LIABILITY FOR ELECTRICAL ACCIDENTS: SAFETY AND RISK

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ABSTRACT

This lecture attempts to explore concepts of engineering safety and probabilistic risk set in the context of foreseeability and negligent liability in common law with emphasis on the deregulated electricity supply industry. While it is not disputed that cost benefit and the quantification of risk is essential to determining operational priorities in the management of such undertakings it is argued that they may not necessarily coincide with the values and choices which a community, through the courts, will consider appropriate. Two cases are reconstructed and analysed using Bayesian and simulation techniques with the aim of determining as to whether the risk involved was unreasonable.

1. INTRODUCTION

The common law of torts is part of the law of obligations concerned with the duty incurred when persons enter into a relationship which may give rise to an accident and an injury. In such circumstances the issue at law is one of an unreasonable risk of harm. This paper sets out to explore the basis of engineering safety and risk set in the context of negligent liability in law, with special reference to the question of immunity from liability in the deregulated electricity supply industry. The discussion takes the form of an introduction to the concept of “duty of care” as postulated in common law of torts, followed by an examination of the meaning of “comparative risk” as a probabilistic notion in the engineering sense. Bayesian and simulation methods are applied to reconstruct and analyse the magnitude of the risk associated with two cases. The first, occurred some 40 years ago and is legally significant in that it foreshadowed concepts later incorporated into Australian occupational safety legislation. The second is the initiation of a “bush” fire by a defective power line in which resulted in the loss of 10 lives and substantial quantities of stock and property. Each poses the question: “as to how foreseeable was the risk?”

Almost all human activity is fraught with some degree of danger. The law will argue that a person, or an entity, such as a power utility, is only required to guard against those risks which the community recognises as sufficiently great to demand precaution. The perception of a reasonable persons response relates to the magnitude of the risk and the degree of the probability of its occurrence, along with the expense, difficulty and inconvenience of taking alleviating action. Only when these elements are balanced will a court determine the response which should be ascribed to the reasonable person (Wyong Shire Council 1980).

What then is meant by safety and risk? Safety has been defined as “freedom from unacceptable risks, from personal harm”. That is, the elimination of danger, where danger is the balance between the chance and the result of an accident (Bolton 1951). Risk, is the potential to do harm which results from the combined effect of some undesirable event and its consequences in a given operating environment. The analysis of risk is an attempt to identify and quantify the likelihood of the adverse event arising from a course of action and to apply it to the decision making process. Studies of electricity supply systems, would indicate, that although comparative levels of safety can be used to state “how safe”, they may be questionable in terms of what society will accept as being “safe enough”. To this end, the legal
argument while endorsing efficient resource allocation as integral to engineering decision making, focuses primarily on the investment in safety and the rights of persons or groups exposed to harm. Hence, the concern is with equity in determining standards of safety.

2. THE DUTY OF CARE AND THE NEIGHBOUR PRINCIPLE

The common law deals with the consequences of unsafe practices through the operation of the law of torts, by statute, by regulations and by codes. Liability in tort exists independent of criminal liability, although the same action may give rise to both. The difference between the two is that in general, an offender will not be criminally responsible if there is reasonable doubt, whereas in tort liability is tested by the probability test: “Is it more probable than not that the defendant was negligent and that the negligence caused the plaintiff’s harm?”. The same conduct may also give rise to criminal liability where a breach of a legislative statute may render the offender liable to pay a fine. For there to be liability in negligence the following needs to be satisfied:

1. there must be an obligation to be careful towards the plaintiff - a duty of care;
2. the defendant must have been negligent in the circumstances - breach of duty;
3. the negligence must have caused the damage and it must be of a kind that is reasonably foreseeable - causation and remoteness of damage; and
4. the defendant must have no relevant defences which would extinguish liability to the plaintiff - defences.

It is difficult to generalise upon what basis a court will hold that there is a duty of care. It is agreed that “duty” in itself involves that at the time of the alleged negligence there is a “foreseeable” risk of injury or harm to a person or persons which arises out of some “relationship”, some “proximity” between parties. The question as to foreseeability varies according to who is being exposed to harm, e.g. small child climbing a pole (Munning (1971), or a pedestrian falling into an electric cable trench (Calf (1972), or a farmer killed by a fallen electric power line (Lamb (1988), or persons killed on the reclosure of a power line (Moore, Kentucky Utilities (1922-7).

The classical formulation of duty of care was enunciated by Atkin LJ in Donoghue v Stevenson (1932). This case, was whether someone who became ill as the result of drinking ginger beer from a bottle bought by a friend containing a decomposed snail could obtain damages from the manufacturer. The principles involved were:

- that no one, other than a party to a contract could complain of a breach of that contract; and
- the neglect of a duty owed, negligence, apart from contract, gave a right of action to the party injured by that negligence.

Aitkin LJ said: “you must take reasonable care to avoid acts or omissions which you can reasonably foresee would be likely to injure your neighbour”. Hence, the manufacturer ought to be held liable. He then went on to explain who in law was one’s neighbour: “is a person who is closely and directly affected by my act that I ought reasonably to have them in contemplation as being so affected when I am directing my mind to the acts of omissions which are called into question”.

The notion of proximity imposes limits on liability for foreseeable harm varying with the type of cases involved e.g. nervous shock or financial loss (Shaddock (1981)). But in ordinary accident cases, where foreseeable physical injury results, normally the relevant proximity will be assumed and we will owe a duty of care. Furthermore, relevant proximity will exist between an injured party and a defendant who is engaged in the same enterprise as the plaintiff, or who was involved in the same activity if they are subject to the same risk. For example, in professional and medical negligence cases, liability is imposed on a doctor for negligently causing injury to another person, even if the doctor did not intend to cause injury to the plaintiff. In such cases, the principle of “proximate cause” is applied.
person and a utility where the utility carries on a highly dangerous activity in a place where the public are entitled to resort, e.g. roads, parks or places where children are allowed to play, e.g. transmission lines through parks and or on roads (Thompson (1953) and Warren (1990). The High Court of Australia has made it clear in Australia, that relevant proximity will exist between the owner or occupier of land and someone whose person or property is at risk of injury or damage in the event of an “escape” of a dangerous substance, e.g. electricity, from the defendant’s premises (Burnie Port Authority(1994).

Legal risk is a relative thing, that is, the same act of omission may be negligent to one individual and not to another. In Bus (1989), the argument centred around the fact that the deceased was a qualified electrical contractor, who knew the risks of working with “live” equipment which was relevant to the nature of the duty owed by the electricity utility. In an earlier decision in Dell’Oro(1979), it was stated that the only duty owed was that owed to an experienced electrical contractor aware of the risk of electrocution, therefore, the utility was not liable. In Bus it was argued that “proximity” was the relationship that existed between the utility and an experienced electrical contractor with authorised access to a “live” electrical installation, consequently, there was no liability for negligence if a known risk occurred. The Court rejected this argument. The fact that the deceased was a qualified person who knew the risks, was only one factor of the negligence issue, another was that the risk of harm and its foreseeability were conditioned by the “inadvertent act” which could have been avoided by the covering of exposed “live” terminals.

How foreseeable should the risk be, and what is the necessity to understand the precise circumstances or sequence (cause) of events leading to injury? For example, the chance of a dead tree falling at the precise time that a rare visitor passed along an infrequently used path was very small, but not small enough to dispense with the need for inspection and maintenance (Schiller(1972); or the case of a child suffering severe electric shock due to an incorrectly wired electric stove (Harris (1994). Because of the almost infinite variability of how accidents can occur, the precise mechanisms, nor the precise damage or its magnitude need to be foreseen. In Vacwell Engineering(1971), a small glass bottle containing boron tribromide marked “harmful vapour” fell into a tub containing a mixture of water and detergent and on shattering caused a violent reaction and a massive explosion. Risks of this nature are exceedingly difficult to risk model. Furthermore, it raises the question of “near misses” which we are aware of, or ought to know of, and which may not be included in the risk evaluation procedure. The test is not what the defendant did foresee, but what a reasonable defendant would have foreseen. Thus, in Wagon Mound [No.1 & 2] (1961-1967), the court in accepting that only in very exceptional circumstances would furnace oil ignite, said it was a real risk which a reasonable person in the position of ships’ officers could not brush aside as far fetched.

3. PUBLIC AND PRIVATE UTILITIES AND THE LIMITATION OF RESOURCES

Can liability be avoided when the utility does not have sufficient funds to meet its obligations? In general, a public authority is protected against liability for its policy and planning decisions. Courts have refused to substitute their judgement as to what public interest requires. Very little litigation in Australia has raised the question of what constitutes a policy or planning decision. This issue was referred to in Sutherland Shire Council (1985). Justice Mason concluded that a public authority has no duty of care in relation to decisions “which involve or are dictated by financial, economic, social or political factors or constraints.”. The case of Cerk (1990) illustrates the difficulties involved. Cerk, was a chronic alcoholic and a psychotic. He had been arrested for drunkenness and placed in a Sydney police cell. He climbed on to a low partition wall and dived head first on to the concrete floor below. As a consequence he became a quadriplegic. In a claim against the
State, Cerkan argued that reasonable care required constant monitoring of prisoners. This would have required costly modifications to cells in many goals across the State. It was found that the State had not been negligent, as the resource issue was a government policy and planning decision, that is, it had decided not to upgrade these facilities. Therefore, it was not subject to review by the court. However, it was accepted by way of obiter, that once a person is taken into custody, the State has a duty to take reasonable care for the safety of that person. Consequently, this did not prevent a duty of care being owed and that a plaintiff could argue that the defendant was negligent in failing to use its existing resources to avoid harm. The application of this concept to the public utility is that although it has a franchise to provide a service, that it may be limited by government funding, this does not give it a licence to act in a negligent manner.

In contrast a utility which is not a public authority cannot rely on lack of resources to avoid liability for negligence. Lack of resources is not taken into account in an assessment of liability save in exceptional circumstances involving trespass and nuisance. Thus, the Red Cross was not permitted to argue that as a charity it was underfunded and that this prevented it from taking steps to ensure the safety of its blood products (PQ (1992). The conduct of the utility is measured against what a prudent utility with average resources would have done. In this context, corporatisation, privatisation and deregulation of public utilities has changed their status and made it easier to treat them in law as private rather than a public providers of services and products. Therefore, they have a “duty of care” to ensure that they have sufficient resources to take reasonable care, for as with any other provider, if the service (product) becomes unmarketable at the price required for safety, then it should not supplied at all, Dugdale,(1994)

4. COST BENEFIT AND NEGLIGENCE

As long ago as 1947 Justice Learned Hand in the United States case of United States v Carroll Towing Co., (1947) suggested that liability for negligence might be expressed algebraically by stating: "If the probability of the accident is P; the cost (or liability) of the injury L; and the burden or cost of preventing or minimising the accident B; liability for negligence depends on whether B is less than L multiplied by P. This can be summarised as: "A reasonable man, before taking any action, weighs the costs and benefits of that action not only from his own personal perspective but also from the broader perspective of all the individuals within the possible scope of any resultant harm". The Hand formula is an expression of the marginal utility of the cost of accident prevention. It can easily be derived by finding the optimal level that will minimize the social cost of an accident expressed by equation:

\[ P_c L + B_c = 0 \]  

(1)

where \( C \) is the cost of reducing or avoiding the risk. The value of L is the award by the court in damages. In practice, a damages award represents only part of the costs involved in litigation. Other costs include - cost of litigation (which can be huge); time lost etc. Indicative of the level of damages awarded is the case of Harris v Briggs (1994). There a girl of 9 years of age was awarded \$1.24 million damages as the result of suffering brain damage due to a severe electric shock. Higher awards are possible where a high income earner is seriously injured and requires a lifetime of nursing. The highest Australian award is one of \$10 million (Dec., 1995).

Figure 1, is a graphical representation of the cost-benefit equation. The curve PL is the marginal change in expected accident costs and is declining; the assumption is that the cost of care has a
diminishing effect in preventing an accident. In practice, as more than one commentator has pointed out, this type of cost based evidence is rarely brought before the courts. A further difficulty with the formula is it suggests that negligence is a purely economic equation without any reference to community expectations or values. The issue is whether a reasonable person balancing risk and the severity of injury against the cost of remedy would have taken steps to reduce or avoid the risk. This is not a simple matter of arithmetic. What is reasonable depends upon what the thinks is reasonable. A defendant who decides to run the risk of liability on economic grounds (the cost of the remedy exceeds possible liability costs) may face loss of public confidence. It is also possible that a defendant may, in the extreme case, expose itself to a punitive damages claim. Such was the fate of CSR in the wake of the asbestos related injury claims (Midalco Pty Ltd v. Rabenalt, 1989) and the Ford Motor Co., in the now famous “Pinto” case.

In Grimshaw v. Ford Motor Co., 1981, the facts were: in May 1972, a Mrs Gray accompanied by 13 year old Richard Grimshaw set out in a “Pinto” to meet Mr Gray. The car was then six months old and had about 3000 miles on the speedometer. On having just changed from the fast lane of the freeway on which they were travelling to a middle lane, the car stalled due to a carburettor problem and coasted to a halt. A car travelling immediately behind them was able to swerve and pass, but the driver of another car was unable to avoid a collision. On impact the “Pinto” caught fire and its interior was engulfed in flames. According to expert testimony the fuel tank had been driven forward and punctured by the exposed bolt heads of the differential housing so that fuel sprayed from the punctured tank and entered the passenger compartment. By the time the car came to rest after the collision, both occupants had sustained serious burns. Mrs Gray died a few days later. Grimshaw managed to survive but over the years underwent numerous and extensive surgery for severe burns.

The design styling of the “Pinto” required that the petrol tank be placed between the rear axle and the bumper bar leaving only 9 to 10 inches of “crush space”. In addition, the rear section lacked reinforcement members and the bumper was little more than a chrome strip. The court described the evidence as follows:

“Prototypes struck from the rear with a moving barrier at 21 mph caused the fuel tank to be driven forward and to be punctured, causing a fuel leakage... A production “Pinto” crash tested at 21 mph into a fixed barrier caused the fuel neck to be punctured by a bolt head on the differential housing. In at least one test, spilled fuel entered the drivers compartment.”

A report prepared by the director of automotive safety of the Ford Co. estimated the cost of improving the safety of the car at $US11.00 (historical value). The cost benefit was given as follows:

![Figure 1: The Cost-Benefit Model](image)
Benefits: Savings - 180 burn deaths, 180 serious burn injuries, 2100 burned vehicles.
Unit Cost - $200000 per death, $67000 per injury, $700 per vehicle.
Total benefits - (180 x 200000) + (180 x 67000) + (2100 x 700) = $ 49.15 million

Costs: Sales - 1 million cars, 5 million light trucks at $11.00 per unit = $137 million

The estimate of $200000 for the social cost of the loss of a human life was based on a National Highway Traffic Safety Administration study.

Grimshaw was awarded $US2.516 million compensatory damages and $US3.5 million in punitive damages (originally $US125 m) in recognition of the callous disregard for life and to act as a deterrent for the future. The Grays were awarded $US559,680 in compensatory damages.

The Hand formulation and negligence tests generally assume that persons are risk neutral when we are fully aware that some are risk-averse and some risk preferring. For example in the 1983 Ash Wednesday fires (Branxholme (Vic) Bushfire, 6th September, 1983, Coroners Court J831/422) almost a year elapsed between the condemnation of a decayed wood pole and its sudden failure a year later which caused a bushfire, with the loss of 12 lives and large losses in stock and property. In Lamb v. Southern Tablelands County Council, (1988), the utility from previous experience, was aware that a particular type of conductor tie constituted a hazard.

5. COMPARATIVE RISK EVALUATION

What do we mean by risk? The term “risk” has different senses. In law, it is the potential to do harm, in engineering analysis it implies the occurrence of a hazardous state, and in insurance, a possible catastrophe. If a utility decides to run with the risk and bear the legal cost consequences, which may involve punitive damages, then it must also anticipate questions of public confidence, Grimshaw (Ford Pinto) (1981), Midalco(Asbestos) (1989).

Probabilistic risk evaluation of complex systems composed of combinations of similar components as found in an overhead electric power system involves: (1) the identification of natural and artificial hazards; (2) determining the functional relationship which exist between components and their failure modes; and (3) calculating the probability of rates of occurrence of failure and the assessment of consequences. Problems include: (1) uncertain estimates of basic failure probabilities; (2) the propagation of errors; (3) the treatment of multiple event common cause failures; and (4) inability to predict every possible combination of circumstances that might lead to failure. Unless quantitative empirical data exists of system reliability, estimates of failure probabilities and the propagation of errors is a problem. The 84 case studies of electric power system accidents detailed in Sappideen and Stillman (1995) are so varied, and of such low probability of occurrence that even with a good data bank there is a need to resort to hypothesis and assumption to construct rational simulation models and event and fault trees. The general approach to risk assessment is to compare the results of the probabilistic evaluation of a hazard state to that of a postulated set of risk criteria based on the assumption that they represent either “acceptable” or “unacceptable” levels of risk. In fact, it could be argued that the so-called tolerable level of safety, is simply a means of convincing management and the public that the system is “safe enough”, and at the same time, insure against over capitalising by an excessive investment in safety. The basis of the comparative method is that involuntary risk to an individual is negligible, or unconditionally acceptable, if it equates to risks due to natural hazards, e.g. $10^{-6}$ accidents p.a., and it is excessive, or unconditionally unacceptable, if it is $>10^{-4}$ p.a. Thus, by inference, conditional acceptability resides in the benefits which may accrue when considering risks levels
6. A CASE STUDIES

6.1 Fraser v Lismore City Council [Electricity Supply], (1957)

The case of Fraser v Lismore City Council concerned Fraser a linesman of many years experience who had been directed to take down overhead line conductors servicing a rural cottage. Prior to ascending a wood pole to disconnect the attached conductors, he made an inspection of the pole at the groundline by applying a "hammer test" to determine if it was solid enough to support his weight and that of a ladder. The hammer test was at the time (and still is), an acceptable method of sounding wood poles to detect internal decay. This was accepted by the court as reasonable. On being satisfied, he placed the ladder against the pole, ascended to the head and began to removed the wires. The pole cracked at the ground line and fell, injuring Fraser, who was subsequently left with a permanent disability. The points at issue were:

- The pole was some 27 years of age. Expert evidence suggested that poles of this age and species had lives in general of 25 years.
- The electricity utility said they had carried out 2-3 yearly inspections of poles, but did not keep records, and there was no indication that the pole in question had been regularly inspected.
- Contributory negligence of Fraser.

Figure 2: The Pole Failure Model

Fraser sued for negligence and was awarded damages. It was found that the duty of the utility was not to absolutely guarantee the safety of the pole but rather a duty to take reasonable care in the provision of a safe working environment. In reconstructing the incident the aim is to determine whether the utility had sufficient foresight to have replaced the pole and prevent the accident? The reconstruction involves the combination of two time dependent events; (1) a wood pole in state of degradation over time and subject to environmental wind stress; and, (2) a sudden randomly applied overturning load applied at any time. These are two mutually exclusive events which occur within the time frame of the life of the pole.
From Figure 2 let:

t, \quad \text{a time at which the pole reaches age } t \text{ and } \beta \text{ a per unit of time.}

F \quad \text{is an event representing some extra load that can be placed on the pole, resultant load due to Fraser.}

\text{Dy} = \text{the strength of the pole as it deteriorates thought time } t - \beta.

L \quad \text{the dynamic load applied to the pole by wind.}

\text{Dy} \text{ and } L \text{ are governed by probability distribution functions (p.d.f). Degradation by a Weibull, wind by a Gumbel, and strength by a Normal. The load represented by Fraser can be applied at any time. The pole at } t_0 \text{ and at age } y_0 \text{ is so designed that it is capable of sustaining the extra load that Fraser represents. The state space diagram of Figure 2 shows the intersection of event } F \text{ with that of a particular state of strength, expressed as:}

\begin{equation}
P(F) = (D_1 \cap F) \cup (D_2 \cap F) \cup (D_3 \cap F) \cup ... \cup (D_y \cap F)
\end{equation}

where \( D_y \cap F \) is mutually exclusive. Consequently in the context of the multiplication rule and the sum of mutually exclusive events:

\begin{equation}
P(F) = P(D_1) \times P(F \cap D_1) + ... + P(D_y) \times P(F \cap D_y)
\end{equation}

and the conditional probability that the pole will fail having an extraneous load suddenly applied by:

\begin{equation}
P(D_y \cap F) = \frac{P(F \cap D_y)}{P(F)}
\end{equation}

Which is the Bayesian proof. The survivor equation for this particular equation can therefore be expressed as:

\begin{equation}
R_s = P(D_y > (L + F) = \int_0^x f_s(D_y) \left[ \int_0^{D_y} f_y(L) \right] dD_y + F
\end{equation}

The Weibull pole degrade parameters are: \( \gamma = \) the theoretical time in which failure cannot occur = 0; \( \beta = \) a dispersion factor = 3.19; and \( \alpha = \) the 63% probability of failure = 27 years. The methodology in respect of the simulation program is detailed in Stillman, (1996). The output is shown in Figure 3. The results indicate that the useful life of the pole is approximately 15 years and that there is little probability of survival after the 27th year( >37%). On the evidence given in the case, this is a rational result. Bush poles, of the Eucalyptus masculata (Spotted Gum) species, although of high extreme fibre strength (100 - 85 MPA) have poor durability unless subject to regular ground line treatment. The court found that there was no evidence to suggest that in fact the utility had carried out ground line inspection and maintenance. The pole failed due to internal decay, which suggests that Fraser may have been lax when testing the pole.

6.2 The Cudgee Bushfire Incident (1983)

During mid-summer of 1983 bushfires swept the south east coastal area of continental Australia culminating on the 16 February 1983 ("Ash Wednesday"). On that day some 400 fires blazed on
a front extending from the edge of Adelaide to the dormitory suburbs of Melbourne, a distance of approximately 1000 km. This study is of a major fire which occurred on that day in the district of Cudgee, about 300 km west of Melbourne. The outcome of the fire was the death of 10 persons and large losses of property and stock. The Coroner found that the probable cause of the fire was a defective power line servicing a local property. Conductors of the line had consistently clashed due to interference by wind blown trees. He said that on the evidence "the utility ought to have known of the risk and taken steps to obviate it". This study attempts to model the conditions which gave rise to the fire, Coroner's Report, 6 Sept.(1983).

The meteorological conditions conducive to disastrous bushfires in southeastern Australia are well established having occurred many times in the past. Necessary and sufficient conditions appear to be: (1) a prolonged antecedent dry spell; (2) hot, dry and strong north to northwesterly winds commencing in mid morning and continuing into the afternoon; and (3) a rapidly approaching trough from the west which brings a wind change to the southwest quadrant across the area during the late afternoon or night. The conditions occur as part of a prolonged heat-wave. A single feature of the 16 September was the strength of the southwesterly change with wind speeds higher than the northerlies which preceded it. The conditions were as follows:

1. The McAuthur Fire Index - had risen from around 30 at 09.00 hrs to 92 by 12.00 hrs remaining at this level until around 18.00 hrs. The index defines conditions conducive to a fire starting, its rate of spread, intensity and difficulty of suppression according to various combinations of temperature, relative humidity, wind speed, and drought effects on forests and pasture. An index of 1 means that a fire burn is minimal, whereas 100 means the fire burn is extremely rapid and virtually impossible to control.

2. At 09.00 hrs - temperature = 28.0 \(^\circ\)C, 15.00 hrs = 43.0 \(^\circ\)C
dew point \((^\circ\)C\) = 4.6 : = (-4.6)
relative humidity = 22%: = 5.0%
wind speed = 4.0 (NE): = 61 km/hr (7 - Beaufort Scale)

*Australian Bureau of Meteorology, (1985)*.

The Baysian model is illustrated by Figure 4 based on the following:

\(W_x\) = the weather state as defined by the McAuthur index of 1 to 100. It consists of the mutually exclusive subset events: (1) wind- hot and dry \((W_s)\); (2) wind hot with moderate humidity \((W_m)\); and (3) wind - hot and very humid \((W_v)\). With in each subset are three mutually exclusive events: (1) strong wind; (2) calm wind; (3) calm conditions (based on the Beaufort scale of field reporting).

\(H_z\) = a hazard brought about by combination of defects in the servicing and design of a power line, e.g. interference by flora and fauna, human agency (vandalism, traffic accidents), defects in design and maintenance, storms. \(H_z\) can occur in any one of the weather state subsets.

\(F_z\) = is the event of a fire resulting from the inter-reaction of the hazard with the weather state. Consequently:

\[
P(F_z) = (W_s \land H_z \land F_z) + (W_m \land H_z \land F_z) + (W_v \land H_z \land F_z) \quad (6)
\]

As no data was available as to the state of the Cudgee lines at the time of the fire, for the purpose of analysis the data utilized is derived from the NSW Risk(Electricity) Management Reports (1986 - 1992). The event tree associated with the hazard model is detailed in Figure 5.
\( H_z \) (the hazard) is derived from a set of conditional events relating to maintenance and interference from trees = \( \text{Pr}(0.001766) \). That is, 1 in 566 faults that occur on the system in the first quarter of the year (summer) would have given rise to clashing conductors due to a combination of wind and interference from trees.

\( W_x \) the weather state is derived from a Gumbel distribution based on the frequency distribution of Figure 6. Days conducive to bushfires, e.g. those where the temperature exceeds 35°C and the relative humidity > 10\%, the probability was assessed at \( \text{Pr}(0.08139) \). Thus, the probability of the fire = \( \text{Pr}(0.000143) \), or 1 in 6993 outages occurring in the first quarter. Thus, as the Coroner found, the risk in not trimming the trees around the line conductors and the state of repair of the line, a situation known to the local utility, was considerable.

7. SUMMARY

This lecture uses Baysian and simulation theory to relate legal liability for negligence with comparative levels of engineering risk. The case studies indicate that with appropriate data it is feasible to establish whether there is liability in the balance between safety and risk. The need to understand the relationship between engineering and legal risk is particularly important in the so-called reformed environment of market economics, loss of public immunity, and an insistence that asset utilisation be maximised at minimum cost.

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Figure 6: Temperature Frequency Distribution