DAY AHEAD CONGESTION FORECAST FOR A SECURE OPERATION OF THE EUROPEAN TRANSMISSION SYSTEM

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Abstract – This paper presents the Day Ahead Congestion Forecast process in operation among European TSOs to help them to ensure the security of the European transmission system. Some statistics are presented to show the variability of aggregated physical flows on cross border tie lines then DACF process is described and an example of results is given.

Keywords:* *Congestion, Operation, Mega grid, Transmission System Operator

1 INTRODUCTION

The liberalization of the European Electricity Market brought major changes and new challenge to the TSOs' environment. In this new context, each producer and consumer wishes restrictions on trade to be reduced as much as possible. Power flows become higher and more dynamic while a significant increase in congestion arises on the European grid when transmission line capacities cannot always cope with energy flows. To prevent severe impact to reliable operation a new process has been approved by all 35 UCTE (Union for the Co-ordination of Transmission of Electricity) members in 21 European countries to predict congestion on the electricity transmission system. This early warning system helps to ensure security of supply in the market opening context.

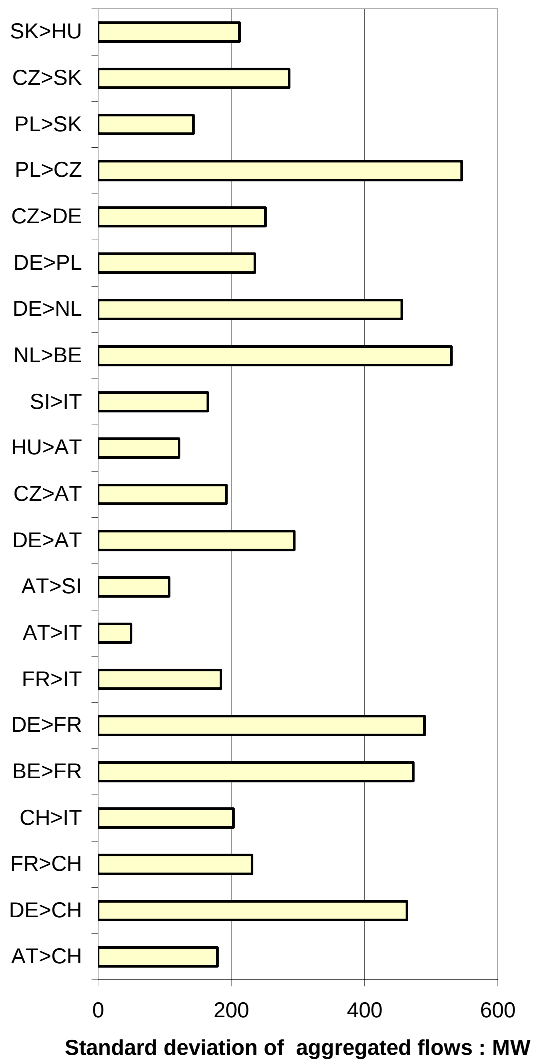
2 PHYSICAL FLOWS IN MESHED ELECTRICAL NETWORK

Even though the operation in an international meshed electrical network gives all the TSOs a lot of advantages for the security in case of major disturbances, we must observe that topological modifications in major Extra High Voltage substations and large changes in generation localization that are not noticed to or not noticeable by any TSO, can produce unforeseen cross-border physical flows which could lead to severe issues for the reliability of the operation of the European transmission system.

The aggregated physical flows on cross border tie-lines are not very constant from one day to the other.

The figure 1 presents for most of the borders of UCTE grid, the standard deviation of aggregated physical flows between "countries" (positive value in the "export" direction from XX to YY : "XX >YY", ISO codes are used for the identification).

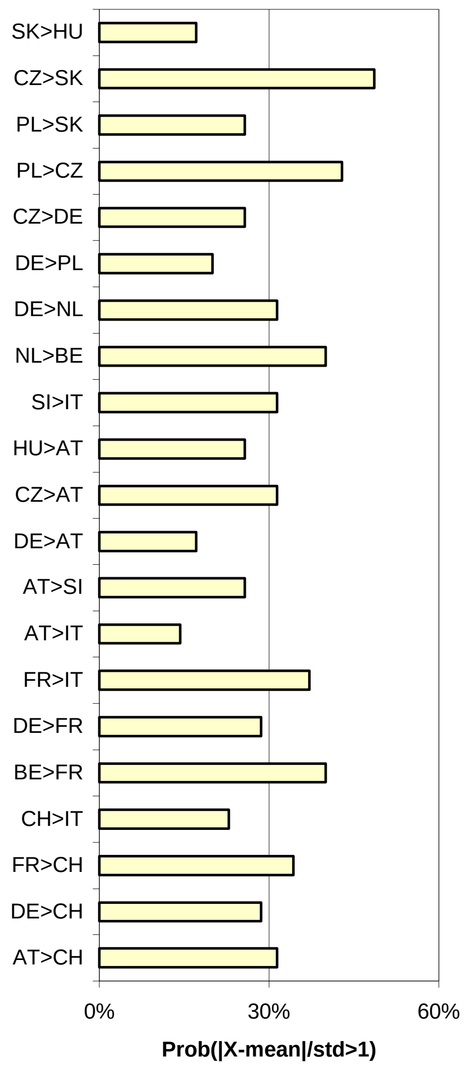
Figure 1:



The standard deviations of the aggregated physical flows on cross border tie lines at 10:30 a.m. are estimated on working days from the 2 November to the 21 December 2004.

The figure 2 presents the estimated probability for the absolute value of standardized aggregated flows (|x-mean|/std) to be greater than 1.

Figure 2:



The variations of some of the aggregated physical flows on cross border tie lines could very large for one day to the other and greater than the expected value considering a normal distribution (probability for the absolute value of the standardized variable to be greater than one is around 30% for a normal distribution). Detailed models and load flow calculations are needed to predict accurately the physical flows on cross border tie lines.

3 DAY AHEAD CONGESTION FORECAST

3.1 Data exchanges to predict physical flows

Transmission System Operators have to ensure the n-1 security of the electric transmission system. In operational planning phase “today for tomorrow”, they have to predict the physical flows, check if they are beyond lines capacity and manage the congestion if any. In the past, the localization of generation was most of the time (except for “special days”) very stable from one day (or week) to the other so the physical flows were easier to predict. Each TSO could obtain a prediction of physical flows by updating a very simple model of neighboring networks based on forecast balances of each “country” (control block). Moreover, the amount of electric exchanges was lower and the uncertainty on forecast physical flows was smaller than the remaining transfer capacity.

Nowadays, power flows become higher and more dynamic due to the increase of short term trading of electricity in Europe but also due to the increase of wind power generation.

An improvement of the accuracy of the forecast of physical flows is required because the transmission system is operated nearest its limits and “old simple” method couldn’t tackle the variability of topology and localization of generation.

An accurate detection of congestion requires carrying out load flow forecasts which demand the exchange of data between neighboring TSOs.

More detailed data must be exchanged between TSOs.

3.2 Beginning of Day Ahead Congestion Forecast (DACF)

In spring 2000, TSOs from France, Belgium and The Netherlands began to work together in order to build a process to predict Day Ahead congestion and began to exchange weekly detailed data. Nearly at the same time the TSOs from Switzerland and Italy started a similar bilateral process.

In summer 2000, the project Central European Data Exchange (CEDEX) was started by the TSOs in Germany, Austria, Poland, Hungary, Czech Republic and Slovak Republic. In the meantime, the two first projects had been merged and Germany had joined it.

In October 2001, all these processes merged in a single process called “DACF: Day Ahead Congestion Forecast”. The UCTE Sub Group “Network Models and Forecast Tools” today has the task to manage this process.

DACF was put in operation on 7 October 2002 and all UCTE members expressed their commitment to swiftly join this process.

3.3 Description of the process and implementation issues

The main principle of the method is that each “country” (e.g. control block) provides to all other “countries” a forecast which comprises a complete load flow data set of its grid. The companies taking part in the forecast have to treat the data sets shipped to them by the other participants with uttermost confidentiality, because they include sensitive production schedules. A second principle to be respected by the participants is the reciprocity of the data exchange: a “country” can get the data from other “countries” only if it agrees to provide data of the same quality for the same time to all the participating “countries”. A third principle is that the load flow data sets are exchanged among the participating TSOs through the dedicated IT-backbone: the ETSO Electronic Highway (EH). After all these data sets have been exchanged, each “country” is able to construct a load flow model that represents the most probable state of the forecast time. That model should preferably include all UCTE networks, but a “country” could also disregard the data sets of countries whose influence on its network is deemed negligible. With this model each “country” is then able to carry out a load flow study and contingency analysis and to identify congestion. Each “country” has the responsibility to test its own network for congestion.

It is important to carry out these calculations with the whole, detailed network model in the interested area. I.e. all 380 and 220 kV elements (nodes, lines, 380/220-kV-transformers, injections into 380- or 220-kV-nodes and loads at 380- or 220-kV-nodes) have to be included in the data set as real models, i.e. no equivalents may be used at this voltage level. Where it is necessary equivalent lines and transformers t

All procedures of forecast creation, data creation in common format and data processing was established and in details described in guidelines of NMFT UCTE subgroup responsible for this process. [1]

The different steps of the DACF load flow forecast are the following:

1. Building of individual forecast load flow data set
    a. On the basis of forecast data for several hours of the following day (load forecast, generation schedules, programmed exchanges, topology, etc.), each “country” builds a load flow data set using their suitable equivalent model for the external networks.
    b. Extract the part of the data set representing the own “country” by cutting all border-crossing tie-lines in their electrical centre (half the line parameters) and adding a fictitious node (starting with the character “X” in its name). The names of these fictitious nodes are defined in a reference document and must be respected. Adjust the injection (load or generation) at the fictitious X-nodes to match the estimated tie-line flows. (The assumed tie-line flow has no influence on the results obtained after the composition of the total interconnected system, because their sole purpose is to allow a plausible load flow forecast to be carried out.)
    c. Carry out a load flow calculation of the “country” load flow data set to check plausibility.
2. Before 6 p.m., each “country” puts its complete load flow data set in a standard format called “UCTE-format” on a ftp server connected to a private communication network between European TSO’s named ETSO EH.
3. Each “country” gets the complete load flow data sets of all other participating “countries”. To build a European network model, data sets have to be merged by connecting the “X-nodes” and setting the X-node injections to zero.
4. Each “country” carries out a load flow calculation and a contingency analysis with the whole, detailed, and adjusted synchronously interconnected grid and identify congestions.
5. Exchange the results (the overloaded elements) with the participants before 8 p.m.
6. In case of a detected congestion: discuss the results with neighbouring TSOs. The Congestion Management procedure should follow in such cases.

All the data are sent each time, there is no central data base with a model of the interconnected system. The model of the interconnected system is built by merging all the individual models. The only predefined and centralized information is the list of “fictitious nodes” on cross border tie-lines.
The only data to maintain is this list. The UCTE sub group “Network Models & Forecast Tools” is in charge

to update this list. It is a very light process because an update is needed only when a new cross border tie-line is built and the update could be done long time before the commissioning of the line.

3.4 *Current status of TSO's participation to DACF*

Several cycles of data delivery are possible from the beginning of the process and each "country" could have a different level of participation according to their current operational organization depending on man power and IT facilities. The objective is that all countries reach as soon as possible a "full" participation.

From the beginning point two timestamps for DACF data sets exchange have been chosen: 10:30 a.m. and 03:30 a.m.. These two timestamps in most of the "countries" coincide respectively with the peak load hour and lowest consumption level hour.

The different cycles of data delivery are described in the following chart.

- Weekly 03:30: delivery the day before of a forecast data set once a week, for Wednesday 03:30 a.m.
- Daily 10:30: delivery the day before of a forecast data set every day for 10:30 a.m.
 (same definition for 03:30).
- Daily 24 hours: delivery the day before of a forecast data set every day and every hour.

	Daily 10:30 Weekly 03:30	**Daily 10:30 & 03:30**	**Daily 24 hours**
AL	W	*W*	*Nf*
AT	W	*W*	*W*
BA	W	*nu*	*nu*
BE	W	*W*	*6m*
BG	W	*W*	*Nf*
CH	W	*W*	*W*
CS	W	*W*	*W*
CZ	W	*W*	*W*
DE	W	*W*	*1y*
ES	W	*W*	*nu*
FR	W	*W*	*Nf*
HR	W	*W*	*6m*
HU	W	*W*	*Nf*
IT	W	*W*	*nu*
MK	W	*W*	*Nf*
NL	W	*W*	*Nf*
PL	W	*nu*	*1y*
PT	W	*W*	*W*
RO	W	*nu*	*Nf*
SI	W	*W*	*nu*
SK	W	*W*	*1y*

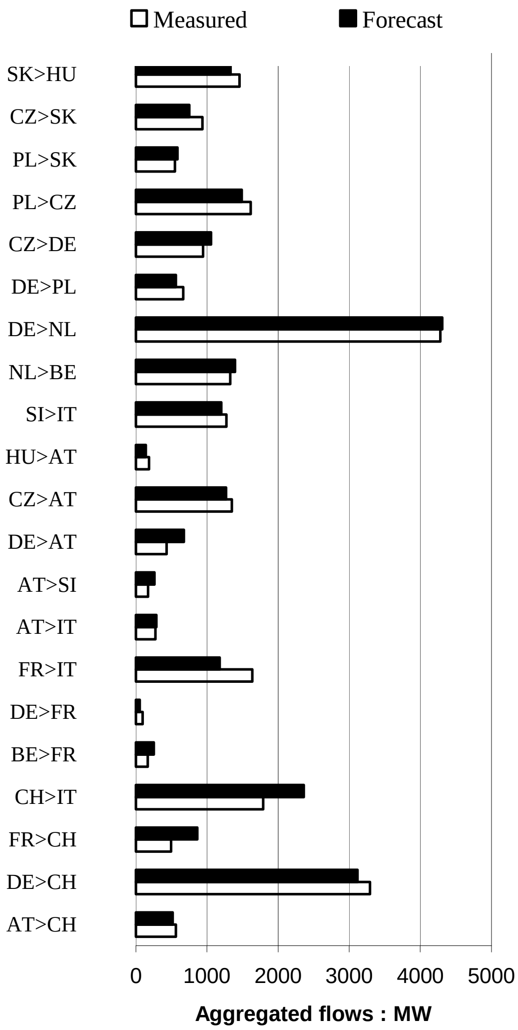
W : working
nu : able to participate, but not useful at the moment
nf : not foreseen at the moment
6m : able to realized within 6 months
1y : able to realized within 1 year.

3.5 Example of DACF results:

We present the results of the forecast physical flows for the 30th of December 2004.

The figure 3 presents for most of the borders of UCTE grid, the measured and the forecast sum of physical flows between "countries" (positive value in the "export" direction from XX to YY : "XX >YY").

Figure 3:



The cross border tie lines between Germany and the Netherlands were heavily loaded and the forecast made using DACF the day before had helped the involved

TSOs to prepare coordinated actions to ensure the security of the system.

The day ahead forecast becomes more and more difficult due to intra day modifications (market but also wind power). The main interest of DACF is to have a common base case for all the European TSOs.

In real time, each TSO could evaluate the impact on security of intra day modifications using the DACF data set as a base case. If some coordinated congestion management is needed between TSOs, this common DACF base case could help to find an efficient solution for solving the detected congestion.

In the example, the global quality of the forecast was acceptable and allowed the European TSO to manage the possible congestion between Germany and the Netherlands. But some differences are large, on the French-Italian border we find a difference of around 450 MW. Most of the time, the main differences could be explained by intra day modifications which are unpredictable the day before.

4 CONCLUSION

The UCTE SG "Network Models and Forecast Tools" keeps on improving the DACF process. The priority is the improvement of data quality and increasing the number of timestamps per day for which the DACF can be performed

Today, DACF is very useful for countries like Belgium, The Netherlands and Switzerland submitted to transit flows which largely depend on the neighboring networks operation status.

With the increase of the variability of the localization of generation in Europe (market and wind power) and the use of phase shifters to control power flows, DACF will be more and more essential to ensure the security of the European high voltage transmission network.

DACF is a tangible result of the improvement of co-ordination between European TSOs.

Thanks to the supply of DACF forecast results, a transparent early warning system for congestion is available to TSOs at an acceptable quality level. This helps them to react in time in order to ensure the security of European high voltage network.

The DACF procedure is a mandatory step to enable Coordinated Congestion Management providing a better use of network transmission capacities in a secure and efficient way for the benefit of all grid access clients

REFERENCES

[1] UCTE, "Operation Handbook: Policy 4, coordinated operational planning, subsections D : Day Ahead Congestion Forecast", www.ucte.org