DYNAMIC LINE RATING

December 2016

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EXECUTIVE SUMMARY

In 2008, in collaboration with Ampacimon©, Dynamic Line Rating (DLR) has been tested for the first time on a 380kV line in Belgium. Elia has been one of the pioneers in Europe by installing such a technology on several lines. Elia is ready to take the use of this technology to another level by integrating it into the capacity calculation mechanisms.

Since the December 5th, 2016, Elia uses the DLR data of Ampacimon to increase the available capacity of all equipped lines in the D2CF, DACF and IDCF files. Elia has fixed a cap of 105% of the seasonal limit for all equipped lines and for all time-horizons (D2CF, DACF and IDCF). In case of a significant cold spell, Elia is also considering the possibility to increase this cap to 110% cap of the seasonal limit for all equipped lines and for all time-horizons (D2CF, DACF and IDCF).

INTRODUCTION

The aim of this document is to explain choices made by Elia regarding the use of dynamic line rating for the congestion forecasting processes from two days ahead up to intraday. The first section contains some technical features and historical context of the Ampacimon technology. The second section shows some statistical results and the resulting operational rules for Elia.

Please note that all statistical results in this document are based on a dataset from 1/01/2015 up to 31/10/2016. Considering that Forecasts 1h (see section 1.1.2.) are relevant only if the flows on a given line are superior to about 30% of the nominal ampacity, depending on the specific line there were only between 2000 and 4000 valid hours retained for the statistical analysis. It is often said that a dataset of minimum 3 years (i.e. 26280 hours) becomes statistically reliable when meteorological forecasts are involved.

1. Ampacimon technology

1.1. Types of Ampacity: Real-time and forecasts

The Ampacimon technology makes use of small modules installed on the most critical spans of a line. Those modules measure continuously the line sag and this allows Ampacimon to calculate the maximum permanent flows that the line can support.

The modules are powered by induction of the current flowing on the line. Due to technical limitations, if those flows are smaller than about 30% of the nominal capacity then the modules are not activated and the ampacity falls back to a degraded value based only on temperature measurements. This limit has been chosen since at that moment at least 70% of the line capacity is still available and the added value of DLR is then negligible. The values received by Ampacimon are then processed by Elia and the limitations of other elements of the line in the bays are then taken into consideration.

1.1.1. Real-Time (RT) Ampacity

The RT Ampacity gives the permanent maximum ampacity of the line. It makes use of real-time measures of the line sag from each of the Ampacimon modules installed on a line. This RT ampacity is accurate and refreshed every 5 minutes. The RT ampacity gives high ampacity values but is too volatile to be used in real-time grid operation (local climate conditions vary continuously).

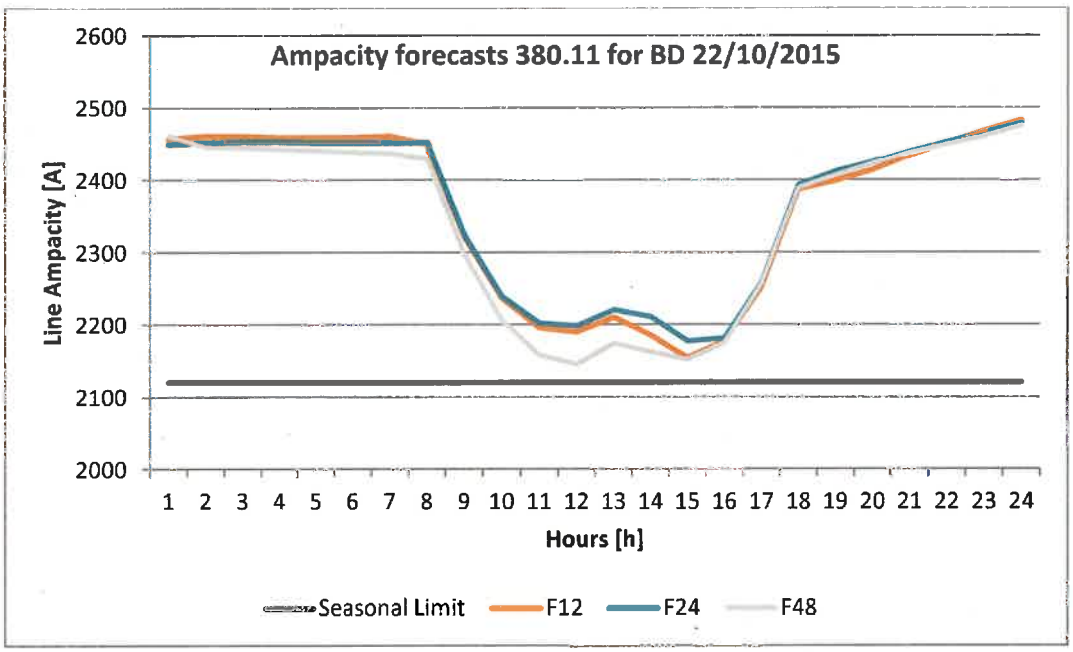
1.1.2. Forecast 1h

This is the ampacity used in real-time by Elia in the grid security calculations. It gives the maximum ampacity of the line which can be used with sufficient certainty for the next hour[1]. As a consequence the forecasted ampacity 1h is on average 10 to 15% lower than the RT ampacity but is more stable and thus suitable to be used in real-time grid operation.

1.1.3. Forecast Horizon

The Forecast Horizon gives an estimation of the ampacity of a line for the coming 60 hours. It requires an extra license. This forecast makes use of weather forecasts and the historical link between weather conditions and measured line-sagging. It is refreshed every 6 hours when new weather forecasts are available. In this document we will use the following convention: the forecast "xx" hours in advance will be noted "Fxx".

Please note that for a given business date and time there are practically no differences between the ampacity F60, F54, F52, etc. This is due to the fact that temperature is the main parameter in the Forecast Horizon algorithm. In Belgium, temperature forecasts are relatively accurate over a 3 days' time horizon. Hereunder the ampacity forecasts for 3 time-horizons for the 22/10/2015 on line 380.11. This is a typical shape showing a lower ampacity forecast during daylight (temperature effect).



[1] 98% of the time the Forecast 1h will not be overestimated even if climate conditions vary.

1.2. Historic

In collaboration with Ampacimon©, the Dynamic Line Rating has been tested for the first time on a 380kV line in 2008. After 3 years of tests of this prototype two 150kV-lines in the coastal region were equipped with Forecast 1h in the framework of the Twenties project. After 3 years of return of experience it has been decided to install Forecast 1h on the most critical overhead lines of the Elia grid. Elia has been one of the pioneers in Europe by making use of this technology.

Since then Forecast 1h has helped Elia during several critical moments on the Elia grid. Some lines have been highly loaded thanks to the DLR demonstrating the utility, reliability and efficiency of this technology for the real-time management of the grid.

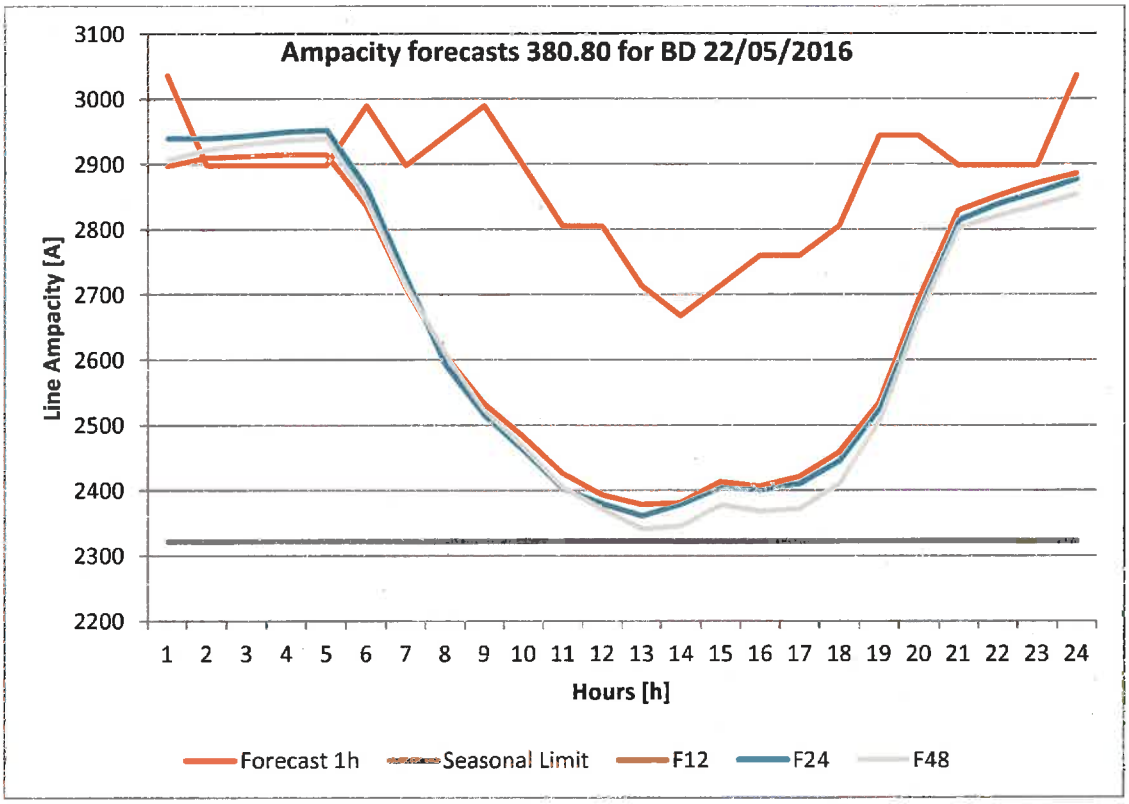
In 2015, Ampacimon developed for Elia a new algorithm, the Forecast Horizon, in order to provide an ampacity forecast on overhead lines up to 60 hours in advance. Elia quickly decided to install such licenses on five 380kV lines due to the adequacy situation at that time in Belgium. It was necessary though to have sufficient statistical data to be able to assess properly the performance of the new algorithm. This document gathers the conclusion of this analysis. The table hereunder shows the different Ampacimon licenses that Elia will have starting from 1/01/2017. At the end of the document those licences are represented on a map of Belgium.

Line ID	Line Name	Forecast 1h license	Horizon license
380.23	Meerhout-Van Eyck	YES	-
380.27	Van Eyck-Maasbracht	YES	-
380.19	Achène-Lony	YES	YES
380.25	Doel-Zandvliet	YES	YES
380.11	Herderen-Van Eyck	YES	YES
380.28	Van Eyck-Maasbracht	YES	YES
380.79	Avelgem-Mastaing	YES	YES
380.29	Zandvliet-Kreekrak	YES	-
380.30	Zandvliet-Kreekrak	YES	-
380.80	Avelgem-Avelin	YES	YES
380.26	Doel-Zandvliet	YES	YES
220.513	Aubange - Moulaine	YES	YES
220.514	Aubange - Moulaine	YES	YES
150.5	Brugge-Langerbrugge	YES	-
150.6	Brugge-Langerbrugge	YES	-
150.15	Brugge-Slijkens	YES	-
150.16	Brugge-Slijkens	YES	-
150.313	Baudour-Chièvres	YES	-
150.314	Baudour-Chièvres	YES	-

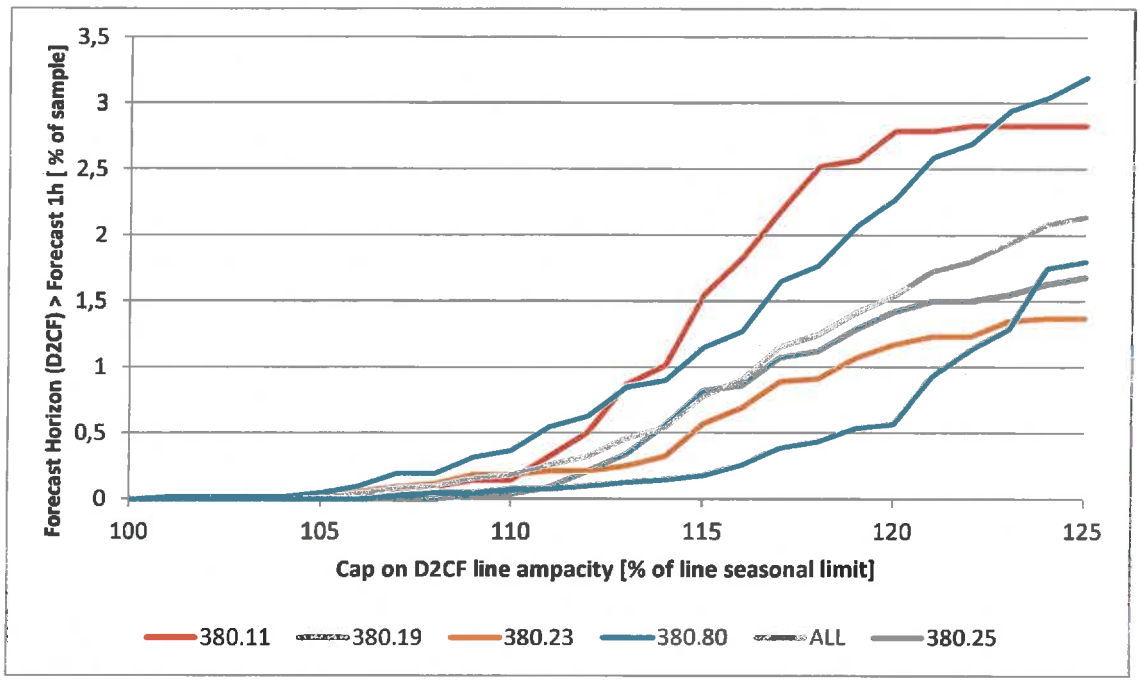
2. Operational values for Forecast Horizon

2.1. Reliability Analysis

The forecast Horizon provided by Ampacimon is not 100% reliable. Sometimes the Horizon values are higher than the values used in real-time in the security analysis (i.e. Forecast Horizon > Forecast 1h for a given date and time). For example, the graph hereunder represents the ampacity forecast on the line 380.80 for business date 22/05/2015. For a couple of hours in the night we observe that the Forecast 1h is smaller than the Forecast Horizon.



Hereunder a graph showing the probability that a Forecast Horizon (D2CF) is greater than the Forecast 1h for each line currently equipped with Horizon licenses.



This graph shows the occurrences where the Forecast Horizon is higher than Forecast 1h (ordinate axis). We observe that the Forecasts Horizon values capped at 105 % of the seasonal limit presents a robust confidence margin (~100%).

2.2. Capping rule

Considering:

- the relatively small statistical sample used for these analyses,
- that FRMs[2] cover only 90% of the situations,
- Ampacimon Forecast remains a relatively young technology,
- using the Forecast Horizon in the D2CF, DACF and IDCF without any capping rule would represent a probability between 1,4% and 3,2% that Forecast 1h < Forecast Horizon
- this probability decreases strongly in case of a significant cold spell,
- our grid exploitation criteria as well as our obligations arising from the ENTSO-E Operational Handbook

[2] Flow Reliability Margins are the predefined shares per line that are not given to the market via the Flow-based mechanism.

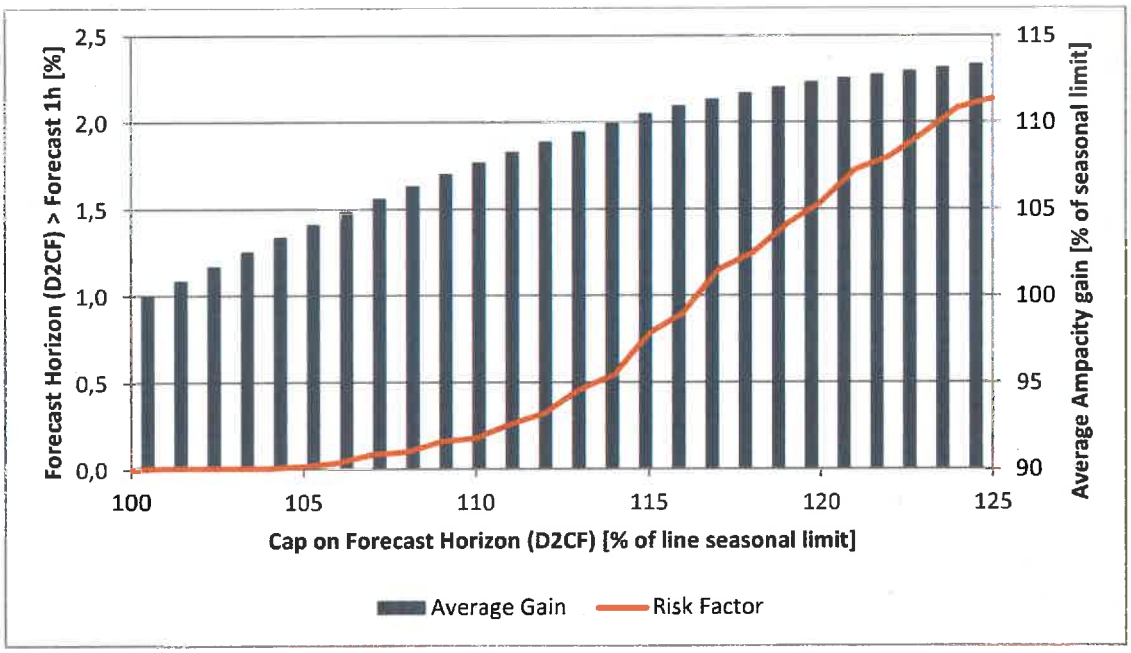
Since the December 5th, 2016, Elia uses the DLR data from Ampacimon to increase the available capacity of all equipped lines in the D2CF, DACF and IDCF files.

Elia makes use of a 105% cap on the seasonal limit for all lines equipped with Forecasts Horizon and for all time-horizons (D2CF, DACF and IDCF).

In case of a significant cold spell[3], Elia is also considering the possibility to increase this cap to 110% of the seasonal limit for all equipped lines and for all time-horizons (D2CF, DACF and IDCF).

As explain earlier, for the same date and time, there are practically no differences between the different Forecasts Horizon. The forecast 60 hours in advance or 6 hours in advance are almost identical. As a result it does not make any sense to differentiate the capping rule between D2CF, DACF and IDCF.

As shown on the graph hereunder, on average a cap of 105% on Horizon forecasts will result in an Ampacity gain of about 104% due to the fact that sometimes the Forecast Horizon is lower than 105%. The graph hereunder shows the average ampacity gain (average of the 5 lines equipped with Forecast Horizon) as well as the risk of delta between Forecast Horizon and Forecast 1h in function of the cap threshold on the Forecast Horizon.



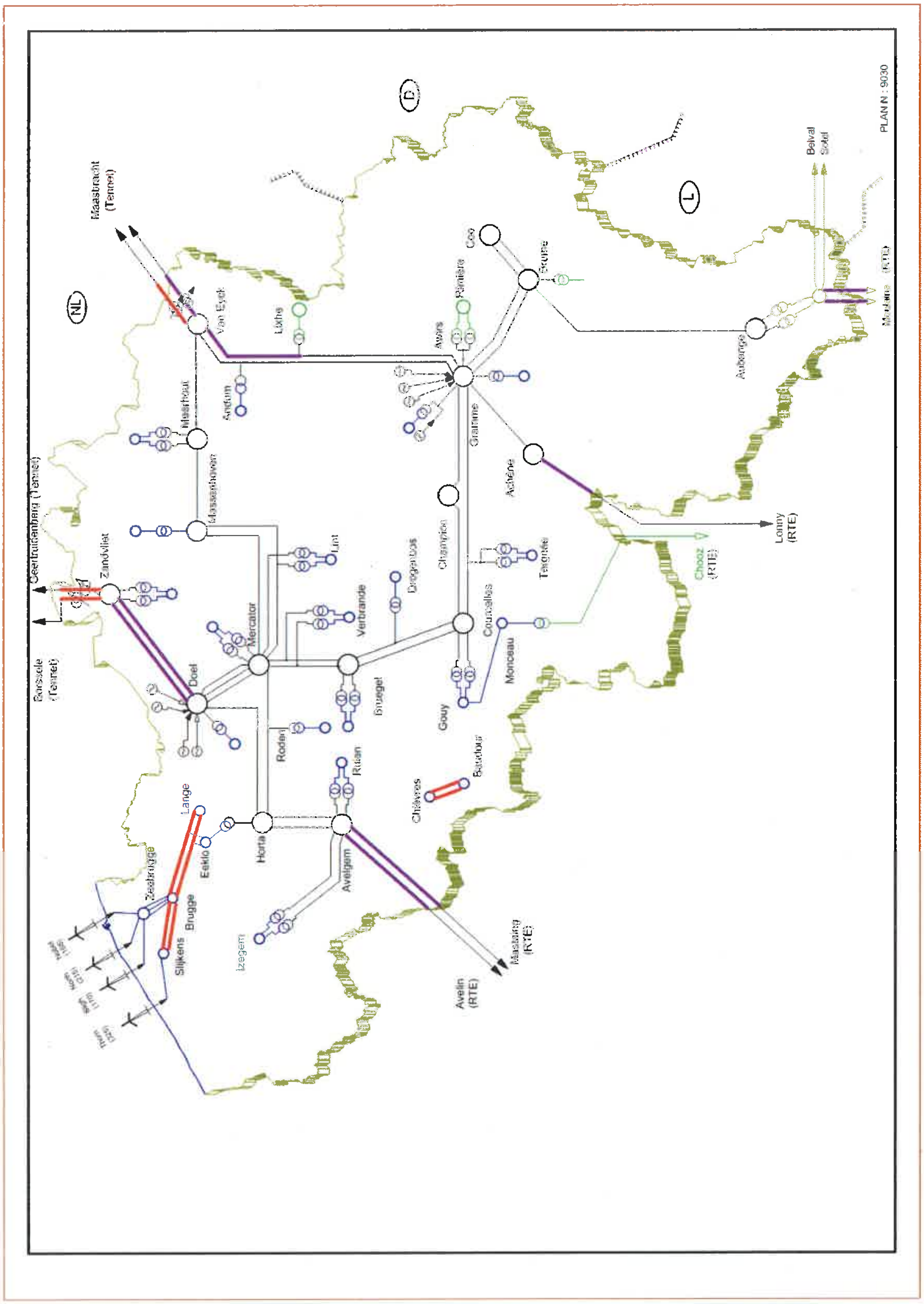
[3] For Belgium, a cold spell is described as a period where the daily temperature is lower than -2 °C for at least 7 consecutive days and when at least one of the following conditions is met: i) the low temperature during this period dropped at least twice to below -7 °C; ii) the high temperature remained below 0 °C for 3 days during the period.

CONCLUSION

We see that using a 105% capping rule limits the additional operational risk taken through the use of DLR. Similarly, using a 110% capping rule during a cold spell could represent a limited additional operational risk due to the fact that the lower the temperature the higher the lines ampacity.

The capping rules might vary in the future after the increase of the statistical sample and the observation of the real effect on the flow-based domain.

Until further notice, Elia is ready to always use the seasonal rating as lower limit, however a study is ongoing in order to evaluate the risk taken. It would only seem logical to also go under seasonal rating when Ampacimon Forecasts foresee such a situation.



NL
D
L
Maastricht (Tennet)
Van Eyck
Lixhe
Gramme
Awirs
Rimière
Coo
Brume
Aubange
Achêne
Lonny (RTE)
Chooz (RTE)
Belval
Sotel
Zandvliet
Doel
Mercator
Massenhoven
Meerhout
Verbrande
Bruegel
Courcelles
Gouy
Monceau
Horta
Rodenhuize
Avelgem
Ruien
Eeklo
Zeebrugge
Brugge
Slijkens
Izegem
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