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WET SNOW MANAGEMENT

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- ABSTRACT -

Forecasting wet snow episodes and modelling wet snow accretion on overhead power lines will allow to take preventive decisions in different fields in order to decrease the harmful effects of a power failure by wet snow overloads.

Mapping the climatological risk including wet snow, rime or glaze problems, will be useful to be established for design of new lines as well as reevaluation of existing lines.

Data bank and sofware system are proposed.

I- INTRODUCTION

We know that wet snow episodes or rime events, of an exceptionnal intensity, can cause an exceptionnal damage on overhead power lines. Not only France and Japan are exposed to this technological hazard, but also are Canada, Russia, Britain and likely many countries of the temperate belt. These events not only disturb the Electrical Company's organization over a long time, but also the whole human activities in an area. The economical consequences are considerable. The financial cost of a severe damage is assessed to be about 70 million dollars in charge for the Company, to which the production loss of the local activity should be added.

At the present time, methods for forecasting and prevent the damages are being investigated in France and Japan. Data processing software adapted to the management of important technological hazards are also available to improve the forecasting, localizing the high risk areas, computing the consequences, setting up the prevention systems and anticipating the arrangement in any field affected by a possible damage: that is to say if on-line data are available and are introduced into data bank, it will be possible to manage a damage.

II- A WORKING TOOL: A DEVELOPPING MODEL

A first model for wet snow accretion was developped by GRENIER and al., (this workshop). It deals with cylindrical-type accretion, which is the most common mechanism for overhead lines. It will soon be followed by an axial-type accretion model which the torsional rigidity of conductors will take into account.

Likewise, the local climatic peculiarities are still neglected, as well as the thickness of atmospheric stratification governing the liquid water content of snowflakes. Many details about the topography, direction and resistance to overloads of lines are not taken into account yet.

In spite of these imperfections, this primary model could be very useful for setting up a preventive method in not-blind conditions :

As an example in Japan, Hokkaido Electric Power Company has carried out some system operation to increase the electric current in the power lines located in the area where severe damages were expected, and they have experiences to prevent damages successfully: in some cases, they switch off one circuit from double circuit line (in this case load flow of the second circuit is doubled), and introduce enough current to prevent wet snow accretion from lower voltage source to short circuited.

At the present time, these operations are carrried out in blind conditions and sometimes HEPCO experienced severe damages (WAKANAI, dec.1, 1972) :

Applying the previous model to the meteorological conditions of this episode, we can see on table 1, that snow overloads reached beetwen 6 and 3 kg.m-1 at 9.00 local time (time of damages on 33 kv line), beetwen 12.6 and 8.2 kg.m-1 at 12.00 local time (time of damages on 100 kv. line). We can also see that a Joule effect of 40 w.m -1 should have been applied for complete preventing action. In this case lines would have been saved.

III-POSSIBLE APPLICATIONS

III-1 MAPPING THE RISK

Mapping the risk provoked by wet snow, rime or glaze to overhead power lines consists in choosing, quantifying and localizing variables and functions which characterize this risk.

This choice should be done in the framework of a range wide enough to avoid arbitrary tendancies, but narrow enough to allow for the creation of a tool for effective decision and action.

This choice can be made from deterministic, aleatory and tendential criteria.

-The deterministic approach consists in the definition of a risk scale analogous to that of earthquakes or wind.

-The statistical approach takes into account the specific nature of a risk which has a climatologic component, that is a natural component. Natural risks follow peculiar statistic laws for their intensity (exponential law) and their time distribution (rectangular law). These variables will lead to the definition of events with determined return periods and confidence intervals.

-The tendential approach consists in the integration of the socio-economical factor which disturbs the statistical factors. This tendential factor has consequences which become more and more important with time. For instance the extension of power networks, the spreading of urban areas and development of industry are tendential factors and the consequences of a same event at different periods would be quite different.

At last, the risk takes into account conditions which stay unaltered at the human scale, for example topography and relief.

Thus definition and characterisation of risk will lead to the definition of zones with quantifiable risk: these zones could be mapped and processed with the help of computers.

Which is the level of sharpness we may hope to obtain in such maps? It can only be a compromise between the available information and the realistic result which is wished for. For example, a ten to thirty kilometer mesh would represent a good choice.

This mapping will then become a tool for elaborating new conditions of contract giving details about elements entering the frame of active and passive risk protection.

-definition of new standards of active protection (use of Joule effect) and passive protection (constraints concerning strength of materials) for a determinate risk on the previous scale.

-refitting of existing power lines; definition of new standards would cover the reinforcing of existing equipment.

III-2 ASSISTANCE TO DECISION FOR ACTIVE PREVENTION

In the introduction, a simple example concerning the Wakanaï wet snow episode makes prominent the effectiveness of use of Joule effect as active mean of prevention.

In the following example (table 2), we propose the management of Joule effect on two parallel lines transmitting power from one zone A to a zone B.

We select four levels of risk:

-level one :no change(two lines servicing)

-level two :one line servicing alternately with 20w/m

-level three:one line servicing alternately second line short-circuited, special Joule effect by low voltage source

-level four :two short circuited lines, transmission interrupted, special Joule effect by low voltage source

This mastery of Joule effect as a mean of prevention supposes a good knowledge of variables of the risk which affects the two lines and the mastery of real time computation. Thus it is not a "blind" method. It is less expensive than repairs.

The counterpart of these constraints is evident and favourably affects the mental picture of the Company by consumers. A better hazard forecasting, a better coordination of action, faster repairs are so many advantages for the public or private Company and its reputation with consumers.

III-3 MANAGEMENT OF A TYPE OF DAMAGE

In our hypothesis, we are ready to forecast a new event which has not yet happened, but we have the synthesis of past events thanks to the collected, stored and processed information and to the model.

Management can then be divided into four following steps:

-III-3.1 Calculation of expected risk: this is done with the space and time characteristics: the 24 hours meteorological forecast will give the localization and level of risk, taking account of geographic and orographic data.

-III-3.2 Survey and decision:real time computation (computed values are compared to observations), whenever necessary,the values are modofied;displacement of the model along power lines to locate the breaking points;choices of intervention (Joule effect...).

-III-3.3 Damage management:since the share of improvisation during and after a damage must be kept as low as possible, the knowledge of avaible staff and stocks and of the constraints (physical damages,areas of priority,temporary or permanent repairs, access to areas...),the model generates a simulation which brings through the planning of the work.

-III-3.4 Balance sheet of the damage:when there is no longer emergency,the next step allows for the set up of the balance sheet (adjustement of statistical and financial calculations) and for the inventory of what else could have been done:the model is run for research instead of forecasting.

The set up of a system for the prevention and management of a first importance natural and technological hazard allows for a reasoned organization and produces a working profit both at the quantitative an qualitative level:decrease of the cost of damages,unsold power and also decrease of consumers losses (for firms).

Of course the detailed statement of the balance sheet will be given by adjustement on the computer of:

-the analysis of type damages,the beginning of which is shown on figure 1 and which gives localization,type and importance of damages.

-the cost-versus-frequency graphs,for each zone,for each type of damage and on the whole,an example of wich is shown on figure 2. The annual raw profit is obtained by substracting the mean value of damages without and with prevention management.

We must emphasize that there are qualitative aspects besides these graphs, for instance the shortening of the failure duration,the mental picture of the Company with the consumers and also the improvement of future lines construction projects.

-III-THE INFORMATION TO BE PROCESSED AND THE CONSTRAINTS TAKEN INTO ACCOUNT

Naturally,hazard prevention and risk management provoked by wet snow,rime or glaze demand a good quality information available in the right time.

Files are numerous and of many types,they give access to:administration data,such as the network of power and dispatching units; the potentialities of weather stations and/or of the company's own stations;snow physics,electrical,mechanical and topographic characteristics of power lines, the staff available in case of damage;the available intervention equipment,the spare equipment...

Bibliography with descriptive files will have to take into account the nature of information on natural and technological hazards (few papers, in several languages, but often of a high technical level).

Particulary important are the data which give the raw material of information event by event.This information is not limited to the scientific and technical aspect,but also includes any record on known events:

-The meteorological information at reliable weather stations with long series of records,at close specific stations with shorter series of records and at particular networks for special information in real time.

-Material damages,temporary or permanent repairs,including human,material and financial aspects.

One must observe that raw data are quantitative data,even the mapping and the photo record,that these data are automatized and that their structure is such that the internal compatibility is global (for instance the files and the mapping are not independant).

All these data must be automatized after checking their quality within a compatible stucture and worked out with the model.

To manage such a type of information,the Company can have several hierarchic levels of decision,namely the central organism, the computer section,the field units.For example,the staff will have a background or education well adapted to their duties: shaping of data,using model managing field operations.

Ten years ago such a management needed a big computing centre.Since year 1985, scientific micro-computers allow to clear up the difficulty in good conditions, provided one is very watchful for the normalization of material and the compatibility with other equipment and programs.The hardware and software investment is then today on current material.

CONCLUSION

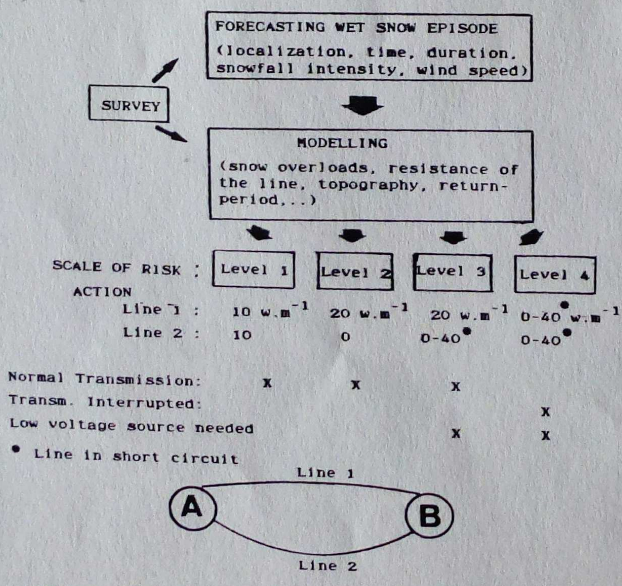
It is possible to have a current and efficient tool for the management of an important hazard adapted to wet snow and also,in the way to rime or glaze,in many countries.

The investment cost is low with regard to the cost of disasters.Considering a decennial risk as a reference (return period of ten years),in first approximation this cost can be estimated to about 1 to 2 % of the cost of a damage of a reference risk.Besides,the computing cost (micro-computer,programs,education) is about 10 % of the total investment.

Lastly, on the basis of studies made for another hazard (flood, G.DUMAS, 1974), the profit is estimaterd to be 30 to 40 % of the mean annual cost of disasters before prevention.

METEOROLOGICAL CONDITIONS				SNOW OVERLOADS (Kg.m^{-1})			
				Joule Effect			
				normal		special	
Local time H	Wind speed m.s^{-1}	Air temp. °C	Snowfall intensity mm.h^{-1}	0	10	30	40 w.m^{-1}
24	15.0	1.0	3.5	.3	.0	.0	.0
03	14.0	1.0	4.5	1.0	.0	.0	.0
06	11.0	1.0	5.5	2.5	.7	.0	.0
09	12.5	.5	11.2	6.2	3.2	1.2	.0
12	18.5	.5	14.5	12.6	8.2	4.9	.0
15	21.0	.5	14.0	20.7	14.8	10.4	.0
18	23.5	.5	11.0	28.7	21.8	16.3	.0
21	23.5	1.0	8.3	34.6	27.0	20.8	.0
24	21.2	1.0	2.8	37.7	29.7	23.8	.0
03	16.0	.5	1.8	39.0	30.9	24.2	.0

Table 1 : Computed snow overloads for WAKANAI episode,dec.1, 1972, showing the theoretical preventive effect of electrical supply up to 40 w.m^{-1}, while under normal Joule Effect (beetwen 0 and 10 w.m^{-1}) damages occur at 8.57 for 33 KV line and 12.13 for 100 KV line.



SCALE OF RISK :	Level 1	Level 2	Level 3	Level 4
ACTION				
Line 1 :	10 w.m^{-1}	20 w.m^{-1}	20 w.m^{-1}	0-40• w.m^{-1}
Line 2 :	10	0	0-40•	0-40•
Normal Transmission:	x	x	x	
Transm. Interrupted:				x
Low voltage source needed			x	x

• Line in short circuit

Table 2 : Forecasting, Modelling and Assistance to decision for active prevention

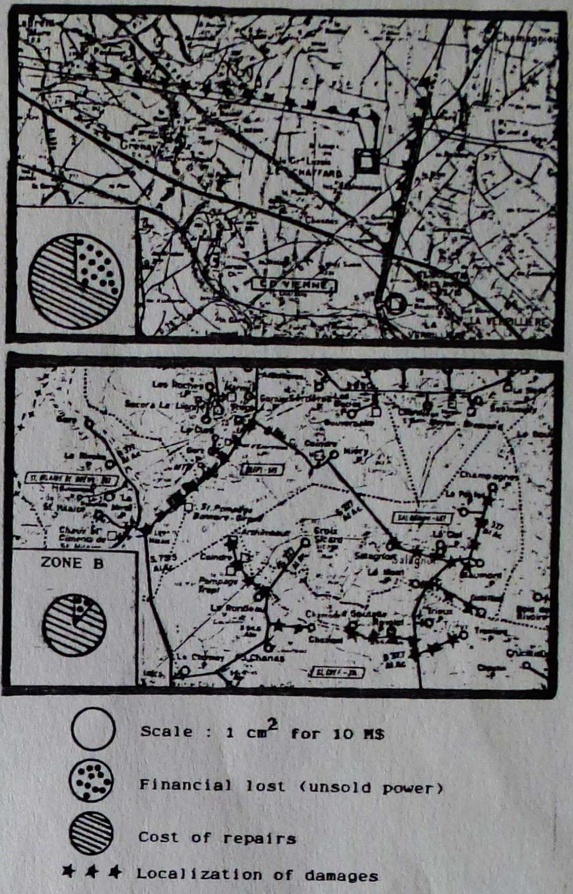


Figure 1 : Detailled economical analysis of the same event, in two different zones (for example in 1984).

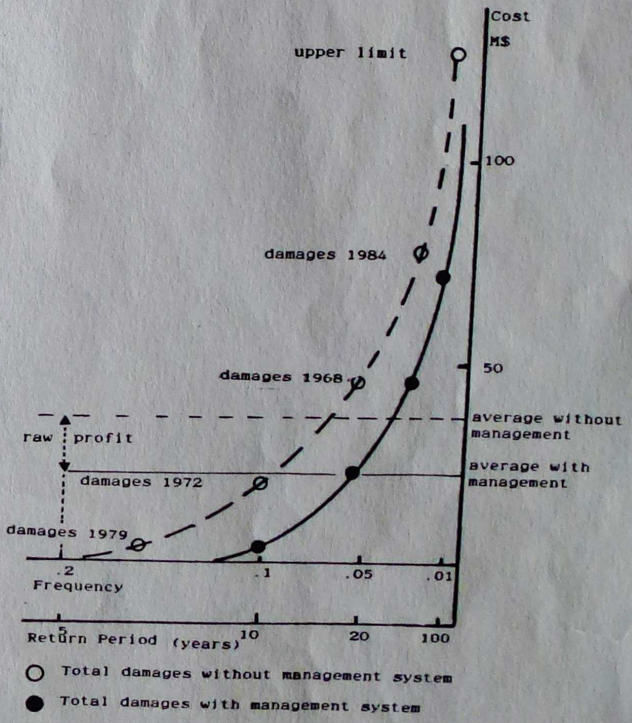


Figure 2 : Cost-versus-frequency graph, for zones A + B, over last twenty years.