Seasonal Climate Forecasting and Electricity - A case study

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The main purpose of this lecture is to give an outline of the way meteorolgy is impacting our activity of producer and distributor of electricity and to give an idea of the possible interest of seasonal forecasts when they will be available.

Some numbers linked with the EDF activity

EDF is the french electricty board (a nationalized company) which produces and supplies electricity in France. The structure of the electricity generation system was as follows in 1997 :

Thermal generation	392,5 TWh
Nuclear	376 TWh
Classic	16,5 TWh
Hydro generation	61 TWh

Total EDF 453,5 TWh
Total national 481 TWh

It is worthwhile also to mention that our company exchanges electricity with its european neighbours with the following picture in 1997 :

United Kingdom	16 TWh
Benelux	5 TWh
Germany	17 TWh
Switzerland	11 TWh
Italy	18 TWh
Spain	3 TWh
Total	60 TWh

(imports : 4,2 TWh)

Facts showing the importance of climatology and meteorology in the management of electricity facilities

Firstable ***electricity is an unstorable product***. One must therefore : adjust in real time electrical power generation, plan hydroelectric reservoirs use (several months), plan thermal power facilities maintenance (several months), and at last adjust the future investments (power generation and networks). Moreover ***different time scales have to be considered*** in the management of facilities, as :

Investment studies and tarification policy > 5 years
(production utilities planning, fuel purchase,.....)

Production utilities management

- REP refueling planning	5 years
- Management of water reservoirs	1 year
- Planning of production units	some hours to 1 day
- Driving the production system	minutes to seconds

The goal is to satisfy electricity demand at lower costs together with a good quality of service.

One must then: adjust in real time elctrical power generation, plan hydroelectric reservoirs use (several months), plan thermal power facilities maintenance (several months) and adjust for the future investments (power generation and networks). In doing so one must take into account first that **electricity consumption is linked to meteorology** (electric heating, lighting, air conditionning) and that **electricity generation is also linked to meteorology** (hydropower/precipitations, nuclear and fossil-fuel power (river flows, temperature). Some figures can be given to illustrate the climate impact on electricity: 1°C less during seceral days in winter means a unit of 1300 MW more in service, 55 Twh on 385 Twh were linked to meteorology in 1992 in France, and in the mild winter of 1989/90 one experimented 10 Twh less generation.

Involvement of EDF/Division R&D on climate issues

EDF participated in the PROVOST program to assess the feasibility of seasonal climate prediction through forced atmospheric simulations calculation and analysis, and to study how such results could be used in the system designed to optimise the yearly management of electricity production facilities. We report then the use of multi-model (all seasons) ensembles to give probabilities of occurrence of each of a number of different electricity consumption time series, issued from temperature distributions observed over France in the past.

Climatic hazard is one factor important to take into account in the yearly electricity generation facilities management. For instance at EDF, it is taken into account through 114 consumption scenarios which are based on passed annual temperature time series over France and are considered to be equiprobable. The time series consist of daily observations of temperature over France for the years 1879 to 1992 and of daily associated electricity consumption. The temperature is measured at Paris Montsouris for the years 1879 to 1959 and corresponds to a mean over France afterward. We formulate here the ensemble simulations results in an appropriate form to attribute to each scenario a probability of occurrence (a priori different from equiprobability) depending on the ensemble predictions for any given month of the period (seasonal prediction information being only pertinent on an aggregated scale, monthly averaged variables have been taken into account). The ensembles involved are the four models simulations of all the seasons simulated in the PROVOST project (36 simulations per winter season and 27 simulations for other seasons).

Two methods have been proposed to use seasonal simulations to attribute different probabilities of occurrence to each of the scenarios. The first one is based on the calculation of probabilities associated to temperature clusters that are previously defined on the set of 114 scenarios; the second one estimates from the N simulations taken into account for a given event, a density probability function (kernel method) which gives the probability associated to each of the temperature scenarios.

The main conclusions are:

- the sets of probabilities issued from the second method are more stable and easier to interpret as independent from any previous clustering on the scenarios,
- the results of the multi-model are more regular than the results issued from individual models, and they provide and good deal between qualities and drawbacks of each model,
- it brings globally an information to involve the simulations in the calculation of probabilities in 65% to 75% of the cases (multi-model results, second method), this percentage involving the totality of « near-normal » months,
- most of the failure cases concern extreme events of temperature (either cold or warm events), which are of crucial interest for the management of electricity production. The probability density functions built from the simulations of cold or warm events display in many cases a correct shift towards temperature extremes, but this signal is never strong enough for high probabilities to be attributed to extreme temperature scenarios.