Claims history during the construction and erection of hydroelectric power

ITSEMAP

INTRODUCTION

The importance of the claims history during the construction and erection of hydroelectric power stations underlies not only the high cost of reconstruction or reinstatement of equipment in the event of claim, but also because of the effect on the period of execution of the works and delays in the start-up of the installation, with the consequent consequential loss. In the context of power generation, hydroelectric production systems are a viable and low cost alternative for electricity production and also contribute to reduce the impact of the Greenhouse Effect Gases released into to the atmosphere. These systems are now absolutely technically proven and mature. The construction of hydraulic power stations in the European context is limited to extending or modernising the existing stations. A greater use of hydro resources with the construction of new hydroelectric power stations is one of the points of focus on which Latin-American countries are focusing their power production capacity for forthcoming years. According to the OLADE (Latin-American Energy Organisation of the Energy), the level of use of the hydroelectric power in the region is only 22 % (source, June, 2013). On a global scale, approximately 16 % of power generation is obtained through the employment of this technology and an increase in the installed capacity is expected, principally in Asia, Africa and Latin America.

WHAT IS A HYDROELECTRIC STATION?

A Hydroelectric Plant is a power station that obtains electrical power from hydraulic force by using a hydraulic turbine. The hydraulic turbine transforms the potential and kinetic energy of water into mechanical movement. On installing a generator to the shaft of the turbine, the mechanical movement is converted directly into electrical current. The power of a hydraulic turbine (P) is determined by the product of the gravitational acceleration (g), the density of the water, the height or water fall (h), the flow level of the turbine (Q) and the output (η), typically with values of 85-95 %.

$$P = \eta * p * g * h * Q$$

Hydraulic turbines operate in accordance with typical curves that relate the aforementioned parameters.

TYPES OF HYDROELECTRIC POWER STATIONS

Starting from the concept of using electricity as described above, there are different types of hydroelectric power stations depending on the civil construction required for the topographical, hydrological or geotechnical conditions.

- **Conventional Stations (Dam)**, are those that involve the construction of a thick wall of diverse materials with the object of storing water in order to deviate or regulate its course.
- **Run-of-the-river Stations** are those where the station uses the force of the river´s flow and its fall to generate electricity without the need to flood the higher part by

means of a reservoir or to deviate the river from its natural course, taking advantage of the narrowing of the river bed to obtain greater water speed.

- **Pumped storage Stations** are accumulation or reversible stations whereby the water stored in a lower reservoir or water from a river is pumped to a higher reservoir for storage and later turbine generation.

TYPES OF HYDROELECTRIC TURBINES

Francis Turbine is a turbine with a radial flow that is widely used, generally where there a large heights and high water flow that favours high output generating Units.

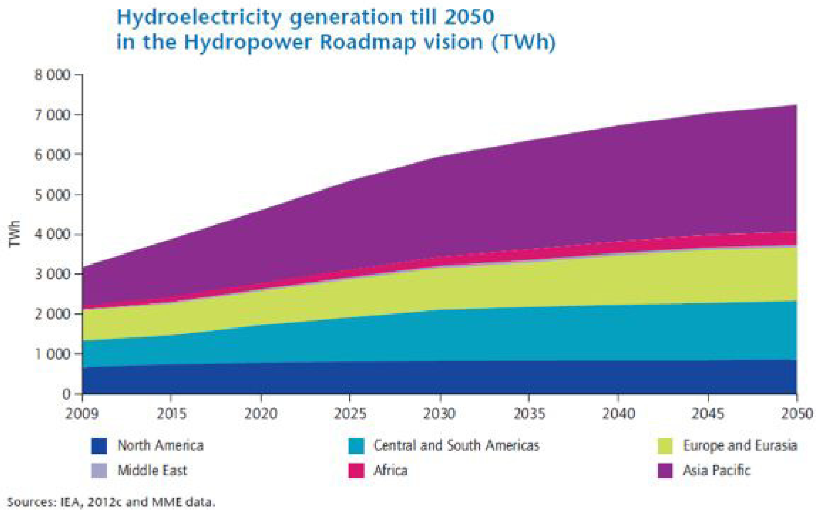
Kaplan Turbine is a propeller-type turbine with completely axial flow. It is used normally where the height of the fall (head) is lower than that where Francis turbines are installed.

Bulb Turbine is a special variation of the Kaplan turbine. These turbines are suitable for use with low heads and high flows and have the peculiarity that the electrical generator is positioned inside a casement or bulb.

Pelton Turbine is an impulse type turbine in which the potential energy from the height of the water is transformed into kinetic energy by means of injectors that project the water to the impeller that has spoons that transform the kinetic energy with the turning of the turbine. It is used where there are very large falls and low flow.

WORLD EVOLUTION OF HYDROELECTRIC GENERATION

Following the conclusions of the IEA report "Technology Roadmap: Hydropower, 2012", it is forecasted that hydroelectric generation could double its contribution by the year 2050, reaching 2000 GW of global installed capacity and power production of around 7000 TWh. This achievement, motivated principally by the quest for clean energy, could avoid up to 3,000 annual CO2 emissions from fossil fuel power stations. The bulk of this growth will come from installations in emerging economies and developing countries.



Gráfica 1. Proyección de generación hidroeléctrica

On a global scale, hydroelectric power is the technology with the greatest impact on renewable electricity generation and it is forecasted that this position will continue. As from 2005, the new hydro electrical facilities have generated more electricity than all of the renewable energies combined. The potential for new hydroelectric plants is considerable, especially in Africa, Asia and Latin America. In these countries, the large and small hydroelectric power station projects can help access modern electrical systems, alleviate poverty and drive social and economic development, especially in local communities. In industrialized countries, additional benefits can arise from the modernisation or improvement of existing power stations.

METHODOLOGY OF ANALYSIS

Research was carried out on the claims under construction and erection insurances for hydroelectric power stations in the MAPFRE portfolio. The main information source for the analysis of the samples was provided by the Century programme. Taking the policy number it was possible to examine the different claim files for the corresponding works. Following an in-depth analysis of the available adjusters' reports and correspondence, one could determine, for most of the claims, a series of defined fields that made it possible to obtain conclusions on the claims experience of hydroelectric works. The analysis of the characteristics of the works and hydroelectric power stations was carried out on the basis of the information provided by the insureds for the underwriting or renewal of the policies, although there is not always detailed technical documentation available. The information in respect of the policies for the works underwritten was extracted from Century application or from adjusters´ reports.

SAMPLES OF HYDROELECTRIC WORKS

As mentioned above, the samples of hydroelectric works were taken from the identification of a series of works in the MAPFRE portfolio. It should be emphasised that an attempt was made to increase the sample from information that could be extracted by class of business (e.g. reinsurance, IMIA), but it was not finally possible to compile sufficient technical / economic details from the claims found to be able to add them to this study. The sample comprises 9 hydroelectric works located principally in the Latin-American region, except for the La Muela II works located in Spain (see Table 1).

Table 1: Main characteristics of the works analysed

Works	Country	Client/Policyholder	Brief description of Works	Start Date	End Date*
LAJA	Chile	EÓLICA MONTE REDONDO	Nueva Power Station. Construction of a dam	Sept-09	Dec-14
LA MUELA II	España	IBERDROLA Generación	Increase of capacity for existing Power Station. Underground construction of the cavern and excavation for pipe for a higher existing reservoir	Aug-05	Sept-15
SAN PEDRO	Chile	COLBUN	New Power Station. Construction of dam and intake tunnel	Jul-10	Works stopped
ANGOSTURA	Chile	COLBUN	New Power Station. Construction of dam and intake tunnel	Jan-10	April-14
EL QUIMBO	Colombia	EMGESA	New Power Station. Construction of dam, auxiliary dike and intake tunnel	Dec-10	May-15
CERRO DEL AGUILA	Peru	CERRO DEL ÁGUILA	New Power Station. Construction of dam with tunnels for pipe work and cavern for machine room	May-11	Oct-15
LA CONFLUENCIA	Chile	HOCHTIEF CONSTRUCTORA CHILENA	New Power Station. Construction of 2 extensive underground tunnels (7-10 km) and no construction of dam	Feb-08	Feb-13
PANDO Y MONTE LIRIO	Panama	COBRA	New Power Station. Two Power Stations at waterfall (Pando - Montelirio) with construction of dams and tunnels	Sep-09	Dec-14
PEDREGALITO I y II	Panama	COBRA	New Power Station. Two Power Stations at waterfall with construction of dam at Pedregalito I	Dec-09	Nov-11

(*) Completion date or last estimate with information available.

Based on the analysis of the underwriting documentation and policies, the following information was obtained: It should be pointed out that within the samples of works analyzed there are differences in respect of the different covers taken out, particularly the purchase, or not, of ALOP cover(Millstone II), of different covers for errors of design, materials or erection (generally LEG 2), or cover / exclusion for machinery on site.

Hydraulic Power Station	Claims Nº	Material Damage €	BI Damage €	Total Damage	% Total Damage
LAJA	6	11,293,000	9,109,724	20,402,724	31.88%
LA MUELA II	3	16,735,604	-	16,735,604	26.15%
LA CONFLUENCIA	33*	13,589,064	-	13,589,064	21.23%
EL QUIMBO	7	7,540,887	-	7,540,887	11.78%
PANDO Y MONTE LIRIO	3	532,000	2,736,000	3,268,000	5.11%
ANGOSTURA	3	1,486,099	-	1,486,099	2.32%
PEDREGALITO I y II	2	466,129	171,000	637,129	1.00%
CERRO DEL ÁGUILA	1	342,000	-	342,000	0.53%
SAN PEDRO	1	-	-	-	0.00%
Total	**59**	**51,984,783**	**12,016,724**	**64,001,507**	**100%**

(*) The Confluencia has 15 claims for vehicle impact act the site and 8 claims for impacts to drilling machinery during the tunnelling works.

CLAIMS SAMPLES

The samples chosen corresponded to the following criteria:

- There were a total of 59 claims related to hydroelectric works, based on claims registered in Century.
- The study of the claims was limited to those with cover for Material Damage and ALOP and those claims and statistics in respect of Liability cover were not analysed or included in the statistics.

Based on an individual analysis of the claims, a series of fields was defined in an Excel table taking certain predefined lists and on completion it provided the analysis of the statistical results. The claims concepts analyzed were classified into three groups of data that included:

- **Analysis of the claim:** cause, damage or consequences, scenario and period of occurrence.
- **Valuation / Handling of the claim:** amount claimed, adjustment and applicable deductible.
- **Details of the works or installation.**

With a view to obtaining relevant conclusions, the amounts considered were always total 100 % figures, for both material damage and consequential loss; in the latter case both the financial loss and the number of days of stoppage.

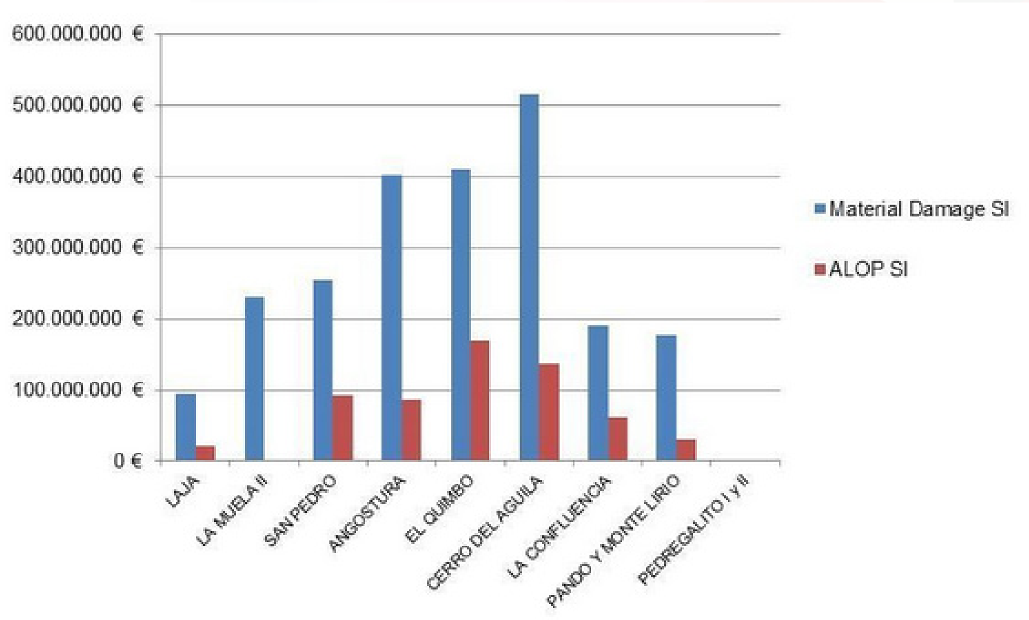
PRINCIPAL CONCLUSIONS

HYDROELECTRIC POWER STATIONS

- **Type of Power Station.** There were three different types of hydraulic Power Stations within the sample analyzed: Run-of-River, Pump and Dam, with a significant concentration of the sums insured in the latter, close to 72 %. Moreover the dam type Power Stations are those with the highest installed capacity, although La Muela has the highest installed capacity at around 850 MW.

Type of Construction	Sum insured €	% SI	Output [MW]	% Output
Run-of-the-River	**574,677,800**	**19.45%**	**273.4**	**10.72%**
LA CONFLUENCIA	250,771,120	8.49%	156.0	6.11%
LAJA	114,760,000	3.88%	34.4	1.35%
PANDO Y MONTE LIRIO	209,146,680	7.08%	83.0	3.25%
Pump/Reversible	**230,498,584**	**7.80%**	**848.0**	**33.24%**
LA MUELA II	230,498,584	7.80%	848.0	33.24%
Dam	**2,149,069,727**	**72.75%**	**1,430.0**	**56.05%**
ANGOSTURA	489,060,000	16.55%	316.0	12.39%
CERRO DEL AGUILA	652,840,000	22.10%	525.0	20.58%
EL QUIMBO	578,853,199	19.59%	400.0	15.68%
SAN PEDRO	346,560,000	11.73%	144.0	5.64%
PEDREGALITO I y II	81,756,528	2.85%	45.0	1.76%
Total	**2,954,246,111**	**100.00%**	**2,551.4**	**100.00%**

- **Distribution by works.** According to the underwriting information and the estimated contract values, significant differences were observed in the magnitudes, as shown in the following graph. There are three works with estimates in excess of 500 MM EURO for material damage, while the Laja Hydroelectric Station is below 100 MM EUR.



CLAIMS

- **Claims distribution by works.** The Laja works have a high claims record with almost 32 % of the damage in the sample.This fact is very significant taking into account its low weighting in the sum insured data shown under the previous point. Similarly, the high claims experience stands out at Laja because of the claim of approx. 14 MM EUR.

Hydraulic Power Station	Claims Nº	Material Damage €	BI Damage €	Total Damage	% Total Damage
LAJA	6	11,293,000	9,109,724	20,402,724	31.88%
LA MUELA II	3	16,735,604	-	16,735,604	26.15%
LA CONFLUENCIA	33*	13,589,064	-	13,589,064	21.23%
EL QUIMBO	7	7,540,887	-	7,540,887	11.78%
PANDO Y MONTE LIRIO	3	532,000	2,736,000	3,268,000	5.11%
ANGOSTURA	3	1,486,099	-	1,486,099	2.32%
PEDREGALITO I y II	2	466,129	171,000	637,129	1.00%
CERRO DEL ÁGUILA	1	342,000	-	342,000	0.53%
SAN PEDRO	1	-	-	-	0.00%
Total	**59**	**51,984,783**	**12,016,724**	**64,001,507**	**100%**

(*) The Confluencia has 15 claims for vehicle impact act the site and 8 claims for impacts to drilling machinery during the tunnelling works.

- **Claims distribution by countries.** With regard to behaviour for geographical analysis and taking into account the corresponding sums insured, Spain stands out negatively with La Muela claim and a high percentage of damage in Chile due to the large number of works analyzed and the Laja claims experience.

Country	Claims Nº	Total Damage €	% Damage	Sum insured €	% Sum insured
CHILE	43*	35,477,887	55.43%	1,201,151,120	41.82%
PANAMA	5	3,905,129	6.10%	209,146,680	7.28%
PERU	1	342,000	0.53%	578,853,199	20.15%
COLOMBIA	7	7540,887	11.78%	652,840,000	22.73%
SPAIN	3	16,735,604	26.15%	230,498,584	8.02%
Total	**59**	**64,001,507**	**100%**	**2,872,489,583**	**100%**

(*) High claims frequency in Chile due to the aforementioned effect of La Confluencia.

- **Distribution by type of Power Station.** Within the sample, there are three different types of Power Stations and the Run-of-the-River stations have the highest claims record, fundamentally due to Laja and La Confluencia. On the other hand and despite a greater concentration of sums insured, the conventional dam type of Stations represents only 15 % of the total damage figure.

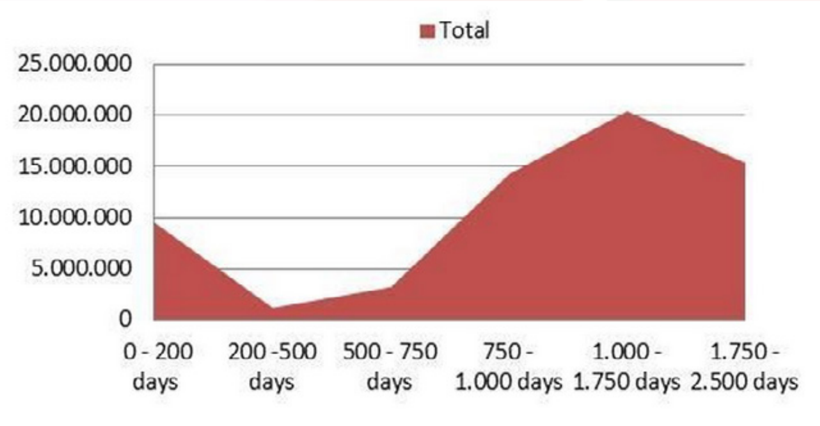
Type of Construction	Total Damage	%
Run-of-the-River	**37,259,788**	**58.22%**
LA CONFLUENCIA	13,589,064	21.23%
LAJA	20,402,724	31.88
PANDO Y MONTE LIRIO	3,268,000	5.11%
Pump/Reversible	**14,434,000**	**22.55%**
LA MUELA II	14,434,000	22.55%
Dam	**10,006,115**	**15.63%**
ANGOSTURA	1,486,099	2.32%
CERRO DEL AGUILA	342,000	0.53%
EL QUIMBO	7,540,887	11.78%
SAN PEDRO	-	0.00%
PEDREGALITO I y II	637,129	1.00%
Total	**64,001,507**	**100%**

- **Claims by project stage.** The high average damage arising during the final stages of the works (testing and start-up) stands out. In this respect two large claims occurred at the Laja and La Muela Power Station.

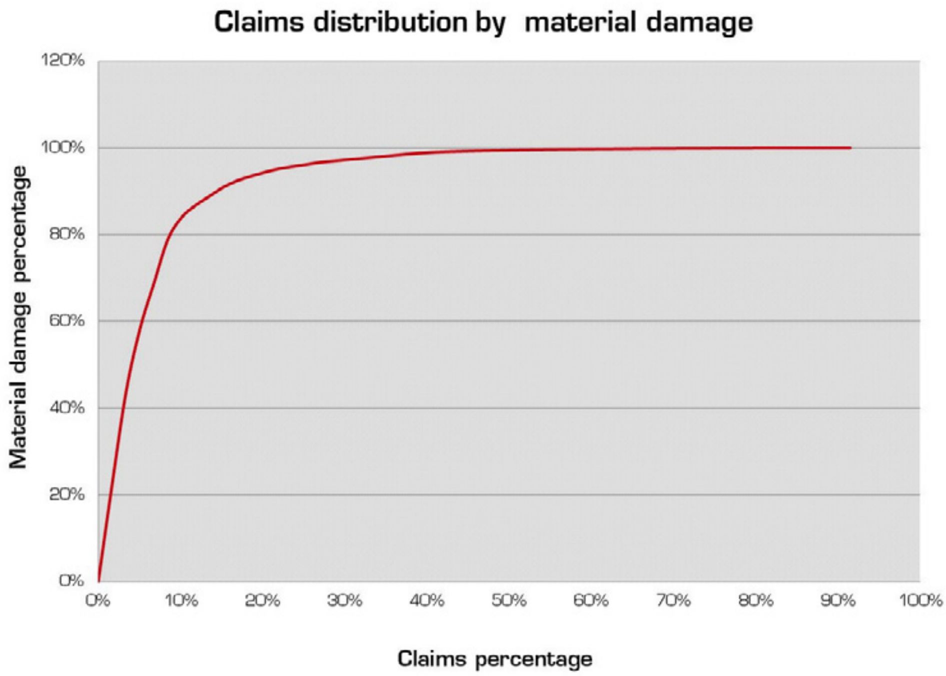
Phase of Work	Number of Claims	Total Damage €	Average damage €
Construction	54	42,267,385	782,729
Testing and start-up	5	21,734,122	4,346,824
Total	**59**	**64,001,507**	**1,084,771**

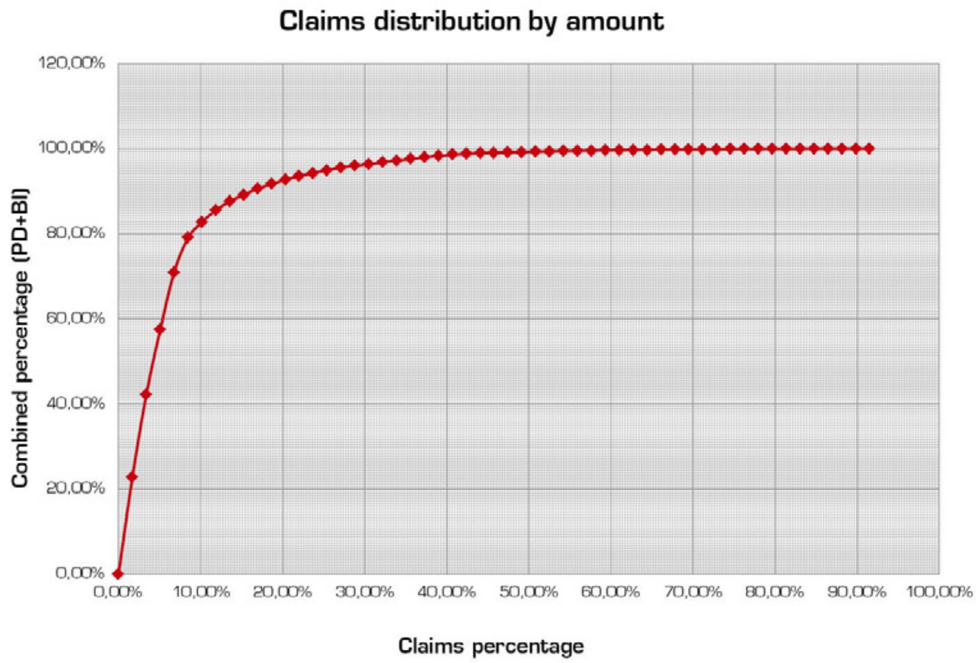
The following results can be seen when analysing in greater detail the period in which the claims arose.

Interval	Total Damage €
0-200 days	9,519,507,68
200-500 days	1,203,933,59
500-750 days	3,222,063,44
750 – 1.000 days	14,266,166,46
1.000 – 1.750 days	20,405,835,78
1.750 – 2.500 days	15,384,000,00
Total	**64,001,506,96**

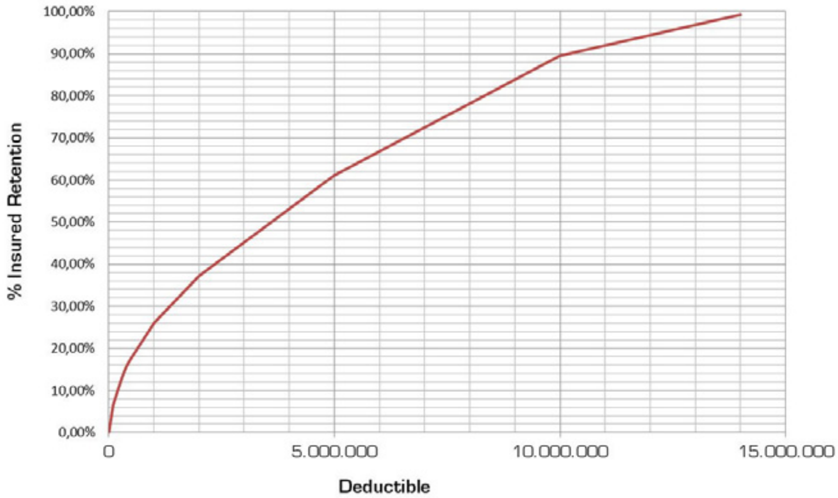


- **Claims distribution by amount.** It can be seen that a relatively small percentage of the claims, i.e. 5 (8 %), represent approximately 80 % of the overall total damage. It should also be pointed out the two largest claims of the sample (Laja and La Muela) represent almost 44 % of the combined losses (MD+BI)





- **Retention of the insured due to deductible.** On the basis of the claims analyzed, the following graph reflects the distribution of the claims by size (material damage) depending on the deductible.



- **Causas de los siniestros**. En cuanto a los grupos de causas se ve una clara incidencia de los fallos en Diseño/ Material (44%) seguido de Operación/Ejecución (32%), tanto en frecuencia como en importes, tal y como se refleja en el siguiente gráfico. Los siniestros como consecuencia de eventos naturales extraordinarios suponen alrededor del 20% del total de daños.

Phase of Work	Number of Claims	Total Damage €	Average damage €
Construction	54	42,267,385	782,729
Testing and start-up	5	21,734,122	4,346,824
Total	**59**	**64,001,507**	**1,084,771**

- **Damage Scenario.** With regard to the circumstances in which claims occur, the following significant information was found. Firstly, the high frequency for the Circulation of Vehicles scenario with a large number of claims for damages to machinery on the site of La Confluencia (15 claims). As a more probable scenario and with greater impact, loss of control or safety deficiencies were observed, to a great extent due to the impact of the two largest claims in the samples for La Muela and Laja.

Damage Scenario	% Affected	Frequency %
Inadequate control / safety	58.10%	32.69%
Flooding	18.32%	19.23%
Landslides	15.20%	3.85%
Fire	3.69%	7.69%
Earthquake	2.81%	3.85%
Explosions	0.99%	5.77%
Circulation of vehicles	0.88%	26.92%
Total	**100%**	**100%**

- **Elements causing the loss.** The importance of claims caused in tunnels is notable and the highest average amount of damage is close to 4MM€. This is followed claims caused by electromechanical equipment. With the exception of the high frequency of claims caused by mobile machinery, the higher frequency in electromechanical equipment, flooding and those involving construction (excavations, embankments, tunnels) stand out.

Element causing the loss	Frequency	% Frequency	Total Amount of Damage €	Total Damages %	Average Damage €
Electromechanical Equipment	8	13.56%	20,947,565	32.73%	2,618,446
Tunnels	5	8.47%	19,383,454	30.29%	3,876,691
Flooding	8	13.56%	10,472,476	16.36%	1,309,060
Embankments	7	11.86%	8,969,954	14.02%	1,281,422
Building/Structure	1	1.69%	1,332,546	2.08%	1,332,546
Accesses	1	1.69%	950,000	1.48%	950,000
Excavations/earth movements	7	11.86%	787,946	1.23%	112,564
Building/Structure/Cofferdams	1	1.69%	576,262	0.90%	576,262
Mobile Machinery	18	30.51%	550,818	0.86%	30,601
Unknown	3	5.08%	30,486	0.05%	10,162
Total	**59**	**100%**	**64,001,507**	**100%**	**1,084,771**

- **Consequences or Damaged Elements.** The consequences with the greatest average amount and worse consequences in terms of loss of associated profit are concentrated in the breakdown of electromechanical equipment. Nevertheless, a large percentage of the material damage amounts are principally construction damage. ■

Consequential Claims	Frequency	Total Damage MD €	Total BI Loss €	Average Amount
Electromechanical equipment breakdown	8	11,828,625	9,109,724	2,617,294
Damage to other infrastructure	10	12,131,131	0	1,213,113
Damage to the construction	17	27,381,630	2,907,000	1,781,684
Machinery / vehicle breakdown	24	643,398	0	26,808
Total	**59**	**51,984,783**	**12,016,724**	**1,084,771**

FINAL CONCLUSIONS

The following conclusions can be made following the analysis of the claims history:

- The sample analyzed comprises a limited number of works (9) and claims (59) of different types and magnitudes. Therefore one should bear in mind the limitations of the statistics presented.
- One should also take into account the difference in the coverages or deductible amounts which affect the information available for the works claims.
- The importance of the final stages of the works during testing and start-up of the Power Stations is notable. In these stages, most of the sum insured has been installed and equipment is subjected to pressure, temperature and power tests.
- Claims for large amounts arise in the electromechanical equipment and this emphasizes the importance of carrying out a rigorous control of the quality in the supplies from factories and in the design stage.