Versicherungsforen Leipzig

Study

Calculation of a risk-adjusted insurance premium to cover the liability risks resulting from the operation of nuclear plants

A study commissioned by the

German Renewable Energy Federation (BEE, Bundesverband Erneuerbare Energie e.V)

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Introduction of the Versicherungsforen Leipzig GmbH

The Versicherungsforen Leipzig GmbH has been a neutral and independent research service provider to the insurance industry since it was founded in 2000 and, therefore, acts as a bridge between science and insurance practice. The Versicherungsforen Leipzig GmbH permanently checks whether and where there are current scientific expertise and methodological, scientific skills which are worth transferring to the insurance industry. Knowledge transfer is expressed in the form of various services related to the circulation of knowledge management.

All of the approximately 40 employees at Versicherungsforen Leipzig GmbH have actuarial training in economics, law, computer science or mathematics. They work closely with the sister companies of the Versicherungsforen Leipzig GmbH (Energieforen Leipzig, Gesundheitsforen Leipzig, Softwareforen Leipzig) to find solutions to inter-disciplinary issues.

The authors of the study have their roots in insurance management and actuarial mathematics.

Presentation of the study

Client / time of commission

This study was commissioned at the turn of the year 2010/2011 by the German Renewable Energy Federation (Bundesverband Erneuerbare Energie e.V), i.e. before the nuclear disaster in Fukushima.

Subject, purpose and structure (outline) of the study

The subject of this study is to calculate a risk-adjusted insurance premium to cover the liability risks resulting from the operation of nuclear power plants.

The aim is to calculate an adequate insurance premium to cover the resulting damage from a nuclear disaster based on existing assessments of probabilities of occurrence and extent of damage ("Total Meltdown", INES Level 7).

Outline:

1. Definitions
2. Operation of NPPs and resulting exposures
3. Extent of insurance cover for a nuclear disaster
4. Existing quantification methods for estimating the extent of damage
5. Probability of occurrence: Current quantification methods and the influence of scenarios on a nuclear disaster
6. Calculation of the liability insurance premium for the risk of a "nuclear disaster"
7. Interpretation of results and conclusion

Assumptions / paradigms for the study

Insurance type

This is liability insurance as an insurance segment of indemnity insurance against third party claims for damages caused by a nuclear disaster. The study is assumed to be an "unlimited interest insurance", which means that the level of compensation is congruent with the amount of damage and is not capped. This configuration is not typical for liability insurance of any kind.

Insured risk: "Nuclear disaster at an NPP"

The study only applies to the liability risk of the NPP owner in case of a nuclear disaster ("Total Meltdown", INES Level 7), which causes maximum damage. The extent of that maximum damage determines the amount of indemnification.

Insured risks

Insured risks are triggers that may lead to the occurrence of insured damage from a nuclear disaster at a nuclear power plant. In this case, basically no exclusions were made, which corresponds to the legal situation in Germany:

The liability for operating a nuclear power plant in Germany is generally defined as a strict liability, i.e. in case of damage, the question of its illegality or the fault of the owner are of no importance. Rather, the owner of a nuclear power plant is liable without limit and regardless of culpability in respect of claims by third parties.

Insured damages

The study is based on article 1, paragraph a, number (vii) of the amendment to the Paris Convention, which essentially takes account of

- the killing and injuring of people,
- the loss of or damage to property assets,
- the costs of measures to restore the damaged environment and
- loss of income from a direct economic interest in the use or enjoyment of the environment

.

The condition for recognising damages as outlined above is that they are caused by ionizing radiation which is caused by a radiation source, nuclear fuel or radioactive products within a nuclear power plant or a nuclear facility and its operation.

Insurance premium / premium calculation

As part of its premium policy, the insurer calculates the price of the offered insurance coverage so that income from the premium would cover the estimated expenses incurred. Normally the calculation would include values taken from past cases reflecting actual expenses already incurred in the past for similar claims and estimated costs for future claims.

The study attempted to calculate the gross risk premium to cover liability risks resulting from the operation of an NPP. Here, we only focussed on the risk premium, i.e. other usual premium components - such as covering the operating costs of the insurer - were excluded from consideration, partly because they are of minor importance to this issue.

In the premium calculation, the pure risk premium usually corresponds to the amount of coverage for the anticipated damages from the risk. The basis for calculating the risk premium is usually the expected value of damage, which is achieved by multiplying the potential extent of loss by the damage probability. This approach is - as will be shown below - only partially applicable here.

Another component of the risk premium is the safety margin, which serves as a contribution margin for possible excessive damages - due to the dispersion of expected damages in the probability distribution. The safety margin is therefore intended to hedge the volatility of actual damage payments by the expected value and represents an additional contribution to cover the risk.

Secondary and primary analyses to determine the likelihood and severity of damages

After comprehensively researching and reviewing the available literature, the different quantification approaches and/or specifically mentioned, presumed damage probabilities and damage amounts from existing expert studies were used in the study. In addition, the study made independent assumptions and, in the context of a primary analysis, took into account weather parameters, i.e. where statistically predictable, the wind speed and direction, precipitation and amount of radioactive material released were included in the calculations.

Conservative assumptions were made to determine the amount of damage and the likelihood of its occurrence.

Assumptions about the likelihood of a nuclear disaster in an NPP

A number of sources were used to estimate the probability of a nuclear disaster. These studies are however only based on technical event sequences and, beyond that, do not take into account any external threats. This has now been done in this study and the following dangers were taken into account:

- Ageing of the NPP
- Terrorism (targeted plane crash, assault with guided missiles, sabotage by insiders)
- Computer virus
- Human error
- Earthquakes

Probabilities were then taken from secondary studies or estimated for each of the damage types, see slide.

Assumptions about the amount of damages from a nuclear disaster in an NPP

In the studies examined, statements were made about potential claims amounts for the following types of damage:

- Fatal and non-fatal cancers
- Genetic damage
- Evacuation and relocation
- Economic losses from the closure of certain areas and bans on consuming certain foodstuffs

The respective results were then extracted from those referred to in past studies. In addition, past weather statistics (in particular wind directions) for the 17 German nuclear power plants were used as a basis for future assumptions, in order to make deductions about the potential extent of the damage for the implementation of relocation measures.

Results

Estimating the distribution of damage amounts / assumptions:

Due to the individual characteristics of the influencing factors, a specific combination of damage amount and loss probability can be generated for each nuclear power plant, with which the risk of a nuclear disaster can be described in the form of damage probability distribution. This means each amount of damage is described by a specific loss probability (see slide with left-biased distribution).

Based on the expected damage values, which originate from own assumptions and/or are taken from expert estimates in the examined studies, we have estimated a distribution function for the amounts of damage from a nuclear disaster using the following parameters.

Minimum damages: 150 billion EUR

Expected damage value:	5,756 billion EUR
10-fold spread:	607 billion EUR
Maximum damages:	6,363 billion EUR

The damages were simulated in several simulation runs using this distribution function and the maximum damages in each case were selected. Since a nuclear disaster in a NPP would lead to an extreme amount of damage but has a very low probability of occurrence, methods of extreme value statistics were applied to these maximum damages to determine the distribution function of the maximum damages, its expected value (expected maximum damage) and its spread. The amount of cover is determined from these maximum expected damages and six times its spread as a safety margin.

Expected maximum damages:	5,900 billion EUR
6-fold spread:	190 billion EUR
Amount of cover:	6,090 billion EUR

The calculated sum which would have to be made available in case of a nuclear disaster is **6.09 trillion euros** (6,090 billion euros).

Present value calculation

This amount of cover was converted into an annual premium for each nuclear power plant, based on actuarial interest of two percent. However, there are deviations from the usual premium calculation: Given the fact that maximum damages - as seen above - take on extreme dimensions, while no or only a very small risk is present, the usual underwriting techniques which assume a collective risk adjustment over time do not work.

Therefore, the insurance premium cannot be based on expected damage values for one year because the collective, in which individual claims excesses and shortfalls balance each other out (meaning negative or positive deviations from expected damage values), is too small or non-existent.

In addition, no institution would be capable of paying for damages which may occur at any time during an assumed implementation period without a corresponding amount of cover being made available. This would result in immediate insolvency.

Consequently, the premium was enforced as a present value calculation for a period in which the amount of cover for the nuclear disaster is built up and then made available for compensatory payments. Since it is uncertain if and when such a disaster will occur, the amount of the premium depends on over what period the amount of cover is built up.

We have, therefore, considered different scenarios in which on the one hand the amount of cover is built up over a period of 100 to 10 years and, on the other hand, taken into account that insuring the liability risks would probably occur by means of an insurance pool which would collectively insure several or all 17 nuclear power plants located in Germany. The insurance premium was then set in relation to the amount of electricity generated by the nuclear power plants in 2009.

When considering these different scenarios, the resulting liability insurance premium would increase the cost per kilowatt/hour by a range of **around EUR 0.14 to 67.3**. This surcharge on the regular electricity price would have to be paid over the entire period of building up the amount of cover.

The pure risk premium to be paid subsequently would mainly depend on the assumed probability of occurrence, the remaining operating term and the number of insured risks in the pool.

Conclusion/recommendations

These calculations show that the premium is determined in particular by the duration assumed for building up the amount of cover, and by the size of the collective (such as from pooling). The need for a timely provision arises from the fact that the damages are just as likely to occur on the first day as they are after one thousand or 10 million years. The overview of costs per kilowatt/hour for each scenario clearly shows that, in view of the situation in Germany, there is no way to guarantee full coverage of the risk. Provision periods taking into account the remaining operating terms of German nuclear power plants and normal operating terms of 25 to 40 years do not appear to be financially feasible. This shows very clearly that the problem lies in the fact that although there is an immediate risk, at the same time, there is also a lack of a sufficiently large amount of cover for compensation claims.

In practical terms, nuclear disasters occurring at NPPs are not insurable. This is due in particular to

- the size of the risk collective being too small,
- the extremely high amount of the expected maximum damage and
- to the probability of occurrence and the amount of damages being difficult to estimate (due to the assumed rarity of the nuclear disaster)

Therefore, the insurance premium calculated as part of this study only represents a notional insurance premium as a measure of the total risk of a nuclear disaster. In calculating this notional premium, assumptions have been included from a variety of existing studies on the dangers and effects of nuclear radiation on surrounding systems and these assumptions are themselves fraught with uncertainties.

The study, therefore, serves to make a contribution to the current debate about the 'residual risk' of a nuclear disaster and to give an estimate of the amount and provision of funds for such an eventuality. The realistic lack of insurability or affordability was also highlighted at various points throughout the study. This would suggest that the use of nuclear energy and the associated risks are less an economic issue and more a matter of society's and the economy's willingness to bear those risks quantified in the study. This can only be answered through social dialogue.

Furthermore, all assumptions and methods applied are to be disclosed; this study is thus released for further studies which could then be implemented with improved assumptions.