energy technology. The chart below illustrates the installed world capacity since 1995.

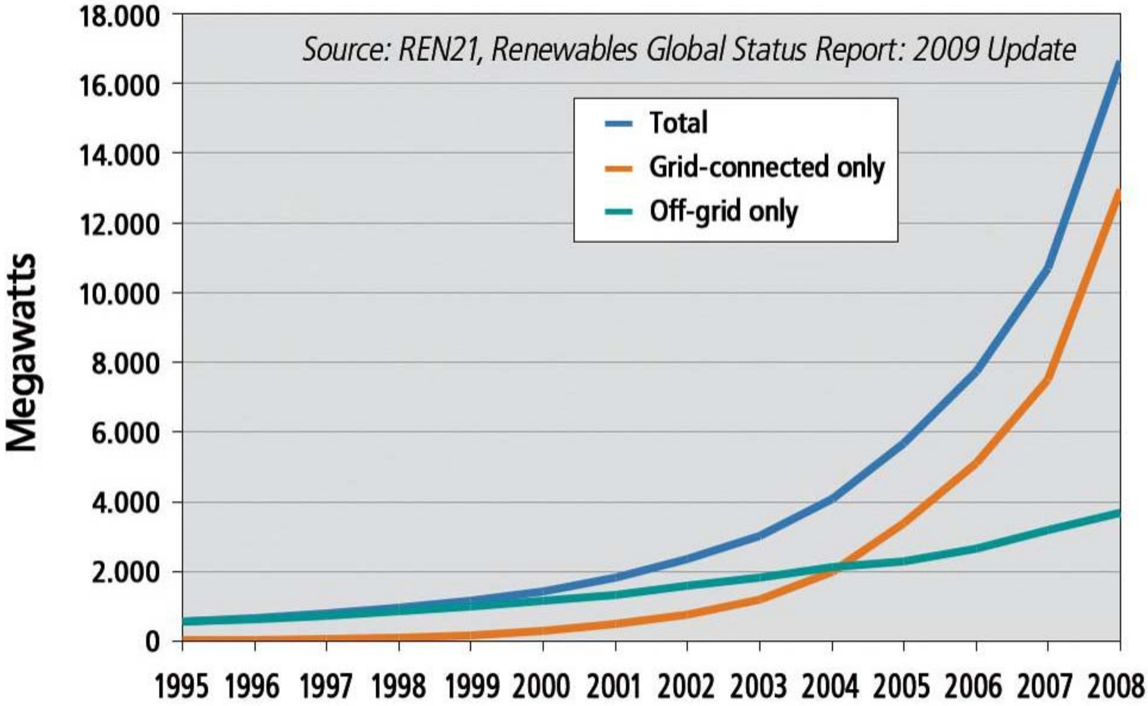
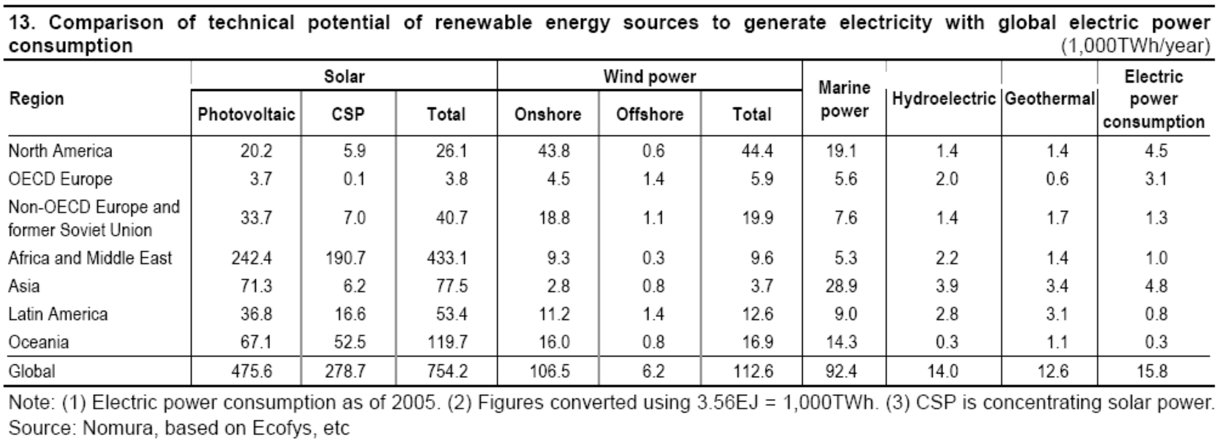


Fig 6 Solar PV, Existing World Capacity 1995 - 2008

This fast development is predominantly due to government incentives directed to promote this alternative renewable energy. This is achieved through special guaranteed tariffs for buying energy produced by PV panels or by investment subsidies.


13. Comparison of technical potential of renewable energy sources to generate electricity with global electric power consumption
(1,000TWh/year)

Region	Solar			Wind power			Marine power	Hydroelectric	Geothermal	Electric power consumption
	Photovoltaic	CSP	Total	Onshore	Offshore	Total				
North America	20.2	5.9	26.1	43.8	0.6	44.4	19.1	1.4	1.4	4.5
OECD Europe	3.7	0.1	3.8	4.5	1.4	5.9	5.6	2.0	0.6	3.1
Non-OECD Europe and former Soviet Union	33.7	7.0	40.7	18.8	1.1	19.9	7.6	1.4	1.7	1.3
Africa and Middle East	242.4	190.7	433.1	9.3	0.3	9.6	5.3	2.2	1.4	1.0
Asia	71.3	6.2	77.5	2.8	0.8	3.7	28.9	3.9	3.4	4.8
Latin America	36.8	16.6	53.4	11.2	1.4	12.6	9.0	2.8	3.1	0.8
Oceania	67.1	52.5	119.7	16.0	0.8	16.9	14.3	0.3	1.1	0.3
Global	475.6	278.7	754.2	106.5	6.2	112.6	92.4	14.0	12.6	15.8

Note: (1) Electric power consumption as of 2005. (2) Figures converted using 3.56EJ = 1,000TWh. (3) CSP is concentrating solar power.
Source: Nomura, based on Ecofys, etc

Table 1 Comparison of technical potential of renewable energy sources to generate electricity with global electric power consumption.

The table above provides a comparison between different renewable energy sources and their potential to generate electricity. In the right hand column are figures for electric power consumption as at 2005. Only a small proportion of the potential available needs to be exploited to meet demand. This table clearly shows solar energy as having the highest renewable energy potential for the next few years.

The main issues facing Photovoltaic and CSP Technology in the near future appear to be as follows:

- performance seems relatively low at the moment
- cost of production high meaning that to be beneficial public subsidies are needed
- use of silicon (very energy intensive to extract)
- transmission of solar energy is needed over long distances to be able to exploit areas with high sunlight intensity to provide power for areas with high demand.

Developments routes are:

For PV production:

- thin film panels to reduce the quantity of raw materials
- alternative materials to silicon to save energy and resources based on CIS or CIGS (Copper, Indium, Selénium and Galium)

For CSP production:

- Larger scale plants (the largest existing to date being 500 MW, whereas most are less than 200MW)
- Cost reduction and efficiency increases in mirrors and receivers (the durability of those new technologies has not yet been proven)

General findings on the above fast developing technologies

The more advanced the stage of development of a power generating device the harder it is to increase its efficiency, power output or availability. Therefore, fast developing technologies (such as gas turbines) often change almost continuously rather than in identifiable steps. Some minor improvements in the design or modification in fluid dynamics leads only to a small increase in power output. These improvements are often the outcomes of new computerised models or the use of newly developed high end materials.

Conversely, the less advanced the stage of development the more potential that exists to increase the output and the larger the technology steps that are possible (e.g. wind turbines).

In general, increased computing power used in the design, development and construction of power turbines and their control and monitoring systems has driven progress in the energy production industry.

While the pace of output development of steam turbines has slowed, the development of gas turbines and wind turbines remains at a high level. The pace of development for photovoltaics is going to increase with the implementation of a recently discovered and fundamental physical principle for conversion of radiation into power.

Both the gas turbine and wind turbine industries are regarded by insurers as fast developing. It is interesting therefore to compare their relative pace of development over the last 20 years. The gas turbine industry has increased the power output only by about 60%, whereas the wind turbine industry has increased the output from 55kW to up to 6.000kW; an increase by more than a factor of 100.

The gas turbine industry has introduced many new highly specialised technical innovations to increase output from similar sized units whereas the wind turbine industry has largely been scaling up the size of its units.

4 Underwriting Issues

For every technological innovation, insurers face the question whether to incur the risk of supporting it. Without insurance few investors would be interested in financing the release of new technologies onto the commercial market since investors need security.

Characterising and quantifying risks

Even industry specialists are not able to predict exactly whether every new technique or technology will prove their worth or what problems may arise. Technological innovations are frequently portrayed as being not amenable to traditional insurance due to lack of actuarial data from which premiums can be calculated. With fast developing technology there can be less reliance by underwriters on claims history as an indicator of future loss performance since such histories may either not exist or be unreliable. Insurers are normally focussed on the downstream stages of innovation but may be prepared to consider risks for which there is no prior experience so long as there are credible methods for characterising and quantifying risks.

To underwrite fast developing technologies the main criteria for risk assessment are:
- The maturity of the technology:
- The maturity of the individual item of property
- The maturity of the plant technology (for example process technology)
- The maturity of the building/assembly procedure

For some risks a minor change in detail can be a key factor in determining the level of risk (for example in a gas turbine). For some projects it is normal to have a completely new design (for example in a new building). The underwriter should not provide cover for research and development costs under any circumstances.

Technical expertise and keeping up to date

To be able to properly underwrite new and fast developing technology risks, it is vital for insurers to have up to date information on the current state of a technology and soon to be released developments and the market in which they operate.

It is often the level of understanding of the underwriter that determines his/her willingness to accept modifications, on the one hand, as slight improvements with no or minor influence on the exposure or, on the other, as unproven technology which can have a disastrous impact. Underwriters who write such fast developing technologies need to keep themselves informed on developments and to judge whether the pace of change is having an influence on the exposure.

More and more Underwriters need to become technical experts. A specialist in the particular technology either from within the insurer or an external expert is often needed to advise the Underwriter particularly in production processes and to obtain information from the insured.

The Underwriter needs to know the “good” and the “bad” in each technological field. It is not economic to obtain very detailed information on every risk so Underwriters have to use their judgement on where to use specialist resources. The Underwriter also needs to be aware that for some technologies there is a limited pool of technical expertise.

To ensure Underwriters have access to the right technical expertise and information various means are already employed by insurers as follows:

- Extensive use of in-house intelligence departments, targeted to find, for underwriters, the most up-to-date technical papers on the technology involved.
- Promotion of the role of in-house industry experts in the key developing technologies, or promoting specialisation of existing underwriters or by training former industry leaders as specialised underwriters or insurance industry experts.
- Promoting in-house cross communication between property underwriters who are up-to-date with the status of a specific market and construction underwriters.
- Using “topic networks” which concentrate on technical issues and produce topic papers using people with a deep knowledge of individual technologies.
- Using a review panel for new technologies.
- Encouraging Industries to present market briefings for insurers similar to those given at present by the gas turbine industry.
- Asking for an industry overview from a proposed insured at the time of underwriting a specific risk.
- Regular briefing sessions, conferences and technical papers such as those produced by IMIA and national technical insurance associations.
- In special cases production of standards related to particular technologies where insurers may be the best source of information on risks, losses and how to prevent them. (e.g. the wind turbine fire protection standard and the tunnelling code of practice, both available on IMIA website, Library)
- Dissemination of up to date knowledge on relevant legislation in each country where insurers operate.

Risk evaluation and calculation should always be conducted by experienced underwriters with special knowledge in the respective fields of technologies. The headline must be: "Only underwrite risks you really understand".

Simulation models

The application of simulation models for certain technologies can be helpful especially when the statistical method of big numbers is applicable. They use information from the past experience to extrapolate into the future.

Simulation models are frequently applied in geothermal projects to calculate the so-called POS (probability of success) to find water of the predicted volume and temperature for energy production. It is only possible to calculate a probability not a certainty. It is up to the Underwriter to evaluate the risk with the help of an experienced geologist.

The simulation model is only an assumed description of reality and for underwriting purposes requires interpretation that can only be done by a knowledgeable and experienced underwriter.

Prototypes and fast developing technology

Defects in design, material, manufacture or erection are more likely with prototypes and can produce property damage and detrimental effects on their surroundings. In case of fast developing technologies, the technological changes are often continuous rather than in the form of identifiable steps. Therefore, the definition of prototype and the policy terms linked to it are often hard to base on distinct changes. Defining a fast developing technology in relation to insurance is not straightforward since contractors and manufacturers often have a different understanding from insurers of fast developing technology.

If a product cycle is shorter than the duration of a typical project then the underwriters run the risk of being overtaken by technical progress. A more advanced technology may be brought into a project than initially described in the tender documents and project description.

This applies particularly where the increase in output/performance can be easily achieved by small improvements of a small percent rather than in technologies where a small increase in margin requires a great effort or the use of high-end technologies. An example of the former is a wind turbine installation and of the latter is gas turbines. A typical project execution time for a wind park project is 2 to 3 years – depending on the project size. A typical product cycle of a wind turbine is two years and sometimes even shorter where the performance of gearing, generators or rotor diameter is being increased. For a gas turbine product cycles tend to be longer than a project cycle and usually a number of years.

One key question which is of great importance to the assessment of risk is "What is a prototype?" or "What is prototypical?" This subject has been addressed in the LEG paper "Prototypicality 2009" referenced at the end of this paper.

Questions related to prototypes are:

- What is the definition of a ‘Prototype’?
- Are there any ‘Prototypical’ design features?
- When does a ‘Prototype’ cease to be a ‘Prototype’?
- Does scaling up or down produce a ‘Prototype’?
- Does reconfiguration produce a ‘Prototype’?

Experience of the Insured

Underwriters should ask their customer about their experiences with a particular technology that can serve as reference parameters or measured operating hours free of claims for a similar type of machine/plant.

Material change in risk

In the case of revenue contracts, a review should be carried out each year to establish what the policyholder is building/assembling and whether there are any untoward signs as a result of company purchase/changes in product/business. This could lead to a material change in risk and in succession to the necessity of re-underwriting the risk. This is covered in more detail in section 5 of this paper.

Munich Re has defined a Material change in risk as follows:

> *“Material change in risk means any change in the nature, exposure, location, execution and maintenance of the insured contract(s) that a reasonably prudent insurer would consider material to the acceptance of the risk under the terms and conditions of this policy of insurance.”*

The meaning of the term “material change in risk” lies in the eye of the reasonably prudent insurer or underwriter and is subject to interpretation. A material change in risk is not necessarily accompanied by a change in exposure. It could be the result of a change in nature, location, execution etc. It can perhaps best be expressed as a change in ”the character of the risk”. So, the initial conditions during the risk assessment and the project execution are no longer the same. Careful use of break-and review clauses also need to be considered to give the Underwriter an opportunity to re-assess a risk mid-way through a policy term.

Deductibles and exclusions

A number of options exist for the underwriter to tailor the policy wording. If an innovation is likely to cause a loss, a high deductible is one possibility to keep the risk from fast developing technologies low for an insurer. A second possibility consists of not covering the risk produced by the innovation, but insuring only known components. A third possibility is to include design exclusions such as those developed by LEG. Where there is uncertainty, the producer's/manufacturer's risk (design, material, manufacture and erection) can either be excluded for the innovative technical unit by using a LEG1/DE1 clause or be limited by using a LEG2/DE3 clause.

Serial loss exposure

A serial loss clause needs to be considered if an underwriter finds difficulty in fully understanding the risks that a particular technology creates. A typical serial loss endorsement as produced by Munich Re is shown below:

> *Endorsement 011 Serial Losses*
>
> *It is agreed and understood that, otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon, the following clause shall apply to this insurance:*
>
> *Loss or damage due to faulty design, defective material or casting, or bad workmanship (other than faults in erection) arising out of the same cause to machines or equipment of the same type or design shall be indemnified after applying the Policy deductible for each loss according to the following scale:*
>
> *100 % of the first loss*
> *% of the 2nd loss*
> *% of the 3rd loss*
> *% of the 4th loss*
> *% of the 5th loss*
>
> *Further losses shall not be indemnified.*
>
> *(The percentages shall be fixed in accordance with the condition of each individual component, e.g. depending on the number of items at risk.)*

As an alternative or possibly in addition Underwriters might consider using a Defect Rectification clause such as that shown below:

> *Defect Rectification Clause*
>
> *If the development or discovery of a defect in any electrical or mechanical equipment similar to any item of the property insured shall indicate or suggest that a similar defect exists in such equipment insured under this Policy, then the Insured shall forthwith investigate and if necessary rectify the defect in such a property at his own expense and shall not recover the costs of such rectification from the Insurers hereunder.*

Output improvements

An “output improvement” clause (see example below) sets out how improvements or betterment are to be handled between insurer and insured.

WILLIS CLAUSE

Output Improvement Clause

Notwithstanding anything contained herein to the contrary, where any Insured Property constitutes property which has a measurable function, capability or output, which is capable of replacement with a new item or items with similar capability or output, then such property shall be valued for insurance purposes as follows, and the value(s) for settlement of any claim in respect thereof shall be on the same basis:-

(a) Where any lost, destroyed or Damaged property is to be replaced by an item or items which have the same or a lesser total function, capability or output, then the insurable value of such lost, destroyed or Damaged property is the new installed cost of such replacement item or items as would give the same total function, capability or output as the lost, destroyed or Damaged property.

(b) Where any Damaged property is to be replaced by an item or items which have a greater total function, capability or output and the new installed cost of such replacement property is no greater than the replacement value of the Damaged property, then no deductions shall be made from any claim for the improved function, capability or output of the replacement property.

(c) If any Damaged property is to be replaced by an item or items which have a greater total function, capability or output and the new installed cost of such replacement property is greater than the replacement value of the Damaged property, then the insurable value of such lost, destroyed or Damaged property is that proportion of the new installed cost of the replacement item or items which the output of the Damaged property bears to the output of the replacement item or items. The difference between the insurable value as defined and the new installed cost of the replacement item or items shall be borne by the Insured.

Provided that where any Damaged Insured Property is to be repaired, the Insurer shall pay the costs of restoration of such damaged property to a condition substantially the same as, but no better or more extensive than, its condition when new and the liability of Insurers shall not exceed the sum representing the cost which the Insurer could have been called upon to pay if such Insured Property had been wholly destroyed.

Repair costs

In certain technologies insurers might consider commissioning an insurance research institute with the task of developing a repair cost index for different models of a particular product (such as a wind turbine) as is currently used in the car industry. The aim would be to encourage manufacturers to think about repair costs when they are developing new models. It is recognised however that the viability of such work may depend on how hard or soft the insurance market is at a particular point.

Underwriters may also want to consider requesting contingency plans from owners, operators and manufacturers of new technology, so that costs of repair, availability of spare parts and lead times can be considered. This is particularly applicable where technology may be difficult to replace after a loss. An example is offshore wind turbines where the availability of barges needed for repair is difficult to predict. In general, sub-limits on repair costs are already widely included where such costs are difficult to predict.

5 Claims

Fast developing technologies create their own types of problems when claims occur and below are some case histories that provide examples. These are followed by an analysis of some of the problems that the working group has either encountered or can anticipate.

Case History 1. Overheated wind turbine

A single wind turbine on a wind park of 28 turbines failed when it caught fire. The cause is thought to have been overheating combined with a poorly manufactured transformer within the nacelle. Overheating was due to high ambient heat in the Australian outback for a unit built and designed to be run in Europe.

The damaged model was no longer in production and a replacement model was not compatible with existing infrastructure. There was an extended Business Interruption claim whilst the original manufacturer retooled specifically to make a one off replacement.

It appears the suppliers of the wind turbines incorrectly assumed that their designs would be suitable for an area where they had no experience instead of properly evaluating the potential problems that a different operating environment could create.

Case History 2. Wind farm pinch points

High demand for cost effective production of electricity has driven construction of new wind power generation with sometimes little thought being given to existing infrastructure in support i.e. single point of export with no back up provision. Two claims were made where the failure of a single component (i.e. a transformer) rendered one wind farm in one case and multiple wind farms in another case incapable of exporting the electricity they produce.

In a more mature technology it seems probable that additional redundancy would have been built in to avoid such disproportionate losses from the failure of a single element.

Case History 3. Scarce lifting resources

Worldwide there are fewer than ten floating cranes available which can mount/demount wind turbines at sea. This is due not only to the high price but also to the specialist nature of the high-tech drives which are able to balance wave movement. With an increasing rotor diameter or weight of gear and generator the number of cranes with the specialist lifting capability is decreasing. This special equipment is booked and scheduled for two or even more projects in advance. In case of a loss involving an offshore wind turbine, the insured may not be able to repair the turbine because no floating crane is available or they may not be willing to pay a premium for rescheduling the floating crane’s programme. The only solution in such circumstances may be to shut down the wind turbine and wait until a floating crane becomes available.

In trying to satisfy customer demand as rapidly as possible it is possible that insufficient effort can be devoted to considering how a newly developed technology will be repaired if damaged. In addition, the economics of developing a costly specialist repair capability may be uncertain while the demand for the repair capability is also known.

Case History 4. Financing development risks in a wind farm

As a result of damage to more than 1000 rotor blades and to more than 100 gearboxes a claim was made for EUR 50 million. The damage was caused by the use of unsuitable production processes, defective design and defective quality control. The rapid technological development in the manufacturing process of rotor blades was underestimated. An economic boom experienced in the wind energy sector led to a reduction in quality control. The boom led to bottlenecks in the supply of high quality components. As a result the supplier initially commenced production under licence and then transferred production completely in-house with ensuing discrepancies in quality. Craft production processes were used with virtually no reproducible quality standards. The production process did not keep pace with the rate of development of the business. The diameter of rotors increased within a very short space of time from approximately 50m to 125m. The scale-up increased the claims potential exponentially.

The underlying policy for the claim was a warranty guarantee cover for wind turbine manufacturers in the form of balance-sheet protection. There was an annual loss aggregate but no serial loss clause. There was a special cancellation clause as follows:

> *Cancellation is only possible if the loss ratio is greater than X and if the policyholder does not implement the improvement proposals of the insurer. These improvement proposals must be achievable in terms of technology and cost with the assessment of the feasibility carried out by a third party expert (German Technical Inspectorate (TÜV), etc).*

The claim was settled in a commercial agreement; otherwise the 3-year cover period would likely have led to a doubling of the amount of the losses.

During this experience, it was concluded that there were virtually no specialists available who were independent from the company. Information from those inside the insured company could not be used because of concerns arising from claims relating to liability law. Those experts that were available were anxious to avoid open disclosure of problem cases out of concern that they would be blocked from future orders by the market/manufacturer.

Analysis by insurers indicated that without the insurance cover the manufacturer would have retained reserves to cover their development risk 8 times higher than the original premium. Where no claims are made in the initial years of a type of policy, pressure on premiums and deductibles by markets/brokers, make it virtually impossible to recoup losses over time.

From this case, insurers concluded that the prototype character in the production of assumed well known developed products was underestimated. Manufacturer’s warranty cover and also machinery breakdown cover is only feasible on the basis of precise knowledge of the entire production process. Complete transparency and openness is necessary between the policyholder and insurer. If a market for this type of cover is to be sustained, brokers need to support this process and promote clear and sound entry and exit clauses. Monitoring technical processes by insurers is vital

Case History 5. Wafer fire

A small fire in a wafer assembly line caused soot formation which contaminated the ventilation system of the clean room. Due to the lack of adequate specialists and loss adjusters the manufacturer of the wafer assembly line was involved in the resulting loss assessment. The manufacturer evaluated that more than 80% of the assembly line was damaged due to soot contamination. Disassembling, cleaning and re-assembling of the equipment was estimated to cost more than building a new wafer assembly line from ground up.

The actual reason for arriving at this conclusion, however, was the fast fluctuation in product prices. Rebuilding of the damaged wafer assembly line was not in the interest of the insured since the market price for the wafer generation that they produced was rapidly decreasing.

From this case insurers concluded that the short life cycle and the rapid obsolescence of products, tools and machines led to an increased moral hazard. Owing to the lack of adequate loss adjusters/specialists insurers were not able to properly assess the damage/loss.

Case History 6. Welding shop with specialised welding

A shop producing steel grills for ramps and buildings used projection welding for welding bars to steel strips. The welding machines used a specialised source of electric current with 12 transformers set up in units of four with one pair working in parallel. One of the transformers short-circuited. The first option would have been to repair this unit, the second to change the connected pair; the third option would have been to change a unit of four. These options were discussed with the insurance company and the insured.

Eventually the insured presented a claim for exchanging all 12 transformers claiming that the other options were not technically feasible and that they had asked the insurance company in an e-mail for acceptance. Since no reply was forthcoming this was interpreted as an acceptance. The new units had a higher output and were water-cooled. After intricate negotiations, the insurance company paid for a part of the new units. It appeared that the manufacturer of the specialised units had changed their offer knowing that they would be able to sell new units to the welding shop. It was advantageous both for the manufacturer of the units and for the shop for the installation to move entirely to more developed technology rather than trying to repair the original units or mix new and original units together.

Case History 7. Short circuited servers

An internet service provider's equipment was damaged due to short-circuiting in a transformer installed outside the Insured's premises. Fluctuation in the electrical supply occurred. The insured had taken out a fire and allied perils insurance policy with a reinstatement clause. Some electronic cards had physical marks on them but mostly the equipment had no apparent signs of damage. The equipment had been purchased by the Insured in 2002.

Stating that replacement components were not available and repair was not possible since the technology had changed over the years, the client claimed for a total loss equivalent to about USD 3 Million.

After much research it was revealed that equipment for internet service providers of the same type and capacity was not available since it was outdated within 7 to 8 years of its launch. An improved version with almost double the capacity was available at almost half the price originally paid by the Insured for the insured equipment. There were issues pertaining to the nature of loss falling within the coverage of the policy, since there was no evidence of fire damage to the equipment. The loss adjuster made the following assessment:

> The price of equipment with a similar capacity but the latest version was estimated at one quarter the price of the original equipment. Since the equipment which was the subject of the claim was obsolete, the obsolescence adjusted value even where the reinstatement clause applied would be 50% of the new replacement value = USD 375,000.00. If the claim were settled on the basis of the actual value and not the reinstatement value, the actual depreciated value worked out to be in the range of USD 187,000.00. This value was less than 7% of the new replacement value just 7 years ago.

Since the insured was paying premium on a value of USD 3 million, the basis of analysis was not accepted and the claim has since become the subject of legal action. In determining the cover to be provided to a customer who is insuring fast developing technology care is needed in matching the form of cover to both their present and future requirements. At the time of policy inception, an insured may not understand how circumstances may change rapidly which could impact their requirements.

Case History 8 - Claim problems associated with photovoltaic panels

The FFSA (Fédération Française des Sociétés d'Assurance) and others produced a paper in 2009 following extensive research made by a dedicated working group. PV panels are often made with polymers which are more prone to fire than ordinary roofing. Fire resistance of the panels is not always certified. There is also the risk of electrocution of the fire brigade coming to extinguish a fire in a building equipped with solar panels. (See notice below)

CAUTION
Solar PV Wiring May Remain Energized
After Disconnection During Daylight Hours.

"Coastside Fire Protection District – Fire Prevention Bureau – Standard Detail & Specification Manual" Effective 7th March 2008

Depending on the way panels are installed, sometimes a defect in only one panel can lead to all the panels needing to be changed to avoid reduced performance. Snow and ice load could be an issue on renovated buildings if the weight of solar panels has not been taken into account.

Below is a diagram produced by the German Insurance Association in 2008 which indicates the number of losses that affected PV systems in 2004 to 2007 and breaks down claims expenditure.

Fig. 2: Number of losses affecting PV systems 2004–2007

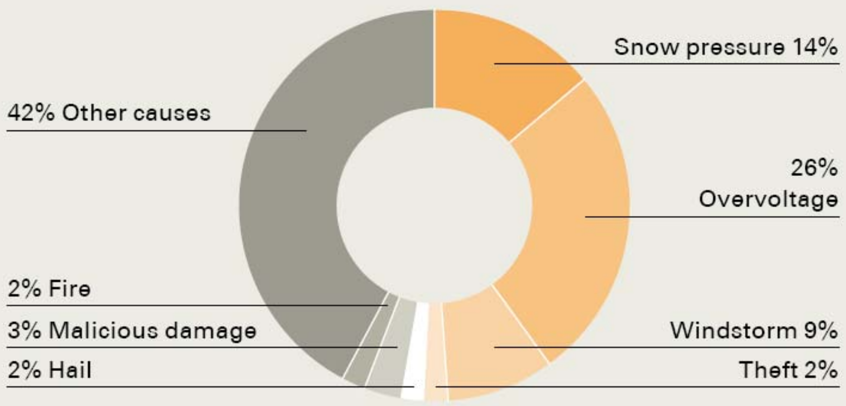
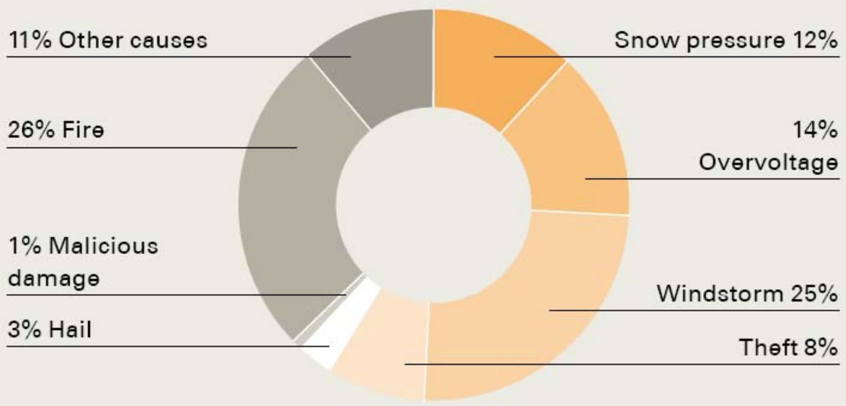


Fig. 3: Claims expenditure 2004–2007



Source: Renewable Energies, German Insurance Association, Berlin 2008

Case History 9 – Flooded microchip plant

A microchip plant was flooded which caused production to cease for a number of months before production could resume. A business interruption analysis examined the costs associated with restoring production. Some of the microchips that were being manufactured were to be used in products aimed solely at that year’s Christmas and Chinese New Year market. Once the opportunity to supply those microchips was lost the microchip design and development work was lost since the product life was so short that they were then obsolete. The claim served to illustrate that technologies are emerging that have a market life measured in months rather than years.

Claims problems

In addition to the issues illustrated by the claims histories, below are some of the problems that the working group has either encountered or can anticipate:

1. It can be difficult to judge a fair price where there is a single source of equipment/components. Insurers and loss adjusters can be trapped in a situation where there is high moral hazard if the manufacturer and service provider join forces in a monopolistic way.
2. High costs for sophisticated OEM parts can stimulate a black market of fake parts, increase the likelihood of thefts and increase the cost of security to protect them. This can lead to an additional exposure for insurers.

3. Fast developing technologies are often subject to patent rights giving the supplier a monopoly. This can lead to higher costs for repair or maintenance by service providers using only OEM parts, due to the lack of alternatives. Customers are forced to buy expensive OEM parts to keep their product guarantees. Thus, suppliers of highly sophisticated technologies often make money both on sales of products and on parts and servicing. Suppliers of such fast developing technologies may thus be able to finance their research and development costs and undertake more of it.

4. OEM replacement parts may be difficult to source when production of the original models has ceased.

5. Technology which becomes quickly obsolete can create a second-hand market for parts or even entire units. As an example, when wind turbines are replaced with higher rated models, the originals are sometimes sold second hand. Experts with a high degree of expertise are necessary to assess the risks posed by second-hand technology. Claims involving second hand equipment may be difficult for insurers to handle.

6. In some fields of technology, the availability of independent expertise and experienced loss adjusters is limited and tied to manufacturers. This applies especially to industrial processes where few companies are involved (e.g. wafer manufacturing). Owing to the scarcity of expertise fee rates may be high.

7. It can be difficult to differentiate between repair/reconstruction costs related to the form of a technology before the loss has occurred and the same costs of the form of the technology after the loss. This is particularly the case where machines are no longer available in the form that was insured or where the originally insured machine was effectively a prototype (perhaps not recognised as such by the original underwriter). Evaluating a fair price, whilst taking account of increasing obsolescence, is not easy. The technical character of insured objects and difficulties in determining the value of losses means that insurers require in depth technical knowledge of what they are insuring. Obsolete equipment with a very low written down value (that perhaps should have been written off) is sometimes insured for its original cost creating a mismatch between its depreciated value and the sum insured. Furthermore, insurers face difficulties indentifying who they can consult for price verification, to give an idea of the fairness of the claimed costs. One solution would be to make it mandatory to define component prices at the time of Insuring. Problems can also be created by rapid depreciation with pressure to upgrade after damage and the price of replacement units may be relatively low. One solution to this type of problem is demonstrated in the Willis Output Improvement Clause shown below:

8. With technologies that have a short life, it can be uneconomic for manufacturers to invest in repair facilities with the result that they are only interested in sales of whole units once a unit has been damaged. This is seen with consumer items such as personal computers and mobile phones but may become increasingly common in certain areas of the market for engineering products.

9. Fast developing technologies are often subject to a disproportionately high volume of claims by the manufactures. These are associated with the shortening of product cycles. Owing to the reduction of transfer times between the research and development phase and the market launch defects or design errors are sometimes too readily accepted in order not to lose the competitive advantage of releasing a product ahead of the competition. Manufacturers sometimes use customers, knowingly or unknowingly, as a test facility increasing the chances of claims caused by a design error.

6 Risk management post underwriting and the future

The role of surveys and risk engineering

The use of risk surveys and programmes of risk engineering can be particularly valuable on major projects that include fast developing technologies. Survey programmes have a dual role:

- They provide an opportunity to visit the site at regular intervals in association with the main insured and the principal contractors to review progress, assess risks, review the contractor's risk management processes and suggest loss prevention recommendations.
- Reports which follow with findings on progress and risk management issues provide information to the insurance follow-market participants.

Surveys and risk engineering should in no way relieve the Insured of their duty to report progress and changes that are occurring on the site to insurers The survey is an addition to, not a substitute for, the insured's reporting to insurers.

For fast developing technology projects, time and adequate budgets for risk surveys should be put in place at the underwriting stage to make sure there is enough to cover the "extra exposure" introduced by the technology involved. Underwriters may need to adjust the amount allowed for fees since the survey frequency may be higher than with other types of risk. The choice of in-house or external technical expert is of importance in risk surveys and claim adjusting when considering fast developing technology risks. An initial survey should assess, with the Insured, where the fast developing technology related risks are and what prevention measures should be taken to avoid a loss happening.

Survey and risk engineering recommendations

Key recommendations can include:

- Better management and procurement of spares in advance of a technology becoming obsolete to help to avoid occasions when a repair proves impossible owing to lack of parts. If only a single supplier is available in the market, particular attention should be given to early procurement and availability of spare parts and redundancies. Underwriters may also insist that such suppliers are subject to key-company insurance (like key-man insurance which is designed to financially protect a business from the effects of prolonged illness or even death of a member of staff who is central to the prosperity of the company). Key company insurance might financially protect a business from the effects of the loss of one of its key suppliers.

- Identifying alternative technological solutions early and identifying opportunities for diversification of supply such as arranging for competing suppliers to produce different technologies to solve the same problem. This can create alternatives rather than having to rely on a single supplier.

- Increased built in redundancy to help to manage risks.

- Increased testing of the new technology at suppliers' premises prior to installation on site. This might include certification of new technologies so that they have a quality label showing that the technology is fit-for-purpose. (Decennial markets already insists on certification).

- Regular updating from the insured to insurers about the technology to be used and the likely changes that they may know about.
- Early procurement of technological items to reduce the risks of delay rather than waiting for the latest developed technology which may only become available towards the end of a project.

Changes in risk

An annual review of underwriting assumptions may also prove useful to determine whether there might have been a material change in risk and whether review-and-break provisions either in a fronting or reinsurance policy should be exercised. A significant change in technology or the market could be material. Risk surveys can prove useful to provide information relevant to material changes in risk. There is however considerable potential for differences of opinion to arise between the insurer and insured as to whether a change in technology represents a material change in risk.

With fast developing technology the level of moral hazard can increase significantly if the property insured is suddenly rendered redundant when superseded by a more efficient innovation. An example of this might be an announcement that solar panels which currently have an energy conversion efficiency of 15 to 17% have been superseded by a new design with an efficiency of perhaps 50 to 60%. In such circumstances an insured might be highly motivated to replace existing panels almost immediately with new versions. A contractor could find their client reluctant to pay for the original installation of low efficiency units.

Innovative solutions

Fast developing technology is found in areas where industries take their own technical risks in testing and introducing new technology to the market. Given that insurance tends to be risk averse it is sometimes difficult for new technologies to obtain proper insurance cover.

Below are examples from 3 industries where solutions have been found to meet the challenges that fast developing or complex technologies have created and make the risk insurable.

- Tunnelling Works
- Nuclear energy
- Photovoltaic Panels

Tunnelling Works

Between 1994 and 2005, the insurance industry faced 19 major tunnel collapse claims for an amount in excess of USD 600 million. Premium income was not sufficient to cover the losses, covers were too wide and repair costs far exceeded original construction costs. As a result, many insurers were not keen to insure tunnelling works any more.

In consequence insurers and the International Tunnelling Association developed a “Joint code of practice for tunnelling works”. This document, now being adopted by owners and contractors, set minimum standards for risk assessment and risk management procedures for tunnelling projects. It defined clear responsibilities for all parties involved in a tunnel project at all stages of development, early conception, design, contracting and execution. This code of practice along with more restrictive cover reinstated insurers' confidence to continue underwriting tunnelling projects and export "best practice" to worldwide tunnelling markets. This provides a model which might be used in the case of a fast developing technology where insurers are reluctant to provide cover without special measures being introduced to raise the level of risk management beyond what an industry might adopt without insurers' insistence.

Nuclear Energy

Although this industry is not considered fast developing it creates a risk environment that has similarities to that created by a fast developing technology where consequences of failure can be severe, failure examples are few and the technology is complex and highly specialised. Insurers have for some time put in place solutions in order to cover nuclear energy risks that all consider very special and quite severe. Traditional Erection All Risks covers do include NMA 1975a (1994) the Nuclear Risks Exclusion Clause or other similar clauses. This clause excludes all risks associated with the nuclear part of the risk, within the high risk zone, defining exactly where the risk is considered traditional and when it is considered "Nuclear".

The Nuclear part of the risk is then covered by the Country Nuclear Pool. Each country involved in Nuclear Power production has its own Nuclear Pool, a group of local and foreign insurers, each giving some capacity for this kind of cover. The Pool is organized with its own rules, solidarity obligations, rates and conditions, and is also participating in the Pools of other countries.

The capacity available can reach EUR 400 million in some countries for construction and property damage, and has to reach EUR 700 million in Europe for liability. Above this figure any higher liability exposure is covered by governments.

This is an example of how insurers can be organised to cover the risks linked with a high risk technology. It provides a model that might be adopted where a fast developing technology is considered to be advantageous to society but where the risks are so high that pooling of the resources of insurers is necessary to provide the necessary cover.

Photovoltaic panels

In France, the installation of solar panels on buildings makes decennial insurers very cautious about insuring them as a "cladding product" for buildings. Insurers are uncertain whether the solar panels are suitable as a "roofing" product, and whether they will perform well as waterproofing for the building and thus be insured for ten years.

As solar panels are a fast developing technology, specific certification as an "ATEX" (technical expertise on an experimental Product") may not be complete when the units are to be used. CSTB (Centre scientifique et Technique du bâtiment) has set up a more rapid certification system called "Pass innovation", which can, in 3 months, give a first certificate detailing the specification and properties of the product, its ability to resist natural catastrophe exposure, its fire resistance, thermal properties and durability under normal conditions. By comparison, it takes 12 or more months to deliver a normal technical approval for a new technology. Pass innovation is designed for foreign products not already proven in France, derivatives of existing products and pure new ideas. It is valid for 2 years, is followed by experiments on site and is a useful tool for the insurance industry to grant cover for ten years. To date 21 “Pass innovation” approvals have been given, with 10 on solar panels, and 5 on new building materials.

The decennial insurance industry has also considered whether the efficiency of production of electricity through solar panels should be insurable under a decennial policy. As a result it has decided that it should not be part of the ten years mandatory decennial cover. FFSA (Fédération Française des Sociétés d’Assurance) is now working with legislators to incorporate this into the law. French Insurers are however looking at creating new insurance products in order to facilitate the development of photovoltaic technology. One solution is that where a building is insured by decennial cover, the insurer would, at the same time, provide the owner with a 10 year guarantee on the performance of the solar panels. This cover would be heavily linked to external technical scrutiny on the quality and reliability of the panels to be covered.

The future

In the longer term future, one way of addressing the insurance demands of technological innovation is to shift insurers’ focus from risk assessment to uncertainty assessment, with an accompanying change in emphasis from prevention to precaution. New procedures may be needed for considering and managing uncertainties with improved methods of horizon scanning. The boundaries of insurability, particularly the limits of entrepreneurial risk, need to be further explored to facilitate the expansion of the insurance sector into new markets. Tackling the fast pace of technological advancement may need earlier engagement in the innovation process on the part of insurers and greater insurance sector participation in stakeholder activities. For many industries, delaying innovations means a loss of competitiveness in international markets and mechanisms are needed for them to reduce the risks that innovation creates.

Technological innovations also assume certain patterns of future behaviour and more research on human responses to risks and new technologies could improve the accuracy with which risks are assessed. Further research also appears warranted on the influence that the availability or unavailability of insurance has on technological choices and directions.

The insurance industry's approach to risk has generally been to intervene once a technological innovation has stabilised, scientific controversies have reached closure and uncertainties have turned into quantifiable risks. In order to intervene earlier in the innovation process, insurers would need a more fundamental understanding of the technologies being developed and the consequences associated with their deployment. Whether insurers can intervene more upstream in the process of technological innovation and scientific controversy will depend on the expertise available and cost involved.

Whilst fast developing technologies provide huge opportunities for advancement they also introduce risks that consumers may increasingly fear. Insurers can provide limits and discipline on what can be released into the market. They can help develop methods for assessing risks in advance of that release so as to avoid using consumers for testing under-developed innovations and exposing companies to the consequences of using unsound methods for developing their products.

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