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**HYDRO-ELECTRIC POWER, TECHNICAL AND  
INSURANCE DEVELOPMENT**

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By  
Bernt Lamark, Storebrand  
Anders Lindberg, Skandia  
Rudolf Wegelin, Swiss National Insurance Co  
Lars Engstedt, Zurich Sweden

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## Introduction and Executive Summary

The topic for this paper was chosen for the IMIA conference 1998 to give the technical background and an introduction to the visit to a hydroelectric power plant being part of the conference program.

The intention with the paper is to give the reader a general overview of hydroelectric power production and technical developments which should be considered by the Insurance Industry.

The working party preparing the paper was from the beginning aware of that the topic is very extensive. In order to give as good overview as possible of the topic the working party has chosen to make use of the information available on the Internet. When searching for information it soon became obvious that the Internet is becoming an almost unlimited source for information and it became more of a question to select than to find information.

In this paper you will find some abstracts from the more interesting web sites found with their references and these shall be directly accessible on the Internet when reading this paper on the IMIA web site <http://www.imia.com>.

In addition to the web sites referred to in this paper, today in principle every major organisation, manufacturer, contractor, insurer, reinsurer etc have their own web site where for example information is published, services and products are marketed.

We would like to thank Michaela Dan at the Royal Institute of Technology in Stockholm Sweden for her search on the Internet in order to find relevant web sites for this paper.

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## History of Hydro Power

The first recorded use of water power was a clock, built around 250 BC. Since that time, humans have used falling water to provide power for grain and saw mills, as well as a host of other applications. The first use of moving water to produce electricity was a waterwheel on the Fox river in Wisconsin in 1882, two years after Thomas Edison unveiled the incandescent light bulb. The first of many hydro electric power plants at Niagara Falls was completed shortly thereafter. Hydro power continued to play a major role in the expansion of electrical service early in this century, both in North America and around the world. Contemporary Hydro-electric power plants generate anywhere from a few kW, enough for a single residence, to thousands of MW, power enough to supply a large city.

Early hydro-electric power plants were much more reliable and efficient than the fossil fuel fired plants of the day. This resulted in a proliferation of small to medium sized hydro-electric generating stations distributed wherever there was an adequate supply of moving water and a need for electricity. As electricity demand soared in the middle years of this century, and the efficiency of coal and oil fueled power plants increased, small hydro plants fell out of favor. Most new hydro-electric development was focused on huge "mega-projects".

The majority of these power plants involved large dams which flooded vast areas of land to provide water storage and therefore a constant supply of electricity. In recent years, the environmental impacts of such large hydro projects are being identified as a cause for concern. It is becoming increasingly difficult for developers to build new dams because of opposition from environmentalists and people living on the land to be flooded. This is shown by the opposition to projects such as Great Whale (James Bay II) in Quebec and the Gabickovo-Nagymaros project on the Danube River in Czechoslovakia.

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## Hydro-Electric Power Production - Technical Principles

Hydro-electric power plants capture the energy released by water falling through a vertical distance, and transform this energy into useful electricity. In general, falling water is channeled through a turbine which converts the water's energy into mechanical power. The rotation of the water turbines is transferred to a generator which produces electricity. The amount of electricity which can be generated at a hydro-electric plant is dependant upon two factors. These factors are (1) the vertical distance through which the water falls, called the "head", and (2) the flow rate, measured as volume per unit time. The electricity produced is proportional to the product of the head and the rate of flow. The following is an equation which may be used to roughly determine the amount of electricity which can be generated by a potential hydro-electric power site:

$$\text{POWER (kW)} = 5.9 \times \text{FLOW} \times \text{HEAD}$$

In this equation, FLOW is measured in cubic meters per second and HEAD is measured in meters.

Based on the facts presented above, hydro-electric power plants can generally be divided into two categories. "High head" power plants are the most common and generally utilize a dam to store water at an increased elevation. The use of a dam to impound water also provides the capability of storing water during rainy periods and releasing it during dry periods. This results in the consistent and reliable production of electricity, able to meet demand. Heads for this type of power plant may be greater than 1000 m. Most large hydro-electric facilities are of the high head variety. High head plants with storage are very valuable to electric utilities because they can be quickly adjusted to meet the electrical demand on a distribution system.

"Low head" hydro-electric plants are power plants which generally utilize heads of only a few meters or less. Power plants of this type may utilize a low dam or weir to channel water, or no dam and simply use the "run of the river". Run of the river generating stations cannot store water, thus their electric output varies with seasonal flows of water in a river. A large volume of water must pass through a low head hydro plant's turbines in order to produce a useful amount of power. Hydro-electric facilities with a capacity of less than about 25 MW (1 MW = 1,000,000 Watts) are generally referred to as "small hydro", although hydro-electric technology is basically the same regardless of generating capacity.

"Pumped Storage" is another form of hydro-electric power. Pumped storage facilities use excess electrical system capacity, generally available at night, to pump water from one reservoir to another reservoir at a higher elevation. During periods of peak electrical demand, water from the higher reservoir is released through turbines to the

lower reservoir, and electricity is produced. Although pumped storage sites are not net producers of electricity - it actually takes more electricity to pump the water up than is recovered when it is released - they are a valuable addition to electricity supply systems. Their value is in their ability to store electricity for use at a later time when peak demands are occurring. Storage is even more valuable if intermittent sources of electricity such as solar or wind are hooked into a system.

Extract from the web site:

How Hydropower Works

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## Technique in Hydro-Electric Power Plants

1. [Conventional power plants](#)
2. [Micro-Hydro electricity Generation](#)

### 1. Conventional Power Plants

#### General

The development in hydro electric power have emphasize on running several power stations from only one control room often located in one major power plant in the river. This is an development which have been on going for 10 to 15 years in the Nordic countries. This development puts very high demands on the control equipment and monitoring all relevant data for processing and safety. Especially for safety reasons it is important to have a very extensive fire and water leakage alarm system.

#### Turbines

The Technique in producing hydroelectric power hasn't changed much during the last 50 years. In large and medium size plants there are mainly 3 different types of turbines, Pelton, Francis and Kaplan. The turbine is connected to the generator normally without any gearbox. The most important development for hydroelectric power plants is the increase of the degree of efficiency over the years. The lifetime for a turbine varies depending on running conditions and can range between 15 to 40 years. When it has been time to exchange a turbine the new turbine could have given an increase of up to 5 % efficiency. Which could depend on more efficient blade shape or a more optimum efficiency curve due to changed flow characteristics of the river.

#### Generators

The design of generators have mainly been the same over the years. Windings in generators older than 35 years have insulation made of a viscous impregnating agent and have today more or less have lost it's original quality. In new generators the windings are insulated with quenching polymeric material with very good aging qualities.

Last year one of the main manufactures of generators announced that they had invented a new generator which could be connected direct to the power grid. Step-up transformers are no longer needed in large generating plants. More information is to be find on the web sites shown below. The increase of total efficiency is obvious as the energy losses in the transformer are eliminated. Today one of these new generators is installed in the hydro-electric power plant in Porjus in northern Sweden.

Web sites:

<http://www.eren.doe.gov>

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## 2. Micro-Hydro Electricity Generation

There is much scope for small-scale locally owned electricity to service the remote communities.

The electricity generated can be used to improve the efficiency of an established local industry, typically allowing the use of small power tools, refrigeration or electric ovens. It can also be used to provide domestic and public lighting, medical refrigeration and other amenities to the community.

Local involvement in the planning, operation and maintenance of the system helps to ensure that the benefits flow on to the community and that unwanted social and environmental side effects are avoided.

Once the plant is established and local operators trained, the overheads are minimal and so community profits are freed for further infrastructures development.

Running costs of micro-hydro schemes are low because the water is free and the APACE equipment is built to last.

In isolated areas the only immediate alternatives are diesel and the petrol driven generators or solar-electric and wind-energy systems. Micro-hydroelectric power brings large benefits in comparison to the fossil fuel alternatives and the continuously available power is often an advantage over solar- electric or wind energy systems.

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## Dams

1. [Dam Safety](#)
2. [Dam Construction](#)
- 2.1 [Concrete Dams](#)
- 2.2 [Embankment Dams](#)

### 1.Dam Safety

Safety of the dam is off course one of the most important issues for a Hydro-electric plant. This is the concern of The International Commission on Large Dams.

The International Commission on Large Dams was founded in Paris in 1928, upon the initiative of representatives from the United States of America, France, Great Britain, Italy, Rumania and Switzerland, during the Congress of the of the International Union of Producers and Distributors of Electrical Energy (UNIPEDA).

The objective of the Commission is to promote progress in the establishment of designs, construction, operation and maintenance of large dams, by the collection and study of relevant data and questions.

Web sites:

The International Commission on Large Dams

<http://public.eurelectric.org>

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## **2. Dam Construction**

### **2.1 Concrete Dams**

Concrete dams are generally constructed on rock foundations, although some low-head structures are founded on gravel. Concrete dams are rigid structures with high compressive strength but low tensile strength. They are shaped to support imposed loads through foundation compression, and tensile stresses are reduced or eliminated by careful shaping.

Construction of concrete dams requires appropriate sources of sand, gravel and aggregate, suitable access to the site and will often necessitate local the construction of batching facilities.

#### **Gravity Dams**

Gravity dams resist reservoir loads through sliding friction due to the weight of water on the dam foundation. On a wide site, gravity dams can be visualised as a series of vertical cantilevers with most of the concrete mass provided on the upstream face to reduce tensile stress due to bending and to obtain favourable gravity load. The foundation rock must be capable of carrying the structure's imposed loading and developing the required sliding friction.

#### **Arch Dams**

As the dam site continues to narrow, more of the load is transferred to the abutments, reducing the portion of the load carried by the cantilever action. This allows the structure to be thinner.

#### **Buttress Dams**

Buttress and multiple-arch dams have been constructed at sites ranging from broad valleys, where a gravity dam could otherwise have been used, to fairly narrow sites. They are rarely "first choice" structures and are often designed because of economic or foundation problems with other dam types. Buttress dam construction is labour intensive, and rely on the lower concrete requirements to be economic.

### **2.2 Embankment Dams**

Embankment dams are generally classified by the materials used in their construction, namely earthfill or rockfill. They are further classified by the type and location of the impervious core or facing. The core may be a central core or inclined core, or the dam may be homogeneous. Embankment dam design is very dependent on the local availability of construction materials.

Embankment dams will necessitate considerable earthworks and are labour intensive (see Impacts of Construction).

Embankment dam stability is based on providing a mass of material heavy enough to resist the applied loadings, with the materials graded to reduce the hydraulic gradients within the embankment and the foundation so that leakage will be minor and that no material will be displaced.

Rockfill dams were originally considered applicable for small structures and were provided with impervious faces. More recently they have been used for high sites and are provided with internal impervious cores.

## **Embankment Shells**

Embankment shells are usually randomly placed pervious material which comprises the bulk of the dam. Its function is to provide mass to the structure and support the impervious core.

## **Impervious Core**

The size of the core depends on the nature of available impervious material. For construction of an impervious upstream face, concrete or asphalt is commonly used.

## **Core Design**

Dam cores are never completely impervious and only reduce the flow. Drainage and filter blankets must be provided to carry leakage flows safely through the dam. Drainage galleries and relief wells have also been used.

## **Slope Protection**

The embankment's upstream face is usually protected by rock or soil. The downstream face is normally protected from rainfall erosion by grass or other hardy vegetation. Care should be taken to assure that the downstream face protection does not become impervious.

Web sites:

<http://npdp.stanford.edu/chronology.html>

Chronology of Major Events in Dam Safety in USA

Dam Safety Office Engineering Guidelines and Technical Notes

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## **The Energy Markets and Power Exchange**

In Europe in general the energy markets are opening up, and each country as well as the EU Commission work hard for a liberalization.

A traditional electricity supply contract is a rather straightforward agreement between a seller and buyer, and usually results in a relatively static and predictable consumption pattern. However, the bundling of such a supply contract with either a call or a put option complicates the operational production planning process considerably, since the consumers' behaviour will not be known in advance. Contractual call and put options must therefore be considered carefully in the planning process.

Due to longer regulating time the nuclear and thermal power plants are primarily used to meet the base load demand. Hydropower has become more of a regulator of peak load demand but also as the most flexible tool in the spot energy market.

The Norwegian Energy act which became effective 1991 is an good example of how a regulated market was turned into an open market place. The act introduced competition to a business sector where the individual energy utilities enjoyed a supply monopoly in their regions. This means that the consumer today can buy the electrical power he needs from the supplier who can offer the lowest price. Presently the consumer can buy The electric power can today be purchased in many different places, the local gas station, the nearest department store or any power company, whoever offer the lowest price.

The purpose of the new Energy Act was to create a more efficient use of resources

in the energy sector, as well as a leveling of prices to customers in different parts of the country.

The Act makes a clear distinction between the generation and sale of power on one hand and the transmission on the other. There is no competition in Norway with respect to transmission, since competition in this area might have led to the development of parallel networks, which was considered not desirable.

Web sites:

<http://public.eurelectric.org>

Electricity Contracts in a Competitive Framework and Strategies for Hydro-Thermal Coordination in Operational Planning

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## Impact on Risk Exposure and Insurance Practice

1. [Risk Evaluation](#)
2. [Technical and Safety Aspects](#)
3. [Plant Safety](#)

Hydroelectric power generation is now used more and more as a peak-load, while it earlier was used mainly as base-load. This means that the generator and the turbine together with other parts are stopped and started with an increasing frequency. When the equipment was manufactured this was not known and therefore it was not designed to fulfill these requirements. Earlier a stop of a hydroelectric power plant was scheduled days ahead, today there may be several stops a day of an unmanned station initiated from a remote control center.

The local power generating companies used to have monopoly in their region and in general they often invested in technical expensive solutions without taking cost factor to much into consideration. They were able to distribute all costs to the consumers. After the new Energy Act in Norway was introduced they have to compete and price is more or less the only variable. What impact the changing operational and maintenance pattern will have on the risk exposure is to early to evaluate.

### 1. Risk Evaluation

The chart below shows how one experienced Scandinavian Underwriter consider the risk exposures for a hydroelectric power plant:

Item /Peril	Frequency			Consequence of loss
	Fire	Machinery Breakdown	Natural Perils	
Dams	-	low	low	large
Water ways	-	low	low	medium
Valves	-	low	low	medium
Turbine	low	medium	low	large
Generator	low	high	low	large
Transformer	low	high	low	medium
Switchgear	low	medium	low	small
Lines	low	medium	low	medium



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## **2. Technical and Safety Aspects**

### **Common Types of Failure in Hydroelectric Power Plants**

The following types of failure, which can cause more or less costly damages and give a long outage of production are, without ranking order, the most frequent losses.

Failure in the stator winding of the generator  
Failure in switch control room and set of electrical tracks and cable fire  
Failure in control equipment  
Disappearance of auxiliary and power supply  
Failure in transformers  
Cracks and breakage in shovels and other turbine failures  
Failure in bearings with lubrication and cooling systems  
Flooding of machine hall and other room for machinery equipment  
Fire in the machine hall or other engine rooms

#### **Failure in the Stator Winding**

The failure frequency in stator windings is often depending on it's age, type of insulation, rated voltage, design, running conditions and maintenance. Windings older than 35 years have insulation made of a viscous impregnating agent, as by time more or less have lost it's original quality and in many older plant it is important to give the generator new electrical windings. Newer electrical windings are insulated with quenching polymeric material with very good aging qualities. Regular control of the windings in the stator reduces the possibility of occurrences that could cause a sever damage.

#### **Failure in Switch Control Room etc.**

The electrical primary system from the generator to the transformer and grid outside has in larger plants a high short-circuit power. A short circuit with electrical arc will lead to considerable damages. The design of those system with connected equipment shall be of such level that the possibility of failure is on an acceptable level and the consequences are reasonable, not the less in respect of the personal safety. Old plants are often deficient in respect of this matter. Modern larger plants have as standard phase enclosed electrical tracks and primary apparatus, which make it safer.

The cables of the auxiliary power system are often laid in areas where access in case of a fire is very difficult. Besides, in old plants is the fire detection poor or nonexistent. The consequences of a cable fire varies of course, but can in worst case be devastating for the plant, not the less due to chloride contents in the fire smoke from fire in PVC -insulated cables

#### **Failure in Control Equipment**

Failure in control- and automatic equipment or in supervision equipment can give damages to the plant. The following examples can be mentioned:

A fault in the automatic synchronization equipment of the generator caused huge currents in the generator windings when the operator failed to phase the unit to the grid.

An unsuccessful cut out of the generator breaker can cause asynchronous running of the generator with overheating damages as a result.

Regularly control and preventive maintenance of the control equipment reduces the possibility for damages.

## **Disappearance of Auxiliary Power Supply**

Some occurrences with very severe damage to machine equipment in hydropower plants have happened due to disappearance of maneuver voltage and all control systems are out of function due to this. High reliability in supply of maneuvering voltage, for example with redundant systems or back-up functions are therefore very important to increase the safety. Many hydropower plants are now days equipped with a diesel driven generator as a spare, which gives the advantage to be able to start the plant without waiting for power on the grid. A secured power supply for opening of the dam gates is in addition of great importance to be able to handle emergency situations.

## **Failure in Transformers**

Transformers have a low statistical frequency of faults. The main transformer is the most important. The outage in case of a damage could be very long if no spare transformer is available. In many huge plants each phase has its own transformer unit and it is very likely that one spare unit is available.

## **Cracks and Breakage in Shovels and other Turbine Failures**

The frequency of damages to turbines of Francis and Kaplan is very low. The claims statistics does not show any systematic reason for faults. Damage due to kavitation on shovels is on the other hand very common. Kavitation causes decreased degree of efficiency and damages are normally repaired long before there is a risk for a damage to the turbine. Inspection and control of the turbine require emptying of the water ways such as head race- and draft tube and this is therefore done in interval of several years. The inspection interval could be shorter if there are special reasons.

## **Failure in bearings with Lubrication and Cooling Systems**

In power units with vertical shafts the thrust bearing is charged by the weight of both the rotating equipment and the water pressure on the turbine wheel which could be considerable at a plant with high vertical drop. Almost without exceptions has the thrust bearing hydrodynamic lubrication with automatic pumping of and external cooling of the oil. Disturbances of lubrication and supply of oil can rapidly lead to damage of the bearing due to the huge pressure on the bearing. Such a disturbance can occur due to a huge sudden leakage in the oil system, and even if the machine is automatically stopped due to low oil level in the bearing a sever damage can occur before the machine has rolled out. Even disturbances in the cooling system can cause damages, but the increase of temperature is normally so low that the machine can be stopped and roll out before any damage occur, provided that the control equipment is of good and high quality. The measuring of temperature should be done of both the oil and the metal of the bearing. Damages to other parts of the machine due to damages to bearing can occur but are very rare.

It is of importance to mention that an external pressurized oil system is of great importance. Such a system is standard in new plants and are often installed when upgrading older. This will decrease the probability for damages to the thrust bearing and it will facilitate inspection and control of the machine due to the fact that you can manually turn rotating parts.

## **Flooding of Machine Hall and other Room for Machinery Equipment**

A number of very sever damages have occurred due to flooding of the machine hall. The cause of flooding varies, in many cases natural catastrophes or dam break trough have the cause. The safety in respect of water damages should be considered separately for each plant, and preventing measures should be taken

## **Fire in the Machine Hall or other Engine Rooms**

The quality of fire safety varies from plant to plant. In new plants the fire protection normally have a high standard. In older plants the fire protection has often been improved gradually with installation of fire alarm, which has a close connection to the

fact that many plants nowadays are unmanned. A fire occurs more often in connection with handling of flammable liquids or hot works.

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### **3. Plant Safety**

To assure a safe operation of a hydro electric power plant it is essential to have well established programs for maintenance and supervision. Such a program should also include a schedule for necessary upgrading and renewal of the mechanical and electrical equipment within the plants. This is of importance not only for a cost efficient operation of the plant but also for safety and to avoid material damage and breakdown. With today's unmanned stations inspections take place according to a scheduled program and this puts a much higher demand on the reliability of the control and safety equipment than it did in the past. Certain types of occurrences, for instance flooding, are very difficult to detect automatically at an early stage in an unmanned power station and the consequence is an increasing level of risk.

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## **Insurances**

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### **1. Introduction**

The insurance solutions for hydroelectric power plants varies greatly from market to market. In markets where the operation of hydroelectric power plants have a long tradition you will find that insurance solutions also are advanced, and may vary from ordinary machinery breakdown and loss of profit insurances with relatively small or with very high deductibles, to more sophisticated financial type of solutions. You also find Captive programs and in some instances clients totally self insured and buying only technical and/or financial services.

In markets where hydroelectric power is new or less developed the insurance solutions are also often less sophisticated, often a compromise between local practice and requirements from International banks.

It should also be mentioned that hydro electric power plants are traditionally covered by CAR during construction or EAR during upgrading. The covers provided do not vary from what is usually found for similar projects. One should bear in mind that quite often a hydro electric power plant is mainly civil engineering works, like roads, dams and tunnels during the construction period.

This year IMIA is visiting a Swiss hydropower plant, and the Swiss delegation was asked to give a short outline how hydroelectric power plants are insured in Switzerland. This may vary from what is the insurance practice in other markets, but the working group decided that a global review of insurance practices as a comparison would be to extensive this paper.

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### **2. Swiss Insurance Practice.**

#### **History**

The content of this chapter is restricted to the machinery breakdown insurance and of business interruption following a machinery breakdown..

Towards the end of the past century the industrial revolution brought the commercial application of electric energy. As a result of this commercial development, the first machinery breakdown insurances started to appear on the market at around the turn of the century, alongside the existing machinery insurance of "steam-boilers". Owing to the electro-mechanical installation of hydro electric power plants having traditionally been part of the very initial equipment to be insured, the standard of insurance for such installations has reached a level which hardly allows for any substantial revisions or improvements.

## **General**

Today there are very few hydro power plant or installations, be it for the production or the distribution of electric energy, whose electro-mechanical installation is not insured against machinery breakdown.

However the philosophy employed by the various parties taking out insurance does vary greatly. e.g.: Large utilities prefer high deductibles, while smaller companies (mainly representing townships/communal interests, with small production facilities and invariably a large number of switchyards and stations for energy distribution) have the tendency to select low deductibles. In general, the complete installation is insured. However, there is a small group of clients who specifically request insurance only for components with a high risk potential.

In a country like Switzerland where the main portion of electricity comes from hydro electric power plants, there are two essential forms of insurance contracts:

- Mutual insurance solutions for utilities or similar companies, all being members of a named association, given by a group of insurance companies;
- Individual insurance solutions for each utility or similar company being member of an association, according to insurance conditions contractually agreed upon between that association and the insurance companies.

In addition there are also individual solutions.

In later years we have seen that the tendency to deregulate the market is increasing as well as the fact that less solidarity among insured parties has given way to more individual approaches. Companies are more interested in the development of their own individual insurance needs, rather than being bound to follow the development of the association's loss ratio and insurance conditions.

Business interruption insurances are only concluded on an individual basis. In general the insured party is a small company who needs to financially cover the loss of profit sustained as a result of a lengthy business interruption.

## **Insurance cover**

The machinery breakdown insurance is a classical "ALL RISKS" insurance. Basically all losses and damages of the insured machinery are covered, as long as incurred suddenly and unforeseeable and as long as not specifically excluded.

With the aim of providing a complete cover for an insured installation, and at the same time avoiding double insurance, the general conditions of the machinery breakdown- and property insurance have been developed complementary, as far as possible.

However, there are combined solutions "Machinery breakdown/Property Insurance" in the Swiss market, but only in very few and individual cases.

The machinery business interruption insurance, covering the loss of profit, is based on the conditions of the machinery breakdown insurance. Covered are, besides the

costs for energy (kWh), also and in single cases, the costs for capacity (kW).

The two mentioned forms of insurance go hand in hand and cover for machinery business interruption insurance without the existence of a relevant machinery breakdown insurance is not known, and definitely not recommended.

### **Sums Insured**

The correct determination of the sums insured for the Swiss installations is a constant problem which is not solved satisfactorily nor can it probably ever be solved satisfactorily. On one side there is the tedious procedure of actual price determination of the major components and on the other side there is the strong fluctuation of prices, especially in the prevailing and long lasting market of strong competition. Periodical checking of the installation, jointly between the insured party and the insurance company, can be a possible solution for renouncing underinsurance. Last but not least, commercial considerations must be applied also in dealing with this problem.

### **Development and Insurance Practice in the Swiss Market**

In the market of hydroelectric power production and distribution, the following developments, some are already introduced into the market, will be of importance to the insurance market:

- Unmanned stations with remote controlled operation;
- Peak-load operation of power plans, originally designed for base load operation, as a result of a surplus of electricity in Europe;
- Step by step liberalization of the European „Electricity-production and distribution market", officially starting in Jan. 1999 (Pressure on costs of investment and overhaul/maintenance).

Underwriters are asked to closely watch these developments and they are challenged to prepare and introduce insurance solutions, taking into account these market developments, at an early point in time.

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### **Large New Projects**

To give an example of the information available about individual projects reference is given to the following web site for a major hydropower project presently in progress.

Web site:

GE Canada-German consortium to supply six turbines and generators for China's three gorges hydropower project

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### **Environmental Impacts**

Hydro-electric power plants have many environmental impacts, some of which are just beginning to be understood. These impacts, however, must be weighed against the environmental impacts of alternative sources of electricity. Until recently there was an almost universal belief that hydro power was a clean and environmentally safe method of producing electricity. Hydro-electric power plants do not emit any of the standard atmospheric pollutants such as carbon dioxide or sulfur dioxide given off by fossil fuel fired power plants. In this respect, hydro power is better than burning coal, oil or natural gas to produce electricity, as it does not contribute to

global warming or acid rain. Similarly, hydro-electric power plants do not result in the risks of radioactive contamination associated with nuclear power plants.

A few recent studies of large reservoirs created behind hydro dams have suggested that decaying vegetation, submerged by flooding, may give off quantities of greenhouse gases equivalent to those from other sources of electricity. If this turns out to be true, hydro-electric facilities such as the James Bay project in Quebec that flood large areas of land might be significant contributors to global warming. Run of the river hydro plants without dams and reservoirs would not be a source of these greenhouse gases.

The most obvious impact of hydro-electric dams is the flooding of vast areas of land, much of it previously forested or used for agriculture. The size of reservoirs created can be extremely large. The La Grande project in the James Bay region of Quebec has already submerged over 10,000 square kilometers of land; and if future plans are carried out, the eventual area of flooding in northern Quebec will be larger than the country of Switzerland. Reservoirs can be used for ensuring adequate water supplies, providing irrigation, and recreation; but in several cases they have flooded the homelands of native peoples, whose way of life has then been destroyed. Many rare ecosystems are also threatened by hydro-electric development.

Large dams and reservoirs can have other impacts on a watershed. Damming a river can alter the amount and quality of water in the river downstream of the dam, as well as preventing fish from migrating upstream to spawn. These impacts can be reduced by requiring minimum flows downstream of a dam, and by creating fish ladders which allow fish to move upstream past the dam. Silt, normally carried downstream to the lower reaches of a river, is trapped by a dam and deposited on the bed of the reservoir. This silt can slowly fill up a reservoir, decreasing the amount of water which can be stored and used for electrical generation. The river downstream of the dam is also deprived of silt which fertilizes the river's flood-plain during high water periods.

Bacteria present in decaying vegetation can also change mercury, present in rocks underlying a reservoir, into a form which is soluble in water. The mercury accumulates in the bodies of fish and poses a health hazard to those who depend on these fish for food. The water quality of many reservoirs also poses a health hazard due to new forms of bacteria which grow in many of the hydro rivers. Therefore, run of the river type hydro plants generally have a smaller impact on the environment.

Web site:

<http://www.alternatives.com/libs/envdams.htm>

Environmental Issues Effect on people

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## **The Future of Hydro-Electric Power**

The theoretical size of the worldwide hydro power is about four times greater than that which has been exploited at this time. The actual amount of electricity which will ever be generated by hydro power will be much less than the theoretical potential. This is due to the environmental concerns outlined above, and economic constraints. Much of the remaining hydro potential in the world exists in the developing countries of Africa and Asia. Harnessing this resource would require billions of dollars, because hydro-electric facilities generally have very high construction costs. In the past, the World Bank has spent billions of foreign aid dollars on huge hydro-electric projects in the third world. Opposition to hydro power from environmentalists and native people, as well as new environmental assessments at the World Bank will restrict the amount of money spent on hydro-electric power construction in the developing countries of the world.

In North-America and Europe, a large percentage of hydro power potential has

already been developed. Public opposition to large hydro schemes will probably result in very little new development of big dams and reservoirs. Small scale and low head hydro capacity will probably increase in the future as research on low head turbines, and standardized turbine production, lowers the costs of hydro-electric power at sites with low heads. New computerized control systems and improved turbines may allow more electricity to be generated from existing facilities in the future. As well, many small hydro electric sites were abandoned in the 1950's and 60's when the price of oil and coal was very low, and their environmental impacts unrealized. Increased fuel prices in the future could result in these facilities being refurbished.

- **Conclusions**

Hydro-electric power has always been an important part of the world's electricity supply, providing reliable, cost effective electricity, and will continue to do so in the future. Hydro power has environmental impacts which are very different from those of fossil fuel power plants. The actual effects of dams and reservoirs on various ecosystems are only now becoming understood. The future of hydro-electric power will depend upon future demand for electricity, as well as how societies value the environmental impacts of hydro-electric power compared to the impacts of other sources of electricity.

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## **References:**

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