Water and sun, certainty and volatility:

IDEAL PAIRING FOR ELECTRICITY SUPPLY IN SIC

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One of the main characteristics of scientific communities related to astronomy studies tells of the connection with the location of clean skies that allows observation through appropriate tools of the space in which the planet is immersed. Chile is privileged in that regard as between the XV and IV regions it has clear skies, which can be translated into a high percentage, within one calendar year, of availability to perform observations. This has motivated the development of numerous investments related to astronomy, one need only think of La Silla, Tololo, Paranal, Alma, Las Campanas, and in the future the Gemini proyect.

The aforementioned quality of the skies in the north of Chile also applies to the excellent quality of solar radiation levels, which can be used in terms of electric energy generation, in an average daily period of 8 hours. The latter condition reveals a clear disadvantage for the development of this type of projects, taking into consideration the current energy trading schemes in the national electrical market. To the aforesaid situation, operational problems stemming from electrical systems which do not have important contributions of hydroelectricity in their generation matrix and where major solar power generation blocks with respect to the size of the system are to be installed. Despite this, this type of generation under the skies of the north of Chile provide an advantage that is not generally taken into account and that, when analyzed in detail, is unique when compared to hydroelectricity and wind power generation. In order to visualize this advantage, consider Chart No. 1 and Chart No. 2.

Chart No. 1 shows the solar radiation records taken on a ten minute reading basis, 24 hours a day, for 5 different days. The shape the curves take, the magnitude of the associated radiation, as well as the fact that said magnitude is similar at the same time of the day, make it possible to pose that there is a high certainty that there will be the same solar radiation characteristics in the future to generate electricity; that is to say, this energy source represents a very low risk, given that the future availability profile is highly deterministic, characteristic that sources that use wind for the generation of electricity do not have. Chart No. 2 shows the wind record of five consecutive days, in which the reading was taken every 10 minutes. At a hydrological level, the background indicated in Chart No. 3 show the historical profile of the Energies.

Chart No. 1: Radiation record every 10 minutes, W/m2, 24 hours

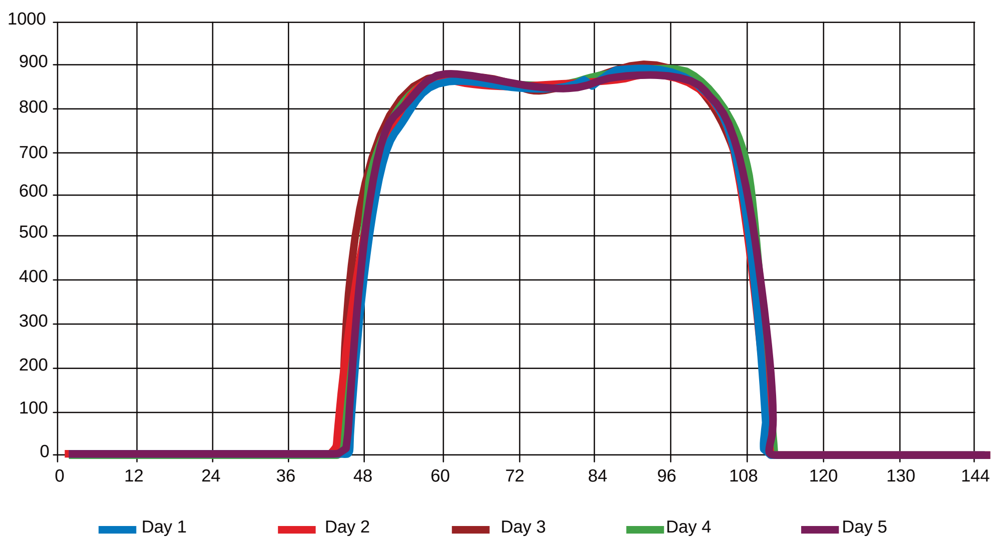
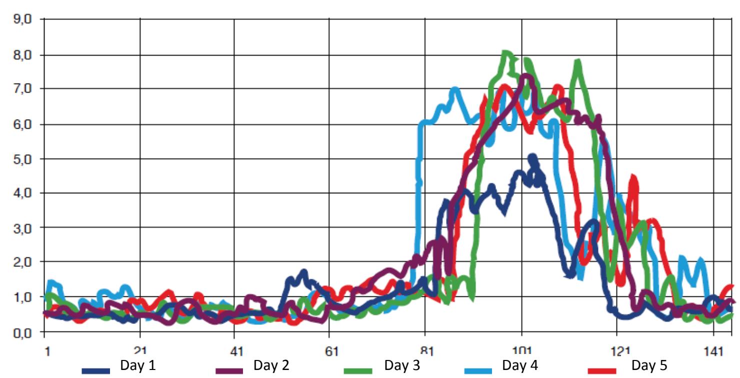


Chart No. 2: Wind Speed [m/s], every 10 minutes, 24 hrs.



Tributaries of the SIC system, period from 1960 to 2008, expressed in °/1 of the historical average.

Given the high volatility of the hydrological profile of the SIC system for electricity generation compared to the low risk profile based on solar radiation, a complementarity between both generation sources (solar and hydrological) can be considered, in order to improve the electricity generation capacity of the SIC system when facing dry hydrologies. This complementarity is valid due to the fact that the SIC has the capacity to collect water, so that in the presence of dry hydrologies, water can be stored for the equivalent of the energy injected by solar power generation. To visualize the effect of the mentioned complementarity, the respective studies were performed. For that purpose, a stochastic model that included the following characteristics was developed:

a) From the 49 existing hydrologies, the first 23 hydrologies from the driest onwards.

b) Each hydrology is expressed in °/1 with respect to a value of 25,776 GWh.

c) The hydrologies are modeled as a continuum, whose value is determined according to the numeral that arises from a uniform distribution whose numbers vary randomly from 1 to 23. The resulting value of the uniform distribution is not necessarily an integer number; the only restriction is that it must be within the indicated range.

d) Three scenarios for the development of generation based on solar power are considered, a block of 250 MW, one of 500 MW and another one of 1000 MW.

e) For solar power generation a period equivalent for 8 hours is considered and that represents the time in which the units inject electricity into the network.

f) For the solar power generation units, an average generation of 95% of its capacity is considered, with a modeled forced departure rate as an lognormal distribution of an average 3% and a standard deviation of 3%.

The performed shaping seeks to determine the improvement of the risk profile of the SIC system when this faces any of the hydrologies within the 1 to 23 range, due to the incorporation of solar power generation. The analyses are repeated for each of the solar power generation blocks considered in the study based on the stochastic analysis and 100,000 iterations.

Chart No. 4, highlights the improvement

achieved in the risk profile of the SIC system before the hydrologies being studied with the presence of solar power generation of 500 and 1,000 MW. Indeed, the 5% percentile of the base scenario, which corresponds to an energy volume of 0.537 °/1 (or 13,842 GWh) jumps to a value of 0.587 °/1 (or 15,131 GWh), which is equivalent to an additional contribution of 1,289 GWh, with the introduction of the indicated solar power generation. In the cases of the behavior of the SIC system with the operation of solar power generation in the 250 and 1,000 MW, These are shown in Table No. 1. From the results given, the positive effect of having solar power generation in the SIC system whose generation capacity strongly depends on hydrological conditions as they present themselves is clear.

Chart No. 3: SIC Tributary Energies °/1 in of the historical average, 1960 - 2008

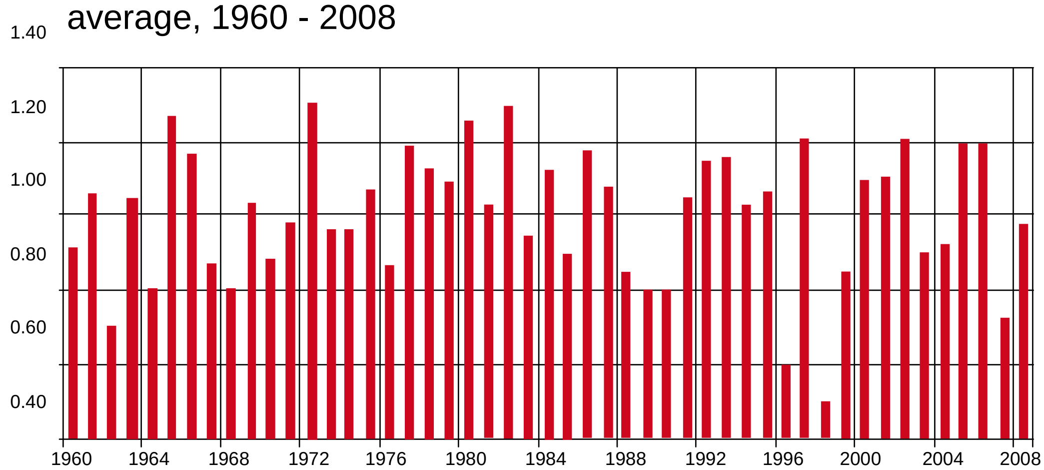
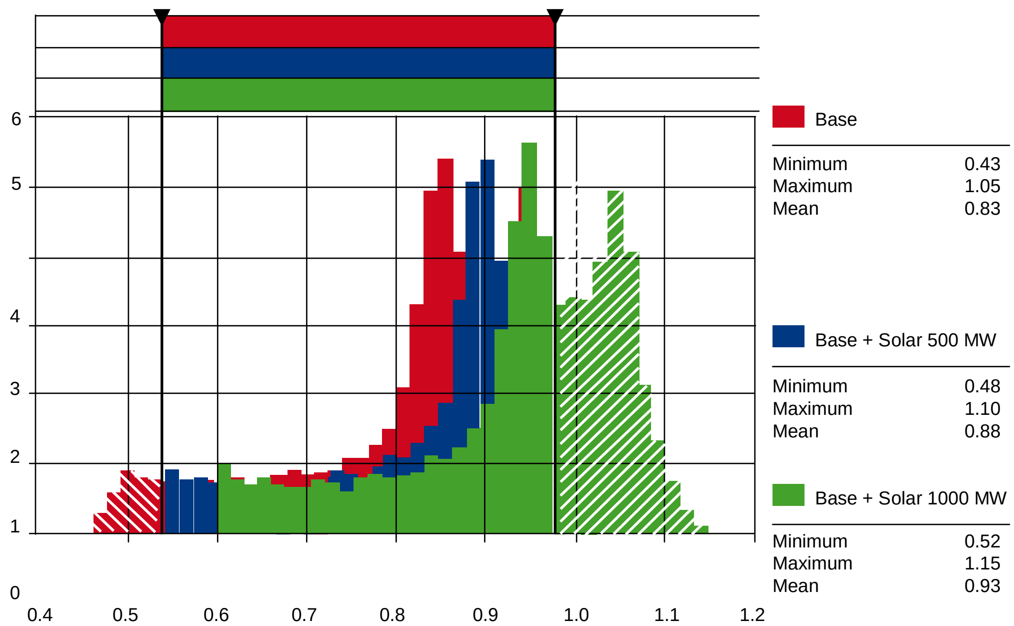


Chart No. 4: Base Base with Solar 500 MW and Base with Solar 1,000 MW base.



In July 2008 a solar measurement station with a tracking system was installed in the north of Chile. The objective of these measurements is to know the potential of global and direct radiation for a possible use of the solar power in the north of Chile for energy efficient production. The station is located in Pozo Almonte, in the Pampa del Tamarugal in the Tarapacá region.

The system was installed by commission of the German Technical Cooperation agency (GTZ) within the framework of the 'Non-conventional Renewable Energies' project implemented by the National Energy Commission (CNE) and GTZ under the agreements of the intergovernmental cooperation between Chile and Germany.

TABLE No. 1: **5% PERCENTILES ACCORDING TO OPERATION SCENARIOS.**

	5% Percentile		Difference
Scenario	°/1	GWh Year	GWh Year
Base	0.537	13,842	- Base
+ Solar 250 MW.	0.562	14,486	644
Base + Solar 500 MW.	0.587	15,131	1,289
Base + Solar 1000 MW.	0.636	16,394	2,552

of hours a day is relevant especially in drought scenarios. Water is stored while the minimum hydrological generation is substituted by solar power generation; the result of this is immediate for all users: the spot market prices would be lower and over all, it dispels the uncertainty of performing power blackouts where everyone can be affected. In hydrological non-drought conditions, the effect

transmission systems, in which the users who receive the benefit pay the difference between the development cost and the income and the marginal cost perceived by the owners of the solar technology.

Incorporating solar power generation, makes the Economic Load Dispatch Center and the CNE perform the studies that tend to determine the amounts in MW to be installed, to develop the tender for the required blocks, calculate the fees with regular updates; as well as requiring

The results of the improvement of the hydrological risk profile of the SIC system due to the introduction of solar power generation merit an in depth study. Unfortunately, the current electricity market conditions are not attractive for a generation source of the type studied, due to its generation characteristics, associated costs, as well as the fact that the market operates with supplying end clients in mind. The aforementioned is attractive, a conjunction that clearly creates a benefit for the country is not used and that due to market reasons is not developed: therefore it is here

that the authorities must make themselves present in order to loosen this type of situations. The conjunction that the SIC system faces currently, given the existence of preventive rationing decree valid until April 2012, leads us to understand and make emotional the topic being discussed.

From a finantial point of view, solar power generation represents the equivalent of a "rain" insurance for the SIC system, especially for hydroelectric plants that operate with reservoirs to impound water; in fact, having a high certainty of solar power generation during a certain quantity

would also be positive, water is stored, lower operation costs and lower spot market prices. As the benefit is received by all end users as well as by hydroelectric plants with reservoir capacity, the cost of this "insurance" must be prorated between all of them, allowing making the development of solar technologies attractive. A business scheme in which solar power generation is taken as an "insurance" of the proposed type, the discussion in regards to recognizing stable power for solar power plants looses validity. A payment scheme of this technology should be similar to that of the existing

the solar power plant operators minimum availability of energy injection to the network so that the "insurance" being contracted operates according to the requirements, incorporating financial compensations in case of not fulfilling the promised solar power generation injection.

Additional advantages to those already mentioned and that are related to the environmental topic are also present: less contribution to the carbon footprint as well as a direct contribution to the goals that the country has set for itself in terms of increasing the NCRE percentage in the generation matrix.